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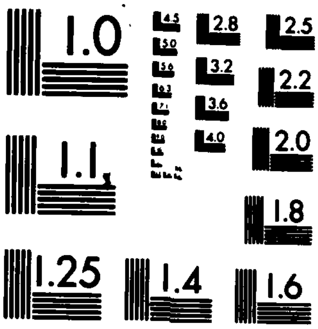

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ABSORPTION COEFFICIENT OF ALKALINE EARTH HALIDES

By

H. H. LI

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20. ABSTRACT (continued)

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ABSTRACT

Experimental data on the absorption coefficients of alkaline earth halides were searched, compiled, and analyzed. It was found that the bulk of available data were concentrated to the absorption edges of the main transparent region and were for the four materials CaF_2, SrF_2, BaF_2 and MgF_2. An equation was formulated to best describe the absorption data in the infrared multiphonon region as a function of both frequency and temperature. Constants in the equation were determined based on data fitting and correlation. It was noted that the same type of equation is equally valid for both alkaline earth halides and alkali halides. Although the intrinsic absorption can be predicted by the proposed equation, discrepansies may occur in the region where absorption is extremely low and where extrinsic absorptions due to impurities and surface contamination dominate the intrinsic absorption by factors ranging from fractions to multiples of ten. Experience has shown that extrinsic contributions can be reduced through improved crystal growing and surface polishing techniques.

Key Words: absorption coefficient, optical constants, alkaline earth halides.

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LIST OF SYMBOLS

A	constant
a	constant
a_0	lattice constant
B	constant
b	constant
C	specific heat, constant
c	constant; velocity of light
D	constant
d	thickness of specimen
E	energy in units of eV, emittance
E_0	constant
f	f number of transition ~1, frequence
f_0	constant
h	Plank constant
k	Boltzmann constant
L	length of specimen
M	molecular weight
M_i	number of i-th type imperfection per unit area
N_i	number density of i-th mode
n	refractive index
$\bar{n}$	Bose-Einstein occupancy factor
R	apparent reflectivity
R_∞	reflectivity at normal incidence without contribution from multiple internal reflection
$\bar{R}$	complex reflectivity
r	radial distance

r_e	classical electron radius
S_i	strengths of the i-th oscillator
T	temperature
t	thickness of specimen

Greek Symbols

α	absorption coefficient in units of cm^{-1}
α_0	constant
γ	damping factor, phase angle
ϵ	complex dielectric constant
ϵ_0	static dielectric constant
ϵ_∞	optical dielectric constant
κ	absorption index
λ	wavelength in units of μm
ν	wavenumber in units of cm^{-1}, frequency
ν_0	constant
ν_{Lo}	wavenumber of longitudinal optical phonon
ρ	resistivity, density
σ	surface absorption, Poisson's ratio
σ_i	absorption cross section
σ_s	steepness parameter in Urbach rule
σ_{so}	constant
τ	collision time, transmission
θ	phase angle
ω	frequency

1. INTRODUCTION

The purpose of this work is to present and review the available data and information on the absorption coefficient of alkaline earth halides, to critically evaluate, analyze the data, and to recommend the most probable values. The analysis covers the widest possible range of the transparent wavelength region and is for the purest form of each alkaline earth halide on which measurements have been made.

In order to utilize any dispersive medium, spectroscopists must have a knowledge of the index of refraction and $dn/d\lambda$ for all wavelengths transmitted by the medium. Laser technology concerns itself with the absorption coefficient and its temperature dependence. Such data are also useful to physicists for evaluating theoretical dispersion equations and for studying the mechanism of the interaction between radiation and matter.

The dispersion in an optical material is intimately related to the microscopic structure of the material. On the short wavelength side transmission is limited by electronic excitation, and for long wavelengths by molecular vibrations and rotations. The width of the transparent spectral region increases as the energy for electronic excitation is increased and that for molecular vibrations is decreased. Theoretical and experimental studies on ionic crystals indicate that crystals having small ions with strong bonding have a wide spectral region of transparency. This is true for alkali halides and alkaline earth halides.

Unlike the alkali halides, which form only cubic crystals, the alkaline earth halides form crystals with a variety of structures. The four types of structure that are found in the alkaline earth halides are indicated in table 1. It should be noted that, with the exception of MgF_2, only crystals of cubic structure have been investigated for optical properties and for practical applications.

Calcium fluoride in its naturally-occuring form is known as fluorite. It is conventional to describe a crystal as having the fluorite structure if its lattice is similar to that of calcium fluoride. In a fluorite-structure crystal of a compound AB_2 each ion of species A is surrounded by eight equivalent nearest-neighbour ions of species B forming the corners of a cube with A at its center. Each ion of species B is surrounded by a tetrahedron of four equivalent A ions. More fundamentally, the structure has a face-centered-cubic translational group and a space lattice of symmetry O_h^5. If the structure is interpreted in terms of a primitive cube of side a, it comprises three interpenetrating face-centered-cubic lattices. The first is a lattice of species A with its origin at the point (0,0,0) and with primitive translational vectors, (0,a/2,a/2), (a/2,0,a/2), and (a/ 2,a/2,0) in the cube of side a. The B species are located on two further lattices with similar translational vectors but with origins at (a/4,a/4,a/4) and at (3a/4,3a/4,3a/4). The site of the A ion has O^5 symmetry and the site of the B ion has T

TABLE 1. CRYSTAL STRUCTURE OF ALKALINE EARTH HALIDES

Material	Structure
BeF_2	Orthorrhombic, Hexagonal, Tetragonal
$BeCl_2$	Orthorrhombic
$BeBr_2$	Orthorrhombic
BeI_2	Orthorrhombic, Tetragonal
MgF_2	Tetragonal
$MgCl_2$	Hexagonal
$MgBr_2$	Hexagonal
MgI_2	Hexagonal
CaF_2	Cubic
$CaCl_2$	Othorrhombic
$CaBr_2$	Othorrhombic
CaI_2	Hexagonal
SrF_2	Cubic
$SrCl_2$	Cubic
$SrBr_2$	Tetragonal
SrI_2	Hexagonal
BaF_2	Cubic
$BaCl_2$	Cubic, Orthorrhombic
$BaBr_2$	Orthorhombic
BaI_2	Orthorhombic

symmetry. The interstitial site again has O_h^5 symmetry, being at the center of a cube of eight B ions. The crystal is not piezoelectric.

It is apparent that the fluorite structure provides close contact between the different species of atom or ion. Furthermore if the ions of species A are sufficiently large, close contact between the ions of species B is prevented. If the constituent species are regarded as hard spheres with radii r(A) and r(B), contact occurs between the A and B ions to the exclusion of B-B contact and of A-A contact [1] when the radii satisfy the condition

$$4.45 > r(A)/r(B) > 0.73. \qquad (1)$$

The energetic advantages of close contact between dissimilar ions suggest that the fluorite structure will be favoured by those strongly ionic compounds with formula AB_2 which possess large ions of type A. A self-consistent set of ionic radii, such as that of Zachariasen [2] summarized in Table 2, shows that one is unlikely to find a hypothetical compound in which contact between A ions could occur. This would require that the A ions be exceptionally large, with

$$r(A) > 4.45r(B) \qquad (2)$$

In fact, the A ions are normally relatively small and it is possible to find several series of compounds in which the lower limiting value is passed, and contact between B ions can occur. For example, among the halides of barium one finds that the fluorite lattice structure occurs for the smaller halide B ions

TABLE 2. THE CRYSTAL RADII OF IONS

Be^{2+}	0.30A	F^-	1.33A
Mg^{2+}	0.65A	Cl^-	1.81A
Ca^{2+}	0.94A	Br^-	1.96A
Sr^{2+}	1.10A	I^-	2.19A
Ba^{2+}	1.29A		

while the iodides possess orthorhombic or sheet-like structures.

Among the compounds of alkaline earth halides those which possess the fluorite structure are, according to Wyckoff [1], CaF_2, SrF_2, BaF_2, $CaCl_2$, $SrCl_2$, $BaCl_2$. The absence of bromides and of iodides may be interpreted in terms of a violation of the radius requirement, the anions being relatively too large. It is apparent on inspection of table 2 that close contact between A and B ions cannot occur for the light cations.

There are two major reasons why only crystals of cubic structure have been investigated. The first is that cubic crystals are optically isotropic. It is true that optical anisotropy is highly desirable in a number of special uses , but for the fabrication of optical components in general, anisotropy of dispersion may become objectionable. It is therefore understandable that early investigations were limited to the cubic crystals, but it is surprising that even at the present stage of modern technology our knowledge of optical properties is still limited to that of cubic crystals. With regard to the optical properties of the non-cubic crystals, little work has been reported.

The second reason for the lack of attention to non-cubic alkaline earth halide crystals is the unavailability of the crystals or their undesirable chemical and physical properties, such as hygroscopy and softness. With advances in the technique of crystal growth, crystals which do not occur naturally are now made available in workable sizes. Examples are BeF_2 [3], $MgCl_2$

[4], and $BaBr_2$ [5]. However, measurements on the optical properties of these crystals are not available in the open literature.

The applications of high-power infrared lasers are partly limited by the lack of suitable transparent optical materials. As a result, much of the high-power laser research is directed toward finding adequate high-temperature window and dome materials in the wavelength regions from 2 to 6 μm and near 10.6 μm. The alkaline earth halides have large transmission ranging from the ultraviolet to the infrared and are available in large sizes and high purity. They are considered as good window materials and are among the serious candidates for laser materials. Efforts are being made to improve their mechanical strength and thermal endurance without altering their optical properties.

Among the various optical properties, those of practical importance are the refractive index and absorption coefficient. The latter is especially important in the application of high-energy lasers because many unfavorable effects, which are not observed at low energy level, are developed at high power levels. No matter how low the absorption is, the effect is objectionable at high-energy levels. As a natural consequence, the magnitude of the absorption coefficient is the key parameter in selecting laser window materials.

Over the past years extensive theoretical and experimental investigations have been conducted in an effort to determine the absorption property for optical materials and to identify the mechanisms influencing the absorption. As a result, numerous measurements and calculations have been reported. However, the available information is dispersed throughout the literature. A comprehensive literature survey, data compilation, and analysis is needed, yet on overall topography of the data and predictions of most probable values are not available for scientific research and engineering applications. Because of these reasons, the present work was initiated. Inherent in the character of this work is the fact that we have drawn most heavily upon the scientific literature and feel a debt of gratitude to the authors whose results have been used.

2. FUNDAMENTAL ABSORPTION MECHANISMS AND THEORIES

In figure 1, a schematic view of the absorption spectrum of a typical alkaline earth halide crystal is shown. At the left, at about 30 μm, are seen the absorption peaks associated with optical phonons, while toward the right, at about 0.1 μm, are seen the absorption peaks associated with excitons. The regions at the edges of the fundamental transparent region are termed as the Urbach tail and the multiphonon regions. In the transparent region, the transparency of the material is limited by many factors which constitute extrinsic absorption.

In this section we will give a brief review of what is known about the physical mechanisms that are responsible for the small residual absorption in the transparent infrared wavelength regions and a brief discussion on the multiphonon absorption theories. It is convenient to separate the origins that give rise to residual absorption into two classes, the extrinsic and intrinsic. Extrinsic absorptions are those associated with impurity atoms and molecules, deviations from stoichiometry, lattice defects and surface contaminations. The intrinsic absorption are those due to the electronic and vibrational absorptions in an ideal crystal of some specified composition. In practice, extrinsic absorptions appear to be more troublesome in the best of currently available materials and there are no appropriate means to completely eliminate the objectionable absorptions in optical materials.

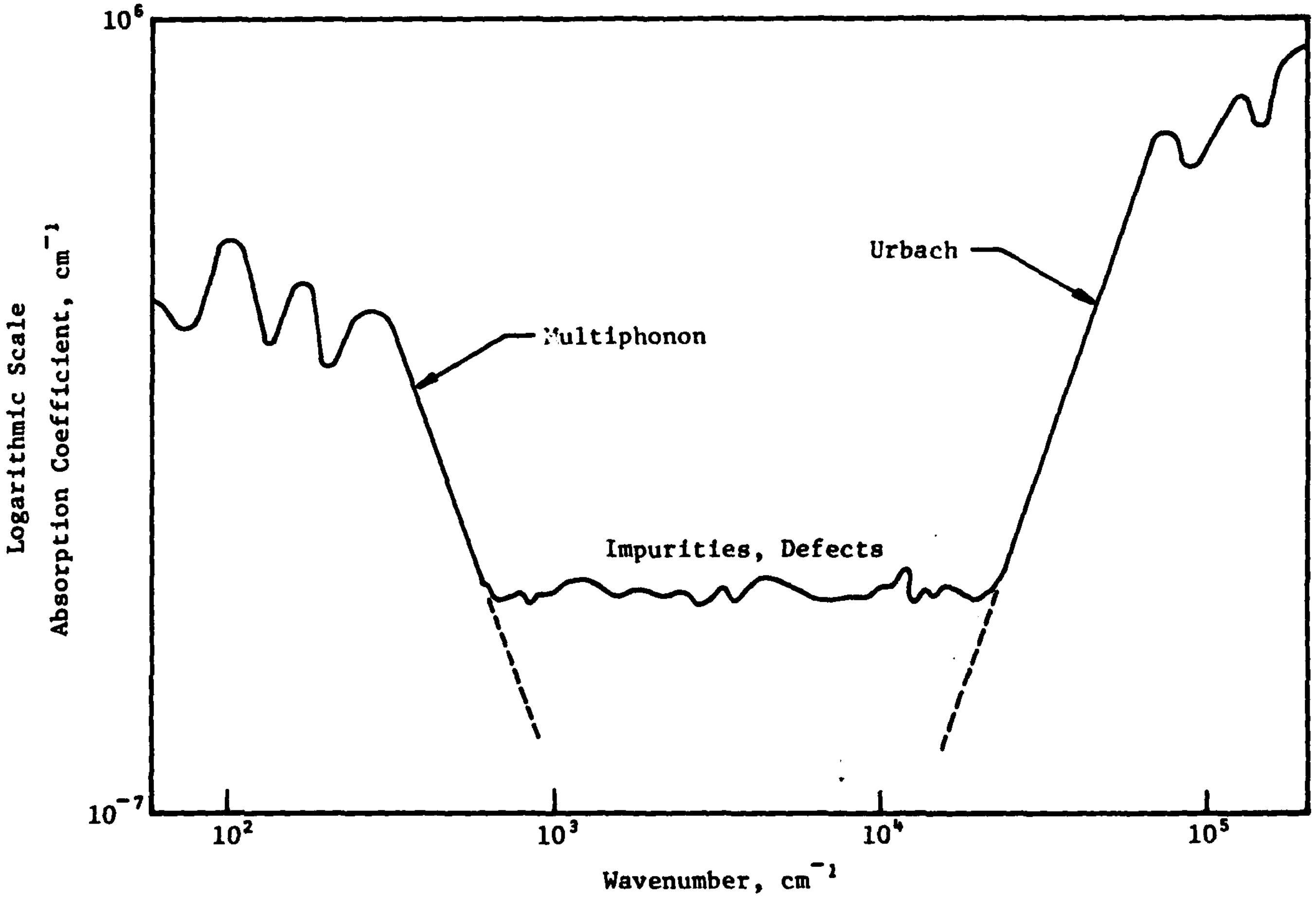

Figure 1. Schematic Absorption Spectrum of an Alkaline Earth Halide in Semilogarithmic Scale

In a given crystal, the total absorption can be considered as simply a superposition of the absorption from various origins. The total absorption coefficient, $\alpha(\nu)$, at frequency ν is well approximated by

$$\alpha(\nu)=\Sigma N_i \sigma_i(\nu), \tag{3}$$

where the sum is over the various modes and types of imperfection. N_i is the number density of the i-th mode or type and σ_i is the corresponding absorption cross-section.

In both of the extrinsic and intrinsic absorptions, the processes that give rise to $\sigma_i(\nu)$ may be of three general types: (1) lattice vibration, (2) free-carrier absorption, and (3) electronic excitation.

2.1. Lattice Vibration Absorption

There have been a number of recent studies on how the infrared absorption drops off as the frequency becomes much greater than the fundamental lattice frequencies. These studies have been mainly on the alkali halides and alkaline earth fluorides. In the highly purified samples, the absorption coefficient exhibits an exponential fall-off over two to four decades to the lowest values of α that can be measured. Whether this exponential absorption tail is characteristic of all other classes of materials is not known.

Presence of impurities can complicate the exponential tail, particularly at low absorption levels. The impurities may enter the lattice singly or multiply in various types of configurations. Unfortunately, the impurity atoms or molecules, which appear to produce troublesome absorptions near 10.6 and 2-5 μm, have not yet been studied adequately. These impurities are primarily the oxygen and hydroxyl radicals whose absorptions are centered at about 3, 9 and 13 μm. The absorption cross sections due to these impurities are in the range of 10^{-18} to 10^{-20} cm^2.

2.2. Free-Carrier Absorption

Free carriers either intrinsic or caused by impurities contribute a term, α_e, to the absorption which can be correlated roughly with the dc resistivity. Except in the very pure nonpolar crystals, the free-carrier collision time, τ, is on the order of an infrared period (i.e., $\nu\tau \leqq 1$). Under this condition, the resistivity at that frequency is not much different from the dc resistivity and can be approximated by the Drude formula

$$\alpha_e(\nu)=[30/\rho \; n(\nu)]/(1+\nu^2\tau^2) \text{ cm}^{-1}, \qquad (4)$$

where ρ is the dc resistivity in units of ohm-cm and $n(\nu)$ is the refractive index at frequency ν. Although free-carrier absorption is negligible for alkali halides and alkaline earth halides, high intensities of laser beam may increase the free-carrier concentration by photo-excitation.

2.3. Electronic Absorption

In the consideration of infrared transparency of the materials, only those with band gap much higher than the infrared frequencies are considered. In the case of alkali halides and alkaline earth halides, electronic excitation contributes little to the infrared absorption. Those which do affect the infrared absorption have their origins due to heavy impurities.

Heavy impurities generally have so low vibration frequencies that the wing of their vibrational absorption contributes negligibly at laser wavelengths. However, heavy impurities may contribute to infrared absorption via their electronic absorption tail. Assuming the profile of impurity electronic absorption is a Lorentzian line at ν and of half width $\Delta\nu$, then the absorption cross section is given by

$$\sigma_e(\nu)=0.5fr_ec\Delta\nu[(\nu-\nu_e)^{-2}-(\nu+\nu_e)^{-2}]\ \mathrm{cm}^2 \qquad (5)$$

where r_e is the classical electron radius, c is the velocity of light and f~1 is the f-number of the transition. In the infrared where $\nu<<\nu_e$ eq. (5) is simplified to

$$\sigma_e(\nu)=2fr_ec\nu\Delta\nu/\nu_e^3. \qquad (6)$$

It is well known that the half width, $\Delta\nu$, of heavy impurities is generally very large and consequently contributes noticeably to absorption in the infrared.

2.4. Surface Absorption

Surface absorption can affect high-power laser window materials in many ways. The heat due to absorption can cause distortions of the optical phase front. In the case of fragile surfaces, the surface may develop cracks which subsequently propagate or enlarge, or become hygroscopic. When anti-reflection coatings are used, surface absorption may tend to dislodge or evaporate the coatings. The theory of surface absorption may be thought of in terms of the same mechanisms that were discussed for bulk absorption. The most commonly observed surface absorptions are those associated with oxygen and hydroxyl radicals whose absorptions are centered respectively at 2.8 and 9.3 μm in various crystals.

The fractional power of radiation, α_S, absorbed at the surface, is expressed in the same form as eq. (3):

$$\alpha_S(\nu)=\Sigma M_i \sigma_i(\nu), \tag{7}$$

where M_i is the number of imperfections of i-th type per surface, and σ_i carries the same meaning as those in eq. (3). In many cases, α_S is estimated to be in the order of 10^{-3} per surface. Although this is a significant figure in high-power laser operations, it is very difficult to eliminate with the existing technology. Moderate reduction of α_S can be achieved through improved crystal growing techniques and surface polishing.

2.5. Urbach's Rule

A central question for the development of ultra-transparent optical materials is: "In an impurity-free solid, what is the ideal or maximum transmission?" In the case of linear optics, this question can be partially solved by observing the absorption edge at low wavelength end of transparent region, the Urbach tail.

Investigation of the Urbach tail region may serve as an indicator to show the extent of impurity and/or defect contents. As generally observed, the purer the sample is, the greater the validity of Urbach rule is extended to the transparent region. By comparing the absorption spectrum at the Urbach tail, the purer sample is self-revealed. Studies on the Urbach rule for alkaline earth halides and alkali halides have been carried out by many workers, notably Haupt [6], Martienssen [7], Kobayashi and Tomiki [8], Miyata and Tomiki [9], Tomiki and Miyata [10], Sano [11], Tomiki [12], and Tomiki et al. [13]. Result of these works is an expression for the intrinsic absorption coefficient in the tail region, of the form:

$$\alpha(E,T)=\alpha_0\exp[-\sigma_S(T)(E_0-E)/kT], \qquad (8)$$

and

$$\sigma_S(T)=\sigma_0A^{-1}\tanh A,$$

where

E = photon energy in uits of eV

T = temperature in units of K

k = the Boltzmann constant

h = the Plank constant

$A = hf_0/2kT$.

The parameters α_0, σ_0 , E_0, and f_0 for various alkaline earth halides are given in Table 3.

Table 3. The Urbach Parameters of Alkaline Earth Fluorides

Crystal	E_0, eV	α_0, cm^{-1}	hf_0, eV	σ_0	Range of E, eV	Remarks
CaF_2	11.228	1.33×10^{10}	4.5×10^{-2}	0.61_7	9.3–10.7	Reported by Tomiki and Miyata [10]
SrF_2	10.670	1.35×10^{9}	4.4×10^{-2}	0.60_0	8.7–10.3	Reported by Tomiki and Miyata [10]
BaF_2	10.162	4.17×10^{8}	4.0×10^{-2}	0.58_8	8.3–9.8	Reported by Tomiki and Miyata [10]

2.8. Theories on the Multiphonon Absorption

Ever since the advent of high-power infrared lasers, the numerical values of absorption coefficient of window materials attracted much attention and have been receiving serious consideration in the wavelength regions where absorption is low. Because the wavelength regions of laser interest are located at the tails of the fundamental absorption bands, a number of theoretical and experimental investigations in the multiphonon absorption region have been carried out in order to define the intrinsic limits on the absorption.

The exponential frequency dependence of absorption coefficient on the high frequency side of the fundamental absorption band has been interpreted by a multiphonon absorption theory, in which the fundamental process which contributes to the absorption is that a photon is absorbed by the crystal through the virtual excitation of the fundamental (TO mode) phonon which in turn emits n phonons. The bulk of the theories concerning multiphonon absorption were developed during the years 1972 to 1974. Significant simplification, modification and improvement of these theories were also made during these years. The intrinsic absorption may be due to two possible mechanisms: the anharmonic coupling of phonons to the fundamental phonon and the displacement-induced electric moment of the ions, which may couple directly to the radiation. The former is termed as anharmonicity and the latter as higher-order moment. Although these two mechanisms are not totally distinct, as both result physically from charge overlap, traditionally, they have been treated differently. For the highly ionic crystals, the constituent molecules are less polarizable and therefore the effect of the higher-order moment is expected to be less important. As a consequence, the bulk of investigations on ionic crystals was centered on the anharmonically induced absorption.

There are two fundamentally different approaches in the calculation of the anharmonic absorption in ionic crystals. Each of them requires the solution of the harmonic lattice problems followed by a perturbation treatment of the anharmonicity. Spark and Sham [14,15] and McGill et al. [16,17] employed diagrammatic techniques for evaluation of the Green's function, while Bendow and Bendow et al. [18-22] used the equation-of-motion method. As detailed discussion on the theories is beyond the scope of the present work, the interested reader is referred to additional references [23-31]. Expressions for α, as obtained in the literature, are rather complicated. All of the theories indicate that corresponding to a given n there is an n-phonon absorption centered at the frequency of the excited phonon and that the observed absorption spectrum actually corresponds to the convolution of all possible n's. It is therefore expected to see structure features in the spectrum. In practice, however, the structure is observable only at low temperatures. At room temperature, the spectrum is well represented by an exponential law of the form

$$\alpha=\alpha_0\exp(-\nu/\nu_0). \qquad (9)$$

Deutsch [32] found that the exponential dependence of the absorption coefficient on frequency holds for alkaline earth fluorides at room temperature. The parameters α_0 and ν_0 of various crystals are given in Table 4.

2.7. Temperature Dependence of Multiphonon Absorption

With regard to the temperature dependence of absorption in the multiphonon absorption region, theories treat the phonons as Bosons and thus lead to the following expression:

$$\alpha \sim (\bar{n}+1)^n-(\bar{n})^n, \qquad (10)$$

where $\bar{n}$ is the usual Bose-Eistein population factor. The transition matrix elements are assumed to be essentially temperature independent. After rearrangement of eq. (10), the coefficient α can be expressed as a function of temperature given by

$$\alpha \sim [1-\exp(-nhf/kT)]/[1-\exp(-hf/k)]^n \qquad (11)$$

where f is the phonon frequency and $nf=\nu$ the photon frequency.

In the limit where $kT>>hf$, we have

$$\alpha \sim n(kT/hf)^{n-1}, \qquad (12)$$

or

$$\alpha \sim T^{n-1}. \qquad (13)$$

Application and discussion of the multiphonon theory can be found in Ref. [33-37].

Table 4. The Parameters of Equation (9)

Crystal	α_0, cm^{-1}	ν_0, cm^{-1}	Range of ν, cm^{-1}	Remarks
CaF_2	1.0568×10^5	93.6	1000–1600	Reported by Deutsch [32]
SrF_2	2.2548×10^4	90.4	850–1450	Reported by Deutsch [32]
BaF_2	4.9641×10^4	75.9	800–1250	Reported by Deutsch [32]
MgF_2	1.1213×10^4	143.8	1250–2000	Reported by Deutsch [32]

3. PRINCIPLES AND TECHNIQUES OF EXPERIMENTAL METHODS

The response of a nonmagnetic solid with isotropic or cubic symmetry to incident electromagnetic radiation can be generally described in terms of two optical constants which are related to each other through dispersion relations. These two optical constants can consist of either the refractive index n and the extinction coefficient κ, or ϵ_1 and ϵ_2, the real and imaginary part of the complex dielectric constant ϵ. These two pairs of constants are related as follows:

$$\epsilon=\epsilon_1+i\epsilon_2=(n+i\kappa)^2=(n^2-\kappa^2)+2in\kappa \qquad (14)$$

It is clear that measurements can be made either for n and κ or for ϵ_1 and ϵ_2. In practice, the former pair is readily accessible for direct observation and is widely used. There are a number of techniques available for determination of the optical constants. Given below are a few of the methods currently used for measuring the absorption coefficient. For general applications where extremely accurate absorption is not required, the ordinary transmission and reflection spectrum observation are adequate for optical constants determination. Precise determination for small absorption coefficients, in the order of 10^{-3} cm^{-1} or lower, was considered impossible until the laser source became available. As the bulk absorption becomes smaller than surface losses, uncovering the former requires amplification of the absorption effect which in turn requires high-level energy input to the sample. The two commonly used methods are laser calorimetry [38] and the differential technique [32]. Among techniques developed for small absorption determination, the emittance method and interferometric calorimetry have the potential to detect absorption coefficient as low as 10^{-6} cm^{-1}.

3.1 Transmission Method

Let R_∞ be the reflectivity at normal incidence of a solid of sufficient thickness so that there is negligible reflection from the rear surface of the solid and τ_∞ be the corresponding transmission at normal incidence. Then R_∞ can be expressed in terms of n and κ as follows:

$$R_\infty=\frac{(n-n')^2+\kappa^2}{(n+n')^2+\kappa^2} \tag{15}$$

Generally, the solid is either in air or in a vacuum, where $n'\sim1$. Therefore, Eq. (15) becomes

$$R_\infty=\frac{(n-1)^2+\kappa^2}{(n+1)^2+\kappa^2} \tag{16}$$

Similarly, τ_∞ can be expressed as

$$\tau_\infty=[(1-R_\infty)^2+4R_\infty\sin^2\psi]\exp(-\alpha t) \tag{17}$$

where

α = absorption coefficient = $4\pi\kappa/\lambda$

λ = wavelength of incident radiation

t = thickness of the sample

$\psi = \tan^{-1}[2\kappa/(n^2+\kappa^2-1)]$

If $n \gg \kappa$, Eq. (17) becomes

$$\tau_\infty=(1-R_\infty)^2\exp(-\alpha t) \tag{18}$$

Equation (18) is commonly used to determine the absorption coefficient directly by observing the decay of incident light along the thickness of the sample.

As mentioned earlier, the above equations are valid only if the reflection from the rear surface of the solid is negligible. For thin samples, where the reflection from the rear surface cannot be neglected, then the expressions for apparent reflectivity and transmission are:

$$R=\frac{R_\infty\{[1-\exp(-\alpha t)]^2+4\exp(-\alpha t)\sin^2\gamma\}}{[1-R_\infty\exp(-\alpha t)]^2+4R_\infty\exp(-\alpha t)\sin^2(\psi+\gamma)} \tag{19}$$

and

$$\tau=\frac{[(1-R_\infty)^2+4R_\infty\sin^2\psi]\exp(-\alpha t)}{[1-R_\infty\exp(-\alpha t)]^2+4R_\infty\exp(-\alpha t)\sin^2(\psi+\gamma)} \tag{20}$$

where

$\gamma = 2\pi nt/\lambda$ (n is an integer),

t = thickness of a thin sample,

R = apparent reflectivity,

τ = apparent transmission.

The second term in the denominator in Eqs. (19) and (20) is an interference term. If no interference fringes are observed because of thickness variation, we then average over γ and obtain:

$$R=\frac{R_\infty[1-\exp(-2\alpha t)]}{1-R_\infty{}^2\exp(-2\alpha t)} \tag{21}$$

and

$$\tau=\frac{(1-R_\infty)^2\exp(-\alpha t)}{1-R_\infty{}^2\exp(-2\alpha t)} \tag{22}$$

It appears that if we know R_∞ and either n or κ, the remaining one can be calculated from this relation. But this usage is only limited to the transparent region where direct measurement of n can be made. It is obvious that the key roles in this method rest on τ and R which are usually difficult to measure accurately because of influencing surface conditions, such as flatness, aging, oxide layers, adsorbed gas, etc. Errors of 1 to 5% in the resulting absorption coefficient are typical. However, this method is self-contained at a given wavelength, and it does not require additional data at other wavelengths or other properties.

3.2 Reflection Spectrum Analysis

Beyond the transparent region, in the high absorption regions, where neither n nor κ are observable, one has to rely on the reflection spectrum from which the optical constants can be derived by the Kramers-Kronig analysis or by the multiple-oscillator fit based on the Lorentz theory [39].

The *Kramers-Kronig relations* are derived from the dispersion relation in that the phase angle $\theta(\omega)$ of the complex reflectivity, $R(\omega)$, is evaluated based on the observed reflection spectrum

$$\overline{R}(\omega)=R(\omega)\exp[i\theta(\omega)] \tag{23}$$

and

$$\theta(\omega)=\frac{\omega}{\pi}P\int_0^\infty \frac{[\ln R(\omega')-\ln R(\omega)]}{\omega^2-\omega'^2}d\omega' \tag{24}$$

where ω is the frequency of radiation and P is the principal value of the Cauchy integral. Based on the amplitude $R(\omega)$, and phase angle of the reflectivity, the refractive index and absorption index can be calculated according to the following equations:

$$n(\omega)=\frac{1-R(\omega)}{1+R(\omega)-2\sqrt{R(\omega)}\cos\theta(\omega)} \tag{25}$$

and

$$\kappa(\omega)=\frac{2\sqrt{R(\omega)}\sin\theta(\omega)}{1+R(\omega)-2\sqrt{R(\omega)}\cos\theta(\omega)} \tag{26}$$

In principle, the calculation of θ requires a complete reflection spectrum with frequency ranging from zero to infinity. In practice, however, since R is measured only in a limited range of frequencies, errors are inevitable in the calculation of θ and hence in n and κ. These errors arise from the extrapolation of $R(\omega)$ beyond the range of measurements. The typical errors in the resulting n and κ are 5 to 10%, or more.

In the Lorentz theory, the refractive index and absorption index are related to the oscillator frequencies, ω_i, the oscillator strengths, S_i, and the damping factors, γ_i, by the expressions

$$n^2-\kappa^2=\epsilon_\infty+\Sigma\frac{S_i[1-(\omega/\omega_i)^2]}{[1-(\omega/\omega_i)^2]^2+\gamma_i{}^2(\omega/\omega_i)^2} \tag{27}$$

and

$$2n\kappa=\Sigma\frac{S_i\gamma_i(\omega/\omega_i)}{[1-(\omega/\omega_i)^2]^2+\gamma_i{}^2(\omega/\omega_i)^2} \tag{28}$$

where ϵ_∞ is the optical dielectric constant. The resulting n and

κ have to satisfy the observed reflectivity by the relation

$$R(\omega)=\frac{[n(\omega)-1+i\kappa(\omega)]^2}{[n(\omega)+1+i\kappa(\omega)]^2} \tag{29}$$

It is clear that this approach requires the knowledge of the oscillator frequencies which in general is not complete because of experimental difficulties. This leaves us no choice but to use only the observed predominant ones. Nevertheless, this method, similar to the Kramers-Kronig analysis, yields good approximations to the properties under consideration.

3.3 Differential Technique

In the differential technique, a dual-beam spectrometer is the basic apparatus and the transmissions and thicknesses of a thick sample (τ_1 and d_1) and a reference sample (τ_2 and d_2) are measured. An optical wedge is added to the reference beam and its transverse position is so adjusted as to balance the transmitted intensity of the sample beam. The transmission of the wedge, τ_3, is then measured. The relation of the three measured transmissions is, therefore

$$\tau_2 x \tau_3 = \tau_1 \tag{30}$$

hence, by using Eq. (22)

$$\tau_3=\exp(-\alpha\Delta d)\frac{1-R^2\exp(-2\alpha d_2)}{1-R^2\exp(-2\alpha d_1)} \tag{31}$$

where $\Delta d = d_1 - d_2$, and

$$R=(n-1)^2/(n+1)^2 \tag{32}$$

The accuracy of this method depends on the accuracies of the refractive index and transmission, respectively. While the former can be determined with high accuracy, accuracies of the latter depend on the instrument utilized. An uncertainty of 1% or greater is in general expected. This imposes a limit, on the order of 1 x 10^{-3} cm^{-1}, to the lowest absorption coefficient that can be measured by this method.

3.4 Laser Calorimetry

In the laser calorimetric method, the absorbed energy is measured in the form of heat. It can be shown that the total absorption is related to the absorbed energy, E_1, by

$$\alpha L+2\sigma=(E_1/E_2)[2n/(1+n^2)] \tag{33}$$

provided $\alpha L < 1$. Here, L is the sample length through which a laser beam passes and σ is the loss per surface. E_1 can be calculated using the specific heat and mass of the sample and the measured temperature rise. The transmitted energy, E_2, can be determined using a black body and its temperature rise. In order to separate the bulk and surface absorptions, the total absorption of a series of samples of different thickness, cut from the same piece of material and polished in the same way must be measured. A plot of total absorption versus sample thickness will give a straight line with slope α and intercept 2σ. This method yields very accurate results and is used to measure absorption as low as 10^{-5} cm^{-1}.

3.5 Emittance Method

Kirchhoff's law states that, at thermal equilibrium, the absorptance, A, is equal to emittance, E,

$$E=A=1-R_{\infty}-\tau_{\infty}. \tag{34}$$

Using Eqs. (21) and (22) the above equation becomes

$$E=\frac{(1-R_{\infty})[1-\exp(-\alpha t)]}{1-R_{\infty}\exp(-\alpha t)} \tag{35}$$

where the quantities E, R_{∞}, α are functions of wavelength and temperature, t is the thickness of the sample. At very low absorption, the quantity αt is neglegibly small for ordinary sample thickness and equation (35) is reduced to

$$E=\alpha t. \tag{36}$$

Thus, by measuring the emittance as a function of wavelength, the spectral dependence of absorption coefficient can be obtained.

The technique is potentially very sensitive, and it has been predicted that $\alpha<10^{-7}$ cm^{-1} could be measurable. But so far α lower than about 10^{-5} cm^{-1} have been found very difficult to measure because of stray radiation and temperature fluctuations in the background. The sensitivity is also heavily dependent on wavelength, since what is being measured is the thermal emission from the sample. For a sample at room temperature the sensitivity is at best in the infrared region around 10 μm, but it falls off rapidly toward the visible.

The observed emission will have contributions from both bulk and surface. In principle, one could distinguish between bulk and surface losses by making measurements on several samples of different thicknesses, provided bulk and surface absorption coefficients did not change from sample to sample. But this is often difficult to accomplish.

3.6 Interferometric Calorimetry

In interferometric calorimetry the sample is made part of an interferometer, and the temperature increase is determined by measuring the change in optical path in the material. No sensor of any kind needs to be attached to the sample, and the scatter problem is eliminated. By moving the probe beam the temperature can be measured at any point in the sample including the position of the heating beam. Several approaches have been suggested to utilize interferometry, but none have gained wide usage, since the equipment is generally more cumbersome than the other calorimetric methods:

3.7 Photoacoustic Calorimetry

When a periodically interrupted light beam is incident on an absorbing medium, heating and subsequent expansion take place with the consequence of generating an elastic or acoustic wave. This phenomenon is called the photoacoustic effect. Hordvik [40, 41, 42] used this effect in the determination of both bulk and surface absorption in solids. The experimental set up consists of a cw laser, a light chopper, a sample with transponder attached, a power meter, and an amplifier. The transponder material is a piezoelectric ceramic.

For bulk absorption, α, the strain ϵ at a distance r from the center of the laser beam is given by [40]

$$\epsilon=\frac{\alpha P\alpha_1(1+\sigma)t}{2\pi C\rho(1-\sigma)r^2}. \qquad (37)$$

where P is the incident power, α_l the thermal linear expansion coefficient of the sample, σ the Poisson's ratio, t the half of the chopping period, C the specific heat of the sample, and ρ the density of the sample. This method allows the separation of the surface and bulk contributions to the total absorption. By choosing a transponder with appropriate piezoelectric constants one finds that the output signal due to surface absorption is 180° out of phase with the output signal due to bulk absorption. Both surface and bulk losses in the range of 10^{-5} have been determined using laser of a few hundred milliwatts [41, 42].

4. AVAILABLE NUMERICAL DATA

Absorption data in the open literature are reported in many equivalent forms. They are given in units of cm^{-1}, or as extinction index, optical density, or normalized values. Energy is presented in terms of wavelength, wavenumber, frequency, or electron volt. In the present work, the absorption coefficient is consistently reported in units of cm^{-1}, the energy in terms of wavenumber, cm^{-1}, and in wavelength, μm. When necessary, all of absorption data were converted to these uniform set of units.

The data and related information are summarized in a number of figures and tables. The conventions used in this presentation, and specific comments on the interpretation and use of data are given below. Each sub-section in this section gives all the information and data for a given material. The sub-sections are arranged in the following order:

4.1 Calcium Fluoride, CaF_2
4.2 Strontium Fluoride, SrF_2
4.3 Barium Fluoride, BaF_2
4.4 Magnesium Fluoride, MgF_2
4.5 Color Centers of Alkaline Earth Fluorides
4.6 Impurities Contributing to Extrinsic Absorption
4.7 Refractive Index of Alkaline Earth Halides

Presented in each sub-section are information and data arranged in the following order:

a. A text describing and discussing the data on a given material, with the thought that in general a reader will concern himself with a specific substance. For the sake of self-containment, each sub-section incorporates important information even if it should constitute a repetition of some of the same subject matter found in other sections or sub-sections.

b. Figures of experimental absorption coefficient (wavenumber dependence). For the purpose of showing the overall spectral distribution as well as the details in each of the multiphonon and Urbach tail regions, three figures are included for clarity.

c. A summary table of experimental data on the absorption coefficient (wavelength dependence). An extract of pertinent information for each data set is given in this table along with the numerical data. The original data reported in this table are converted to the adopted set of units. The order of magnitude of absorption coefficient varies over a wide range, from 10^{-5} cm^{-1} to 10^{+7} cm^{-1}, and that of wavenumber varies from 10 cm^{-1} to 10^{6} cm^{-1}. Therefore, it is convenient to present the data in powers of ten. In this table, the numerical value 1.259E±n stands for $1.259 \times 10^{\pm n}$.

d. A figure of experimental absorption coefficients (temperature dependence).

e. A summary table of measurements on the absorption coefficient (temperature dependence).

In figures containing experimental data, if data sets are distinguishable, the data sets are labeled by appropriate legends and denoted by the numbers corresponding to those assigned in the corresponding tables on the experimental data. The tables of the experimental data give for each set of data the following information: the reference number, author's name (or names), year of publication, the description and characterization of the specimen, and information on measurement conditions contained in the original paper. Furthermore, the collected data sets in the tables are appropriately ordered chronologically, first for the infrared wavelength region followed by the data sets in the ultraviolet region.

Errors in observed data on the absorption coefficient usually amount to 5-10% for high absorption levels, inaccuracies progressively increasing with decreasing absorption level, a natural consequence of decreasing in instrumental sensitivity. There is no clear cut demarcation separating the high and low absorption levels. A reasonable criterion may be based on the type of measuring technique used. In general, absorption coefficients, which can be measured with high degree of reliability by directly observing the decay of light through the crystal or indirectly deduced from reflectivity and/or transmission measurements, are considered as high absorption with the lower limit approaching 0.1 cm^{-1} or higher. Lower absorption has to be determined by a high sensitivity method, such as laser calorimetry.

Non-experimental errors are added to the data when these are reported only graphically with no accompanying tabulation reporting all relevant significant figures. Additionally, inadequate scales used in graphic data presentation further contribute significantly to data uncertainties to a point which may make the data unacceptable.

Investigations of absorption coefficient for practical applications are generally classified into three wavelength regions: the ultraviolet and the infrared edges of transparency, and the transparent regions. In the ultraviolet region, the purposes of the studies were to investigate the exciton states in the crystal and to determine the Urbach-rule parameters. Measurements of absorption coefficient in the infrared were made for the purpose of studying the optically active lattice vibrations. On the short wavelength side of the reststrahlen band, where a photon is absorbed and two or more phonons are generated, multiphonon absorption can occur and lead to absorption coefficients that range from 10^{-4} cm^{-1} to 100 cm^{-1}, depending on the number of phonons generated.

Measurements of the absorption coefficient in the transparent region are relatively recent events as the development of high-power IR lasers has led to a need for better characterization of IR window materials. Among other things, the absorption coefficient plays a decisive role in determining whether a material is adequate for laser optical components. For this reason, absorption coefficients of a number of selected materials were investigated at wavelengths of laser interest. It is a coincidence that the wavelengths of laser interest are located in the region where the absorption coefficient is influenced by the multiphonon absorption. Therefore, investigation of multiphonon absorption becomes important in the understanding of the absorption mechanisms. Regarding the absorption at wavelengths other than laser interest, little attention was paid as the needs for this information was not felt. As a result, practically no absorption coefficient data are available except at wavelengths of color centers where only qualitative observations were made.

4.1 Calcium Fluoride, CaF_2

Calcium fluoride is of considerable interest both from the experimental and theoretical point of view. The compound is ionic but, in contrast to binary NaCl-type crystals, it has a number of structural features associated primarily with the presence of two equivalent F^- ions in a unit fluorite cell.

Single crystals of calcium fluoride, in rather pure state, are found in nature and are called "Fluorite" or "Fluorspar". Calcium fluoride of similar purity, but of larger dimensions, has been produced by controlled freezing of purified molten calcium fluoride after an initial scavenging with lead fluoride.

Calcium fluoride has been an important optical material used in the design of optical components and systems for many years because it occurs naturally in large sizes and many measurements on the optical constants are available. The crystal is transparent in the region from about 0.15 to 15 μm. The transparent region may be divided into three subregions, in each of which CaF_2 has useful applications. From 0.15 up to 0.3 μm and from 6.0 up to 15 μm the dispersion is high and the crystal is used for high dispersion devices in spite of low transmittance at the limits. In the region from 0.3 up to 6.0 μm where dispersion is low and transmission is high, it is used as windows and lenses in the optical systems.

Available spectral absorption-coefficient data of CaF_2 are given in Table 5 and plotted in Figure 2, with the details of the Urbach tail and multiphonon absorption regions plotted in enlarged form in Figures 3 and 4. Comparing these figures with Figure 1, a striking similarity is apparent. Each data set in these regions appears as nearly a straight line in the semilogarithmic scale.

Kaiser et al. [43] determined absorption coefficient from analysis of reflectivity and transmission measurements using classical dispersion theory. Their investigation covered a spectral range from 9.1 to 17 μm at two temperatures, 77 K and 300 K. Although the primary purpose of their study was to obtain information on the lattice vibrations, the resulting absorption data are in agreement with the subsequent measurements of others. The frequency of the longitudinal optical phonon and the static and the optical dielectric constants deduced from their analysis are also consistent with those from recent studies [67,68].

Whether they used pure or contaiminated sample was not known since the absorption in the region they covered is quite high and hence the results are not readily affected by contributions due to minute imperfections.

Heilmann [44] determined room-temperature spectral optical constants for ranges from 6.2 to 8.9 μm and from 17 to 48 μm, using the simple transmission method for the former region and polarized reflection spectrum analysis for the latter. The absorption coefficients obtained for the former region can be considered as an extension of the work of Kaiser et al. [43] in the short-wavelength wing of the fundamental absorption peak as shown in Figure 3. Compared with other data sets measured at room temperature, a general consistency is observed.

Rupprecht [45] deduced optical constants of commercially available hot-pressed polycrystalline CaF_2 from spectral transmittance measurements. The transmittance data were analyzed according to the approximate formula $\tau \approx (1-R)^2 \exp(-\alpha d)$, where d is the thickness of the plane parallel sample. He found the relationship between absorption index and frequency can be expressed as $\kappa(\nu)=\kappa_0 \exp(-\nu/\nu_0)$, where $\kappa=26$, $\nu_0=83.5$ cm^{-1} and $\alpha=4\pi\kappa\nu$. After converting his absorption index to absorption coefficient and comparing with other room-temperature data, his results show a steeper slope indicating that polycrystalline CaF_2 is less absorbing at the lower level of absorption.

Bosomworth [46] was mainly interested in the optical constants for the long wavelength wing of fundamental phonon.

Direct transmission interference fringes were observed for thin specimens, and the resulting interferograms were reduced to refractive index and absorption coefficient through an iterative data fitting process using eqs. (32), (22), (16), and (20), under the condition that $2\pi nd/\lambda_m + \gamma = N\pi/2$, where N is an integer, λ_m is the wavelength corresponding to maximum and minimum of interference pattern. Their results indicate that the absorption coefficient in the long wavelength wing varies with frequency linearly when plotted on a log-log scale as shown in Figure 2.

Using the differential technique, Deutsch [32,47] was able to determine the absorption coefficient of CaF_2 crystal for the spectral region between 5.3 and 10.6 μm with better accuracy and to separate the bulk and surface contributions from the total absorption. Errors in his results were estimated based on the observed transmittance, τ. Around $\tau \sim 0.9$, the error in α is about ±10% while around $\tau \sim 0.5$, it is about ±3%. Combined with the results of Kaiser et al., Deutsch established eq. (9) to represent the relation of room-temperature absorption coefficient and frequency, with parameters of the equation given in Table 4. This equation has been cited in the literature since then.

As the needs of absorption data at laser wavelengths were felt, Harrington et al. [48] measured α at wavelengths 2.7 and 3.8 μm, for samples of various origins, using laser calorimetry. Variation in α among samples was found to be about one order of magnitude. It is not surprising to see such large variation because the absorption coefficients are low, in the range of 10^{-4}

cm^{-1}, at these wavelengths. At low absorption, surface absorption and other undesirable contributions may become important and in many cases predominate. They also measured absorption coefficient in an extended wavelength region from 3.8 to 8.2 μm for a polycrystalline sample using the emittance method. Their results are in agreement with those reported by others.

Subsequent measurements of α at 2.7 and 3.8 μm were made by Harrington et al. [54], Rosenstock et al. [55], and Hordvik and Skolnik [42]. Their results are collectively plotted in Figure 2 at wavenumber 2632 cm^{-1} (λ=3.8μm) and 3704 cm^{-1} (2.7 μm). Large discrepancies, as much as 2 orders of magnitude, are clearly seen, however, the lowest value of α at the former wavenumber is in line with the intrinsic value. Evidently, at low absorption levels, absorption coefficient is very sensitive to imperfections in the sample.

Lipson et al. [52,53] utilized transmission spectroscopy methods to measure the absorption coefficient of CaF_2 in the wavelength range from 6.7 to 10.5 μm and over a temperature range from 295 and 800 K. The fact that their room-temperature observation was in close agreement with those of Deutsche's measurement indicated that there were no extrinsic contributions in the wavelength range of interest. When their results were plotted in a semi-logarithmic scale, as in Figure 3, the absorption curves are essentially straight lines indicating that the exponential relation between absorption coefficient and frequency, eq. (9), is also valid at temperatures higher than room temperature. Errors in their results were not quoted in their report, but can be estimated from their graphical presentation. At the highest absorption (α=3 to 4 cm^{-1}), the error bars in the graph indicate errors of 3-5% in absorption coefficient. The percent error is expected to progressively increase in the spectral region where the absorption coefficient decreases. An error of 10% or more may be assigned to the lowest absorptions in their results. They also used the emittance method in the determination of absorption coefficient in the wavelength region between 5 to 10 μm for the same sample at 350 K. Good agreement between the results obtained using the emittance and transmission methods, as well as the exponential behavior, is retained in the wavelength range from 6 to 10 μm. In the region between 5 to 6 μm, where the absorption is low, extrinsic absorption probably due to surface absorption starts to predominate and the data deviate from exponential behavior.

In order to find the intrinsic absorption at 5.3 μm to support the exponential relation, eq. (9), a number of measurements were made by Deutsch [47], Winston et al. [49], Kraatz and Mendosa [50], Newberg et al [57], and Allen and Rudisill [57], with the lowest value 4.2 x 10^{-4} cm^{-1} which is considered as intrinsic since the value follows the expoential relation. In the transparent region between 0.3 to 2 μm, there is practically no observation that has been reported except at wavelengths 1.06 and 0.515 μm; where, for each case there is only one measurement available. Hass et al. [56] measured the absorption coefficient for a forged polycrystalline sample by calorimetry at a wavelength of 1.06 μm. The result is 4.0 x 10^{-5} cm^{-1} which represents the lowest absorption coefficient ever measured for CaF_2. Absorption coefficient at 0.515 μm was determined by Hordvik and Schlossberg [40] using photoacoustic calorimetry. The result is 9.3 x 10^{-4} cm^{-1}. If there are no other complications, absorption coefficient in the high transparent region normally is in the range of 5 x 10^{-5} to 1 x 10^{-4} cm^{-1}. The high absorption observed at 0.515 μm probably has its origin in the presence of surface contamination and/or the existence of color centers.

Investigation of absorption spectrum in the ultraviolet region, including the absorption edge, normally has as its purpose the identification of the electronic states and determination of the Urbach-rule parameters. Tomiki and Miyata [10] carried reflectivity and absorption measurements in the intrinsic wavelength region (the absorption edge) for cleaved CaF_2 specimens at a series of temperatures from 78 to 573 K. Specimens were obtained from different sources and were subjected to different treatments. It was noted that specimens with cleaved surfaces had better transmission in the tail region than those gone through the polishing process. Through a systematic observation and analysis, they were able to define the parameters of the Urbach rule, eq. (8), given in Table 3. However, whether the absorption tail is intrinsic or extrinsic was not confirmed. Other investigations in the ultraviolet were made by Fabre et al. [58], Stephan et al. [59], and Ganin et al. [60]. Details of ultraviolet results are shown in Figure 4 where data of Fabre et al. are highly discrepant because a thin film sample was used.

Data on the temperature dependence of absorption coefficient are very limited. Available data shown in Figure 5 and Table 6 were obtained only from two sources. It is very fortunate that both works covered a wide temperature range and the general behavior of the absorption coefficient versus temperature can be seen. It is observed that the curves in Figure 5 appear as straight lines and tend to converge to a point located at the upper-right outside the figure. A straight line in the log-log plot indicates a power law relation of the two variables.

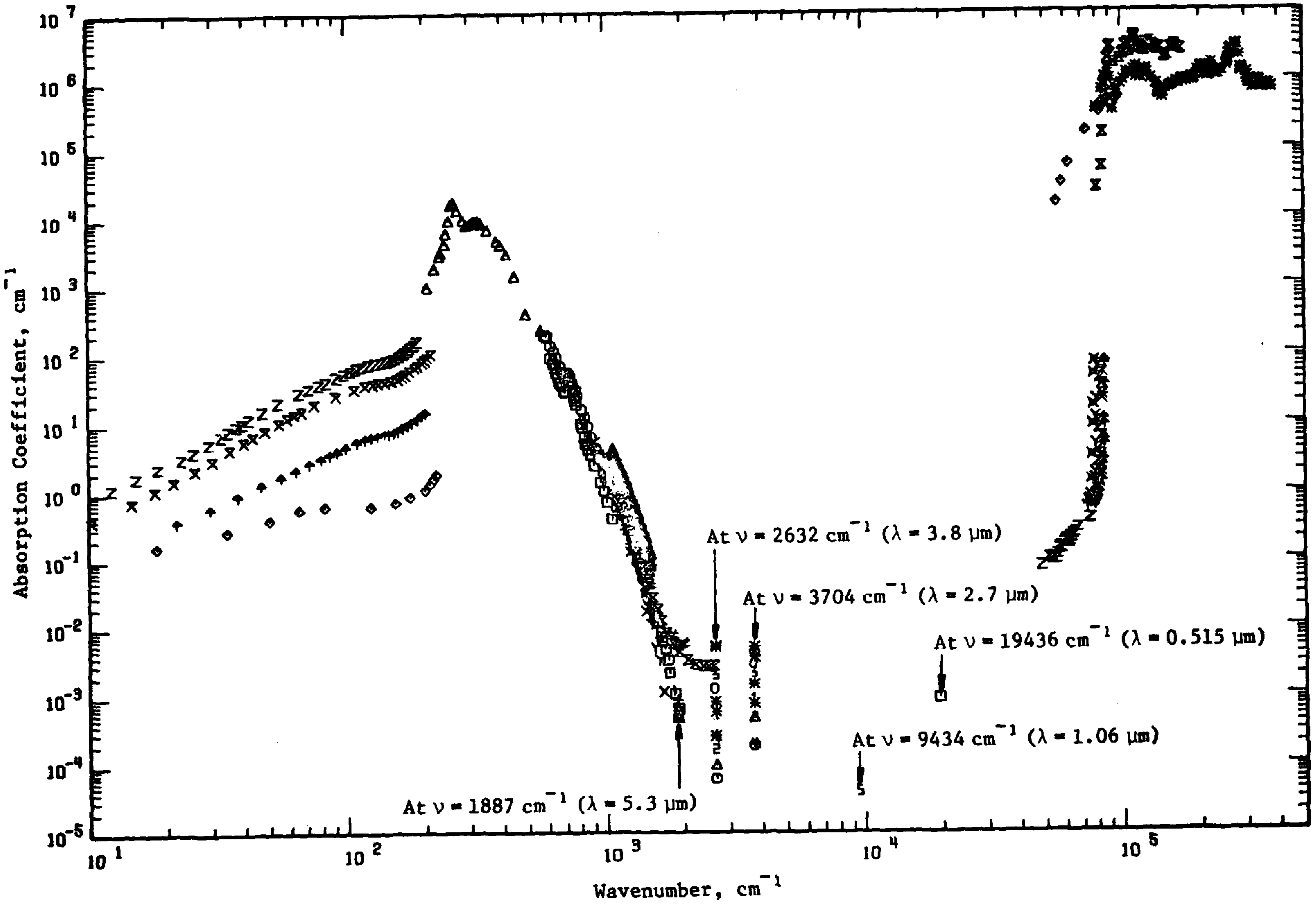

Figure 2. Absorption Coefficient of Calcium Fluoride (Wavenumber Dependence)

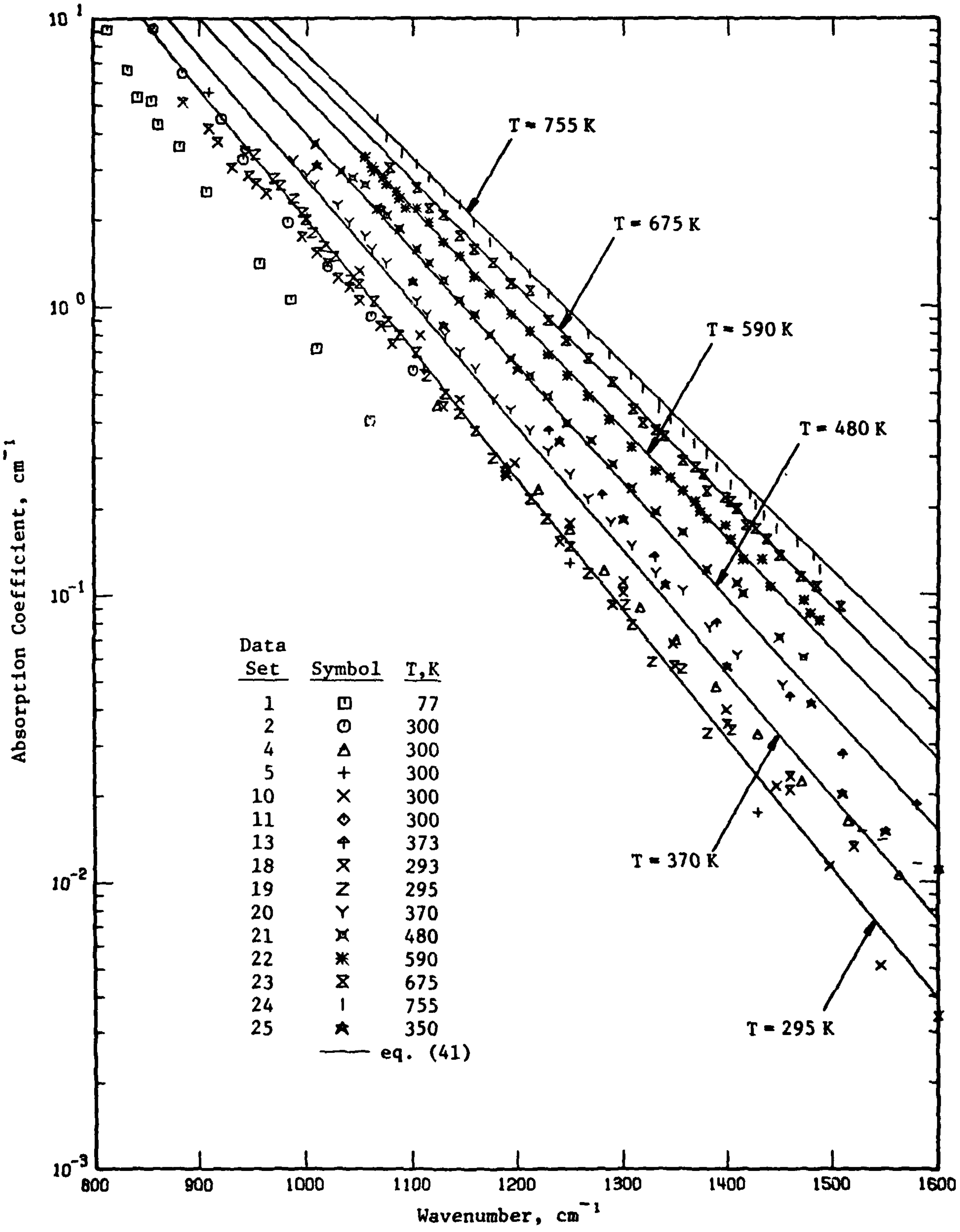

Figure 3. Absorption Coefficient of Calcium Fluoride in the Multiphonon Region (Wavenumber Dependence)

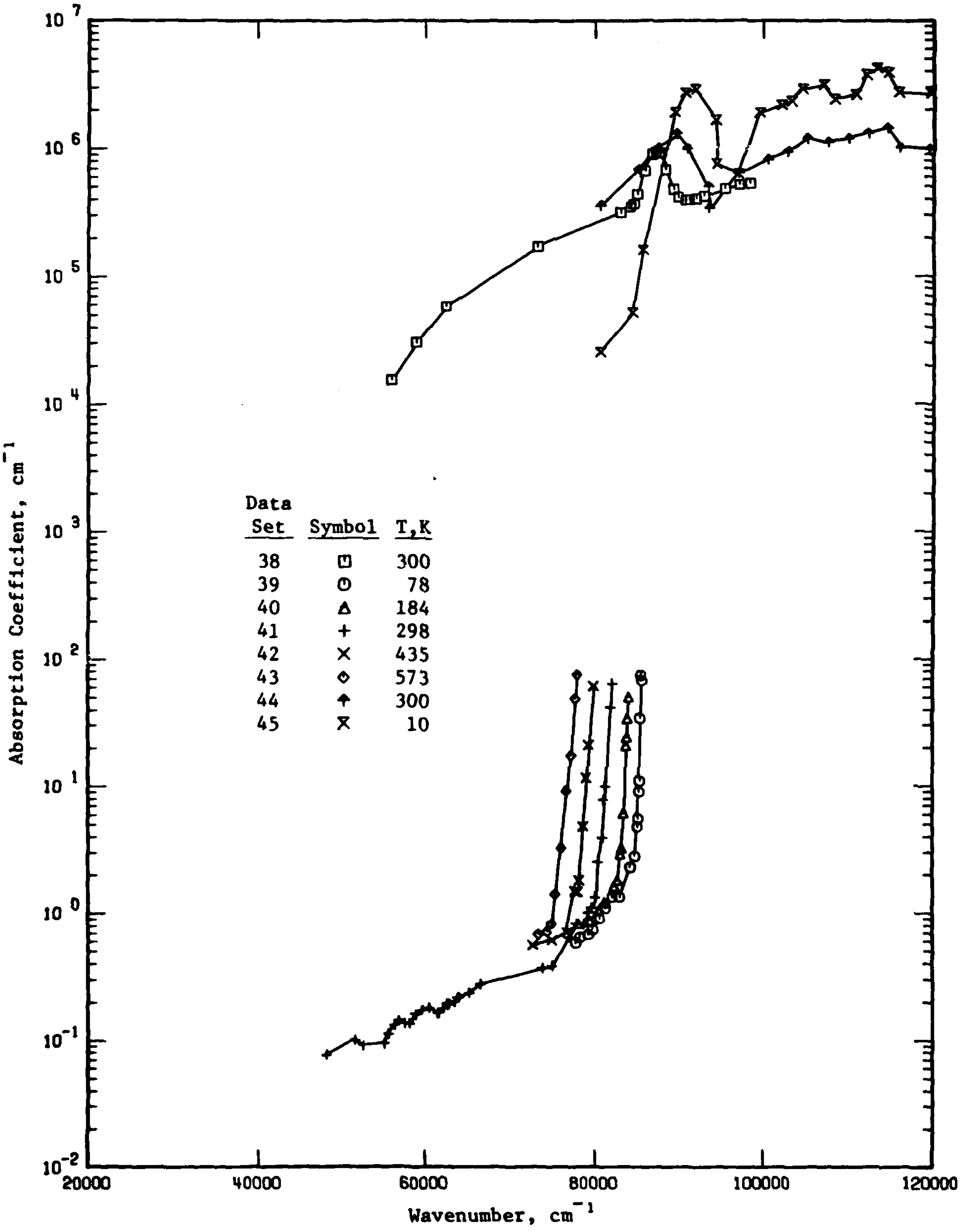

Figure 4. Absorption Coefficient of Calcium Fluoride in the Urbach Tail Region (Wavenumber Dependence)

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm^{-1}; Absorption Coefficient, α, cm^{-1}]

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [43] Kaiser, W., Spitzer, W. G., Kaiser, R. H., Howarth, L. E., 1962		(T = 77 K)		Single crystal; plate specimens of 0.1 - 5 mm thick; absorption coefficient determined from transmission and reflectivity measurements; data taken from a figure.
	9.434E+0	1.060E+3	4.020E-1	
	9.901E+0	1.010E+3	7.140E-1	
	1.014E+1	9.860E+2	1.060E+0	
	1.045E+1	9.570E+2	1.410E+0	
	1.103E+1	9.070E+2	2.510E+0	
	1.134E+1	8.820E+2	3.590E+0	
	1.161E+1	8.610E+2	4.290E+0	
	1.170E+1	8.550E+2	5.150E+0	
	1.188E+1	8.420E+2	5.330E+0	
	1.202E+1	8.320E+2	6.610E+0	
	1.230E+1	8.130E+2	9.150E+0	
	1.239E+1	8.070E+2	1.020E+1	
	1.285E+1	7.780E+2	1.950E+1	
	1.297E+1	7.710E+2	2.170E+1	
	1.311E+1	7.630E+2	2.420E+1	
	1.325E+1	7.550E+2	3.120E+1	
	1.355E+1	7.380E+2	4.160E+1	
	1.377E+1	7.260E+2	3.720E+1	
	1.414E+1	7.070E+2	2.880E+1	
	1.431E+1	6.990E+2	2.980E+1	
	1.458E+1	6.860E+2	3.570E+1	
	1.484E+1	6.740E+2	3.970E+1	
	1.504E+1	6.650E+2	4.760E+1	
	1.527E+1	6.550E+2	5.300E+1	
	1.546E+1	6.470E+2	6.580E+1	
	1.567E+1	6.380E+2	7.330E+1	
	1.577E+1	6.340E+2	7.600E+1	
	1.618E+1	6.180E+2	9.090E+1	
	1.669E+1	5.990E+2	1.810E+2	
	1.695E+1	5.900E+2	1.940E+2	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
2 [43]		(T = 300 K)		Same as above.
Kaiser, W.,	9.091E+0	1.100E+3	6.030E-1	
et al.,	9.434E+0	1.060E+3	9.270E-1	
1962	9.804E+0	1.020E+3	1.380E+0	
	1.017E+1	9.830E+2	1.970E+0	
	1.062E+1	9.420E+2	3.250E+0	
	1.086E+1	9.210E+2	4.490E+0	
	1.131E+1	8.840E+2	6.430E+0	
	1.167E+1	8.570E+2	9.210E+0	
	1.196E+1	8.360E+2	1.230E+1	
	1.230E+1	8.130E+2	1.640E+1	
	1.269E+1	7.880E+2	2.610E+1	
	1.294E+1	7.730E+2	3.130E+1	
	1.330E+1	7.520E+2	4.020E+1	
	1.348E+1	7.420E+2	4.810E+1	
	1.370E+1	7.300E+2	5.360E+1	
	1.387E+1	7.210E+2	5.550E+1	
	1.403E+1	7.130E+2	5.540E+1	
	1.427E+1	7.010E+2	5.530E+1	
	1.462E+1	6.840E+2	5.720E+1	
	1.484E+1	6.740E+2	6.850E+1	
	1.531E+1	6.530E+2	9.140E+1	
	1.567E+1	6.380E+2	1.130E+2	
	1.608E+1	6.220E+2	1.360E+2	
3 [44]		(T = 300 K)		Single crystal window sample of 8 cm diameter and 0.8 cm thick; absorption coefficients were determined through reflectivity measurements at an oblique angle of 70°; data extracted from a figure.
Heilmann, G.,	1.750E+1	5.714E+2	2.298E+2	
1963	2.000E+1	5.000E+2	4.021E+2	
	2.200E+1	4.545E+2	1.434E+3	
	2.370E+1	4.219E+2	2.980E+3	
	2.500E+1	4.000E+2	4.077E+3	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
3 [44] (cont.)	2.570E+1	3.891E+2	4.728E+3	
	2.800E+1	3.571E+2	6.853E+3	
	2.960E+1	3.378E+2	8.461E+3	
	2.980E+1	3.356E+2	8.796E+3	
	3.050E+1	3.278E+2	9.237E+3	
	3.130E+1	3.195E+2	9.126E+3	
	3.190E+1	3.135E+2	8.958E+3	
	3.250E+1	3.077E+2	8.433E+3	
	3.300E+1	3.030E+2	8.187E+3	
	3.380E+1	2.959E+2	8.109E+3	
	3.490E+1	2.865E+2	9.643E+3	
	3.680E+1	2.717E+2	1.350E+4	
	3.790E+1	2.639E+2	1.661E+4	
	3.810E+1	2.625E+2	1.734E+4	
	3.820E+1	2.618E+2	1.750E+4	
	3.890E+1	2.571E+2	1.608E+4	
	3.960E+1	2.525E+2	9.491E+3	
	4.030E+1	2.481E+2	6.227E+3	
	4.110E+1	2.433E+2	4.305E+3	
	4.250E+1	2.353E+2	3.247E+3	
	4.290E+1	2.331E+2	2.850E+3	
	4.500E+1	2.222E+2	1.854E+3	
	4.810E+1	2.079E+2	1.006E+3	
4 [44] Heilmann, G., 1963		(T = 300 K)		Single crystal cylinder sample of 12 cm diameter and 11.17 cm long; spectrometer transmission measured and absorption coefficients were determined according to eq. (18); data extracted from a figure.
	6.200E+0	1.613E+3	7.256E-3	
	6.400E+0	1.563E+3	1.054E-2	
	6.600E+0	1.515E+3	1.626E-2	
	6.800E+0	1.471E+3	2.236E-2	
	7.000E+0	1.429E+3	3.267E-2	
	7.200E+0	1.389E+3	4.765E-2	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
4 [44] (cont.)	7.400E+0	1.351E+3	6.945E-2	
	7.600E+0	1.316E+3	9.044E-2	
	7.800E+0	1.282E+3	1.212E-1	
	8.000E+0	1.250E+3	1.681E-1	
	8.200E+0	1.220E+3	2.314E-1	
	8.400E+0	1.190E+3	2.768E-1	
	8.900E+0	1.124E+3	4.532E-1	
5 [45] Rupprecht, G., 1964		(T = 300 K)		Commercial hot-pressed polycrystalline; sample thickness ranging from about 1 cm to 10^{-3} cm with parallel and highly polished surfaces; transmittances were measured and absorption coefficients were determined according to eq. (18); it was found that absorption index, κ, and wavenumber are related by the expression $\kappa=\kappa_0\exp(-\nu/\nu_0)$, where $\kappa_0=26$ and $\nu_0=83.5$ cm^{-1}; data were calculated according to this equation; wavelength region was not given, 6–12 μm was assumed.
	6.000E+0	1.667E+3	1.180E-3	
	7.000E+0	1.429E+3	1.745E-2	
	8.000E+0	1.250E+3	1.287E-1	
	9.000E+0	1.111E+3	6.046E-1	
	1.000E+1	1.000E+3	2.056E+0	
	1.100E+1	9.091E+2	5.552E+0	
	1.200E+1	8.333E+2	1.261E+1	
6 [46] Bosomworth, D. R. 1967		(T = 5 K)		Single crystals; obtained from the Harshaw Chemical Co., or grown in laboratory; samples from different sources gave identical results; dominant impurity was Fe (10–200 ppm); plane-parallel slab specimens of 0.3 to 10 mm thick; mechanically
	4.502E+1	2.221E+2	1.890E+0	
	4.602E+1	2.173E+2	1.630E+0	
	4.764E+1	2.099E+2	1.370E+0	
	4.975E+1	2.010E+2	1.110E+0	
	5.675E+1	1.762E+2	8.900E-1	
	6.468E+1	1.546E+2	7.300E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
6 [46] (cont.)	8.071E+1	1.239E+2	6.400E-1	polished with 0.3 to 1.0 μm alumina; direct transmission measured and absorption coefficient then determined; uncertainties about 100%; data taken from a figure.
	1.215E+2	8.230E+1	6.400E-1	
	1.527E+2	6.550E+1	5.800E-1	
	1.992E+2	5.020E+1	4.000E-1	
	2.915E+2	3.430E+1	2.700E-1	
	5.464E+2	1.830E+1	1.600E-1	
7 [46]		(T = 80 K)		Similar to above; except uncertainty about 25%.
Bosomworth, D. R.	4.921E+1	2.032E+2	1.471E+1	
1967	5.097E+1	1.962E+2	1.348E+1	
	5.302E+1	1.886E+2	1.210E+1	
	5.549E+1	1.802E+2	1.084E+1	
	5.794E+1	1.726E+2	9.760E+0	
	6.031E+1	1.658E+2	8.920E+0	
	6.297E+1	1.588E+2	8.240E+0	
	6.527E+1	1.532E+2	7.810E+0	
	6.812E+1	1.468E+2	7.470E+0	
	7.102E+1	1.408E+2	7.230E+0	
	7.570E+1	1.321E+2	6.950E+0	
	7.994E+1	1.251E+2	6.650E+0	
	8.489E+1	1.178E+2	6.200E+0	
	9.083E+1	1.101E+2	5.640E+0	
	1.007E+2	9.930E+1	4.810E+0	
	1.082E+2	9.240E+1	4.160E+0	
	1.156E+2	8.650E+1	3.710E+0	
	1.250E+2	8.000E+1	3.220E+0	
	1.387E+2	7.210E+1	2.780E+0	
	1.572E+2	6.360E+1	2.230E+0	
	1.799E+2	5.560E+1	1.750E+0	
	2.146E+2	4.660E+1	1.330E+0	
	2.646E+2	3.780E+1	9.200E-1	
	3.390E+2	2.950E+1	6.000E-1	
	4.566E+2	2.190E+1	3.700E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
8 [46]		(T = 200 K)		Similar to above; except uncertainty about 10 to 20%.
Bosomworth, D. R.	4.706E+1	2.125E+2	1.034E+2	
1967	4.838E+1	2.067E+2	9.300E+1	
	4.950E+1	2.020E+2	8.540E+1	
	5.066E+1	1.974E+2	7.960E+1	
	5.252E+1	1.904E+2	7.160E+1	
	5.402E+1	1.851E+2	6.650E+1	
	5.640E+1	1.773E+2	5.970E+1	
	5.858E+1	1.707E+2	5.310E+1	
	6.042E+1	1.655E+2	4.900E+1	
	6.281E+1	1.592E+2	4.630E+1	
	6.653E+1	1.503E+2	4.360E+1	
	7.027E+1	1.423E+2	4.120E+1	
	7.452E+1	1.342E+2	4.040E+1	
	7.831E+1	1.277E+2	3.910E+1	
	8.425E+1	1.187E+2	3.670E+1	
	9.268E+1	1.079E+2	3.280E+1	
	1.094E+2	9.140E+1	2.650E+1	
	1.325E+2	7.550E+1	1.990E+1	
	1.481E+2	6.750E+1	1.600E+1	
	1.587E+2	6.300E+1	1.430E+1	
	1.686E+2	5.930E+1	1.275E+1	
	1.821E+2	5.490E+1	1.083E+1	
	2.070E+2	4.830E+1	8.470E+0	
	2.304E+2	4.340E+1	6.840E+0	
	2.500E+2	4.000E+1	5.830E+0	
	2.833E+2	3.530E+1	4.440E+0	
	3.311E+2	3.020E+1	3.120E+0	
	3.876E+2	2.580E+1	2.230E+0	
	4.695E+2	2.130E+1	1.510E+0	
	5.556E+2	1.800E+1	1.110E+0	
	6.849E+2	1.460E+1	7.400E-1	
	9.804E+2	1.020E+1	3.900E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
9 [46]		(T = 300 K)		Similar to above; except uncertainty about 10%.
Bosomworth, D. R.	5.316E+1	1.881E+2	1.600E+2	
1967	5.423E+1	1.844E+2	1.472E+2	
	5.525E+1	1.810E+2	1.374E+2	
	5.627E+1	1.777E+2	1.286E+2	
	5.731E+1	1.745E+2	1.202E+2	
	5.893E+1	1.697E+2	1.123E+2	
	6.028E+1	1.659E+2	1.059E+2	
	6.188E+1	1.616E+2	9.930E+1	
	6.431E+1	1.555E+2	9.290E+1	
	6.649E+1	1.504E+2	8.820E+1	
	6.930E+1	1.443E+2	8.440E+1	
	7.267E+1	1.376E+2	8.060E+1	
	7.680E+1	1.302E+2	7.790E+1	
	8.157E+1	1.226E+2	7.460E+1	
	8.726E+1	1.146E+2	6.970E+1	
	9.099E+1	1.099E+2	6.560E+1	
	9.597E+1	1.042E+2	6.070E+1	
	1.015E+2	9.850E+1	5.610E+1	
	1.087E+2	9.200E+1	4.950E+1	
	1.186E+2	8.430E+1	4.220E+1	
	1.279E+2	7.820E+1	3.800E+1	
	1.395E+2	7.170E+1	3.390E+1	
	1.524E+2	6.560E+1	2.990E+1	
	1.828E+2	5.470E+1	2.140E+1	
	2.105E+2	4.750E+1	1.600E+1	
	2.381E+2	4.200E+1	1.264E+1	
	2.525E+2	3.960E+1	1.097E+1	
	2.667E+2	3.750E+1	9.750E+0	
	2.890E+2	3.460E+1	8.260E+0	
	3.077E+2	3.250E+1	7.130E+0	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
9 [46] (cont.)	3.425E+2	2.920E+1	5.510E+0	
	3.937E+2	2.540E+1	4.160E+0	
	4.367E+2	2.290E+1	3.300E+0	
	5.405E+2	1.850E+1	2.430E+0	
	6.579E+2	1.520E+1	1.740E+0	
	8.197E+2	1.220E+1	1.200E+0	
	1.235E+3	8.100E+0	7.500E-1	
	2.000E+3	5.000E+0	4.300E-1	
10 [32] Deutsch, T. F., 1973		(T = 300 K)		Single crystals; obtained from the Harshaw Chemical Co.; typical sample dimensions 2.54 cm diameter and 2.54 cm thick; transmission measured with differential technique and absorption coefficient calculated by using eq. (31) uncertainties of α in high transparent and low transparent regions are respectively about 10% and 3%; data taken from a figure.
	6.250E+0	1.600E+3	3.400E-3	
	6.470E+0	1.546E+3	5.100E-3	
	6.680E+0	1.497E+3	1.130E-2	
	6.910E+0	1.447E+3	2.150E-2	
	7.150E+0	1.399E+3	3.960E-2	
	7.420E+0	1.348E+3	6.750E-2	
	7.690E+0	1.300E+3	1.109E-1	
	8.000E+0	1.250E+3	1.774E-1	
	8.350E+0	1.198E+3	2.864E-1	
	8.730E+0	1.145E+3	4.764E-1	
	9.030E+0	1.107E+3	7.962E-1	
	9.520E+0	1.050E+3	1.331E+0	
	1.000E+1	1.000E+3	2.028E+0	
11 [47] Deutsch, T. F., 1975		(T = 300 K)		Absorption coefficient at 5.25 and 10.6 μm measured with Raytheon CO_2/CO laser calorimeter; no other details were reported; data taken from a table.
	5.252E+0	1.904E+3	5.000E-4	
	1.060E+1	9.434E+2	3.500E+0	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
12 [48]		(T = 300 K)		Several specimens received from various laboratories; absorption coefficients measured by laser calorimetry technique; laser used was of the SF_6 variety delivering from 5 to 10 watts of cw multiline HF power and about 5 watts of cw multiline DF power; letters following absorption coefficient values have the meaning: PH - polycrystaline from Harshaw, SH - single crystal from Harshaw, SO - single crystal from Optovac, PR - polycrystalline from Raytheon; data taken from a table.
Harrington, J. A.	3.799E+0	2.632E+3	5.420E-3PH	
Bendow, B.,	3.799E+0	2.632E+3	2.670E-4SH	
Namjoshi, K. V.,	3.799E+0	2.632E+3	8.400E-4SO	
Mitra, S. S.,	3.799E+0	2.632E+3	5.180E-3PR	
Stierwalt, D. L.,	3.799E+0	2.632E+3	6.000E-4PR	
1975	3.799E+0	2.632E+3	6.000E-4PR	
	2.700E+0	3.704E+3	3.670E-3PH	
	2.700E+0	3.704E+3	5.210E-3SH	
	2.700E+0	3.704E+3	7.800E-4SO	
	2.700E+0	3.704E+3	4.560E-3PR	
	2.700E+0	3.704E+3	1.480E-3PR	
13 [48]		(T = 373 K)		Polished polycrystalline (Polytran) sample; received from the Harshaw Chemical Co.; the normal spectral emittance, E, was measure; the low absorption coefficients in the transparent region were calculated from E=αL, where L is the sample length in cm and α<2.5; in the intermediate absorption region, α can be obtained from eq. (35); absorption coefficient data extracted from a curve.
Harrington, J. A.	8.130E+0	1.230E+3	3.710E-1	
et al.,	7.813E+0	1.280E+3	2.220E-1	
1975	7.519E+0	1.330E+3	1.350E-1	
	7.194E+0	1.390E+3	7.950E-2	
	6.849E+0	1.460E+3	4.400E-2	
	6.623E+0	1.510E+3	2.770E-2	
	6.329E+0	1.580E+3	1.850E-2	
	6.135E+0	1.630E+3	1.290E-2	
	5.848E+0	1.710E+3	8.490E-3	
	5.556E+0	1.800E+3	5.870E-3	
	5.236E+0	1.910E+3	4.520E-3	
	4.878E+0	2.050E+3	3.430E-3	
	4.545E+0	2.200E+3	2.890E-3	
	4.219E+0	2.370E+3	2.710E-3	
	4.032E+0	2.480E+3	2.710E-3	
	3.861E+0	2.590E+3	2.790E-3	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
14 [49]		(T = 300 K)		Crystal produced with Bridgman growth in a reactive atmosphere of HF; forged at 1173 K under a 50-ton press; the polishing of high-temperature forgings showed lower loss than that of lower-temperature forgings and exhibited no obvious flaws or defects; absorption coefficient measure in a desicated calorimeter chamber; digitized data was given.
Winston, H. V.,	5.501E+0	1.818E+3	1.200E-3	
Turk, R. R.,				
Pastor, R. C.,				
Scholl, R. f.,				
1975				
15 [50]		(T = 300 K)		CaF_2 window sample from Harshaw Chemical Co.; absorption measured by an adiabatic calorimeter with a carbon monoxide laser producing up to 50 W of multiline power in the 4.9 to 5.6 μm spectral region; total absorption coefficient is given by eq. (33); absorption coefficients at 5.3 μm determined at two partial pressures of CO in the laser gas mix; digitized data were given; temperature was not given, 300 K assumed.
Kraatz, P.,	5.299E+0	1.887E+3	6.530E-4	
Mendosa, P. J.,	5.299E+0	1.887E+3	5.000E-4	
1975				
16 [51]		(T = 300 K)		Casting CaF_2 with high purity; window sample of six inch diameter, one-half inch thick; heat treatment at various temperatures and atmospheres; absorption coefficients measured with
Newberg, R. T.,	5.302E+0	1.886E+3	4.600E-4A	
Readey, D. W.,	5.302E+0	1.886E+3	4.200E-4B	
Newborn, H. A.,	5.302E+0	1.886E+3	4.900E-4D	
Miles, P. A.,	5.302E+0	1.886E+3	8.000E-4E	
1975				

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
16 [51] (cont.)	5.302E+0	1.886E+3	6.100E-4EF	calorimetric method; digitized total absorption coefficient data were given; symbols followed the absorption values correspond to the following heat treatments: A-as cast, B-as cast (RAP), C-800°C, D-900°C E-1000°C, F-1000°C + teflon vapors, G-as received.
17 [51]		(T = 300 K)		Similar to above except for single crystal.
Newberg, R. T.,	5.302E+0	1.886E+3	5.000E-4	
et al.,	5.302E+0	1.886E+3	5.000E-4	
1975	5.302E+0	1.886E+3	4.700E-4	
	5.302E+0	1.886E+3	7.100E-4	
	5.302E+0	1.886E+3	6.200E-4	
	5.302E+0	1.886E+3	5.000E-4	
18 [52]		(T = 293 K)		Single crystal samples prepared from high purity Optovac material; sample thickness of 10.12 cm with polished ends; absorption coefficient were determined with a double beam spectrometer; no impurity absorption bands were found in the frequency range investigated; data extracted from a figure.
Lipson, H. G.,	6.623E+0	1.510E+3	1.310E-2	
Bendow, B.,	6.579E+0	1.520E+3	1.320E-2	
Mitra, S. S.,	6.849E+0	1.460E+3	2.080E-2	
1975	6.849E+0	1.460E+3	2.320E-2	
	7.143E+0	1.400E+3	3.540E-2	
	7.407E+0	1.350E+3	5.640E-2	
	7.752E+0	1.290E+3	9.190E-2	
	7.692E+0	1.300E+3	1.020E-1	
	8.065E+0	1.240E+3	1.530E-1	
	8.403E+0	1.190E+3	2.600E-1	
	8.850E+0	1.130E+3	4.520E-1	
	9.259E+0	1.080E+3	7.430E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
18 [52] (cont.)	9.346E+0	1.070E+3	8.560E-1	
	9.524E+0	1.050E+3	1.050E+0	
	9.615E+0	1.040E+3	1.170E+0	
	9.709E+0	1.030E+3	1.260E+0	
	9.804E+0	1.020E+3	1.410E+0	
	9.901E+0	1.010E+3	1.540E+0	
	1.004E+1	9.960E+2	1.750E+0	
	1.038E+1	9.630E+2	2.470E+0	
	1.048E+1	9.540E+2	2.670E+0	
	1.056E+1	9.470E+2	2.850E+0	
	1.074E+1	9.310E+2	3.040E+0	
	1.089E+1	9.180E+2	3.730E+0	
	1.100E+1	9.090E+2	4.160E+0	
	1.130E+1	8.850E+2	5.110E+0	
19 [53]		(T = 295 K)		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
Lipson, H.,	1.049E+1	9.533E+2	3.381E+0	
Bendow, B.,	1.030E+1	9.707E+2	2.793E+0	
Skolnik, L.,	1.024E+1	9.765E+2	2.642E+0	
Mitra, S.,	1.012E+1	9.882E+2	2.371E+0	
Massa, N.,	1.003E+1	9.963E+2	2.128E+0	
1976	1.000E+1	9.998E+2	2.014E+0	
	9.944E+0	1.006E+3	1.803E+0	
	9.830E+0	1.017E+3	1.618E+0	
	9.747E+0	1.026E+3	1.493E+0	
	9.610E+0	1.041E+3	1.233E+0	
	9.531E+0	1.049E+3	1.199E+0	
	9.400E+0	1.064E+3	1.047E+0	
	9.299E+0	1.075E+3	8.892E-1	
	9.199E+0	1.087E+3	7.962E-1	
	9.054E+0	1.104E+3	6.950E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
19 [53] (cont.)	8.983E+0	1.113E+3	5.741E-1	
	8.844E+0	1.131E+3	5.012E-1	
	8.732E+0	1.145E+3	4.256E-1	
	8.623E+0	1.160E+3	3.715E-1	
	8.495E+0	1.177E+3	2.985E-1	
	8.412E+0	1.189E+3	2.679E-1	
	8.250E+0	1.212E+3	2.153E-1	
	8.152E+0	1.227E+3	1.828E-1	
	8.001E+0	1.250E+3	1.469E-1	
	7.890E+0	1.267E+3	1.183E-1	
	7.679E+0	1.302E+3	9.247E-2	
	7.645E+0	1.308E+3	7.852E-2	
	7.528E+0	1.328E+3	5.821E-2	
	7.367E+0	1.357E+3	5.508E-2	
	7.242E+0	1.381E+3	3.281E-2	
	7.123E+0	1.404E+3	3.373E-2	
20 [53]		(T = 370 K)		Same as above.
Lipson, H.,	1.012E+1	9.881E+2	3.206E+0	
et al.,	1.000E+1	9.997E+2	2.871E+0	
1976	9.917E+0	1.008E+3	2.649E+0	
	9.720E+0	1.029E+3	2.249E+0	
	9.612E+0	1.040E+3	1.959E+0	
	9.479E+0	1.055E+3	1.758E+0	
	9.427E+0	1.061E+3	1.578E+0	
	9.300E+0	1.075E+3	1.413E+0	
	9.055E+0	1 104E+3	1.047E+0	
	8.984E+0	1.113E+3	9.397E-1	
	8.845E+0	1.131E+3	7.980E-1	
	8.733E+0	1.145E+3	6.966E-1	
	8.624E+0	1.160E+3	6.081E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
20 [53] (cont.)	8.496E+0	1.177E+3	4.753E-1	
	8.372E+0	1.194E+3	4.385E-1	
	8.251E+0	1.212E+3	3.724E-1	
	8.134E+0	1.229E+3	3.155E-1	
	8.002E+0	1.250E+3	2.612E-1	
	7.892E+0	1.267E+3	2.158E-1	
	7.767E+0	1.288E+3	1.782E-1	
	7.646E+0	1.308E+3	1.472E-1	
	7.512E+0	1.331E+3	1.183E-1	
	7.368E+0	1.357E+3	1.033E-1	
	7.228E+0	1.383E+3	7.656E-2	
	7.094E+0	1.410E+3	6.152E-2	
	6.882E+0	1.453E+3	4.819E-2	
21 [53]		(T = 480 K)		Same as above.
Lipson, H.,	9.918E+0	1.008E+3	3.673E+0	
et al.,	9.694E+0	1.032E+3	2.951E+0	
1976	9.586E+0	1.043E+3	2.799E+0	
	9.481E+0	1.055E+3	2.649E+0	
	9.377E+0	1.066E+3	2.188E+0	
	9.301E+0	1.075E+3	2.075E+0	
	9.201E+0	1.087E+3	1.858E+0	
	9.056E+0	1.104E+3	1.578E+0	
	8.962E+0	1.116E+3	1.416E+0	
	8.846E+0	1.130E+3	1.236E+0	
	8.734E+0	1.145E+3	1.050E+0	
	8.625E+0	1.159E+3	9.397E-1	
	8.518E+0	1.174E+3	7.980E-1	
	8.373E+0	1.194E+3	6.607E-1	
	8.252E+0	1.212E+3	5.754E-1	
	8.135E+0	1.229E+3	4.887E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
21 [53] (cont.)	8.021E+0	1.247E+3	3.936E-1	
	7.875E+0	1.270E+3	3.436E-1	
	7.750E+0	1.290E+3	2.838E-1	
	7.647E+0	1.308E+3	2.344E-1	
	7.513E+0	1.331E+3	1.936E-1	
	7.369E+0	1.357E+3	1.644E-1	
	7.244E+0	1.380E+3	1.219E-1	
	7.095E+0	1.409E+3	1.094E-1	
	7.066E+0	1.415E+3	1.007E-1	
	6.896E+0	1.450E+3	7.063E-2	
	6.787E+0	1.473E+3	5.998E-2	
22 [53]		(T = 590 K)		Same as above.
Lipson, H.,	9.481E+0	1.055E+3	3.296E+0	
et al.,	9.429E+0	1.061E+3	3.041E+0	
1976	9.403E+0	1.063E+3	2.958E+0	
	9.327E+0	1.072E+3	2.799E+0	
	9.302E+0	1.075E+3	2.649E+0	
	9.227E+0	1.084E+3	2.512E+0	
	9.202E+0	1.087E+3	2.377E+0	
	9.153E+0	1.093E+3	2.193E+0	
	9.057E+0	1.104E+3	2.193E+0	
	8.963E+0	1.116E+3	1.963E+0	
	8.847E+0	1.130E+3	1.667E+0	
	8.735E+0	1.145E+3	1.496E+0	
	8.625E+0	1.159E+3	1.271E+0	
	8.519E+0	1.174E+3	1.109E+0	
	8.373E+0	1.194E+3	9.419E-1	
	8.253E+0	1.212E+3	8.222E-1	
	8.136E+0	1.229E+3	6.792E-1	
	8.022E+0	1.247E+3	5.768E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
22 [53] (cont.)	7.893E+0	1.267E+3	4.898E-1	
	7.768E+0	1.287E+3	4.046E-1	
	7.647E+0	1.308E+3	3.251E-1	
	7.514E+0	1.331E+3	2.685E-1	
	7.433E+0	1.345E+3	2.547E-1	
	7.369E+0	1.357E+3	2.286E-1	
	7.307E+0	1.369E+3	2.104E-1	
	7.276E+0	1.374E+3	1.941E-1	
	7.245E+0	1.380E+3	1.837E-1	
	7.155E+0	1.398E+3	1.738E-1	
	7.125E+0	1.403E+3	1.560E-1	
	7.066E+0	1.415E+3	1.324E-1	
	6.981E+0	1.433E+3	1.324E-1	
	6.938E+0	1.441E+3	1.064E-1	
	6.788E+0	1.473E+3	9.550E-2	
	6.761E+0	1.479E+3	8.570E-2	
	6.722E+0	1.488E+3	8.110E-2	
23 [53]		(T = 675 K)		Same as above.
Lipson, H.,	9.277E+0	1.078E+3	3.041E+0	
et al.,	9.057E+0	1.104E+3	2.582E+0	
1978	8.963E+0	1.116E+3	2.193E+0	
	8.848E+0	1.130E+3	2.075E+0	
	8.735E+0	1.145E+3	1.762E+0	
	8.626E+0	1.159E+3	1.581E+0	
	8.498E+0	1.177E+3	1.419E+0	
	8.374E+0	1.194E+3	1.205E+0	
	8.254E+0	1.212E+3	1.140E+0	
	8.136E+0	1.229E+3	8.933E-1	
	8.023E+0	1.246E+3	7.586E-1	
	7.894E+0	1.267E+3	6.607E-1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
23 [53] (cont.)	7.752E+0	1.290E+3	5.470E-1	
	7.631E+0	1.310E+3	4.395E-1	
	7.581E+0	1.319E+3	3.945E-1	
	7.514E+0	1.331E+3	3.733E-1	
	7.466E+0	1.339E+3	3.532E-1	
	7.370E+0	1.357E+3	2.917E-1	
	7.307E+0	1.369E+3	2.767E-1	
	7.261E+0	1.377E+3	2.618E-1	
	7.245E+0	1.380E+3	2.286E-1	
	7.155E+0	1.398E+3	2.163E-1	
	7.126E+0	1.403E+3	2.109E-1	
	7.096E+0	1.409E+3	1.995E-1	
	7.052E+0	1.418E+3	1.742E-1	
	7.009E+0	1.427E+3	1.694E-1	
	6.953E+0	1.438E+3	1.560E-1	
	6.897E+0	1.450E+3	1.361E-1	
	6.802E+0	1.470E+3	1.156E-1	
	6.735E+0	1.485E+3	1.067E-1	
	6.631E+0	1.508E+3	9.057E-2	
24 [53] Lipson, H., et al., 1976		(T = 755 K)		Same as above.
	9.379E+0	1.066E+3	4.457E+0	
	9.303E+0	1.075E+3	3.890E+0	
	9.179E+0	1.089E+3	3.388E+0	
	9.058E+0	1.104E+3	3.126E+0	
	8.963E+0	1.116E+3	2.805E+0	
	8.848E+0	1.130E+3	2.512E+0	
	8.736E+0	1.145E+3	2.254E+0	
	8.626E+0	1.159E+3	1.968E+0	
	8.520E+0	1.174E+3	1.671E+0	
	8.375E+0	1.194E+3	1.500E+0	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
24 [53] (cont.)	8.254E+0	1.212E+3	1.306E+0	
	8.137E+0	1.229E+3	1.109E+0	
	8.023E+0	1.246E+3	9.419E-1	
	7.894E+0	1.267E+3	8.017E-1	
	7.769E+0	1.287E+3	6.808E-1	
	7.649E+0	1.307E+3	5.781E-1	
	7.581E+0	1.319E+3	5.176E-1	
	7.499E+0	1.334E+3	4.645E-1	
	7.498E+0	1.334E+3	4.395E-1	
	7.434E+0	1.345E+3	4.055E-1	
	7.370E+0	1.357E+3	3.631E-1	
	7.307E+0	1.368E+3	3.350E-1	
	7.246E+0	1.380E+3	3.083E-1	
	7.200E+0	1.389E+3	2.767E-1	
	7.126E+0	1.403E+3	2.415E-1	
	7.038E+0	1.421E+3	2.223E-1	
	7.010E+0	1.427E+3	2.051E-1	
	6.967E+0	1.435E+3	1.888E-1	
	6.911E+0	1.447E+3	1.694E-1	
	6.815E+0	1.467E+3	1.521E-1	
	6.749E+0	1.482E+3	1.365E-1	
	6.722E+0	1.488E+3	1.222E-1	
25 [53] Lipson, H., et al., 1976		(T = 350 K)		Single crystal samples cut from long rod of Optopac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; emittance was measured and absorption
	5.000E+0	2.000E+3	5.910E-3	
	5.102E+0	1.960E+3	5.620E-3	
	5.263E+0	1.900E+3	5.220E-3	
	5.405E+0	1.850E+3	6.060E-3	
	5.525E+0	1.810E+3	7.790E-3	
	5.848E+0	1.710E+3	8.190E-3	
	6.250E+0	1.600E+3	1.110E-2	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
25 [53] (cont.)	6.452E+0	1.550E+3	1.490E-2	coefficient was determined; in the transparent region the emittance is proportitional to absorption times sample length; data extracted from a figure.
	6.623E+0	1.510E+3	2.020E-2	
	6.757E+0	1.480E+3	4.160E-2	
	7.143E+0	1.400E+3	5.620E-2	
	7.463E+0	1.340E+3	1.080E-1	
	7.692E+0	1.300E+3	1.820E-1	
	8.065E+0	1.240E+3	3.410E-1	
	8.333E+0	1.200E+3	6.060E-1	
	8.850E+0	1.130E+3	8.610E-1	
	9.091E+0	1.100E+3	1.220E+0	
	9.346E+0	1.070E+3	2.170E+0	
	9.901E+0	1.010E+3	3.080E+0	
26 [54]		(T = 300 K)		Forged bar sample acquired from Hughes Research Laboratories; polished and chemically cleaned; laser calorimetric method used for measurement; bulk absorption coefficient obtained; absorption due to two surfaces amounted at 1.3 x 10^{-4} for the DF laser wavelength and 2.8 x 10^{-4} for the HF wavelength; temperature not given, 300 K assumed; data extracted from a table.
Harrington, J. A.	3.799E+0	2.632E+3	2.700E-4	
Gregory, D. A., Otto, W. F. Jr., 1976	2.700E+0	3.704E+3	1.800E-4	
27 [54]		(T = 300 K)		Similar to above except the total absorption coefficient for a forged disk sample.
Harrington, J. A.	3.799E+0	2.632E+3	1.300E-3	
et al., 1976	2.700E+0	3.704E+3	3.000E-3	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
28 [54]		(T = 300 K)		Similar to above except the total absorption coefficient for a single crystal as received.
Harrington, J. A.	3.799E+0	2.632E+3	5.500E-4	
et al.,	2.700E+0	3.704E+3	9.300E-4	
1976				
29 [54]		(T = 300 K)		Above sample except repolished.
Harrington, J. A.	3.799E+0	2.632E+3	1.700E-4	
et al.,	2.700E+0	3.704E+3	4.900E-4	
1976				
30 [54]		(T = 300 K)		Similar to above but the total absorption coefficient for the sample acquired from the Adolf Meller Co.
Harrington, J. A.	3.799E+0	2.632E+3	2.100E-3	
et al.,	2.700E+0	3.704E+3	2.200E-3	
1976				
31 [55]		(T = 300 K)		Long rod samples received from the Naval Research Lab., Harshaw Chemical Co., and Raytheon Corporation; mechanical polishing with Linde B and isopropanol; final cleaning with spectrograde CCl_4 just prior to measurement; laser calorimetric data were analyzed involving solution of the heat equation for the temperature distribution in a sample that is heated both internally and on the surface; both the bulk and the surface absorption were deduced: digited data on bulk absorption were given; temperature unknown, 300 K.
Rosenstock, H.,	3.801E+0	2.631E+3	2.500E-4	
Gregory, D.,	2.701E+0	3.703E+3	2.000E-4	
Harrington, J.,				
1978				

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
31 [55] (cont.)				assumed; surface absorption coefficients were found 2.7 x 10^{-3} at frequency 2.631E+03 and 3.5 x 10^{-3} at frequency 3.703E+03.
32 [56]		(T = 298 K)		Forged polycrystalline sample obtained from Hughes Co.; highly purified and polished rod specimen; measured with laser calorimetric techniques; an Nd:YAG laser was used; data extracted from a table.
Hass, M.,	1.060E+0	9.434E+3	4.000E-5	
Harrington, J. A.				
Gregory, D. A.,				
Davison, J. W.,				
1976				
33 [40]		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficients; CO_2, CO and Ar cw lasers were used; both surface and bulk losses were determined; bulk absorption data extracted from a table.
Hordvik, A.,	5.145E-1	1.944E+4	9.300E-4	
Schlossberg, H.,	5.257E+0	1.902E+3	6.700E-4	
1977	5.424E+0	1.844E+3	1.100E-3	
	5.700E+0	1.754E+3	2.200E-3	
	5.782E+0	1.730E+3	3.400E-3	
	5.906E+0	1.693E+3	4.900E-3	
	6.086E+0	1.643E+3	6.300E-3	
	6.137E+0	1.629E+3	7.300E-3	
	6.330E+0	1.580E+3	1.150E-2	
	6.466E+0	1.547E+3	1.400E-2	
	6.546E+0	1.528E+3	1.500E-2	
	1.060E+1	9.434E+2	3.600E+0	
34 [42]		(T = 300 K)		Standard commercial quality crystals; obtained in finished form from the A. Meller Company; sample size of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic technique was used to
Hordvik, A.,	2.700E+0	3.704E+3	1.900E-4	
Skolnik, H.,	3.800E+0	2.632E+3	6.200E-5	
1977				

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
34 [42] (cont.)				determine the absorption coefficients; the HF/DF laser used in the measurement was operated multiline for both HF and DF measurements; typical laser power of 300 mW was adequate for the measurements; digitized bulk absorption data were given.
35 [42] Hordvik, A., et al., 1977		(T = 300 K)		Similar to above except for surface absorption; the letter "S" follow the absorption value denotes the loss per surface.
	2.700E+0	3.704E+3	5.000E-4S	
	3.800E+0	2.632E+3	1.000E-4S	
36 [57] Allen, S. D., Rudisill, J. E., 1977		(T = 300 K)		Rod sample (6.955 cm long) cut from a large piece of Raytheon cast CaF_2; surface treatment as received with some scratches on surfaces from cutting; measurements carried out with laser calorimetry; power output of the CO laser was 8-10 W; the total absorption coefficient was obtained; data taken from a table.
	5.300E+0	1.887E+3	9.000E-4	
37 [57] Allen, S. D., et al., 1977		(T = 300 K)		Similar to above except for a polished single crystal rod sample of 4.991 cm long obtained from the Hughes Research Lab.
	5.300E+0	1.887E+3	5.900E-4	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
38 [58]		(T = 300 K)		Thin film specimens of various
Fabre, D.,	1.016E-1	9.843E+4	5.356E+5	thickness on sustrate of known
Romand, J.,	1.029E-1	9.718E+4	5.154E+5	reflectivity; the resultant
Vodar, B.,	1.048E-1	9.542E+4	4.832E+5	reflectance as a function of sample
1964	1.076E-1	9.294E+4	4.193E+5	thickness observed and absorption
	1.087E-1	9.200E+4	3.988E+5	coefficient was determined; data
	1.097E-1	9.116E+4	3.952E+5	extracted from a curve which best fit
	1.102E-1	9.074E+4	3.934E+5	the experimental data.
	1.113E-1	8.985E+4	4.144E+5	
	1.120E-1	8.929E+4	4.746E+5	
	1.132E-1	8.834E+4	6.772E+5	
	1.139E-1	8.780E+4	9.190E+5	
	1.142E-1	8.757E+4	9.287E+5	
	1.147E-1	8.718E+4	9.302E+5	
	1.152E-1	8.681E+4	8.956E+5	
	1.164E-1	8.591E+4	6.607E+5	
	1.177E-1	8.496E+4	4.335E+5	
	1.183E-1	8.453E+4	3.633E+5	
	1.188E-1	8.418E+4	3.470E+5	
	1.204E-1	8.306E+4	3.162E+5	
	1.365E-1	7.326E+4	1.694E+5	
	1.600E-1	6.250E+4	5.812E+4	
	1.696E-1	5.896E+4	3.038E+4	
	1.787E-1	5.596E+4	1.547E+4	
39 [10]		(T = 78 K)		Single crystal; obtained from the
Tomiki, T.,	1.168E-1	8.560E+4	6.750E+1	Harshaw Chemical Co.; freshly
Miyata, T.,	1.170E-1	8.550E+4	7.440E+1	cleaved plate specimens from Harshaw
1969	1.171E-1	8.540E+4	3.400E+1	optical-quality block; absorption
	1.172E-1	8.530E+4	1.100E+1	coefficient determined from
	1.174E-1	8.520E+4	9.060E+0	transmission and reflectivity

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
39 [10] (cont.)	1.175E-1	8.510E+4	5.550E+0	measurements; data taken from a figure; samples from Harshaw ultraviolet quality block and other sources were also investigated with results higher than those obtained for the optical- quality samples.
	1.176E-1	8.500E+4	4.790E+0	
	1.181E-1	8.470E+4	2.800E+0	
	1.188E-1	8.420E+4	2.300E+0	
	1.206E-1	8.290E+4	1.350E+0	
	1.220E-1	8.200E+4	1.350E+0	
	1.232E-1	8.120E+4	1.110E+0	
	1.242E-1	8.050E+4	9.120E-1	
	1.255E-1	7.970E+4	7.500E-1	
	1.263E-1	7.920E+4	6.810E-1	
	1.279E-1	7.820E+4	6.490E-1	
	1.287E-1	7.770E+4	5.890E-1	
40 [10]		(T = 184 K)		Same as above.
Tomiki, T.,	1.190E-1	8.400E+4	5.040E+1	
et al.,	1.192E-1	8.390E+4	3.410E+1	
1969	1.193E-1	8.380E+4	2.420E+1	
	1.195E-1	8.370E+4	2.090E+1	
	1.199E-1	8.340E+4	6.140E+0	
	1.203E-1	8.310E+4	3.250E+0	
	1.205E-1	8.300E+4	2.950E+0	
	1.211E-1	8.260E+4	1.810E+0	
	1.217E-1	8.220E+4	1.640E+0	
	1.233E-1	8.110E+4	1.220E+0	
	1.259E-1	7.940E+4	8.700E-1	
	1.282E-1	7.800E+4	8.300E-1	
41 [10]		(T = 298 K)		Same as above.
Tomiki, T.,	1.218E-1	8.210E+4	6.460E+1	
et al.,	1.221E-1	8.190E+4	4.160E+1	
1969	1.232E-1	8.120E+4	1.000E+1	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
41 [10] (cont.)	1.235E-1	8.100E+4	7.870E+0	
	1.236E-1	8.090E+4	3.960E+0	
	1.244E-1	8.040E+4	2.550E+0	
	1.250E-1	8.000E+4	1.350E+0	
	1.256E-1	7.960E+4	1.110E+0	
	1.263E-1	7.920E+4	1.010E+0	
	1.271E-1	7.870E+4	8.290E-1	
	1.285E-1	7.780E+4	8.300E-1	
	1.300E-1	7.690E+4	6.500E-1	
	1.333E-1	7.500E+4	3.870E-1	
	1.355E-1	7.380E+4	3.740E-1	
	1.504E-1	6.650E+4	2.800E-1	
	1.534E-1	6.520E+4	2.380E-1	
	1.563E-1	6.400E+4	2.200E-1	
	1.567E-1	6.380E+4	2.210E-1	
	1.575E-1	6.350E+4	2.030E-1	
	1.592E-1	6.280E+4	1.950E-1	
	1.597E-1	6.260E+4	1.960E-1	
	1.608E-1	6.220E+4	1.800E-1	
	1.621E-1	6.170E+4	1.660E-1	
	1.626E-1	6.150E+4	1.660E-1	
	1.653E-1	6.050E+4	1.820E-1	
	1.675E-1	5.970E+4	1.760E-1	
	1.698E-1	5.890E+4	1.620E-1	
	1.718E-1	5.820E+4	1.370E-1	
	1.736E-1	5.760E+4	1.380E-1	
	1.757E-1	5.690E+4	1.450E-1	
	1.773E-1	5.640E+4	1.330E-1	
	1.795E-1	5.570E+4	1.130E-1	
	1.812E-1	5.520E+4	9.540E-2	
	1.898E-1	5.270E+4	9.300E-2	
	1.934E-1	5.170E+4	1.020E-1	
	2.075E-1	4.820E+4	7.750E-2	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
42 [10]		(T = 435 K)		Same as above.
Tomiki, T.,	1.252E-1	7.990E+4	6.170E+1	
et al.,	1.261E-1	7.930E+4	2.100E+1	
1969	1.266E-1	7.900E+4	1.170E+1	
	1.272E-1	7.860E+4	4.840E+0	
	1.280E-1	7.810E+4	1.820E+0	
	1.282E-1	7.800E+4	1.490E+0	
	1.289E-1	7.760E+4	1.490E+0	
	1.304E-1	7.670E+4	7.170E-1	
	1.335E-1	7.490E+4	6.210E-1	
	1.377E-1	7.260E+4	5.650E-1	
43 [10]		(T = 573 K)		Same as above.
Tomiki, T.,	1.282E-1	7.800E+4	7.520E+1	
et al.,	1.287E-1	7.770E+4	4.840E+1	
1969	1.295E-1	7.720E+4	1.730E+1	
	1.305E-1	7.660E+4	9.170E+0	
	1.316E-1	7.600E+4	3.280E+0	
	1.328E-1	7.530E+4	1.430E+0	
	1.335E-1	7.490E+4	8.330E-1	
	1.346E-1	7.430E+4	7.200E-1	
	1.364E-1	7.330E+4	6.860E-1	
44 [59]		(T = 300 K)		Single crystal; no details on the sample were given; reflection spectra at incident angles of 20°, 45°, 60° and 70° were obtained; absorption coefficients were determined using Fresnel Formulae; data extracted from a figure.
Stephan, G.,	2.613E-2	3.827E+5	6.980E+5	
Le Calvez, Y.,	2.697E-2	3.708E+5	7.710E+5	
Lemonier, J. C.,	2.732E-2	3.660E+5	8.010E+5	
Robin, S.,	2.768E-2	3.613E+5	7.710E+5	
1969	2.786E-2	3.589E+5	7.120E+5	
	2.796E-2	3.577E+5	6.970E+5	
	2.843E-2	3.518E+5	7.260E+5	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
44 [59] (cont.)	2.912E-2	3.434E+5	8.590E+5	
	2.933E-2	3.410E+5	8.880E+5	
	2.953E-2	3.386E+5	8.580E+5	
	3.017E-2	3.315E+5	7.250E+5	
	3.083E-2	3.244E+5	6.950E+5	
	3.060E-2	3.268E+5	7.240E+5	
	3.129E-2	3.196E+5	8.130E+5	
	3.153E-2	3.172E+5	9.010E+5	
	3.177E-2	3.148E+5	8.720E+5	
	3.200E-2	3.125E+5	8.120E+5	
	3.213E-2	3.112E+5	9.010E+5	
	3.251E-2	3.076E+5	1.004E+6	
	3.264E-2	3.064E+5	1.167E+6	
	3.303E-2	3.028E+5	1.152E+6	
	3.397E-2	2.944E+5	1.226E+6	
	3.423E-2	2.921E+5	1.225E+6	
	3.425E-2	2.920E+5	1.299E+6	
	3.448E-2	2.900E+5	1.338E+6	
	3.494E-2	2.862E+5	2.048E+6	
	3.557E-2	2.811E+5	2.905E+6	
	3.573E-2	2.799E+5	2.994E+6	
	3.604E-2	2.775E+5	2.875E+6	
	3.663E-2	2.730E+5	2.313E+6	
	3.679E-2	2.718E+5	2.269E+6	
	3.712E-2	2.694E+5	2.298E+6	
	3.729E-2	2.682E+5	2.505E+6	
	3.730E-2	2.681E+5	2.549E+6	
	3.762E-2	2.658E+5	2.490E+6	
	3.812E-2	2.623E+5	2.135E+6	
	3.845E-2	2.601E+5	1.795E+6	
	3.867E-2	2.586E+5	1.638E+6	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
44 [59] (cont.)	3.920E-2	2.551E+5	1.475E+6	
	4.072E-2	2.456E+5	1.252E+6	
	4.110E-2	2.433E+5	1.237E+6	
	4.193E-2	2.385E+5	1.104E+6	
	4.277E-2	2.338E+5	1.104E+6	
	4.299E-2	2.326E+5	1.104E+6	
	4.367E-2	2.290E+5	1.163E+6	
	4.437E-2	2.254E+5	1.177E+6	
	4.462E-2	2.241E+5	1.606E+6	
	4.484E-2	2.230E+5	1.325E+6	
	4.556E-2	2.195E+5	1.058E+6	
	4.581E-2	2.183E+5	1.029E+6	
	4.632E-2	2.159E+5	1.073E+6	
	4.735E-2	2.112E+5	1.058E+6	
	4.762E-2	2.100E+5	1.087E+6	
	4.819E-2	2.075E+5	1.354E+6	
	4.876E-2	2.051E+5	1.427E+6	
	4.933E-2	2.027E+5	1.383E+6	
	5.051E-2	1.980E+5	1.235E+6	
	5.171E-2	1.934E+5	9.390E+5	
	5.236E-2	1.910E+5	8.940E+5	
	5.269E-2	1.898E+5	9.380E+5	
	5.302E-2	1.886E+5	9.970E+5	
	5.336E-2	1.874E+5	9.970E+5	
	5.438E-2	1.839E+5	9.380E+5	
	5.546E-2	1.803E+5	8.490E+5	
	5.737E-2	1.743E+5	9.370E+5	
	5.814E-2	1.720E+5	9.080E+5	
	5.981E-2	1.672E+5	8.040E+5	
	6.068E-2	1.648E+5	8.630E+5	
	6.293E-2	1.589E+5	7.740E+5	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
44 [59] (cont.)	6.390E-2	1.565E+5	7.440E+5	
	6.485E-2	1.542E+5	7.140E+5	
	6.693E-2	1.494E+5	6.840E+5	
	6.798E-2	1.471E+5	5.960E+5	
	6.911E-2	1.447E+5	5.070E+5	
	7.087E-2	1.411E+5	5.660E+5	
	7.148E-2	1.399E+5	5.950E+5	
	7.273E-2	1.375E+5	8.170E+5	
	7.605E-2	1.315E+5	9.650E+5	
	7.899E-2	1.266E+5	1.142E+6	
	7.974E-2	1.254E+5	1.290E+6	
	8.052E-2	1.242E+5	1.319E+6	
	8.210E-2	1.218E+5	1.230E+6	
	8.368E-2	1.195E+5	9.930E+5	
	8.621E-2	1.160E+5	1.023E+6	
	8.726E-2	1.146E+5	1.437E+6	
	8.905E-2	1.123E+5	1.318E+6	
	9.091E-2	1.100E+5	1.200E+6	
	9.294E-2	1.076E+5	1.111E+6	
	9.506E-2	1.052E+5	1.200E+6	
	9.718E-2	1.029E+5	9.330E+5	
	9.940E-2	1.006E+5	8.150E+5	
	1.030E-1	9.707E+4	6.370E+5	
	1.068E-1	9.361E+4	3.410E+5	
	1.069E-1	9.355E+4	5.040E+5	
	1.099E-1	9.098E+4	9.920E+5	
	1.115E-1	8.968E+4	1.302E+6	
	1.144E-1	8.740E+4	1.006E+6	
	1.174E-1	8.515E+4	6.810E+5	
	1.240E-1	8.065E+4	3.550E+5	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
45 [60]		(T = 10 K)		Single crystal samples; freshly cleaved surfaces; near normal (10°) reflection spectrum obtained; absorption coefficients were determined with the Roessler method; data extracted from a figure.
Ganin, V. A.,	1.240E-1	8.065E+4	2.534E+4	
Karin, M. G.,	1.184E-1	8.443E+4	5.172E+4	
Sidorin, V. K.,	1.167E-1	8.569E+4	1.588E+5	
Sidorin, K. K.,	1.118E-1	8.947E+4	1.901E+6	
Starostin, N. V.,	1.102E-1	9.073E+4	2.711E+6	
Startsev, G. P.,	1.087E-1	9.198E+4	2.861E+6	
Shepilov, M. P.,	1.059E-1	9.440E+4	1.660E+6	
1975	1.058E-1	9.451E+4	7.571E+5	
	1.031E-1	9.702E+4	6.279E+5	
	1.005E-1	9.955E+4	1.901E+6	
	9.794E-2	1.021E+5	2.169E+6	
	9.681E-2	1.033E+5	2.323E+6	
	9.560E-2	1.046E+5	2.900E+6	
	9.337E-2	1.071E+5	3.134E+6	
	9.225E-2	1.084E+5	2.404E+6	
	9.017E-2	1.109E+5	2.630E+6	
	8.921E-2	1.121E+5	3.764E+6	
	8.818E-2	1.134E+5	4.227E+6	
	8.718E-2	1.147E+5	3.919E+6	
	8.628E-2	1.159E+5	2.750E+6	
	8.354E-2	1.197E+5	2.691E+6	
	8.183E-2	1.222E+5	2.523E+6	
	8.097E-2	1.235E+5	2.434E+6	
	8.019E-2	1.247E+5	3.304E+6	
	7.782E-2	1.285E+5	3.285E+6	
	7.559E-2	1.323E+5	2.935E+6	
	7.485E-2	1.336E+5	2.839E+6	
	7.348E-2	1.361E+5	2.599E+6	
	7.215E-2	1.386E+5	2.519E+6	
	7.087E-2	1.411E+5	2.738E+6	

TABLE 5. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
45 [60] (cont.)	6.784E-2	1.474E+5	1.952E+6	
	6.614E-2	1.512E+5	2.095E+6	
	6.402E-2	1.562E+5	2.744E+6	
	6.105E-2	1.638E+5	2.725E+6	
	6.154E-2	1.625E+5	2.954E+6	
	6.057E-2	1.651E+5	2.694E+6	
	5.879E-2	1.701E+5	2.568E+6	

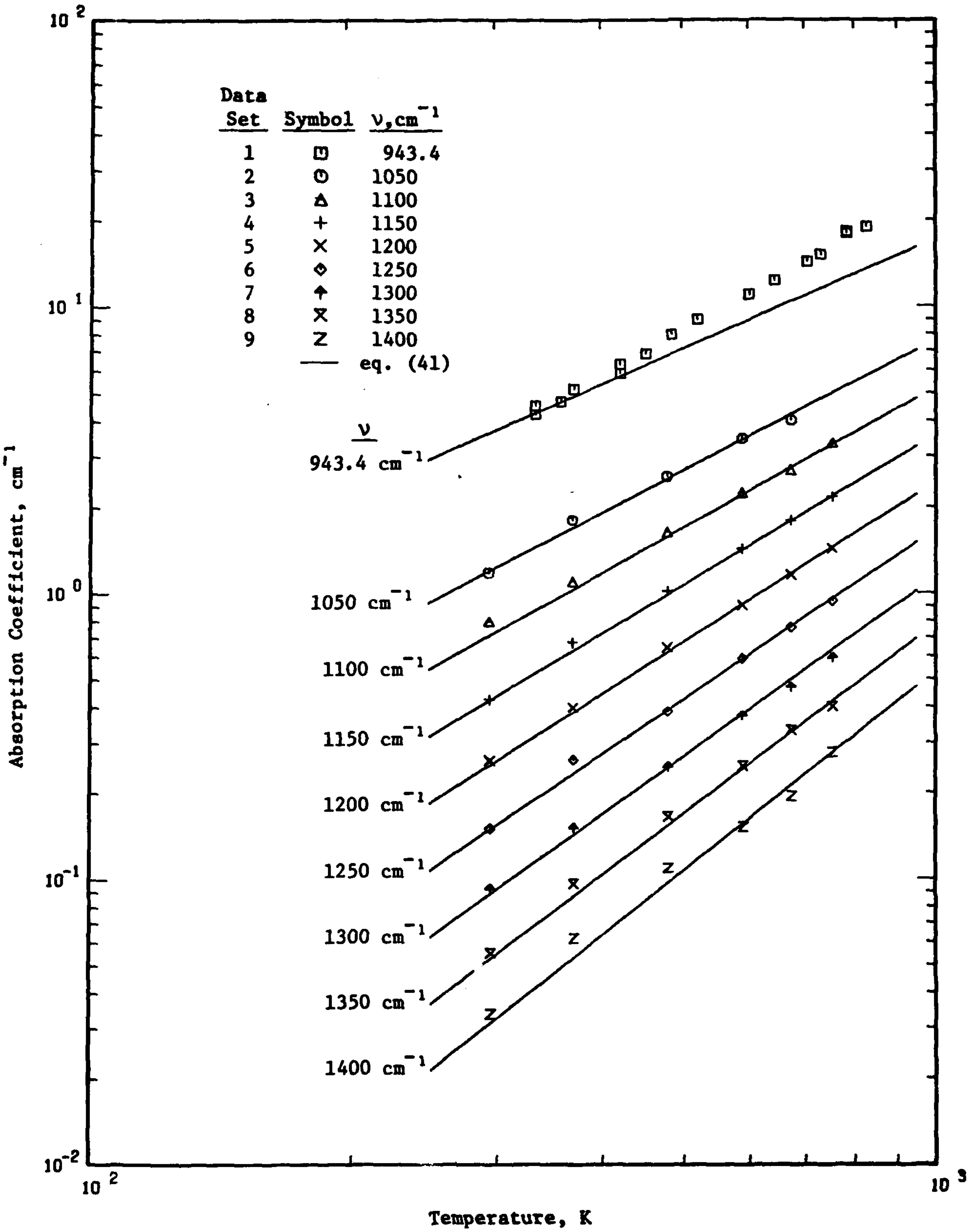

Figure 5. Absorption Coefficient of Calcium Fluoride in the Multiphonon Region (Temperature Dependence)

TABLE 6. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (TEMPERATURE DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm⁻¹; Absorption Coefficient, α, cm⁻¹]

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
1 [61] Chen, M., Hass, M., McGill, T. C., 1975	(ν = 943.4 cm^{-1})		Single crystal obtained from Hughes Research Laboratory; sample thicknesses were so selected to provide adequate transmission over the temperature range of measurement and the absorption coefficients at room temperature agreed with values reported previously; absorption coefficients were determined with a simple laser transmission method using the relation where L is the thickness of the sample, τ the transmission, ρ the calculated single surface reflectivity, α the absorption coefficient; the laser power ranged from 2 to 4 watts; on recycling down to room temperature, the absorption level did not change; data extracted from a figure.
	3.350E+2	4.200E+0	
	3.350E+2	4.500E+0	
	3.590E+2	4.650E+0	
	3.720E+2	5.160E+0	
	4.220E+2	5.830E+0	
	4.220E+2	6.250E+0	
	4.530E+2	6.810E+0	
	4.860E+2	7.960E+0	
	5.220E+2	8.980E+0	
	6.020E+2	1.100E+1	
	6.460E+2	1.230E+1	
	7.060E+2	1.430E+1	
	7.320E+2	1.510E+1	
	7.860E+2	1.790E+1	
	7.860E+2	1.820E+1	
	8.290E+2	1.890E+1	
2 [53] Lipson, H., Bendow, B., Skolnik, L., Mitra, S., Massa, N., 1976	(ν = 1050 cm^{-1})		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were
	2.950E+2	1.179E+0	
	3.700E+2	1.797E+0	
	4.800E+2	2.552E+0	
	5.900E+2	3.458E+0	
	6.750E+2	3.994E+0	

TABLE 6. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
2 [53] (cont.)			determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
3 [53]	(ν = 1100 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	7.950E-1	
et al.,	3.700E+2	1.097E+0	
1976	4.800E+2	1.633E+0	
	5.900E+2	2.237E+0	
	6.750E+2	2.677E+0	
	7.550E+2	3.322E+0	
4 [53]	(ν = 1150 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	4.250E-1	
et al.,	3.700E+2	6.720E-1	
1976	4.800E+2	1.016E+0	
	5.900E+2	1.428E+0	
	6.750E+2	1.785E+0	
	7.550E+2	2.156E+0	
5 [53]	(ν = 1200 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	2.600E-1	
et al.,	3.700E+2	3.980E-1	
1976	4.800E+2	6.450E-1	
	5.900E+2	9.070E-1	
	6.750E+2	1.154E+0	
	7.550E+2	1.429E+0	

TABLE 6. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
6 [53]	(ν = 1250 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	1.500E-1	
et al.,	3.700E+2	2.610E-1	
1976	4.800E+2	3.850E-1	
	5.900E+2	5.910E-1	
	6.750E+2	7.560E-1	
	7.550E+2	9.350E-1	
7 [53]	(ν = 1300 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	9.240E-2	
et al.,	3.700E+2	1.510E-1	
1976	4.800E+2	2.470E-1	
	5.900E+2	3.720E-1	
	6.750E+2	4.680E-1	
	7.550E+2	5.920E-1	
8 [53]	(ν = 1350 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	5.500E-2	
et al.,	3.700E+2	9.600E-2	
1976	4.800E+2	1.650E-1	
	5.900E+2	2.480E-1	
	6.750E+2	3.310E-1	
	7.550E+2	4.000E-1	
9 [53]	(ν = 1400 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	3.370E-2	
et al.,	3.700E+2	6.200E-2	
1976	4.800E+2	1.090E-1	
	5.900E+2	1.520E-1	
	6.750E+2	1.940E-1	
	7.550E+2	2.760E-1	

4.2 Strontium Fluoride, SrF_2

Strontium fluoride crystal has a large electronic forbidden gap and therefore the fundamental absorption is found to be in the vacuum ultraviolet beyond 10 eV. As a consequence, transparency of the crystal extends into the ultraviolet region to as low as 0.12 μm. This makes strontium fluoride a material useful in fabrication of optical components for vacuum ultraviolet investigations.

The strontium fluoride crystal belongs to the space group O^5 and is expected to have one infrared active transverse optical mode (TO) of vibration. The corresponding strong resonant absorption occurs at about 46 μm. However, the long wavelength limit of transparency for optical usages is about 20 μm.

Although the crystal is transparent from 0.12 up to 20 μm, only in the region 0.3-7 μm is the dispersion low and the transmission high. Less transmission and higher dispersion are found near the low and high limits. From the point of view of optical applications, the crystal is a good window material for wavelengths from 0.3 to 7.0 μm, and is a preferred material for dispersion devices, such as prisms, for regions near the ultraviolet and infrared limits of the crystal.

Having low dispersion and high transmission in the spectral region of 2-6 μm, being not hygroscopic, having a high optical figure of merit and having better mechanical properties than the alkali halides, the strontium fluoride crystal is among the serious candidates for laser window materials. The widespread use of SrF_2 as a host crystal in laser applications encouraged attempts to grow single crystals with low impurity content. However, difficulties were experienced in the growth of pure crystals because of the low electronic mobility of conduction electrons in the crystal. Synthetic material of high purity is now commercially available or is made by reacting the purified oxide or chloride with gaseous HF. Single crystals of SrF_2 can be grown by using the Stockbarger-Bridgman technique if adequate precautions are taken to eliminate oxygen and water from the atmosphere in the growing process. The crystal cleaves readily along [1,1,1] planes which meet to form <1,1,0> cleavage edges.

In the present work we have collected 38 data sets of wavenumber-dependent absorption coefficient and 12 sets of temperature-dependent data. These available data are plotted in Figures 6 and 9 and given in Tables 7 and 8. To show the details of the multiphonon absorption and Urbach tail regions of Figure 6, Figures 7 and 8 are provided. By comparing Figure 6 with Figure 1, one will note that the absorption spectrum of SrF_2 is typical among ionic crystals.

Early study on the absorption property of SrF_2 crystal was performed by Kaiser et al. [43] in 1962. Their work was concentrated near the reststrahlen region, 10 to 19 μm, at temperatures 77 and 300 K and the absorption data were deduced from the reflection spectrum by classic dispersion theory.

Useful information related to the lattice vibration was also obtained. Their results on the spectral position of the fundamental absorption phonons and the static and optical dielectric constants are in agreement with the measurements of Andeen et al. [67] and Lowndes [68].

For the purpose of providing new absorption data to fill the missing part in the long wavelength side of fundamental absorption peak, Bosomworth [46] measured absorption data for all accessible wavelengths in the region between 46 to 750 μm at 4 temperatures, 5, 80, 200 and 300 K, using the direct transmission interference method. His results are shown in Figure 6. It is clearly seen that the relation between absorption coefficient and frequency can be well approximated by a straight line in the log-log scale.

As the development of high-power lasers led to a need for better characterization of window materials, Deutsch [32] employed an improved method, the differential technique, in the determination of bulk absorption coefficient in the spectral region between 6.8 to 12 μm for the SrF_2 crystal. Errors in his results varies from 3% at high absorption levels to 10% at low absorption. His measurement is effectively a continuation of the work of Kaiser et al. extended into the lower wavelength region. Incorporated with the data of Kaiser et al., he found that the absorption coefficient as a function of frequency at room temperature can be best represented by eq. (9). The parameters he found for SrF_2 are given in Table 4. While most of the data fit the equation well, the very last point at the low absorption level 3.4 x 10^{-3} cm^{-1}, shows considerable deviation. Clearly this disagreement can be attributed to either imperfection of the sample or inadequate sensitivity of equipment as the limit of this method is about 10^{-3} cm^{-1}.

In order to find out how far into the transparent region eq. (9) remains valid, the absorption coefficient was carefully measured at and near 5.3 μm in a number of investigations by Deutsch [47], Winston et al. [49], Newberg et al. [51], Hordvik and Schlossberg [40], Hordvik [41], and Allen and Rudisill [57]. Their results vary over quite a wide range, from 4.1 x 10^{-5} cm^{-1} to 1.7 x 10^{-3} cm^{-1}, as shown in Figure 6. The lowest value agrees with the prediction of eq. (9).

Although the wavelengths 2.7 and 3.8 μm are very close to the multiphonon absorption region and it is highly possible that the exponential relation mentioned above may be extended to these wavelengths, experimental evidence is not able to substantiate it. Efforts focused on these two wavelengths was made by Harrington et al. [48], Harrington et al. [54], and Hordvik and Skolnik [42]. The resulting absorption coefficient varies from 9.0 x 10^{-5} cm^{-1} to 1.7 x 10^{-3} cm^{-1} at 3.8 μm and from 2.7 x 10^{-4} cm^{-1} to 3.3 x 10^{-3} cm^{-1} at 2.7 μm as indicated in Figure 6, while the values predicted by eq. (9) are respectively about 10^{-6} cm^{-1} and 10^{-8} cm^{-1}. Other than at wavelengths 5.3, 3.8, and 2.7 μm there is practically no absorption data available in the high transparent region except a single value, 4.7 x 10^{-4} cm^{-1}, measured at 0.515 μm reported by Hordvik and Schlossberg [40]. This value was determined with a photoacoustic calorimenter and is believed to be a representative absorption value in the highly transparent region.

The most informative experimental work was performed by Lipson et al. [52,53] in the wavelength region between 7.6 to 12 μm at six discrete temperatures from 295 to 800 K using a simple transmission method. The same samples examined in preliminary measurements made at room temperature showed no impurity bands in the wavelength region of interest. Additional measurements were made for an extended range from 12.5 μm down to 5 μm at temperatures 213 and 350 K using an emittance method. A strong absorption band was observed in the region below 7 μm. This band was tentatively attributed to surface contamination since no bulk impurity bands were detected by spectroscopic transmission even in long samples of 7.5 cm. Aside from the troublesome band, their results are believed to be mostly intrinsic. When plotted in a semi-logarithmic scale, the curves obtained at different temperatures are straight lines, an indication that the exponential relation, eq. (9), also holds at temperatures considerably higher than room temperature as shown in Figure 7.

The exponential variation of the absorption coefficient with frequency is also observed at the ultraviolet edge. For the purpose of clarifying the excitonic transitions and determining the Urbach parameters, Tomiki and Miyata [10] performed a series of measurements in the tail region at five temperatures, 78, 195,

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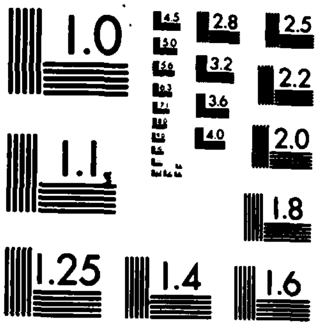

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299, 418, and 573 K. Through a systematic analysis, they were able to find that the observed absorption coefficients in the tail region can be best represented by equation (8) with parameters given in Table 3. However, as some of the key factors and parameters do not follow theoretical predictions, they concluded that whether the Urbach tail observed for the specimen is intrinsic or not remains unresolved. Additional observations in the ultraviolet region were made by Nisar and Robin [62], and Ganin et al. [60]. Their results are plotted in Figures 6 and 8. Since the results at high absorption levels can only be deduced from reflection spectrum analysis, much of the resulting values carry high uncertainties. However, the main features of the structure of the spectra agree with the results of others with respect to positions of the absorption peaks.

Temperature-dependence absorption measurements were rarely carried out systematically. We have reported in the present work only three sources which were found to be quite informative though their coverage is relatively limited. Chen et al. [61] measured absorption coefficients at the wavelength 10.6 μm (943.4 cm^{-1}) over a temperature range from 295 to 785 K using a simple laser transmission method. The purpose of their work was to provide experimental evidence to compare the predictions based on various theories of multiphonon absorption. They found that the Bose-Einstein model yields the closest agreement with the experimental data when appropriate choice of n, the number of phonons created, is made. Lipson et al. [52,53] reported temperature dependent absorption data over a temperature range from 300 to 800 K at a number of frequencies based on spectrometer transmission measurements. Their results are shown in Figure 9. It is interesting to note that all the curves in this figure are nearly straight lines and tend to converge to a point located in the high temperature and high absorption region. When compared with the results of Chen et al., the laser calorimetric measurements of Chen et al. are consistently higher than spectrometric results because the actual temperature of the sample is higher due to laser heating.

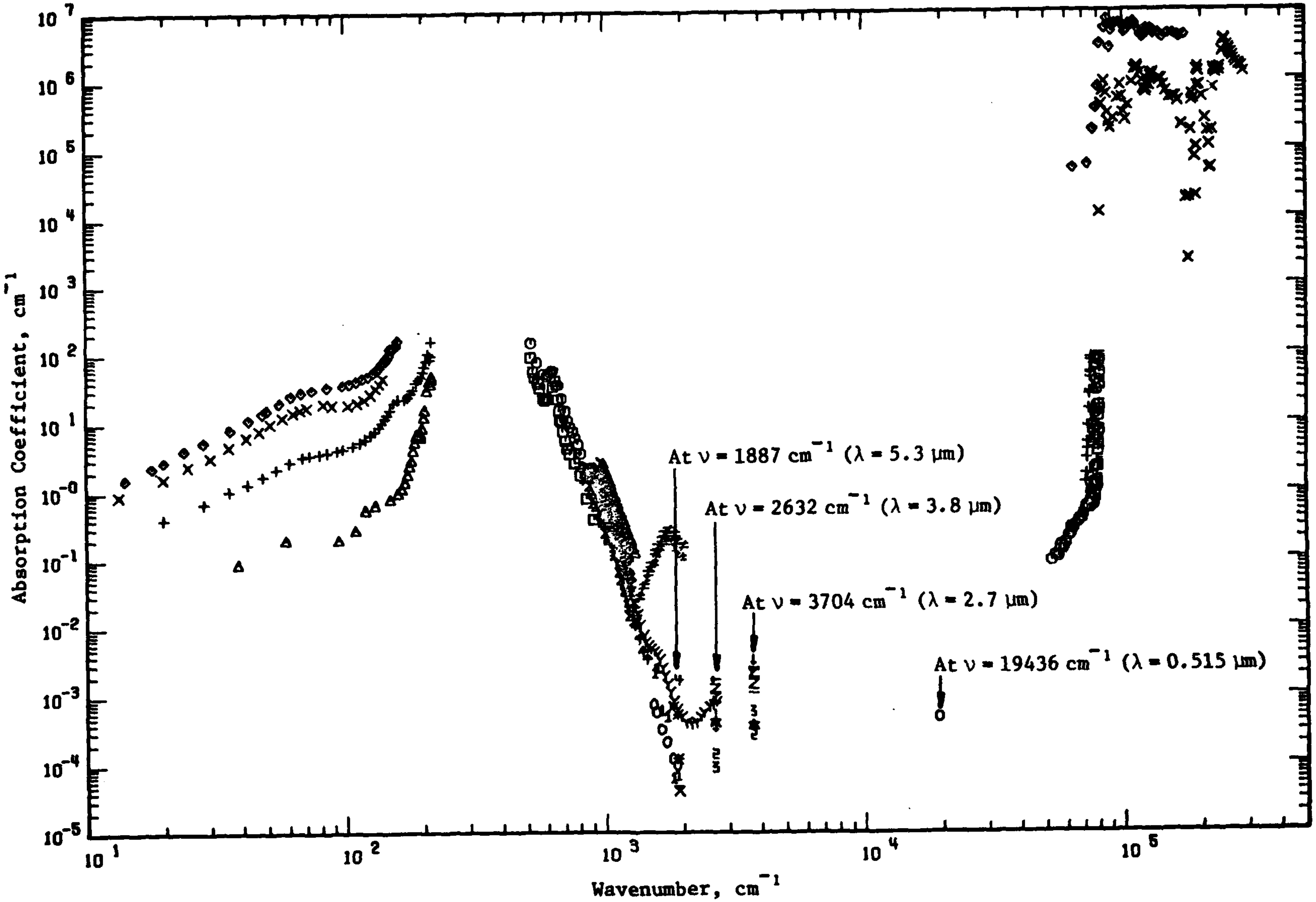

Figure 6. Absorption Coefficient of Strontium Fluoride (Wavenumber Dependence)

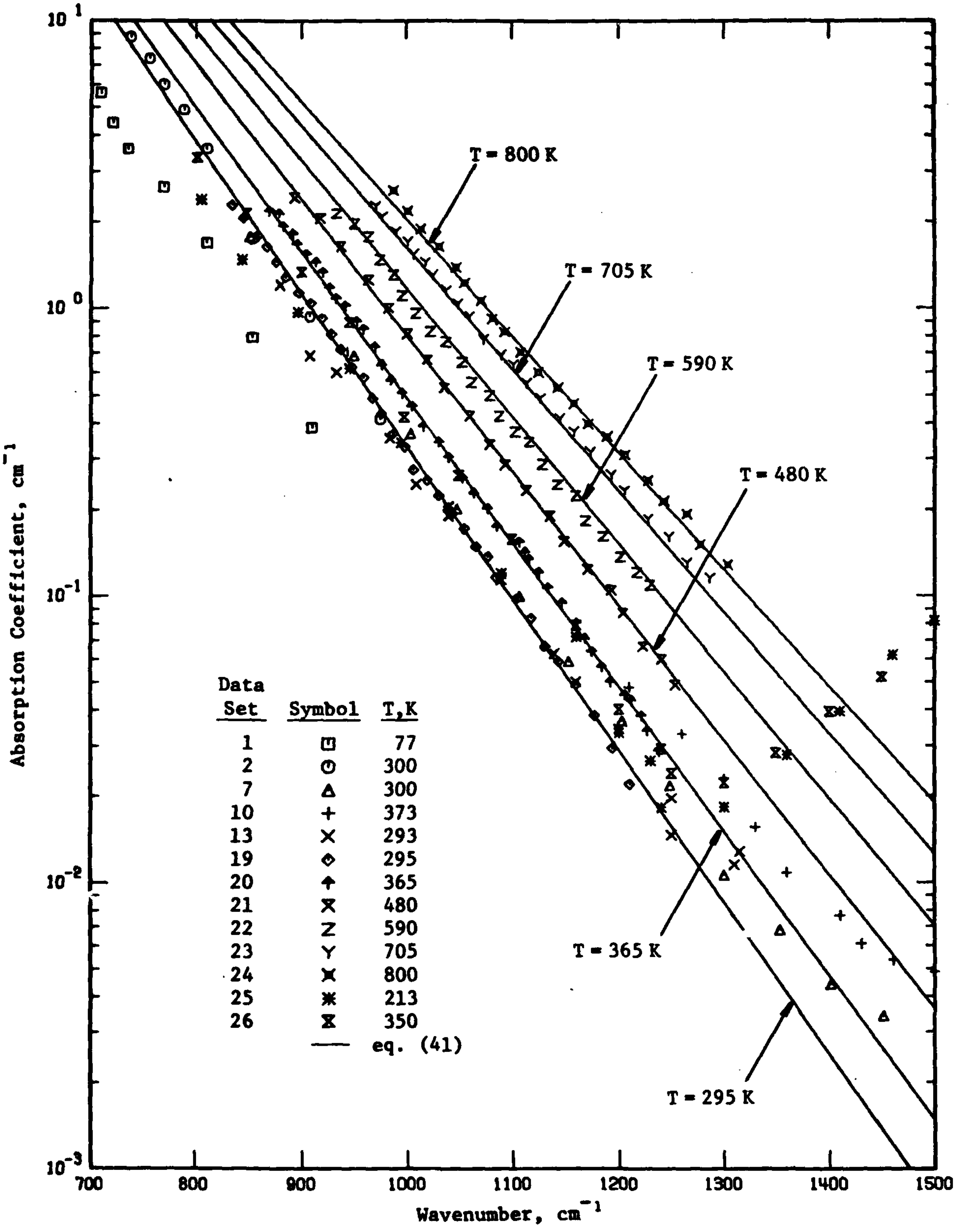

Figure 7. Absorption Coefficient of Strontium Fluoride in the Multiphonon Region (Wavenumber Dependence)

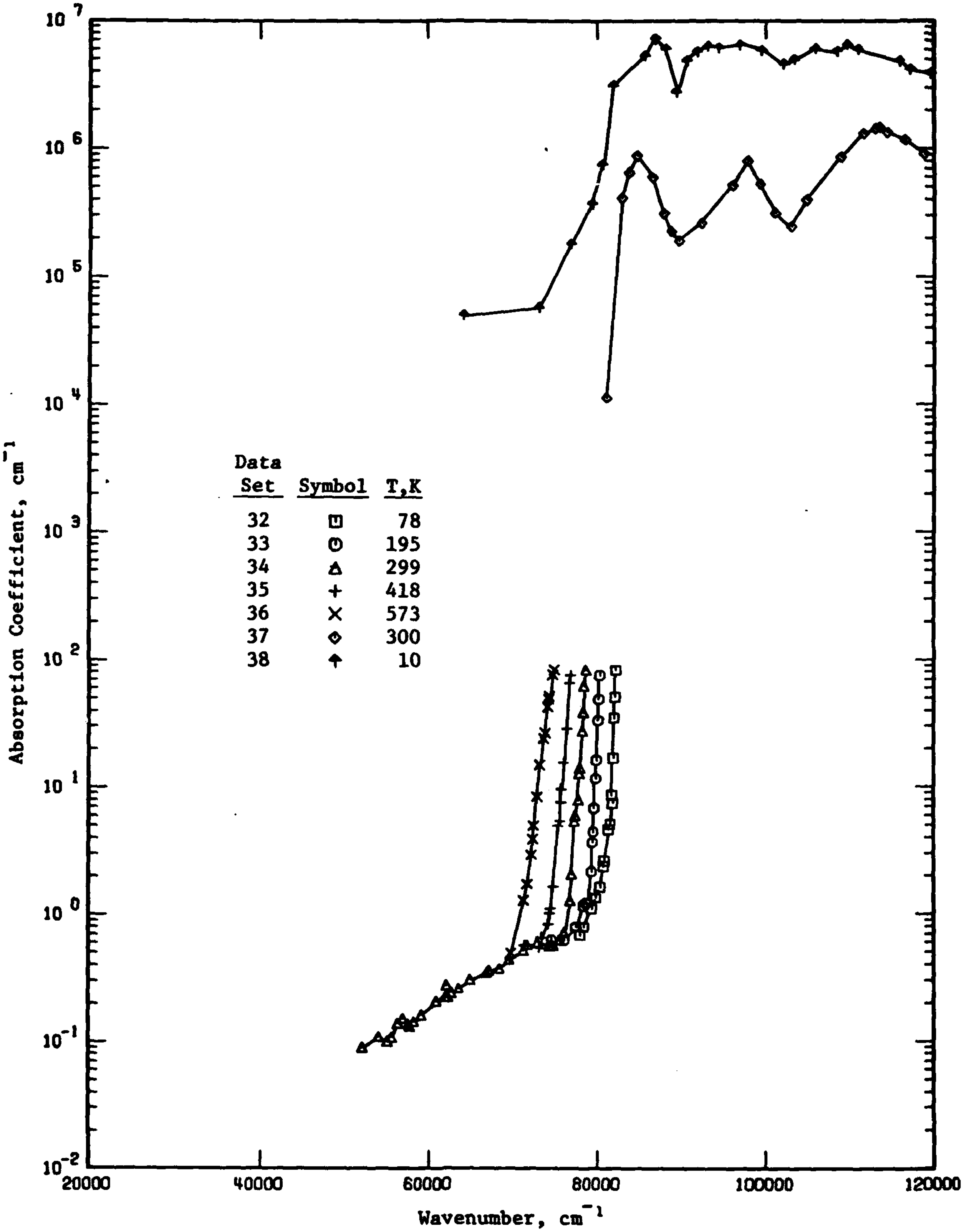

Figure 8. Absorption Coefficient of Strontium Fluoride in the Urbach Tail Region (Wavenumber Dependence)

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm^{-1}; Absorption Coefficient, α, cm^{-1}]

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [43]		(T = 77 K)		Single crystal; plate specimens of
Kaiser, W.,	1.099E+1	9.100E+2	3.870E−1	0.1 − 5 mm thick; absorption
Spitzer, W. G.,	1.171E+1	8.540E+2	7.940E−1	coefficient determined from
Kaiser, R. H.,	1.233E+1	8.110E+2	1.690E+0	transmission and reflectivity
Howarth, L. E.,	1.299E+1	7.700E+2	2.640E+0	measurements; data taken from a
1962	1.359E+1	7.360E+2	3.590E+0	figure.
	1.387E+1	7.210E+2	4.410E+0	
	1.410E+1	7.090E+2	5.610E+0	
	1.439E+1	6.950E+2	7.640E+0	
	1.456E+1	6.870E+2	1.040E+1	
	1.471E+1	6.800E+2	1.110E+1	
	1.488E+1	6.720E+2	1.520E+1	
	1.511E+1	6.620E+2	2.210E+1	
	1.538E+1	6.500E+2	3.570E+1	
	1.548E+1	6.460E+2	4.100E+1	
	1.585E+1	6.310E+2	3.340E+1	
	1.647E+1	6.070E+2	2.210E+1	
	1.678E+1	5.960E+2	2.370E+1	
	1.701E+1	5.880E+2	2.140E+1	
	1.718E+1	5.820E+2	2.290E+1	
	1.773E+1	5.640E+2	3.220E+1	
	1.802E+1	5.550E+2	3.700E+1	
	1.815E+1	5.510E+2	3.960E+1	
	1.855E+1	5.390E+2	4.540E+1	
	1.883E+1	5.310E+2	5.580E+1	
	1.919E+1	5.210E+2	9.020E+1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
2 [43]		(T = 300 K)		Same as above.
Kaiser, W.,	1.026E+1	9.750E+2	4.140E-1	
et al.,	1.101E+1	9.080E+2	9.430E-1	
1962	1.171E+1	8.540E+2	1.750E+0	
	1.233E+1	8.110E+2	3.590E+0	
	1.267E+1	7.890E+2	4.890E+0	
	1.299E+1	7.700E+2	6.010E+0	
	1.323E+1	7.560E+2	7.380E+0	
	1.355E+1	7.380E+2	8.760E+0	
	1.383E+1	7.230E+2	1.080E+1	
	1.406E+1	7.110E+2	1.470E+1	
	1.462E+1	6.840E+2	2.290E+1	
	1.511E+1	6.620E+2	3.570E+1	
	1.585E+1	6.310E+2	5.780E+1	
	1.595E+1	6.270E+2	5.780E+1	
	1.616E+1	6.190E+2	5.390E+1	
	1.637E+1	6.110E+2	5.040E+1	
	1.667E+1	6.000E+2	4.870E+1	
	1.706E+1	5.860E+2	5.210E+1	
	1.815E+1	5.510E+2	7.600E+1	
	1.912E+1	5.230E+2	1.460E+2	
3 [46]		(T = 5 K)		Single crystals; obtained from the Harshaw Chemical Co., or grown in laboratory; samples from different sources gave identical results; dominant impruity was Fe (10-200 ppm); plane-parallel slab specimens of 0.3 to 10 mm thick; mechanically polished with 0.3 to 1.0 μm alumina; direct transmission measured and
Bosomworth, D. r.,	4.651E+1	2.150E+2	4.940E+1	
1967	4.664E+1	2.144E+2	4.490E+1	
	4.688E+1	2.133E+2	3.830E+1	
	4.766E+1	2.098E+2	4.120E+1	
	4.850E+1	2.062E+2	3.040E+1	
	4.912E+1	2.036E+2	1.600E+1	
	4.950E+1	2.020E+2	1.247E+1	
	5.030E+1	1.988E+2	8.750E+0	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
3 [46] (cont.)	5.089E+1	1.965E+2	7.250E+0	absorption coefficient then determined; uncertainties about 50 to 100%; data taken from a figure.
	5.118E+1	1.954E+2	6.570E+0	
	5.168E+1	1.935E+2	6.430E+0	
	5.227E+1	1.913E+2	6.620E+0	
	5.244E+1	1.907E+2	6.850E+0	
	5.263E+1	1.900E+2	7.060E+0	
	5.305E+1	1.885E+2	6.800E+0	
	5.379E+1	1.859E+2	5.360E+0	
	5.447E+1	1.836E+2	4.190E+0	
	5.531E+1	1.808E+2	2.950E+0	
	5.599E+1	1.786E+2	2.450E+0	
	5.711E+1	1.751E+2	1.860E+0	
	5.872E+1	1.703E+2	1.410E+0	
	6.028E+1	1.659E+2	1.150E+0	
	6.254E+1	1.599E+2	9.900E-1	
	6.689E+1	1.495E+2	8.000E-1	
	7.663E+1	1.305E+2	6.500E-1	
	8.333E+1	1.200E+2	5.500E-1	
	9.116E+1	1.097E+2	2.800E-1	
	1.063E+2	9.410E+1	2.000E-1	
	1.695E+2	5.900E+1	2.000E-1	
	2.597E+2	3.850E+1	9.000E-2	
4 [46]		(T = 80 K)		Similar to above except uncertainty about 15 to 25%.
Bosomworth, D. r., 1967	4.651E+1	2.150E+2	1.549E+2	
	4.682E+1	2.136E+2	9.560E+1	
	4.704E+1	2.126E+2	8.510E+1	
	4.766E+1	2.098E+2	1.018E+2	
	4.857E+1	2.059E+2	8.100E+1	
	4.941E+1	2.024E+2	6.840E+1	
	5.003E+1	1.999E+2	5.680E+1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
4 [46] (cont.)	5.099E+1	1.961E+2	4.650E+1	
	5.211E+1	1.919E+2	4.340E+1	
	5.319E+1	1.880E+2	3.910E+1	
	5.461E+1	1.831E+2	3.080E+1	
	5.583E+1	1.791E+2	2.740E+1	
	5.727E+1	1.746E+2	2.400E+1	
	5.875E+1	1.702E+2	2.240E+1	
	6.250E+1	1.600E+2	2.240E+1	
	6.464E+1	1.547E+2	2.010E+1	
	6.667E+1	1.500E+2	1.600E+1	
	6.826E+1	1.465E+2	1.331E+1	
	6.969E+1	1.435E+2	1.171E+1	
	7.163E+1	1.396E+2	1.020E+1	
	7.364E+1	1.358E+2	8.910E+0	
	7.663E+1	1.305E+2	7.710E+0	
	7.968E+1	1.255E+2	6.830E+0	
	8.347E+1	1.198E+2	5.930E+0	
	8.757E+1	1.142E+2	5.310E+0	
	9.311E+1	1.074E+2	4.740E+0	
	1.016E+2	9.840E+1	4.330E+0	
	1.072E+2	9.330E+1	4.070E+0	
	1.168E+2	8.560E+1	3.830E+0	
	1.259E+2	7.940E+1	3.620E+0	
	1.370E+2	7.300E+1	3.480E+0	
	1.462E+2	6.840E+1	3.280E+0	
	1.637E+2	6.110E+1	2.770E+0	
	1.835E+2	5.450E+1	2.200E+0	
	2.075E+2	4.820E+1	1.730E+0	
	2.370E+2	4.220E+1	1.330E+0	
	2.809E+2	3.560E+1	1.050E+0	
	3.509E+2	2.850E+1	6.900E-1	
	5.051E+2	1.980E+1	4.000E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
5 [4		(T = 200 K)		Similar to above except uncertainty about 15%.
Bosomworth, D. r.,	7.143E+1	1.400E+2	4.500E+1	
1967	7.364E+1	1.358E+2	3.740E+1	
	7.605E+1	1.315E+2	3.250E+1	
	7.955E+1	1.257E+2	2.620E+1	
	8.418E+1	1.188E+2	2.200E+1	
	8.961E+1	1.116E+2	1.960E+1	
	9.690E+1	1.032E+2	1.840E+1	
	1.120E+2	8.930E+1	1.840E+1	
	1.211E+2	8.260E+1	1.930E+1	
	1.404E+2	7.120E+1	1.710E+1	
	1.490E+2	6.710E+1	1.600E+1	
	1.582E+2	6.320E+1	1.451E+1	
	1.742E+2	5.740E+1	1.228E+1	
	1.946E+2	5.140E+1	1.012E+1	
	2.146E+2	4.660E+1	7.980E+0	
	2.404E+2	4.160E+1	6.400E+0	
	2.809E+2	3.560E+1	4.680E+0	
	3.322E+2	3.010E+1	3.300E+0	
	4.049E+2	2.470E+1	2.460E+0	
	5.051E+2	1.980E+1	1.590E+0	
	7.519E+2	1.330E+1	9.000E-1	
	1.087E+3	9.200E+0	5.000E-1	
6 [46]		(T = 300 K)		Similar to above except uncertainty about 10 - 15%.
Bosomworth, D. r.,	6.250E+1	1.600E+2	1.600E+2	
1967	6.353E+1	1.574E+2	1.348E+2	
	6.439E+1	1.553E+2	1.256E+2	
	6.510E+1	1.536E+2	1.207E+2	
	6.614E+1	1.512E+2	1.240E+2	
	6.676E+1	1.498E+2	1.225E+2	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
6 [46] (cont.)	6.761E+1	1.479E+2	9.700E+1	
	6.840E+1	1.462E+2	8.780E+1	
	6.906E+1	1.448E+2	8.370E+1	
	7.072E+1	1.414E+2	7.950E+1	
	7.215E+1	1.386E+2	7.320E+1	
	7.380E+1	1.355E+2	6.530E+1	
	7.524E+1	1.329E+2	5.920E+1	
	7.782E+1	1.285E+2	5.380E+1	
	8.150E+1	1.227E+2	4.870E+1	
	8.584E+1	1.165E+2	4.460E+1	
	9.074E+1	1.102E+2	4.070E+1	
	9.634E+1	1.038E+2	3.810E+1	
	1.024E+2	9.770E+1	3.590E+1	
	1.175E+2	8.510E+1	3.360E+1	
	1.344E+2	7.440E+1	3.080E+1	
	1.481E+2	6.750E+1	2.830E+1	
	1.623E+2	6.160E+1	2.530E+1	
	1.795E+2	5.570E+1	1.980E+1	
	2.000E+2	5.000E+1	1.600E+1	
	2.079E+2	4.810E+1	1.422E+1	
	2.347E+2	4.260E+1	1.146E+1	
	2.778E+2	3.600E+1	8.310E+0	
	3.534E+2	2.830E+1	5.450E+0	
	4.184E+2	2.390E+1	4.140E+0	
	5.025E+2	1.990E+1	2.790E+0	
	5.587E+2	1.790E+1	2.310E+0	
	7.092E+2	1.410E+1	1.540E+0	
	1.099E+3	9.100E+0	8.700E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
7 [32]		(T = 300 K)		Single crystals; obtained from the Harshaw Chemical Co.; typical sample dimensions 2.54 cm diameter and 2.54 cm thick; transmission measured with differential technique and absorption coefficient calculated; uncertainties of α in high transparent and low transparent regions are respectively about 10% and 3%; data taken from a figure.
Deutsch, T. F.,	6.890E+0	1.451E+3	3.400E-3	
1973	7.140E+0	1.401E+3	4.400E-3	
	7.390E+0	1.353E+3	6.800E-3	
	7.690E+0	1.300E+3	1.060E-2	
	8.010E+0	1.248E+3	2.180E-2	
	8.310E+0	1.203E+3	3.660E-2	
	8.670E+0	1.153E+3	5.900E-2	
	9.030E+0	1.107E+3	9.980E-2	
	9.540E+0	1.048E+3	2.018E-1	
	9.960E+0	1.004E+3	3.681E-1	
	1.053E+1	9.497E+2	6.871E-1	
	1.175E+1	8.511E+2	1.778E+0	
8 [47]		(T = 300 K)		Absorption coefficient at 5.25 μm measured with Raytheon CO_2/CO laser calorimeter; no other details were reported; data taken from a table.
Deutsch, T. F.,	5.252E+0	1.904E+3	4.100E-5	
1975				
9 [48]		(T = 300 K)		Specimens received from various laboratories; absorption coefficients measured by laser calorimetry technique; laser used was of the SF_6 variety delivering from 5 to 10 watts of cw multiline HF power and about 5 watts of cw multiline DF power; letters following absorption coefficient values have the meaning: PH – polycrystalline from Harshaw, SO – single crystal from Optovac; data taken from a table.
Harrington, J. A.	3.799E+0	2.632E+3	1.250E-3PH	
Bendow, B.,	3.799E+0	2.632E+3	9.480E-4SO	
Namjoshi, K. V.,	2.700E+0	3.704E+3	2.220E-3PH	
Mitra, S. S.,	2.700E+0	3.704E+3	1.500E-3SO	
Stierwalt, D. L.,				
1975				

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
10 [48]		(T = 373 K)		Polished and polycrystalline (Polytran) sample; received from the Harshaw Chemical Co.; the normal spectral emittance, E, was measure; the low absorption coefficients in the transparent region were calculated from $\alpha L=E$, where L is the sample length in cm and $\alpha L<2.5$; in the intermediate absorption region, α can be obtained from eq. (35); absorption-coefficient data extracted from a curve.
Harrington, J. A.	8.264E+0	1.210E+3	4.790E-2	
et al.,	7.937E+0	1.260E+3	3.290E-2	
1975	7.692E+0	1.300E+3	2.290E-2	
	7.519E+0	1.330E+3	1.560E-2	
	7.353E+0	1.360E+3	1.080E-2	
	7.092E+0	1.410E+3	7.650E-3	
	6.993E+0	1.430E+3	6.090E-3	
	6.849E+0	1.460E+3	5.330E-3	
	6.667E+0	1.500E+3	4.850E-3	
	6.494E+0	1.540E+3	4.420E-3	
	6.329E+0	1.580E+3	3.970E-3	
	6.173E+0	1.620E+3	3.380E-3	
	6.024E+0	1.660E+3	2.550E-3	
	5.917E+0	1.690E+3	1.950E-3	
	5.780E+0	1.730E+3	1.470E-3	
	5.618E+0	1.780E+3	1.130E-3	
	5.464E+0	1.830E+3	8.400E-4	
	5.291E+0	1.890E+3	6.430E-4	
	5.102E+0	1.960E+3	4.990E-4	
	4.902E+0	2.040E+3	4.020E-4	
	4.673E+0	2.140E+3	3.810E-4	
	4.484E+0	2.230E+3	4.020E-4	
	4.310E+0	2.320E+3	4.920E-4	
	4.184E+0	2.390E+3	5.620E-4	
	3.984E+0	2.510E+3	6.780E-4	
	3.861E+0	2.590E+3	7.350E-4	
	3.745E+0	2.670E+3	8.180E-4	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
11 [49]		(T = 300 K)		Crystal produced with Bridgman growth in a reactive atmosphere of HF; forged at 1173° K under a 50-ton press; the polishing of high-temperature forgings showed lower loss than that of lower-temperature forgings and exhibited no obvious flaws or defects; absorption coefficient measure in a desicated calorimeter chamber; digitized data was given.
Winston, H. V.,	5.501E+0	1.818E+3	7.000E-4	
Turk, R., R.,				
Pastor, R. C.,				
Scholl, R. F.,				
1975				
12 [51]		(T = 300 K)		Single crystal and casting SrF_2 of same purity; total absorption coefficient measured with calorimetric method; digitized values were given; symbols after the values have the meaning: S - single crystal, P - casting polycrystaline.
Newberg, R. T.,	5.302E+0	1.886E+3	5.300E-4S	
Readey, D. W.,	5.302E+0	1.886E+3	1.200E-4P	
Newborn, H. A.,				
Miles, P. A.,				
1975				
13 [52]		(T = 293 K)		Single crystal samples prepared from high purity Optovac material; sample thickness of 7.5 cm with polished ends; absorption coefficient were determined with a double beam spectrometer; no impurity absorption bands were found in the frequency range investigated; data extracted from a figure.
Lipson, H. G.,	7.604E+0	1.315E+3	1.280E-2	
Bendow, B.,	7.634E+0	1.310E+3	1.150E-2	
Mitra, S. S.,	8.000E+0	1.250E+3	1.460E-2	
1975	8.000E+0	1.250E+3	1.970E-2	
	8.333E+0	1.200E+3	3.420E-2	
	8.621E+0	1.160E+3	5.000E-2	
	8.772E+0	1.140E+3	6.270E-2	
	9.174E+0	1.090E+3	1.140E-1	
	9.615E+0	1.040E+3	1.910E-1	
	9.615E+0	1.040E+3	2.060E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
13 [52] (cont.)	9.901E+0	1.010E+3	2.450E-1	
	1.016E+1	9.840E+2	3.550E-1	
	1.072E+1	9.330E+2	6.030E-1	
	1.101E+1	9.080E+2	6.870E-1	
	1.136E+1	8.800E+2	1.210E+0	
14 [54]		(T = 300 K)		Cast polycrystalline provided by Raytheon Research Lab.; rectangular parallelpiped specimen of dimension 0.86 x 1.88 x 4.44 cm; polished using Linde B and water followed by a CCl_4 rinse; measured in a vacuum calorimeter; the bulk absorption coefficient determined; data extracted from a table; temperature not given; 300 K assumed.
Harrington, J. A.	3.799E+0	2.632E+3	5.400E-4	
Gregory, D. A.,	2.700E+0	3.704E+3	3.700E-4	
Otto, W. F., Jr.				
1975				
15 [54]		(T = 300 K)		Similar to above but total absorption coefficient determined along the length of 4.4 cm.
Harrington, J. A.	3.799E+0	2.632E+3	4.100E-4	
et al.,	2.700E+0	3.704E+3	3.800E-4	
1975				
16 [54]		(T = 300 K)		Similar to above but total absorption coefficient determined along the length of 1.88 cm.
Harrington, J. A.	3.799E+0	2.632E+3	7.700E-4	
et al.,	2.700E+0	3.704E+3	1.100E-3	
1975				
17 [54]		(T = 300 K)		Similar to above but total absorption coefficient determined along the length of 0.86 cm.
Harrington, J. A.	3.799E+0	2.632E+3	1.700E-3	
et al.,	2.700E+0	3.704E+3	2.400E-3	
1975				

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
18 [54]		(T = 300 K)		Similar to above but total absorption coefficient determined for a disk specimen of 5 cm diameter and 1 cm thick.
Harrington, J. A.	3.799E+0	2.632E+3	3.500E-4	
et al.,	2.700E+0	3.704E+3	3.300E-3	
1975				
19 [53]		(T = 295 K)		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
Lipson, H. G.,	1.198E+1	8.345E+2	2.286E+0	
Bendow, B.,	1.183E+1	8.454E+2	2.061E+0	
Skolnik, L.,	1.165E+1	8.585E+2	1.786E+0	
Mitra, S. S.,	1.153E+1	8.673E+2	1.644E+0	
Massa, N.,	1.142E+1	8.760E+2	1.452E+0	
1976	1.130E+1	8.847E+2	1.285E+0	
	1.114E+1	8.978E+2	1.135E+0	
	1.100E+1	9.087E+2	1.047E+0	
	1.087E+1	9.196E+2	9.247E-1	
	1.077E+1	9.284E+2	8.166E-1	
	1.067E+1	9.371E+2	7.228E-1	
	1.055E+1	9.480E+2	6.266E-1	
	1.043E+1	9.589E+2	5.768E-1	
	1.033E+1	9.676E+2	4.887E-1	
	1.024E+1	9.763E+2	4.325E-1	
	1.013E+1	9.872E+2	3.673E-1	
	1.002E+1	9.982E+2	3.311E-1	
	9.932E+0	1.007E+3	2.754E-1	
	9.804E+0	1.020E+3	2.535E-1	
	9.700E+0	1.031E+3	2.239E-1	
	9.579E+0	1.044E+3	1.941E-1	
	9.480E+0	1.055E+3	1.714E-1	
	9.383E+0	1.066E+3	1.486E-1	
	9.288E+0	1.077E+3	1.368E-1	
	9.213E+0	1.085E+3	1.161E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
19 [53] (cont.)	9.049E+0	1.105E+3	9.840E-2	
	8.943E+0	1.118E+3	8.356E-2	
	8.840E+0	1.131E+3	6.668E-2	
	8.739E+0	1.144E+3	5.888E-2	
	8.624E+0	1.160E+3	4.898E-2	
	8.496E+0	1.177E+3	3.828E-2	
	8.372E+0	1.194E+3	2.931E-2	
	8.266E+0	1.210E+3	2.198E-2	
20 [53]		(T = 365 K)		Same as above.
Lipson, H. G.,	1.150E+1	8.695E+2	2.188E+0	
et al.,	1.139E+1	8.783E+2	2.143E+0	
1976	1.133E+1	8.826E+2	1.936E+0	
	1.122E+1	8.914E+2	1.820E+0	
	1.116E+1	8.957E+2	1.675E+0	
	1.106E+1	9.045E+2	1.545E+0	
	1.095E+1	9.132E+2	1.452E+0	
	1.087E+1	9.197E+2	1.337E+0	
	1.080E+1	9.263E+2	1.183E+0	
	1.072E+1	9.328E+2	1.089E+0	
	1.062E+1	9.416E+2	1.023E+0	
	1.050E+1	9.525E+2	9.057E-1	
	1.043E+1	9.590E+2	8.511E-1	
	1.031E+1	9.699E+2	7.362E-1	
	1.024E+1	9.765E+2	6.383E-1	
	1.015E+1	9.852E+2	5.649E-1	
	1.004E+1	9.961E+2	5.093E-1	
	9.952E+0	1.005E+3	4.592E-1	
	9.845E+0	1.016E+3	3.899E-1	
	9.699E+0	1.031E+3	3.443E-1	
	9.618E+0	1.040E+3	3.048E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
20 [53] (cont.)	9.498E+0	1.053E+3	2.582E-1	
	9.401E+0	1.064E+3	2.286E-1	
	9.286E+0	1.077E+3	2.018E-1	
	9.212E+0	1.086E+3	1.750E-1	
	9.030E+0	1.107E+3	1.545E-1	
	8.995E+0	1.112E+3	1.426E-1	
	8.960E+0	1.116E+3	1.340E-1	
	8.890E+0	1.125E+3	1.208E-1	
	8.822E+0	1.134E+3	1.069E-1	
	8.721E+0	1.147E+3	9.441E-2	
	8.622E+0	1.160E+3	8.017E-2	
	8.558E+0	1.168E+3	7.079E-2	
	8.510E+0	1.175E+3	6.397E-2	
	8.448E+0	1.184E+3	5.649E-2	
	8.386E+0	1.192E+3	5.000E-2	
	8.295E+0	1.206E+3	4.508E-2	
	8.250E+0	1.212E+3	4.325E-2	
	8.191E+0	1.221E+3	3.828E-2	
	8.147E+0	1.227E+3	3.381E-2	
	8.076E+0	1.238E+3	2.871E-2	
21 [53]		(T = 480 K)		Same as above.
Lipson, H. G.,	1.119E+1	8.937E+2	2.427E+0	
et al.,	1.090E+1	9.177E+2	2.056E+0	
1976	1.067E+1	9.373E+2	1.641E+0	
	1.038E+1	9.635E+2	1.256E+0	
	1.017E+1	9.832E+2	1.002E+0	
	9.994E+0	1.001E+3	8.166E-1	
	9.801E+0	1.020E+3	6.637E-1	
	9.657E+0	1.036E+3	5.297E-1	
	9.438E+0	1.060E+3	4.227E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
21 [53] (cont.)	9.266E+0	1.079E+3	3.373E-1	
	9.137E+0	1.094E+3	2.864E-1	
	8.976E+0	1.114E+3	2.328E-1	
	8.803E+0	1.136E+3	1.897E-1	
	8.703E+0	1.149E+3	1.545E-1	
	8.541E+0	1.171E+3	1.233E-1	
	8.384E+0	1.193E+3	1.045E-1	
	8.309E+0	1.204E+3	8.690E-2	
	8.175E+0	1.223E+3	6.653E-2	
	8.060E+0	1.241E+3	5.998E-2	
	7.976E+0	1.254E+3	4.887E-2	
22 [53]		(T = 590 K)		Same as above.
Lipson, H. G.,	1.072E+1	9.330E+2	2.143E+0	
et al.,	1.052E+1	9.505E+2	1.972E+0	
1976	1.038E+1	9.636E+2	1.778E+0	
	1.026E+1	9.745E+2	1.479E+0	
	1.013E+1	9.876E+2	1.309E+0	
	1.004E+1	9.963E+2	1.109E+0	
	9.907E+0	1.009E+3	9.616E-1	
	9.780E+0	1.023E+3	8.318E-1	
	9.636E+0	1.038E+3	7.656E-1	
	9.496E+0	1.053E+3	6.501E-1	
	9.418E+0	1.062E+3	5.521E-1	
	9.265E+0	1.079E+3	4.977E-1	
	9.191E+0	1.088E+3	4.227E-1	
	9.064E+0	1.103E+3	3.733E-1	
	8.957E+0	1.116E+3	3.436E-1	
	8.854E+0	1.129E+3	2.858E-1	
	8.752E+0	1.143E+3	2.427E-1	
	8.620E+0	1.160E+3	2.234E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
22 [53] (cont.)	8.556E+0	1.169E+3	1.820E-1	
	8.430E+0	1.186E+3	1.607E-1	
	8.323E+0	1.202E+3	1.365E-1	
	8.218E+0	1.217E+3	1.205E-1	
	8.131E+0	1.230E+3	1.089E-1	
23 [53]		(T = 705 K)		Same as above.
Lipson, H. G.,	1.031E+1	9.703E+2	2.275E+0	
et al.,	1.024E+1	9.768E+2	2.094E+0	
1976	1.010E+1	9.899E+2	1.854E+0	
	9.992E+0	1.001E+3	1.706E+0	
	9.927E+0	1.007E+3	1.542E+0	
	9.820E+0	1.018E+3	1.449E+0	
	9.758E+0	1.025E+3	1.306E+0	
	9.634E+0	1.038E+3	1.156E+0	
	9.534E+0	1.049E+3	1.042E+0	
	9.436E+0	1.060E+3	9.397E-1	
	9.321E+0	1.073E+3	7.816E-1	
	9.171E+0	1.090E+3	6.902E-1	
	9.080E+0	1.101E+3	6.368E-1	
	8.974E+0	1.114E+3	5.508E-1	
	8.869E+0	1.127E+3	4.875E-1	
	8.734E+0	1.145E+3	4.130E-1	
	8.635E+0	1.158E+3	3.733E-1	
	8.523E+0	1.173E+3	3.162E-1	
	8.382E+0	1.193E+3	2.630E-1	
	8.291E+0	1.206E+3	2.323E-1	
	8.144E+0	1.228E+3	1.854E-1	
	8.016E+0	1.248E+3	1.603E-1	
	7.905E+0	1.265E+3	1.306E-1	
	7.771E+0	1.287E+3	1.156E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
24 [53]		(T = 800 K)		Same as above.
Lipson, H. G.,	1.012E+1	9.878E+2	2.570E+0	
et al.,	9.991E+0	1.001E+3	2.183E+0	
1976	9.862E+0	1.014E+3	1.888E+0	
	9.695E+0	1.031E+3	1.637E+0	
	9.553E+0	1.047E+3	1.390E+0	
	9.474E+0	1.055E+3	1.227E+0	
	9.339E+0	1.071E+3	1.064E+0	
	9.245E+0	1.082E+3	9.204E-1	
	9.153E+0	1.093E+3	8.299E-1	
	9.026E+0	1.108E+3	7.047E-1	
	8.886E+0	1.125E+3	5.984E-1	
	8.750E+0	1.143E+3	5.284E-1	
	8.635E+0	1.158E+3	4.667E-1	
	8.538E+0	1.171E+3	3.963E-1	
	8.413E+0	1.189E+3	3.573E-1	
	8.291E+0	1.206E+3	3.097E-1	
	8.143E+0	1.228E+3	2.523E-1	
	8.043E+0	1.243E+3	2.138E-1	
	7.904E+0	1.265E+3	1.928E-1	
	7.823E+0	1.278E+3	1.507E-1	
	7.666E+0	1.304E+3	1.279E-1	
25 [53]		(T = 213 K)		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; emittance was measured and absorption
Lipson, H. G.,	5.000E+0	2.000E+3	1.600E-1	
et al.,	5.263E+0	1.900E+3	1.820E-1	
1976	5.376E+0	1.860E+3	2.350E-1	
	5.682E+0	1.760E+3	2.670E-1	
	5.882E+0	1.700E+3	2.390E-1	
	6.024E+0	1.660E+3	1.970E-1	
	6.250E+0	1.600E+3	1.500E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
25 [53] (cont.)	6.410E+0	1.560E+3	1.260E-1	coefficient was determined; in the transparent regime the emittance is proportional to absorption times sample length; data extracted from a figure.
	6.667E+0	1.500E+3	8.150E-2	
	6.849E+0	1.460E+3	6.200E-2	
	7.092E+0	1.410E+3	3.950E-2	
	7.353E+0	1.360E+3	2.780E-2	
	7.692E+0	1.300E+3	1.830E-2	
	8.065E+0	1.240E+3	1.830E-2	
	8.130E+0	1.230E+3	2.650E-2	
	8.333E+0	1.200E+3	3.320E-2	
	8.621E+0	1.160E+3	7.180E-2	
	9.174E+0	1.090E+3	1.200E-1	
	9.615E+0	1.040E+3	2.040E-1	
	1.005E+1	9.950E+2	3.420E-1	
	1.057E+1	9.460E+2	6.190E-1	
	1.115E+1	8.970E+2	9.720E-1	
	1.185E+1	8.440E+2	1.480E+0	
	1.241E+1	8.060E+2	2.390E+0	
26 [53]		(T = 350 K)		Same as above.
Lipson, H. G.,	5.000E+0	2.000E+3	1.050E-1	
et al.,	5.236E+0	1.910E+3	1.140E-1	
1976	5.405E+0	1.850E+3	1.430E-1	
	5.556E+0	1.800E+3	1.760E-1	
	5.714E+0	1.750E+3	1.790E-1	
	5.848E+0	1.710E+3	1.820E-1	
	6.061E+0	1.650E+3	1.450E-1	
	6.250E+0	1.600E+3	1.180E-1	
	6.410E+0	1.560E+3	8.820E-2	
	6.623E+0	1.510E+3	7.050E-2	
	6.897E+0	1.450E+3	5.200E-2	
	7.143E+0	1.400E+3	3.950E-2	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
26 [53] (cont.)	7.407E+0	1.350E+3	2.820E-2	
	7.692E+0	1.300E+3	2.220E-2	
	8.000E+0	1.250E+3	2.400E-2	
	8.065E+0	1.240E+3	2.920E-2	
	8.333E+0	1.200E+3	4.020E-2	
	8.621E+0	1.160E+3	7.900E-2	
	9.091E+0	1.100E+3	1.580E-1	
	9.524E+0	1.050E+3	2.640E-1	
	1.002E+1	9.980E+2	4.210E-1	
	1.057E+1	9.460E+2	8.960E-1	
	1.111E+1	9.000E+2	1.340E+0	
	1.179E+1	8.480E+2	2.140E+0	
	1.247E+1	8.020E+2	3.350E+0	
27 [40] Hordvik, A., Schlossberg, H., 1977		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficients; CO_2, CO and Ar cw lasers were used; both surface and bulk losses were determined; bulk absorption data extracted from a table.
	5.145E-1	1.944E+4	4.700E-4	
	5.280E+0	1.894E+3	9.800E-5	
	5.488E+0	1.822E+3	1.200E-4	
	5.782E+0	1.730E+3	2.100E-4	
	6.058E+0	1.651E+3	3.200E-4	
	6.330E+0	1.580E+3	5.700E-4	
	6.466E+0	1.547E+3	7.400E-4	
	1.060E+1	9.434E+2	7.100E-1	
28 [41] Hordvik, A., 1977		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficient; at low absorption levels, a CO laser with tunable discrete lines in the 5-6 μm region; both surface and
	6.466E+0	1.547E+3	2.150E-3	
	6.330E+0	1.580E+3	2.510E-3	
	6.058E+0	1.651E+3	6.160E-4	
	5.782E+0	1.730E+3	4.950E-4	
	5.488E+0	1.822E+3	6.310E-5	
	5.280E+0	1.894E+3	6.930E-5	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
28 [41] (cont.)				bulk losses were determined using laser power of a few hundred milliwatts; surface absorption data extracted from a figure.
29 [42]		(T = 300 K)		Standard commercial quality crystals; obtained in finished form from the A. Meller Company; sample size of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic technique was used to determine the absorption coefficients; the HF/DF laser used in the measurement was operated multiline for both HF and DF measurements; typical laser power of 300 mW was adequate for the measurements; digitized bulk absorption data were given.
Hordvik, A.,	2.700E+0	3.704E+3	2.700E-4	
Skolnik, H.,	3.800E+0	2.632E+3	1.400E-4	
1977				
30 [42]		(T = 300 K)		Similar to above except for surface absorption; the letter"S" follow the absorption value denotes the loss per surface.
Hordvik, A.	3.800E+0	2.632E+3	9.000E-5S	
et al.,	2.700E+0	3.704E+3	8.000E-4S	
1977				
31 [57]		(T = 300 K)		Single crystal polished rod sample of 6.357 cm long obtained from the Hughes Research Lab.; measured with laser calorimetry; power output of the CO laser was 8-10 W; the total absorption coefficient was determined; data taken from a table;
Allen, S. D.,	5.300E+0	1.887E+3	1.700E-3	
Rudisill, J. E.,				
1977				

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
31 [57] (cont.)				high absorption of this sample was probably due to defective sample boule which cracked upon cooling down during growth.
32 [10] Tomiki, T., Miyata, T., 1969		(T = 78 K)		Single crystal; ultraviolet quality; obtained from the Harshaw Chemical Co.; freshly cleaved plate specimen; absorption coefficient determined from transmission and reflectivity measurements; data extracted from a figure.
	1.217E-1	8.220E+4	8.230E+1	
	1.218E-1	8.210E+4	5.100E+1	
	1.220E-1	8.200E+4	3.470E+1	
	1.221E-1	8.190E+4	1.690E+1	
	1.224E-1	8.170E+4	8.640E+0	
	1.222E-1	8.180E+4	7.480E+0	
	1.227E-1	8.150E+4	5.100E+0	
	1.230E-1	8.130E+4	4.640E+0	
	1.239E-1	8.070E+4	2.370E+0	
	1.245E-1	8.030E+4	1.620E+0	
	1.253E-1	7.980E+4	1.340E+0	
	1.261E-1	7.930E+4	1.100E+0	
	1.277E-1	7.830E+4	7.900E-1	
	1.284E-1	7.790E+4	6.850E-1	
33 [10] Tomiki, T., et al., 1969		(T = 195 K)		Same as above.
	1.245E-1	8.030E+4	7.500E+1	
	1.247E-1	8.020E+4	4.870E+1	
	1.248E-1	8.010E+4	3.320E+1	
	1.252E-1	7.990E+4	1.620E+1	
	1.253E-1	7.980E+4	1.160E+1	
	1.256E-1	7.960E+4	6.830E+0	
	1.258E-1	7.950E+4	4.430E+0	
	1.259E-1	7.940E+4	3.660E+0	
	1.261E-1	7.930E+4	2.160E+0	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
33 [10] (cont.)	1.272E-1	7.860E+4	1.220E+0	
	1.277E-1	7.830E+4	1.160E+0	
	1.292E-1	7.740E+4	7.910E-1	
	1.316E-1	7.600E+4	6.240E-1	
	1.342E-1	7.450E+4	6.260E-1	
34 [10]		(T = 299 K)		Same as above.
Tomiki, T.,	1.272E-1	7.860E+4	8.280E+1	
et al.,	1.276E-1	7.840E+4	6.210E+1	
1969	1.277E-1	7.830E+4	3.850E+1	
	1.279E-1	7.820E+4	2.750E+1	
	1.284E-1	7.790E+4	1.410E+1	
	1.285E-1	7.780E+4	1.280E+1	
	1.287E-1	7.770E+4	7.910E+0	
	1.294E-1	7.730E+4	5.930E+0	
	1.295E-1	7.720E+4	5.390E+0	
	1.300E-1	7.690E+4	2.070E+0	
	1.304E-1	7.670E+4	1.280E+0	
	1.316E-1	7.600E+4	7.210E-1	
	1.325E-1	7.550E+4	6.250E-1	
	1.326E-1	7.540E+4	6.250E-1	
	1.339E-1	7.470E+4	5.680E-1	
	1.344E-1	7.440E+4	5.690E-1	
	1.348E-1	7.420E+4	5.690E-1	
	1.374E-1	7.280E+4	5.980E-1	
	1.397E-1	7.160E+4	5.710E-1	
	1.404E-1	7.120E+4	5.190E-1	
	1.439E-1	6.950E+4	4.390E-1	
	1.464E-1	6.830E+4	3.730E-1	
	1.490E-1	6.710E+4	3.600E-1	
	1.497E-1	6.680E+4	3.460E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
34 [10] (cont.)	1.541E-1	6.490E+4	3.080E-1	
	1.575E-1	6.350E+4	2.620E-1	
	1.595E-1	6.270E+4	2.420E-1	
	1.605E-1	6.230E+4	2.230E-1	
	1.610E-1	6.210E+4	2.770E-1	
	1.613E-1	6.200E+4	2.230E-1	
	1.642E-1	6.090E+4	2.070E-1	
	1.692E-1	5.910E+4	1.620E-1	
	1.718E-1	5.820E+4	1.430E-1	
	1.733E-1	5.770E+4	1.320E-1	
	1.740E-1	5.750E+4	1.380E-1	
	1.757E-1	5.690E+4	1.510E-1	
	1.776E-1	5.630E+4	1.390E-1	
	1.799E-1	5.560E+4	1.080E-1	
	1.815E-1	5.510E+4	9.960E-2	
	1.848E-1	5.410E+4	1.090E-1	
	1.916E-1	5.220E+4	8.940E-2	
35 [10]		(T = 418 K)		Same as above.
Tomiki, T.,	1.302E-1	7.680E+4	7.550E+1	
et al.,	1.304E-1	7.670E+4	6.540E+1	
1969	1.309E-1	7.640E+4	2.390E+1	
	1.316E-1	7.600E+4	1.560E+1	
	1.321E-1	7.570E+4	9.610E+0	
	1.323E-1	7.560E+4	7.560E+0	
	1.325E-1	7.550E+4	5.410E+0	
	1.328E-1	7.530E+4	4.920E+0	
	1.339E-1	7.470E+4	1.630E+0	
	1.344E-1	7.440E+4	1.110E+0	
	1.346E-1	7.430E+4	1.010E+0	
	1.350E-1	7.410E+4	8.350E-1	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
35 [10] (cont.)	1.364E-1	7.330E+4	6.580E-1	
	1.370E-1	7.300E+4	5.430E-1	
	1.395E-1	7.170E+4	5.710E-1	
	1.403E-1	7.130E+4	5.720E-1	
	1.437E-1	6.960E+4	4.510E-1	
36 [10]		(T = 573 K)		Same as above.
Tomiki, T.,	1.335E-1	7.490E+4	8.340E+1	
et al.,	1.339E-1	7.470E+4	7.580E+1	
1969	1.346E-1	7.430E+4	5.170E+1	
	1.348E-1	7.420E+4	4.920E+1	
	1.349E-1	7.410E+4	4.260E+1	
	1.355E-1	7.380E+4	2.640E+1	
	1.359E-1	7.360E+4	2.400E+1	
	1.368E-1	7.310E+4	1.490E+1	
	1.374E-1	7.280E+4	8.370E+0	
	1.381E-1	7.240E+4	4.940E+0	
	1.383E-1	7.230E+4	3.890E+0	
	1.387E-1	7.210E+4	2.920E+0	
	1.397E-1	7.160E+4	1.720E+0	
	1.404E-1	7.120E+4	1.290E+0	
	1.435E-1	6.970E+4	4.960E-1	
37 [62]		(T = 300 K)		Single crystal of ultraviolet quality
Nisar, M.,	1.233E-1	8.110E+4	1.121E+4	procured from the Harshaw Chemical
Robin, S.,	1.206E-1	8.294E+4	4.096E+5	Company; cleaved in vacuum of about
1974	1.192E-1	8.386E+4	6.513E+5	10^{-5} torr and studied without
	1.179E-1	8.479E+4	8.854E+5	being exposed in air; the cleaved
	1.155E-1	8.659E+4	5.985E+5	specimens were left in the
	1.137E-1	8.794E+4	3.105E+5	experimental chamber for sometime
	1.125E-1	8.885E+4	2.255E+5	until objectionable fluorescent

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
37 [62] (cont.)	1.114E-1	8.976E+4	1.895E+5	disappeared; reflectance measurements
	1.081E-1	9.249E+4	2.604E+5	at 20° incidence were carried out
	1.040E-1	9.615E+4	5.147E+5	and the absorption coefficients were
	1.021E-1	9.798E+4	8.015E+5	determined with the method of
	1.007E-1	9.933E+4	5.317E+5	Kramers-Kronig transformation;
	9.891E-2	1.011E+5	3.139E+5	data extracted from a figure.
	9.709E-2	1.030E+5	2.458E+5	
	9.542E-2	1.048E+5	3.990E+5	
	9.183E-2	1.089E+5	8.594E+5	
	8.961E-2	1.116E+5	1.323E+6	
	8.850E-2	1.130E+5	1.434E+6	
	8.811E-2	1.135E+5	1.473E+6	
	8.741E-2	1.144E+5	1.355E+6	
	8.576E-2	1.166E+5	1.168E+6	
	8.410E-2	1.189E+5	9.040E+5	
	8.313E-2	1.203E+5	6.937E+5	
	8.224E-2	1.216E+5	6.511E+5	
	8.130E-2	1.230E+5	6.229E+5	
	8.071E-2	1.239E+5	6.804E+5	
	8.065E-2	1.240E+5	8.019E+5	
	8.013E-2	1.248E+5	8.439E+5	
	7.955E-2	1.257E+5	7.963E+5	
	7.868E-2	1.271E+5	7.698E+5	
	7.837E-2	1.276E+5	1.024E+6	
	7.813E-2	1.280E+5	1.136E+6	
	7.728E-2	1.294E+5	1.075E+6	
	7.622E-2	1.312E+5	1.164E+6	
	7.246E-2	1.380E+5	9.712E+5	
	7.199E-2	1.389E+5	9.183E+5	
	7.107E-2	1.407E+5	9.498E+5	
	6.993E-2	1.430E+5	7.836E+5	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
37 [62] (cont.)	6.817E-2	1.467E+5	6.376E+5	
	6.614E-2	1.512E+5	5.073E+5	
	6.402E-2	1.562E+5	5.241E+5	
	6.274E-2	1.594E+5	5.348E+5	
	6.116E-2	1.635E+5	4.561E+5	
	5.935E-2	1.685E+5	2.075E+5	
	5.688E-2	1.758E+5	1.767E+4	
	5.602E-2	1.785E+5	2.243E+3	
	5.531E-2	1.808E+5	1.817E+4	
	5.464E-2	1.830E+5	1.725E+5	
	5.423E-2	1.844E+5	4.612E+5	
	5.397E-2	1.853E+5	5.683E+5	
	5.342E-2	1.872E+5	4.939E+5	
	5.291E-2	1.890E+5	7.124E+4	
	5.241E-2	1.908E+5	1.918E+4	
	5.206E-2	1.921E+5	9.900E+4	
	5.179E-2	1.931E+5	7.546E+5	
	5.168E-2	1.935E+5	1.274E+6	
	5.131E-2	1.949E+5	1.421E+6	
	5.118E-2	1.954E+5	1.232E+6	
	5.061E-2	1.976E+5	7.724E+5	
	4.958E-2	2.017E+5	5.298E+5	
	4.796E-2	2.085E+5	2.542E+5	
	4.704E-2	2.126E+5	1.683E+5	
	4.662E-2	2.145E+5	1.078E+5	
	4.623E-2	2.163E+5	4.892E+4	
	4.577E-2	2.185E+5	4.943E+4	
	4.529E-2	2.208E+5	1.748E+5	
	4.500E-2	2.222E+5	7.092E+5	
	4.464E-2	2.240E+5	1.253E+6	
	4.437E-2	2.254E+5	1.354E+6	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
37 [62] (cont.)	4.384E-2	2.281E+5	1.178E+6	
	4.350E-2	2.299E+5	1.283E+6	
	4.314E-2	2.318E+5	1.360E+6	
	4.274E-2	2.340E+5	1.273E+6	
	4.248E-2	2.354E+5	1.248E+6	
	4.216E-2	2.372E+5	1.425E+6	
	4.129E-2	2.422E+5	2.411E+6	
	4.090E-2	2.445E+5	3.436E+6	
	4.058E-2	2.464E+5	3.669E+6	
	4.029E-2	2.482E+5	3.521E+6	
	3.971E-2	2.518E+5	2.933E+6	
	3.908E-2	2.559E+5	2.656E+6	
	3.880E-2	2.577E+5	2.455E+6	
	3.854E-2	2.595E+5	2.254E+6	
	3.820E-2	2.618E+5	2.234E+6	
	3.761E-2	2.659E+5	2.008E+6	
	3.736E-2	2.677E+5	1.793E+6	
	3.672E-2	2.723E+5	1.632E+6	
	3.595E-2	2.782E+5	1.510E+6	
	3.565E-2	2.805E+5	1.523E+6	
	3.492E-2	2.864E+5	1.432E+6	
	3.442E-2	2.905E+5	1.205E+6	
38 [60]		(T = 10 K)		Single crystal samples; freshly cleaved surfaces; near normal (10°) reflection spectrum obtained; absorption coefficients were determined with the Roessler method; data extracted from a figure.
Ganin, V. A.,	1.556E-1	6.427E+4	5.007E+4	
Karin, M. G.,	1.368E-1	7.308E+4	5.694E+4	
Sidorin, V. K.,	1.301E-1	7.686E+4	1.797E+5	
Sidorin, K. K.,	1.260E-1	7.939E+4	3.711E+5	
Starostin, N. V.,	1.240E-1	8.065E+4	7.520E+5	
Startsev, G. P.,	1.221E-1	8.190E+4	3.119E+6	
Shepilov, M. P., 1975	1.167E-1	8.569E+4	5.328E+6	

TABLE 7. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
38 [60] (cont.)	1.150E-1	8.694E+4	7.298E+6	
	1.134E-1	8.820E+4	6.034E+6	
	1.118E-1	8.947E+4	2.781E+6	
	1.102E-1	9.073E+4	4.866E+6	
	1.087E-1	9.198E+4	5.719E+6	
	1.072E-1	9.325E+4	6.307E+6	
	1.058E-1	9.451E+4	6.171E+6	
	1.031E-1	9.702E+4	6.486E+6	
	1.005E-1	9.955E+4	5.882E+6	
	9.794E-2	1.021E+5	4.602E+6	
	9.681E-2	1.033E+5	4.981E+6	
	9.452E-2	1.058E+5	6.089E+6	
	9.225E-2	1.084E+5	5.812E+6	
	9.124E-2	1.096E+5	6.560E+6	
	9.017E-2	1.109E+5	6.034E+6	
	8.628E-2	1.159E+5	4.866E+6	
	8.532E-2	1.172E+5	4.191E+6	
	8.354E-2	1.197E+5	3.908E+6	
	8.264E-2	1.210E+5	4.232E+6	
	8.097E-2	1.235E+5	5.183E+6	
	8.019E-2	1.247E+5	4.847E+6	
	7.782E-2	1.285E+5	5.194E+6	
	7.704E-2	1.298E+5	4.844E+6	
	7.634E-2	1.310E+5	4.483E+6	
	7.283E-2	1.373E+5	4.484E+6	
	7.022E-2	1.424E+5	3.872E+6	
	6.667E-2	1.500E+5	4.428E+6	
	6.349E-2	1.575E+5	4.406E+6	
	6.154E-2	1.625E+5	4.044E+6	
	6.057E-2	1.651E+5	3.850E+6	
	5.794E-2	1.726E+5	4.161E+6	

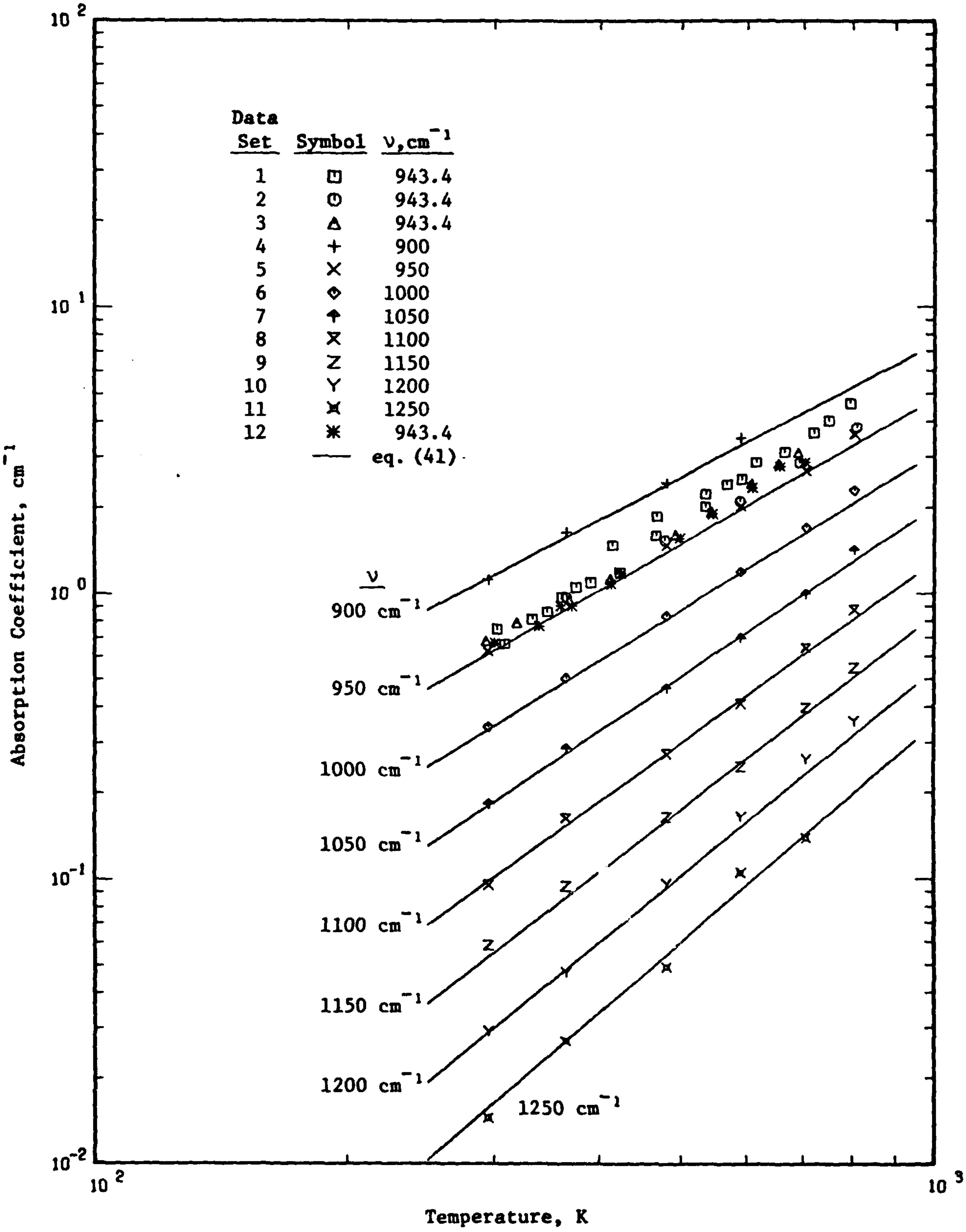

Figure 9. Absorption Coefficient of Strontium Fluoride in the Multiphonon Region (Temperature Dependence).

TABLE 8. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (TEMPERATURE DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm⁻¹; Absorption Coefficient, α, cm⁻¹]

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
1 [61]	(ν = 943.4 cm^{-1})		Single crystal obtained from Hughes Research Laboratory; sample thicknesses were so selected to provide adequate transmission over the temperature range of measurement and the absorption coefficients at room temperature agreed with values reported previously; absorption coefficients were determined with a simple laser transmission method using the relation , where L is the thickness of the sample, τ the transmission, ρ the calculated single surface reflectivity, α the absorption coefficient; the laser power ranged from 2 to 4 watts; on recycling down to room temperature, the absorption level increased slightly, but not enough to affect the trend of the result; data extracted from a figure.
Chen, M.,	3.020E+2	7.490E-1	
Hass, M.,	3.080E+2	6.660E-1	
McGill, T. C.,	3.330E+2	8.110E-1	
1975	3.470E+2	8.600E-1	
	3.610E+2	9.690E-1	
	3.750E+2	1.050E+0	
	3.900E+2	1.090E+0	
	4.140E+2	1.470E+0	
	4.220E+2	1.180E+0	
	4.660E+2	1.590E+0	
	4.670E+2	1.860E+0	
	5.350E+2	2.010E+0	
	5.360E+2	2.220E+0	
	5.680E+2	2.400E+0	
	5.910E+2	2.500E+0	
	6.150E+2	2.870E+0	
	6.650E+2	3.110E+0	
	7.200E+2	3.640E+0	
	7.490E+2	4.010E+0	
	7.950E+2	4.610E+0	
2 [53]	(ν = 943.4 cm^{-1})		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct
Lipson, H.,	3.660E+2	9.640E-1	
Bendow, B.,	4.780E+2	1.529E+0	
Skolnik, L.,	5.890E+2	2.102E+0	
Mitra, S.,	6.920E+2	2.866E+0	
Massa, N.,	8.090E+2	3.796E+0	
1976			

TABLE 8. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
2 [53] (cont.)			spectrometer transmission method was used; absorption coefficients were determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
3 [53]	(ν = 943.4 cm^{-1})		Similar to above except measured by laser calorimetric method with laser power levels of 2 to 3 watts.
Lipson, H.,	2.930E+2	6.810E-1	
et al.,	3.190E+2	7.890E-1	
1976	3.680E+2	9.470E-1	
	4.110E+2	1.122E+0	
	4.920E+2	1.604E+0	
	5.440E+2	1.928E+0	
	6.070E+2	2.418E+0	
	6.540E+2	2.841E+0	
	6.890E+2	3.107E+0	
4 [53]	(ν = 900 cm^{-1})		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were determined using a program which relates absorption, transmission,
Lipson, H.,	2.950E+2	1.117E+0	
et al.,	3.650E+2	1.636E+0	
1976	4.800E+2	2.428E+0	
	5.900E+2	3.493E+0	

TABLE 8. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
4 [53] (cont.)			reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
5 [53]	(ν = 950 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	6.260E-1	
et al.,	3.650E+2	9.270E-1	
1976	4.800E+2	1.473E+0	
	5.900E+2	2.020E+0	
	7.050E+2	2.675E+0	
	8.050E+2	3.590E+0	
6 [53]	(ν = 1000 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	3.400E-1	
et al.,	3.650E+2	5.040E-1	
1976	4.800E+2	8.330E-1	
	5.900E+2	1.188E+0	
	7.050E+2	1.694E+0	
	8.050E+2	2.294E+0	
7 [53]	(ν = 1050 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	1.830E-1	
et al.,	3.650E+2	2.860E-1	
1976	4.800E+2	4.640E-1	
	5.900E+2	6.970E-1	
	7.050E+2	9.980E-1	
	8.050E+2	1.422E+0	

TABLE 8. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
8 [53]	$(\nu = 1100\ \text{cm}^{-1})$		Same as above.
Lipson, H.,	2.950E+2	9.500E-2	
et al.,	3.650E+2	1.630E-1	
1976	4.800E+2	2.730E-1	
	5.900E+2	4.110E-1	
	7.050E+2	6.440E-1	
	8.050E+2	8.760E-1	
9 [53]	$(\nu = 1150\ \text{cm}^{-1})$		Same as above.
Lipson, H.,	2.950E+2	5.850E-2	
et al.,	3.650E+2	9.400E-2	
1976	4.800E+2	1.640E-1	
	5.900E+2	2.470E-1	
	7.050E+2	3.980E-1	
	8.050E+2	5.490E-1	
10 [53]	$(\nu = 1200\ \text{cm}^{-1})$		Same as above.
Lipson, H.,	2.950E+2	2.930E-2	
et al.,	3.650E+2	4.700E-2	
1976	4.800E+2	9.600E-2	
	5.900E+2	1.650E-1	
	7.050E+2	2.620E-1	
	8.050E+2	3.580E-1	
11 [53]	$(\nu = 1250\ \text{cm}^{-1})$		Same as above.
Lipson, H.,	2.950E+2	1.450E-2	
et al.,	3.650E+2	2.700E-2	
1976	4.800E+2	4.900E-2	
	5.900E+2	1.050E-1	
	7.050E+2	1.390E-1	

TABLE 8. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
12 [52] Lipton, H. G., Bendow, B., Mitra, S. S., 1975	(ν = 943.4 cm^{-1})		Single crystal sample cut from Optovac material on which room temperature measurements revealed no impurity bands in the frequency range of interest; polished specimen of 1.64 cm thick; laser transmission method used and absorption coefficient determined according to the relation: where ρ is the reflectivity, τ the transmission and d the sample thickness; data read from a figure.
	3.000E+2	6.700E-1	
	3.390E+2	7.660E-1	
	3.600E+2	9.040E-1	
	3.710E+2	9.040E-1	
	4.120E+2	1.081E+0	
	4.230E+2	1.173E+0	
	4.980E+2	1.557E+0	
	5.460E+2	1.894E+0	
	6.090E+2	2.339E+0	
	6.560E+2	2.776E+0	
	7.020E+2	2.869E+0	

4.3 Barium Fluoride, BaF_2

Barium fluoride is transparent over a wide spectral range from 0.14 up to 15 μm. The transmittance of a BaF_2 plate 2.3 mm thick increases rapidly from a sharp cutoff at 0.1345 μm to 85 percent at 0.4 μm and continues at that level to about 10 μm, after which it falls off rapidly. The observed transmittance at longer wavelength varys with the thickness of the sample. For a plate 10 mm thick, the transmittance is 50 percent at 11.7 μm and 10 percent at 13.5 μm, while a transmittance of 60 percent can be obtained at 15 μm for a 3.5 mm thick plate. Because of its uniform transparency in the spectral region 0.4 to 10 μm, barium fluoride is used for window and lens fabrication. As laser technology advances, the need for optical material with high optical figure of merit and adequate mechanical properties is increasing. Barium fluoride, having the required advantages, is among the serious candidates for window materials for the spectral region between 2 to 6 μm.

Unlike calcium fluoride, which occurs naturally in large sizes of optical quality, barium fluoride crystals for optical applications is synthesized. As a result, early investigations of optical properties did not include barium fluoride. Synthetic barium fluoride crystals of optical quality were successfully grown by Stockbarger during World War II. In the 1950's synthetic BaF_2 crystals became available commercially and found acceptance because of their favorable physical characteristics and broad transparent range. BaF_2 transmits further into the infrared than does either CaF_2 or LiF.

Available data on the absorption coefficient are given in Tables 9 and 10 and plotted in Figures 10 and 13. Kaiser et al. [43] investigated the reflection spectrum of BaF_2 in the reststrahlen region from 10 to 80 μm. Refractive and absorption indices for wavelengths from 11.3 to 22.5 μm were deduced from the analysis of the reflection spectrum using the Lorentz oscillator theory. The strong resonance at 54.3 μm was identified as the optically active TO resonance. A second resonance about one order of magnitude weaker than the main resonance is at 36 μm. The origin of the weaker absorption was unkown, and Kaiser proposed the possibility of a two-phonon combination band involving the TO mode. However, this weak absorption does not appear in Lowndes' work [68], in which the reflection spectrum was reduced by the Kramers-Kronig analysis. Instead of the weak resonance at 36 μm, Lowndes obtained a weak absorption at 29.07 μm, which was identified as the longitudinal optical resonance, LO mode. Since Lowndes may have used a purer sample than that used by Kaiser, it is likely that the weak absorption at 36 μm is due to impurities in Kaiser's sample. In the short-wavelength side of the fundamental phonon, however, their results are in close agreement with those obtained later by other investigators.

As the infrared transmission at elevated temperatures became of great interest for a number applications, Oppenheim and Goldman [63] determined the spectral absorption coefficient in the 5 to 14 μm region of the spectrum at temperatures 300, 573, 923 and 1273 K. The spectral measurements were made point by point with an estimated error of ±3%. Observation at elevated temperatures was also made by Lipson et al. [53] in the 8.0-13.6 μm region at six temperatures from 293 to 800 K. Their results are collectively plotted in Figures 10 and 11. A general agreement is clearly seen except for the data set measured at a temperature of 1273 K, which is close to the melting point of BaF_2 (1280 K). The mechanism of rapid increase of absorption at 1273 K was unknown, but it was observed that BaF_2 became less transparent to the eye at temperatures higher than 923 K, and after a number of hours at 1273 K it acquired a permanent milky-white color. Harrington et al. [48] measured the absorption coefficient of single crystal and polycrystalline specimens in the 3.5 to 8.1 μm region at temperature 373 K, using the emittance method. Their results deviate considerably from those reported by others as can be seen in Figure 10. The cause of such discrepancies was attributed to the presence of impurities.

Absorption measurements in the highly transparent region are very limited. Several measurements were made for each of the wavelength, 5.3, 3.8 and 2.7 μm because they are of interest in chemical lasers. Only one measurement was reported for each of the wavelengths at 1.06 μm and 0.515 μm. At 5.3 μm, values reported by Deutsch [47], Hordvik and Schlossberg [40] are essentially the same and are in agreement with the prediction of eq. (9). It should be noted that at this wavelength, surface absorption has about the same magnitude as that of bulk. At wavelengths 3.8 and 2.8 μm, efforts were made to establish the controlling factors in sample growing and polishing processes which would reduce absorption. When the results obtained by Harrington et al. [48,54], Hass et al. [56], and Hordvik and Skolnic [42] are brought together as shown in Figure 10, one can see that even the lowest available absorption coefficient is largely extrinsic which is attributed to surface contamination. The only available absorption data at 1.06 μm was reported by Hass et al. [56]. The value is 3.0 x 10^{-5} cm^{-1}. Since they found little or no indication of surface absorption in the inspection of the thermal rise curves, it is believed that absorption data measured at 1.06 μm may provide an indication of the lower limit that can be obtained in a particular sample and that the cause of the limiting factor is likely to be the scattering effect. The absorption coefficient at 0.515 μm was found to be 1.9 x 10^{-4} cm^{-1} as reported by Hordvik and Schlossberg [40]. At this wavelength, an additional limiting factor arises from the presence of color centers.

At the long wavelength side of the reststrahlen region, absorption data were determined by Bosomworth [46] for the wavelength range from 55 to 1000 μm at four temperatures, 5, 80, 200 and 300 K. It is clearly seen in Figure 10 that aside from the structure of the spectrum below 200 μm, the behavior of the absorption coefficient in the region above 200 μm is quite predictable.

In vacuum ultraviolet, Fabre et al. [58] investigated the spectral region from 0.1 to 0.17 μm by Kramers-Kronig analysis of the reflection spectrum, and found a strong absorption peak at 0.122 μm which is the lower limit of the transparency of BaF_2. Nisar et al. [62] studied the reflection spectrum in the energy range 8-35 eV and analyzed the absorption spectrum beyond the lower transparent limit. Similar observations were carried out by Ganin et al. [60]. Absorption spectrum in the tail region was studied by Tomiki and Miyata [10]. They performed a series of spectral measurements at five temperatures from 78 to 573 K. A systematic data analysis was made to define the parameters of eq. (8). In spite of the fact that the observed absorption coefficient can indeed be described by eq. (8), with the best fit parameters listed in Table 3, the fact that the parameter values do not conform with the theoretically predicted trend has led them to conclude that whether the tail is intrinsic or extrinsic remains unresolved.

The temperature dependence of the multiphonon absorption of BaF_2 at 10.6 μm over temperatures from 300 to 800 K was obtained by Chen et al. [61] using a laser transmission experiment. Although there is no experiment error reported along with the data, the error bar given in their graphic presentation indicates a 50% error for an absorption coefficient of 0.2 cm^{-1}, and about a 10% error for an absorption of 1.0 cm^{-1}. In the data analysis they found that the experimental results were best represented by the 4-phonon absorption in the Bose-Einstein model. Absorption data covering both wide spectral and wide temperature ranges were generated by Lipson et al. [53] using the spectrometer transmission method. Experimental errors of their data were not reported but can be roughly estimated from their graphs. Errors ranging from 5% at high absorption levels to more than 10% at low absorption are estimated. The available data are collectively plotted in Figure 13 and all the curves appear to be straight lines and, if extended, tend to converge at a point in the upper right corner outside the figure. Indeed, we did find such a point as will be discussed in Section 5.

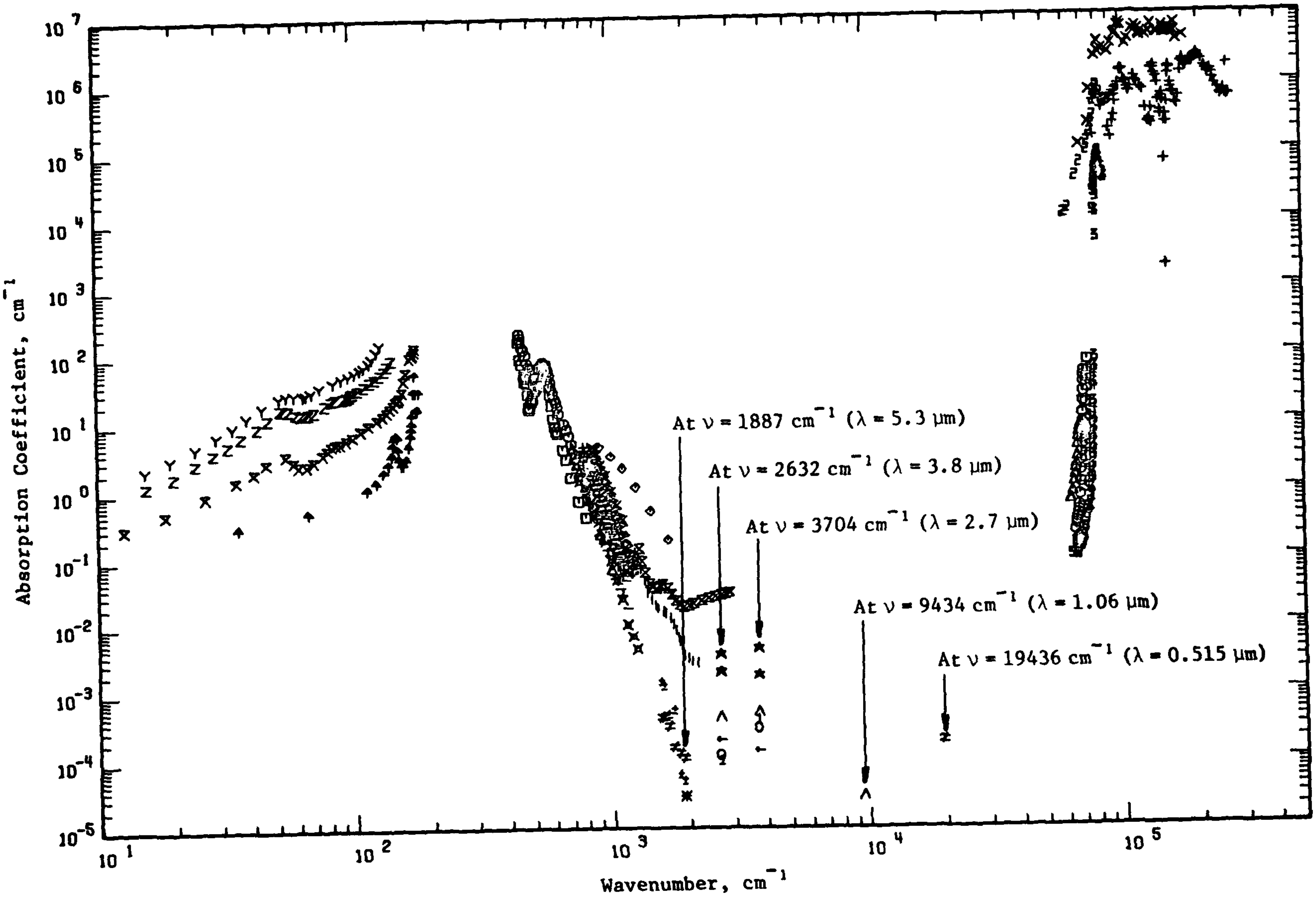

Figure 10. Absorption Coefficient of Barium Fluoride (Wavenumber Dependence)

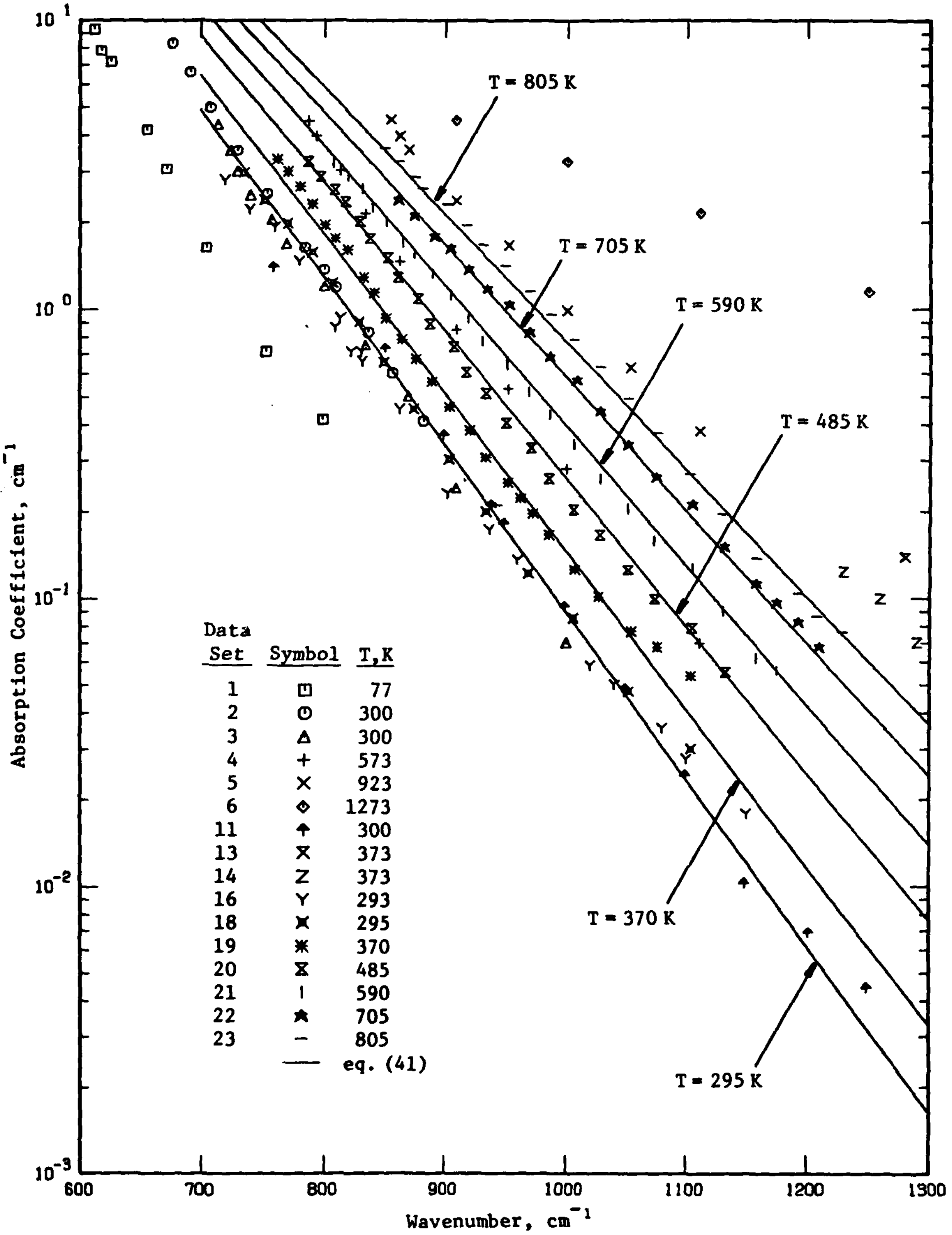

Figure 11. Absorption Coefficient of Barium Fluoride in the Multiphonon Region (Wavenumber Dependence)

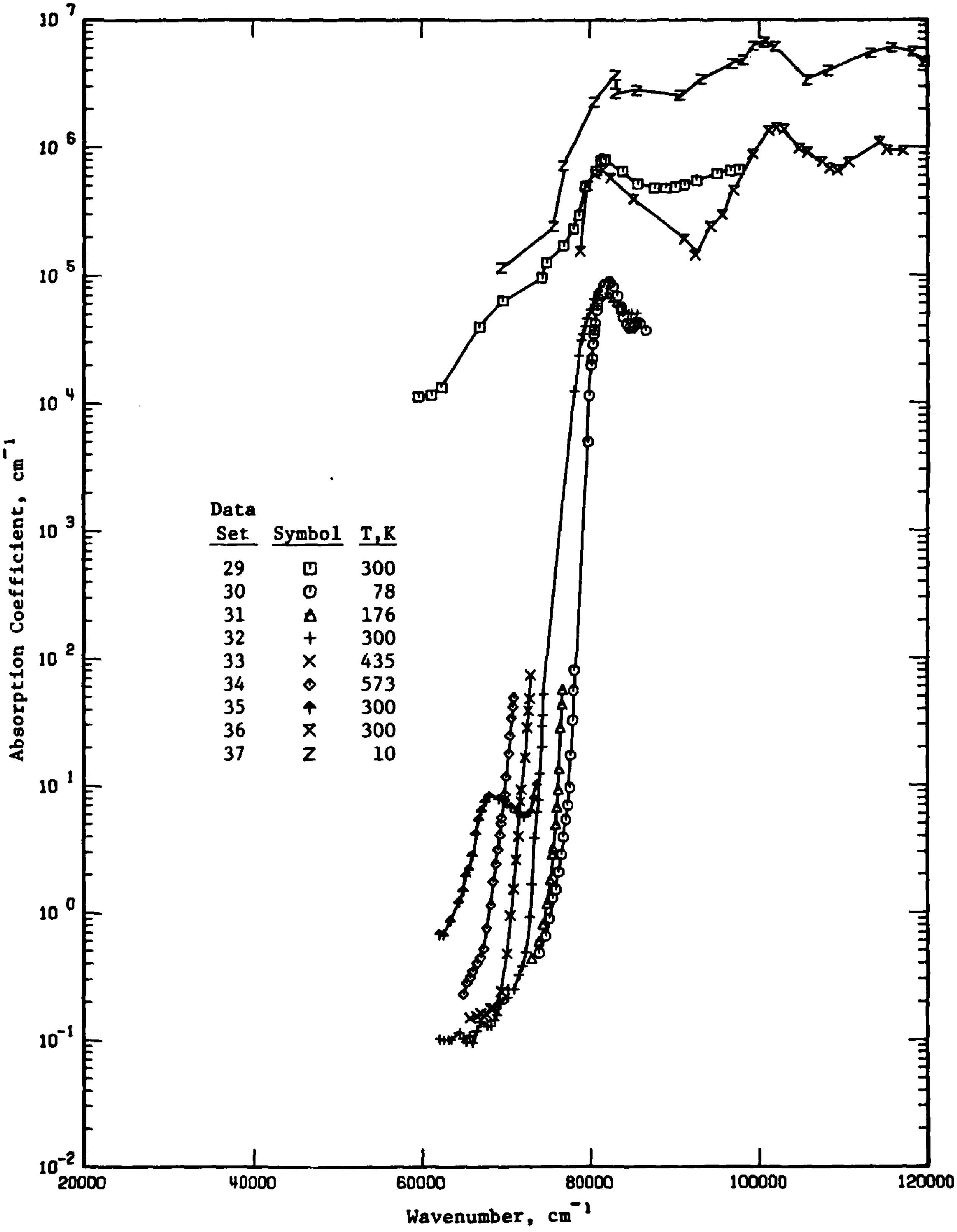

Figure 12. Absorption Coefficient of Barium Fluoride in the Urbach Tail Region (Wavenumber Dependence)

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm^{-1}; Absorption Coefficient, α, cm^{-1}]

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [43] Kaiser, W., Spitzer, W. G., Kaiser, R. H., Howarth, L. E., 1962		(T = 77 K)		Single crystal; plate specimens of 0.1 - 5 mm thick; absorption coefficient determined from transmission and reflectivity measurements; data taken from a figure.
	1.252E+1	7.990E+2	4.170E-1	
	1.328E+1	7.530E+2	7.160E-1	
	1.418E+1	7.050E+2	1.640E+0	
	1.488E+1	6.720E+2	3.060E+0	
	1.524E+1	6.560E+2	4.190E+0	
	1.597E+1	6.260E+2	7.190E+0	
	1.618E+1	6.180E+2	7.830E+0	
	1.634E+1	6.120E+2	9.290E+0	
	1.653E+1	6.050E+2	1.200E+1	
	1.672E+1	5.980E+2	1.890E+1	
	1.698E+1	5.890E+2	2.670E+1	
	1.712E+1	5.840E+2	3.450E+1	
	1.733E+1	5.770E+2	4.330E+1	
	1.748E+1	5.720E+2	6.100E+1	
	1.764E+1	5.670E+2	7.450E+1	
	1.779E+1	5.620E+2	6.640E+1	
	1.799E+1	5.560E+2	5.140E+1	
	1.821E+1	5.490E+2	4.090E+1	
	1.848E+1	5.410E+2	3.640E+1	
	1.887E+1	5.300E+2	3.750E+1	
	1.912E+1	5.230E+2	3.340E+1	
	1.942E+1	5.150E+2	3.160E+1	
	1.980E+1	5.050E+2	2.310E+1	
	2.004E+1	4.990E+2	2.120E+1	
	2.024E+1	4.940E+2	1.730E+1	
	2.045E+1	4.890E+2	1.640E+1	
	2.053E+1	4.870E+2	1.780E+1	
	2.066E+1	4.840E+2	2.730E+1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [43] (cont.)	2.083E+1	4.800E+2	3.960E+1	
	2.096E+1	4.770E+2	4.980E+1	
	2.119E+1	4.720E+2	4.700E+1	
	2.123E+1	4.710E+2	4.190E+1	
	2.141E+1	4.670E+2	5.270E+1	
	2.188E+1	4.570E+2	7.630E+1	
	2.217E+1	4.510E+2	9.050E+1	
	2.252E+1	4.440E+2	1.650E+2	
2 [43]		(T = 300 K)		Same as above.
Kaiser, W.,	1.134E+1	8.820E+2	4.110E-1	
et al.,	1.168E+1	8.560E+2	6.020E-1	
1962	1.196E+1	8.380E+2	8.330E-1	
	1.236E+1	8.090E+2	1.190E+0	
	1.250E+1	8.000E+2	1.370E+0	
	1.276E+1	7.840E+2	1.640E+0	
	1.326E+1	7.540E+2	2.510E+0	
	1.370E+1	7.300E+2	3.540E+0	
	1.412E+1	7.080E+2	4.980E+0	
	1.445E+1	6.920E+2	6.620E+0	
	1.477E+1	6.770E+2	8.310E+0	
	1.511E+1	6.620E+2	1.010E+1	
	1.567E+1	6.380E+2	1.430E+1	
	1.592E+1	6.280E+2	1.740E+1	
	1.610E+1	6.210E+2	2.070E+1	
	1.631E+1	6.130E+2	2.320E+1	
	1.653E+1	6.050E+2	2.750E+1	
	1.672E+1	5.980E+2	3.260E+1	
	1.689E+1	5.920E+2	4.090E+1	
	1.709E+1	5.850E+2	5.000E+1	
	1.727E+1	5.790E+2	5.930E+1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
2 [43] (cont.)	1.757E+1	5.690E+2	6.640E+1	
	1.773E+1	5.640E+2	7.440E+1	
	1.795E+1	5.570E+2	8.110E+1	
	1.815E+1	5.510E+2	8.110E+1	
	1.838E+1	5.440E+2	7.650E+1	
	1.883E+1	5.310E+2	6.830E+1	
	1.901E+1	5.260E+2	6.630E+1	
	1.938E+1	5.160E+2	6.630E+1	
	1.972E+1	5.070E+2	6.630E+1	
	2.024E+1	4.940E+2	6.440E+1	
	2.062E+1	4.850E+2	7.010E+1	
	2.075E+1	4.820E+2	7.860E+1	
	2.110E+1	4.740E+2	1.040E+2	
	2.146E+1	4.660E+2	1.240E+2	
	2.179E+1	4.590E+2	1.350E+2	
	2.212E+1	4.520E+2	1.700E+2	
	2.217E+1	4.510E+2	1.850E+2	
	2.227E+1	4.490E+2	2.130E+2	
3 [63]		(T = 300 K)		Single crystal obtained from the Meller Company; round window specimen of 8.0 mm thick; spectral external transmittance measured and absorption coefficient determined according to eq. (22); estimated accuracy 5%; data read from a curve.
Oppenheim, U. P.,	1.000E+1	1.000E+3	7.000E-2	
Goldman, A.,	1.100E+1	9.091E+2	2.400E-1	
1964	1.150E+1	8.696E+2	5.000E-1	
	1.200E+1	8.333E+2	7.500E-1	
	1.250E+1	8.000E+2	1.200E+0	
	1.300E+1	7.692E+2	1.690E+0	
	1.320E+1	7.576E+2	2.040E+0	
	1.350E+1	7.407E+2	2.490E+0	
	1.370E+1	7.299E+2	3.010E+0	
	1.380E+1	7.246E+2	3.550E+0	
	1.400E+1	7.143E+2	4.360E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
4 [63]		(T = 573 K)		Same as above.
Oppenheim, U. P.,	9.000E+0	1.111E+3	7.000E-2	
et al.,	1.000E+1	1.000E+3	2.800E-1	
1964	1.050E+1	9.524E+2	5.300E-1	
	1.100E+1	9.091E+2	8.500E-1	
	1.160E+1	8.621E+2	1.460E+0	
	1.200E+1	8.333E+2	2.140E+0	
	1.230E+1	8.130E+2	3.010E+0	
	1.260E+1	7.937E+2	3.980E+0	
	1.270E+1	7.874E+2	4.490E+0	
5 [63]		(T = 923 K)		Same as above.
Oppenheim, U. P.,	9.000E+0	1.111E+3	3.800E-1	
et al.,	9.500E+0	1.053E+3	6.300E-1	
1964	1.000E+1	1.000E+3	9.900E-1	
	1.050E+1	9.524E+2	1.660E+0	
	1.100E+1	9.091E+2	2.370E+0	
	1.150E+1	8.696E+2	3.560E+0	
	1.160E+1	8.621E+2	3.980E+0	
	1.170E+1	8.547E+2	4.530E+0	
6 [63]		(T = 1273 K)		Similar to above except for a sample of thickness 7.6 mm.
Oppenheim, U. P.,	6.000E+0	1.667E+3	1.900E-1	
et al.,	7.000E+0	1.429E+3	5.100E-1	
1964	8.000E+0	1.250E+3	1.150E+0	
	9.000E+0	1.111E+3	2.150E+0	
	1.000E+1	1.000E+3	3.240E+0	
	1.100E+1	9.091E+2	4.500E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
7 [46]		(T = 5 K)		Single crystals; obtained from the Harshaw Chemical Co. or grown in laboratory; samples from different sources gave identical results; dominant impurity was Fe (10-200 ppm); plane-parallel slab specimens of 0.3 to 10 mm thick; mechanically polished with 0.3 to 1.0 μm alumina; direct transmission measured and absorption coefficient then determined; uncertainties about 25 to 50%; data taken from a figure.
Bosomworth, D. R.	5.528E+1	1.809E+2	3.000E+1	
1967	5.605E+1	1.784E+2	1.670E+1	
	5.634E+1	1.775E+2	1.620E+1	
	5.682E+1	1.760E+2	1.640E+1	
	5.711E+1	1.751E+2	3.000E+1	
	5.754E+1	1.738E+2	5.450E+1	
	5.807E+1	1.722E+2	3.000E+1	
	5.886E+1	1.699E+2	1.370E+1	
	5.914E+1	1.691E+2	1.020E+1	
	5.938E+1	1.684E+2	8.400E+0	
	5.988E+1	1.670E+2	6.800E+0	
	6.083E+1	1.644E+2	4.800E+0	
	6.242E+1	1.602E+2	3.100E+0	
	6.402E+1	1.562E+2	2.600E+0	
	6.515E+1	1.535E+2	2.600E+0	
	6.631E+1	1.508E+2	3.100E+0	
	6.689E+1	1.495E+2	4.300E+0	
	6.748E+1	1.482E+2	6.500E+0	
	6.835E+1	1.463E+2	7.000E+0	
	6.940E+1	1.441E+2	6.200E+0	
	7.003E+1	1.428E+2	5.000E+0	
	7.107E+1	1.407E+2	3.500E+0	
	7.315E+1	1.367E+2	2.600E+0	
	7.616E+1	1.313E+2	2.000E+0	
	8.137E+1	1.229E+2	1.400E+0	
	8.850E+1	1.130E+2	1.100E+0	
	1.508E+2	6.630E+1	5.000E-1	
	2.841E+2	3.520E+1	3.000E-1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
8 [46]		(T = 80 K)		Similar to above except uncertainty
Bosomworth, D. R.	5.737E+1	1.743E+2	1.202E+2	about 25 to 30%.
1967	5.794E+1	1.726E+2	1.099E+2	
	5.845E+1	1.711E+2	1.049E+2	
	5.999E+1	1.667E+2	9.720E+1	
	6.200E+1	1.613E+2	5.870E+1	
	6.305E+1	1.586E+2	4.420E+1	
	6.402E+1	1.562E+2	3.000E+1	
	6.575E+1	1.521E+2	2.480E+1	
	6.671E+1	1.499E+2	2.280E+1	
	6.780E+1	1.475E+2	2.220E+1	
	6.940E+1	1.441E+2	1.950E+1	
	7.128E+1	1.403E+2	1.730E+1	
	7.337E+1	1.363E+2	1.540E+1	
	7.639E+1	1.309E+2	1.360E+1	
	8.052E+1	1.242E+2	1.180E+1	
	8.696E+1	1.150E+2	9.800E+0	
	9.320E+1	1.073E+2	8.200E+0	
	1.004E+2	9.960E+1	6.700E+0	
	1.065E+2	9.390E+1	6.000E+0	
	1.121E+2	8.920E+1	5.300E+0	
	1.167E+2	8.570E+1	5.200E+0	
	1.212E+2	8.250E+1	4.900E+0	
	1.258E+2	7.950E+1	4.300E+0	
	1.316E+2	7.600E+1	3.700E+0	
	1.431E+2	6.990E+1	2.900E+0	
	1.522E+2	6.570E+1	2.500E+0	
	1.639E+2	6.100E+1	2.500E+0	
	1.712E+2	5.840E+1	2.900E+0	
	1.835E+2	5.450E+1	3.600E+0	
	2.193E+2	4.560E+1	2.800E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSOFPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
8 [46] (cont.)	2.445E+2	4.090E+1	2.000E+0	
	2.882E+2	3.470E+1	1.500E+0	
	3.817E+2	2.620E+1	9.000E-1	
	5.464E+2	1.830E+1	5.000E-1	
	7.937E+2	1.260E+1	3.000E-1	
9 [46]		(T = 200 K)		Similar to above except uncertainty about 25%.
Bosomworth, D. R.	7.072E+1	1.414E+2	8.980E+1	
1967	7.315E+1	1.367E+2	7.440E+1	
	7.519E+1	1.330E+2	6.350E+1	
	7.837E+1	1.276E+2	5.480E+1	
	8.190E+1	1.221E+2	4.780E+1	
	8.518E+1	1.174E+2	4.240E+1	
	9.025E+1	1.108E+2	3.680E+1	
	9.569E+1	1.045E+2	3.240E+1	
	1.000E+2	1.000E+2	3.000E+1	
	1.007E+2	9.930E+1	2.880E+1	
	1.026E+2	9.750E+1	2.740E+1	
	1.055E+2	9.480E+1	2.570E+1	
	1.093E+2	9.150E+1	2.460E+1	
	1.176E+2	8.500E+1	2.380E+1	
	1.215E+2	8.230E+1	2.320E+1	
	1.285E+2	7.780E+1	1.960E+1	
	1.410E+2	7.090E+1	1.590E+1	
	1.488E+2	6.720E+1	1.480E+1	
	1.534E+2	6.520E+1	1.430E+1	
	1.590E+2	6.290E+1	1.430E+1	
	1.664E+2	6.010E+1	1.500E+1	
	1.773E+2	5.640E+1	1.670E+1	
	1.862E+2	5.370E+1	1.720E+1	
	1.923E+2	5.200E+1	1.700E+1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
9 [46] (cont.)	2.151E+2	4.650E+1	1.250E+1	
	2.375E+2	4.210E+1	9.400E+0	
	2.740E+2	3.650E+1	6.800E+0	
	3.096E+2	3.230E+1	5.100E+0	
	3.534E+2	2.830E+1	3.900E+0	
	4.167E+2	2.400E+1	2.800E+0	
	5.051E+2	1.980E+1	1.800E+0	
	6.452E+2	1.550E+1	1.300E+0	
	1.020E+3	9.800E+0	6.000E-1	
10 [46]		(T = 300 K)		*Similar to above except uncertainty about 15%.*
Bosomworth, D. R.	7.794E+1	1.283E+2	1.500E+2	
1967	8.058E+1	1.241E+2	1.194E+2	
	8.389E+1	1.192E+2	9.510E+1	
	8.613E+1	1.161E+2	8.200E+1	
	9.066E+1	1.103E+2	7.010E+1	
	9.381E+1	1.066E+2	6.460E+1	
	9.804E+1	1.020E+2	5.830E+1	
	1.036E+2	9.650E+1	5.250E+1	
	1.106E+2	9.040E+1	4.700E+1	
	1.188E+2	8.420E+1	4.220E+1	
	1.340E+2	7.460E+1	3.570E+1	
	1.447E+2	6.910E+1	3.000E+1	
	1.517E+2	6.590E+1	2.750E+1	
	1.555E+2	6.430E+1	2.690E+1	
	1.692E+2	5.910E+1	2.790E+1	
	1.815E+2	5.510E+1	2.740E+1	
	1.942E+2	5.150E+1	2.520E+1	
	2.257E+2	4.430E+1	1.860E+1	
	2.604E+2	3.840E+1	1.320E+1	
	2.959E+2	3.380E+1	9.400E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
10 [46] (cont.)	3.425E+2	2.920E+1	6.900E+0	
	4.149E+2	2.410E+1	4.700E+0	
	5.208E+2	1.920E+1	3.200E+0	
	6.536E+2	1.530E+1	2.200E+0	
	1.010E+3	9.900E+0	1.100E+0	
11 [32]		(T = 300 K)		Single crystals; obtained from the Harshaw Chemical Co., typical sample dimensions 2.54 cm diameter and 2.54 cm thick; transmission measured with differential technique and absorption coefficient calculated according to eq. (31); uncertainties of α in high transparent and low transparent regions are respectively about 10% and 3%; data taken from a figure.
Deutsch, T. F.,	8.006E+0	1.249E+3	4.440E-3	
1973	8.326E+0	1.201E+3	6.900E-3	
	8.711E+0	1.148E+3	1.026E-2	
	9.099E+0	1.099E+3	2.443E-2	
	9.533E+0	1.049E+3	4.887E-2	
	1.001E+1	9.990E+2	9.376E-2	
	1.054E+1	9.490E+2	1.820E-1	
	1.066E+1	9.380E+2	2.109E-1	
	1.112E+1	8.990E+2	3.681E-1	
	1.176E+1	8.500E+2	7.328E-1	
	1.318E+1	7.590E+2	1.400E+0	
12 [47]		(T = 300 K)		Absorption coefficient at 5.25 μm measured with Raytheon CO_2/CO laser calorimeter; no other details were reported; data taken from a table.
Deutsch, T. F.,	5.252E+0	1.904E+3	3.000E-5	
1975				
13 [48]		(T = 373 K)		Polished and polycrystalline (Polytran) sample; received from the Hawshaw Chemical Co.; the normal spectral emittance, E, was measure; the low absorption coefficients in the transparent region were calculated according to eq. (35) and
Harrington, J. A.	7.813E+0	1.280E+3	1.390E-1	
Bendow, B.,	7.634E+0	1.310E+3	9.150E-2	
Namjoshi, K. V.,	7.407E+0	1.350E+3	6.160E-2	
Mitra, S. S.,	7.092E+0	1.410E+3	4.260E-2	
Stierwalt, D. L.,	6.944E+0	1.440E+3	3.740E-2	
1975	6.711E+0	1.490E+3	3.550E-2	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
13 [48] (cont.)	6.494E+0	1.540E+3	3.900E-2	(36); absorption-coefficient data extracted from a curve.
	6.329E+0	1.580E+3	4.170E-2	
	6.061E+0	1.650E+3	3.570E-2	
	5.848E+0	1.710E+3	2.890E-2	
	5.650E+0	1.770E+3	2.310E-2	
	5.464E+0	1.830E+3	1.980E-2	
	5.263E+0	1.900E+3	1.860E-2	
	5.025E+0	1.990E+3	1.960E-2	
	4.808E+0	2.080E+3	2.100E-2	
	4.464E+0	2.240E+3	2.310E-2	
	4.184E+0	2.390E+3	2.510E-2	
	3.953E+0	2.530E+3	2.660E-2	
	3.759E+0	2.660E+3	2.820E-2	
	3.610E+0	2.770E+3	2.940E-2	
	3.472E+0	2.880E+3	3.070E-2	
14 [48]		(T = 373 K)		Similar to above except for a single crystal sample.
Harrington, J. A.	8.130E+0	1.230E+3	1.240E-1	
et al.,	7.937E+0	1.260E+3	1.000E-1	
1975	7.752E+0	1.290E+3	7.020E-2	
	7.463E+0	1.340E+3	4.730E-2	
	7.246E+0	1.380E+3	3.060E-2	
	6.993E+0	1.430E+3	2.450E-2	
	6.757E+0	1.480E+3	2.010E-2	
	6.623E+0	1.510E+3	1.810E-2	
	6.329E+0	1.580E+3	1.610E-2	
	6.173E+0	1.620E+3	1.510E-2	
	5.917E+0	1.690E+3	1.270E-2	
	5.780E+0	1.730E+3	1.030E-2	
	5.618E+0	1.780E+3	8.480E-3	
	5.525E+0	1.810E+3	6.690E-3	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
14 [48] (cont.)	5.435E+0	1.840E+3	5.720E-3	
	5.348E+0	1.870E+3	4.280E-3	
	5.236E+0	1.910E+3	3.560E-3	
	5.051E+0	1.980E+3	3.210E-3	
	4.902E+0	2.040E+3	2.890E-3	
	4.651E+0	2.150E+3	2.750E-3	
15 [48]		(T = 300 K)		Specimens received from various suppliers; absorption coefficients measured by laser calorimetry technique; laser used was of SF_6 variety delivering from 5 to 10 watts of cw multiline HF power and about 5 watts of cw multiline DF power; letters following absorption coefficient values have the meaning: PH – polycrystalline from Harshaw, SO – single crystal from Optovac; data taken from a table.
Harrington, J. A.	3.799E+0	2.632E+3	3.660E-3PH	
et al.,	3.799E+0	2.632E+3	2.000E-3SO	
1975	2.700E+0	3.704E+3	4.420E-3PH	
	2.700E+0	3.704E+3	1.800E-3SO	
16 [52]		(T = 293 K)		Single crystal samples prepared from high purity Optovac material; sample thickness of 5.4 cm with polished ends; absorption coefficient were determined with a double beam spectrometer; no impurity absorption bands were found in the frequency range investigated; data extracted from a figure.
Lipson, H. G.,	8.696E+0	1.150E+3	1.790E-2	
Bendow, B.,	9.091E+0	1.100E+3	2.770E-2	
Mitra, S. S.,	9.259E+0	1.080E+3	3.550E-2	
1975	9.615E+0	1.040E+3	5.020E-2	
	9.804E+0	1.020E+3	5.850E-2	
	1.042E+1	9.600E+2	1.360E-1	
	1.067E+1	9.370E+2	1.730E-1	
	1.109E+1	9.020E+2	2.310E-1	
	1.160E+1	8.620E+2	4.520E-1	
	1.203E+1	8.310E+2	6.600E-1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
16 [52] (cont.)	1.205E+1	8.300E+2	7.120E-1	
	1.217E+1	8.220E+2	7.120E-1	
	1.230E+1	8.130E+2	9.330E-1	
	1.236E+1	8.090E+2	8.650E-1	
	1.282E+1	7.800E+2	1.470E+0	
	1.316E+1	7.600E+2	1.930E+0	
	1.351E+1	7.400E+2	2.220E+0	
	1.389E+1	7.200E+2	2.810E+0	
17 [54] Harrington, J. A. Gregory, D. A., Otto, W. F. Jr., 1976		(T = 300 K)		Commercial sample obtained from Adolf Meller Co.; total absorption coefficient determined by the calorimeter method; data extracted from a table; temperature not given, 300 K assumed.
	3.799E+0	2.632E+3	2.000E-4	
	2.700E+0	3.704E+3	1.400E-4	
18 [53] Lipson, H., Bendow, B., Skolnik, L., Mitra, S., Massa, N., 1976		(T = 295 K)		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
	1.360E+1	7.352E+2	2.965E+0	
	1.330E+1	7.519E+2	2.388E+0	
	1.298E+1	7.703E+2	1.986E+0	
	1.265E+1	7.903E+2	1.574E+0	
	1.239E+1	8.070E+2	1.230E+0	
	1.207E+1	8.287E+2	9.036E-1	
	1.178E+1	8.487E+2	6.546E-1	
	1.144E+1	8.737E+2	4.519E-1	
	1.106E+1	9.038E+2	3.027E-1	
	1.071E+1	9.338E+2	1.995E-1	
	1.032E+1	9.689E+2	1.219E-1	
	9.944E+0	1.006E+3	8.551E-2	
	9.502E+0	1.052E+3	4.764E-2	
	9.056E+0	1.104E+3	2.999E-2	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
19 [53]		(T = 370 K)		Same as above.
Lipson, H.,	1.312E+1	7.620E+2	3.296E+0	
et al.,	1.298E+1	7.704E+2	3.006E+0	
1976	1.281E+1	7.804E+2	2.661E+0	
	1.265E+1	7.904E+2	2.312E+0	
	1.249E+1	8.004E+2	1.954E+0	
	1.236E+1	8.088E+2	1.754E+0	
	1.221E+1	8.188E+2	1.600E+0	
	1.202E+1	8.322E+2	1.288E+0	
	1.190E+1	8.405E+2	1.138E+0	
	1.176E+1	8.505E+2	9.311E-1	
	1.158E+1	8.639E+2	7.870E-1	
	1.142E+1	8.755E+2	6.745E-1	
	1.125E+1	8.889E+2	5.610E-1	
	1.106E+1	9.039E+2	4.592E-1	
	1.086E+1	9.206E+2	3.811E-1	
	1.071E+1	9.340E+2	3.069E-1	
	1.050E+1	9.523E+2	2.512E-1	
	1.039E+1	9.624E+2	2.223E-1	
	1.028E+1	9.724E+2	1.963E-1	
	1.014E+1	9.857E+2	1.660E-1	
	9.926E+0	1.007E+3	1.256E-1	
	9.732E+0	1.027E+3	1.012E-1	
	9.486E+0	1.054E+3	7.674E-2	
	9.294E+0	1.076E+3	6.776E-2	
	9.055E+0	1.104E+3	5.383E-2	
20 [53]		(T = 485 K)		Same as above.
Lipson, H.,	1.270E+1	7.872E+2	3.243E+0	
et al.,	1.254E+1	7.972E+2	2.871E+0	
1976	1.236E+1	8.089E+2	2.576E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
20 [53] (cont.)	1.224E+1	8.172E+2	2.350E+0	
	1.206E+1	8.289E+2	2.014E+0	
	1.194E+1	8.373E+2	1.754E+0	
	1.173E+1	8.523E+2	1.503E+0	
	1.162E+1	8.606E+2	1.288E+0	
	1.140E+1	8.774E+2	1.086E+0	
	1.127E+1	8.874E+2	8.892E-1	
	1.102E+1	9.071E+2	7.396E-1	
	1.090E+1	9.174E+2	6.053E-1	
	1.071E+1	9.341E+2	5.105E-1	
	1.052E+1	9.508E+2	4.055E-1	
	1.030E+1	9.709E+2	3.311E-1	
	1.014E+1	9.859E+2	2.588E-1	
	9.941E+0	1.006E+3	2.023E-1	
	9.731E+0	1.028E+3	1.656E-1	
	9.515E+0	1.051E+3	1.256E-1	
	9.307E+0	1.074E+3	9.954E-2	
	9.054E+0	1.105E+3	7.907E-2	
	8.827E+0	1.133E+3	5.546E-2	
21 [53] Lipson, H., et al., 1976		(T = 590 K)		Same as above.
	1.239E+1	8.073E+2	3.192E+0	
	1.221E+1	8.190E+2	2.871E+0	
	1.204E+1	8.307E+2	2.612E+0	
	1.192E+1	8.390E+2	2.239E+0	
	1.175E+1	8.507E+2	2.014E+0	
	1.157E+1	8.641E+2	1.698E+0	
	1.144E+1	8.741E+2	1.549E+0	
	1.125E+1	8.891E+2	1.327E+0	
	1.106E+1	9.042E+2	1.119E+0	
	1.088E+1	9.192E+2	9.311E-1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
21 [53] (cont.)	1.074E+1	9.309E+2	7.727E-1	
	1.052E+1	9.509E+2	6.427E-1	
	1.032E+1	9.693E+2	5.176E-1	
	1.014E+1	9.860E+2	4.305E-1	
	9.940E+0	1.006E+3	3.412E-1	
	9.730E+0	1.028E+3	2.588E-1	
	9.513E+0	1.051E+3	2.051E-1	
	9.321E+0	1.073E+3	1.581E-1	
	9.053E+0	1.105E+3	1.274E-1	
	8.839E+0	1.131E+3	9.078E-2	
	8.635E+0	1.158E+3	6.166E-2	
	8.512E+0	1.175E+3	5.623E-2	
22 [53]		(T = 705 K)		Same as above.
Lipson, H.,	1.162E+1	8.608E+2	2.382E+0	
et al.,	1.144E+1	8.742E+2	2.104E+0	
1976	1.122E+1	8.909E+2	1.778E+0	
	1.106E+1	9.043E+2	1.618E+0	
	1.088E+1	9.193E+2	1.368E+0	
	1.070E+1	9.344E+2	1.172E+0	
	1.050E+1	9.528E+2	1.035E+0	
	1.032E+1	9.695E+2	8.337E-1	
	1.014E+1	9.862E+2	6.823E-1	
	9.922E+0	1.008E+3	5.675E-1	
	9.728E+0	1.028E+3	4.436E-1	
	9.512E+0	1.051E+3	3.412E-1	
	9.305E+0	1.075E+3	2.624E-1	
	9.051E+0	1.105E+3	2.113E-1	
	8.838E+0	1.132E+3	1.507E-1	
	8.634E+0	1.158E+3	1.125E-1	
	8.511E+0	1.175E+3	9.638E-2	
	8.380E+0	1.193E+3	8.260E-2	
	8.264E+0	1.210E+3	6.761E-2	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (*continued*)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
23 [53]		(T = 805 K)		Same as above.
Lipson, H.,	1.178E+1	8.492E+2	3.606E+0	
et al.,	1.162E+1	8.609E+2	3.243E+0	
1976	1.144E+1	8.743E+2	2.864E+0	
	1.135E+1	8.810E+2	2.612E+0	
	1.110E+1	9.010E+2	2.307E+0	
	1.090E+1	9.178E+2	1.945E+0	
	1.074E+1	9.311E+2	1.667E+0	
	1.053E+1	9.495E+2	1.409E+0	
	1.031E+1	9.696E+2	1.153E+0	
	1.014E+1	9.863E+2	9.572E-1	
	9.937E+0	1.006E+3	7.834E-1	
	9.727E+0	1.028E+3	6.310E-1	
	9.511E+0	1.051E+3	4.932E-1	
	9.290E+0	1.076E+3	3.741E-1	
	9.065E+0	1.103E+3	2.704E-1	
	8.850E+0	1.130E+3	1.959E-1	
	8.633E+0	1.158E+3	1.374E-1	
	8.379E+0	1.193E+3	1.040E-1	
	8.275E+0	1.208E+3	8.650E-2	
	8.140E+0	1.229E+3	7.638E-2	
24 [56]		(T = 298 K)		Single crystal obtained from the Harshaw Co.; highly purified and polished rod specimen; measured with laser calorimetric technique; a multiline gas laser was used at wavelength 2.7 and 3.8 μm and an Nd:YAG laser used at wavelength 1.06 μm; data taken from a table.
Hass, M.,	3.801E+0	2.631E+3	4.400E-4	
Harrington, J. A.	2.700E+0	3.704E+3	5.200E-4	
Davison, J. W.,	1.060E+0	9.434E+3	3.000E-5	
1976				

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
25 [40] Hordvik, A., Schlossberg, H., 1977		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficients; CO_2, CO and Ar cw lasers were used; both surface and bulk losses were determined; bulk absorption data extracted from a table.
	5.145E-1	1.944E+4	1.900E-4	
	5.280E+0	1.894E+3	1.100E-4	
	5.488E+0	1.822E+3	1.300E-4	
	5.782E+0	1.730E+3	1.600E-4	
	6.058E+0	1.651E+3	3.200E-4	
	6.330E+0	1.580E+3	4.300E-4	
	6.466E+0	1.547E+3	4.400E-4	
	1.060E+1	9.434E+2	2.100E-1	
26 [40] Hordvik, A., et al., 1977		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficient; at low absorption levels, a CO laser with tunable discrete lines in the 5-6 μm region; both surface and bulk losses were determined using laser power of a few hundred milliwatts; surface absorption data extracted from a figure.
	6.466E+0	1.547E+3	1.410E-3	
	6.330E+0	1.580E+3	1.210E-3	
	6.058E+0	1.651E+3	4.610E-4	
	5.782E+0	1.730E+3	5.370E-4	
	5.488E+0	1.822E+3	6.070E-5	
	5.280E+0	1.894E+3	4.910E-5	
27 [42] Hordvik, A., Skolnik, H., 1977		(T = 300 K)		Standard commercial quality crystals; obtained in finished form from the A. Meller Company; sample size of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic technique was used to determine the absorption coefficients; the HF/DF laser used in the measurement was operated multiline for both HF and DF
	2.700E+0	3.704E+3	3.000E-4	
	3.800E+0	2.632E+3	1.200E-4	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
27 [42] (cont.)				measurements; typical laser power of 300 mW was adequate for the measurements; digitized bulk absorption data were given.
28 [42]		(T = 300 K)		Similar to above except for surface absorption; the letter "S" follow the absorption value denotes the loss per surface.
Hordvik, A.,	2.700E+0	3.704E+3	4.000E-4S	
et al.,	3.800E+0	2.632E+3	1.000E-4S	
1977				
29 [58]		(T = 300 K)		Thin film specimens of various thickness on sustrate of known reflectivity; the resultant reflectance as a function of sample thickness observed and absorption coefficient was determined; data extracted from a curve that best fit the experimental data.
Fabre, D.,	1.024E-1	9.766E+4	6.664E+5	
Romand, J.,	1.035E-1	9.662E+4	6.520E+5	
Vodar, B.,	1.052E-1	9.506E+4	6.223E+5	
1964	1.080E-1	9.259E+4	5.469E+5	
	1.097E-1	9.116E+4	5.063E+5	
	1.110E-1	9.009E+4	4.879E+5	
	1.124E-1	8.897E+4	4.796E+5	
	1.141E-1	8.764E+4	4.813E+5	
	1.168E-1	8.562E+4	5.186E+5	
	1.192E-1	8.389E+4	6.505E+5	
	1.221E-1	8.190E+4	7.986E+5	
	1.224E-1	8.170E+4	8.029E+5	
	1.229E-1	8.137E+4	7.883E+5	
	1.238E-1	8.078E+4	6.547E+5	
	1.259E-1	7.943E+4	4.931E+5	
	1.271E-1	7.868E+4	2.946E+5	
	1.282E-1	7.800E+4	2.294E+5	
	1.302E-1	7.680E+4	1.689E+5	
	1.338E-1	7.474E+4	1.249E+5	
	1.349E-1	7.413E+4	9.502E+4	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
29 [58] (cont.)	1.440E-1	6.944E+4	6.283E+4	
	1.498E-1	6.676E+4	3.943E+4	
	1.603E-1	6.238E+4	1.333E+4	
	1.636E-1	6.112E+4	1.152E+4	
	1.677E-1	5.963E+4	1.124E+4	
30 [10] Tomiki, T., Miyata, T., 1969		(T = 78 K)		Single crystal; ultraviolet quality; obtained from the Harshaw Chemical Co.; freshly cleaved plate specimen; absorption coefficient determined from transmission and reflectivity measurements; data extracted from a figure.
	1.155E-1	8.660E+4	3.696E+4	
	1.164E-1	8.588E+4	4.207E+4	
	1.169E-1	8.554E+4	4.246E+4	
	1.172E-1	8.531E+4	4.140E+4	
	1.175E-1	8.513E+4	3.997E+4	
	1.177E-1	8.496E+4	3.853E+4	
	1.181E-1	8.468E+4	3.856E+4	
	1.184E-1	8.446E+4	4.147E+4	
	1.186E-1	8.434E+4	4.148E+4	
	1.191E-1	8.396E+4	4.729E+4	
	1.195E-1	8.368E+4	5.346E+4	
	1.196E-1	8.363E+4	5.599E+4	
	1.202E-1	8.320E+4	6.868E+4	
	1.209E-1	8.272E+4	8.137E+4	
	1.214E-1	8.239E+4	8.682E+4	
	1.215E-1	8.228E+4	8.827E+4	
	1.218E-1	8.210E+4	8.431E+4	
	1.222E-1	8.181E+4	8.397E+4	
	1.225E-1	8.164E+4	8.146E+4	
	1.227E-1	8.151E+4	7.496E+4	
	1.229E-1	8.139E+4	6.991E+4	
	1.231E-1	8.122E+4	7.209E+4	
	1.233E-1	8.110E+4	6.921E+4	
	1.235E-1	8.098E+4	6.488E+4	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
30 [10] (cont.)	1.237E-1	8.086E+4	5.875E+4	
	1.238E-1	8.079E+4	5.297E+4	
	1.240E-1	8.065E+4	4.177E+4	
	1.241E-1	8.058E+4	3.708E+4	
	1.243E-1	8.047E+4	3.420E+4	
	1.244E-1	8.040E+4	2.878E+4	
	1.246E-1	8.027E+4	2.228E+4	
	1.248E-1	8.015E+4	1.976E+4	
	1.251E-1	7.991E+4	1.147E+4	
	1.253E-1	7.978E+4	4.972E+3	
	1.280E-1	7.810E+4	8.120E+1	
	1.282E-1	7.800E+4	5.600E+1	
	1.284E-1	7.790E+4	3.280E+1	
	1.289E-1	7.760E+4	1.740E+1	
	1.290E-1	7.750E+4	9.690E+0	
	1.295E-1	7.720E+4	7.050E+0	
	1.299E-1	7.700E+4	5.420E+0	
	1.304E-1	7.670E+4	3.950E+0	
	1.307E-1	7.650E+4	2.870E+0	
	1.314E-1	7.610E+4	2.100E+0	
	1.319E-1	7.580E+4	1.530E+0	
	1.326E-1	7.540E+4	1.310E+0	
	1.333E-1	7.500E+4	9.050E-1	
	1.342E-1	7.450E+4	6.610E-1	
	1.357E-1	7.370E+4	4.850E-1	
31 [10]		(T = 176 K)		Same as above.
Tomiki, T.,	1.304E-1	7.670E+4	5.680E+1	
et al.,	1.305E-1	7.660E+4	4.360E+1	
1969	1.309E-1	7.640E+4	2.850E+1	
	1.312E-1	7.620E+4	1.350E+1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
31 [10] (cont.)	1.314E-1	7.610E+4	9.330E+0	
	1.318E-1	7.590E+4	6.790E+0	
	1.319E-1	7.580E+4	4.940E+0	
	1.325E-1	7.550E+4	3.240E+0	
	1.326E-1	7.540E+4	2.910E+0	
	1.332E-1	7.510E+4	1.810E+0	
	1.339E-1	7.470E+4	1.190E+0	
	1.348E-1	7.420E+4	8.210E-1	
	1.357E-1	7.370E+4	6.000E-1	
	1.374E-1	7.280E+4	4.410E-1	
32 [10]		(T = 300 K)		Same as above.
Tomiki, T.,	1.170E-1	8.550E+4	5.042E+4	
et al.,	1.179E-1	8.481E+4	5.011E+4	
1969	1.184E-1	8.447E+4	4.978E+4	
	1.192E-1	8.391E+4	5.163E+4	
	1.201E-1	8.324E+4	5.747E+4	
	1.209E-1	8.273E+4	6.149E+4	
	1.214E-1	8.240E+4	6.657E+4	
	1.218E-1	8.207E+4	7.058E+4	
	1.223E-1	8.179E+4	7.277E+4	
	1.227E-1	8.151E+4	7.351E+4	
	1.234E-1	8.105E+4	7.283E+4	
	1.243E-1	8.047E+4	6.492E+4	
	1.249E-1	8.005E+4	5.411E+4	
	1.255E-1	7.969E+4	4.583E+4	
	1.259E-1	7.945E+4	3.970E+4	
	1.263E-1	7.916E+4	3.466E+4	
	1.266E-1	7.898E+4	3.106E+4	
	1.271E-1	7.868E+4	2.350E+4	
	1.281E-1	7.809E+4	1.234E+4	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
32 [10] (cont.)	1.344E-1	7.440E+4	5.250E+1	
	1.347E-1	7.425E+4	3.620E+1	
	1.348E-1	7.420E+4	2.930E+1	
	1.350E-1	7.410E+4	2.020E+1	
	1.355E-1	7.380E+4	1.250E+1	
	1.359E-1	7.360E+4	7.770E+0	
	1.361E-1	7.350E+4	6.290E+0	
	1.366E-1	7.320E+4	3.900E+0	
	1.372E-1	7.290E+4	1.670E+0	
	1.377E-1	7.260E+4	9.320E-1	
	1.387E-1	7.210E+4	4.940E-1	
	1.395E-1	7.170E+4	3.800E-1	
	1.403E-1	7.130E+4	3.260E-1	
	1.414E-1	7.070E+4	2.510E-1	
	1.428E-1	7.005E+4	2.530E-1	
	1.429E-1	7.000E+4	2.160E-1	
	1.431E-1	6.990E+4	2.160E-1	
	1.445E-1	6.920E+4	1.960E-1	
	1.456E-1	6.870E+4	1.590E-1	
	1.462E-1	6.840E+4	1.440E-1	
	1.471E-1	6.800E+4	1.300E-1	
	1.479E-1	6.760E+4	1.300E-1	
	1.497E-1	6.680E+4	1.390E-1	
	1.506E-1	6.640E+4	1.190E-1	
	1.517E-1	6.590E+4	9.660E-2	
	1.524E-1	6.560E+4	1.080E-1	
	1.534E-1	6.520E+4	9.740E-2	
	1.543E-1	6.480E+4	1.030E-1	
	1.553E-1	6.440E+4	1.140E-1	
	1.577E-1	6.340E+4	1.010E-1	
	1.585E-1	6.310E+4	1.010E-1	
	1.597E-1	6.260E+4	1.010E-1	
	1.610E-1	6.210E+4	1.020E-1	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
33 [10]		(T = 435 K)		Same as above.
Tomiki, T.,	1.374E-1	7.280E+4	7.370E+1	
et al.,	1.376E-1	7.270E+4	4.820E+1	
1969	1.379E-1	7.250E+4	3.900E+1	
	1.381E-1	7.240E+4	2.840E+1	
	1.387E-1	7.210E+4	1.670E+1	
	1.397E-1	7.160E+4	9.340E+0	
	1.399E-1	7.150E+4	7.560E+0	
	1.403E-1	7.130E+4	4.000E+0	
	1.408E-1	7.100E+4	2.620E+0	
	1.414E-1	7.070E+4	1.540E+0	
	1.422E-1	7.030E+4	9.580E-1	
	1.431E-1	6.990E+4	4.810E-1	
	1.445E-1	6.920E+4	2.420E-1	
	1.462E-1	6.840E+4	1.780E-1	
	1.471E-1	6.800E+4	1.790E-1	
	1.481E-1	6.750E+4	1.620E-1	
	1.488E-1	6.720E+4	1.540E-1	
	1.495E-1	6.690E+4	1.630E-1	
	1.506E-1	6.640E+4	1.550E-1	
	1.524E-1	6.560E+4	1.490E-1	
34 [10]		(T = 573 K)		Same as above.
Tomiki, T.,	1.412E-1	7.080E+4	4.930E+1	
et al.,	1.414E-1	7.070E+4	4.210E+1	
1969	1.418E-1	7.050E+4	3.410E+1	
	1.422E-1	7.030E+4	2.480E+1	
	1.425E-1	7.020E+4	1.800E+1	
	1.433E-1	6.980E+4	1.180E+1	
	1.435E-1	6.970E+4	8.600E+0	
	1.437E-1	6.960E+4	7.740E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
34 [10] (cont.)	1.443E-1	6.930E+4	5.640E+0	
	1.445E-1	6.920E+4	5.080E+0	
	1.447E-1	6.910E+4	4.100E+0	
	1.451E-1	6.890E+4	3.150E+0	
	1.458E-1	6.860E+4	2.420E+0	
	1.464E-1	6.830E+4	1.760E+0	
	1.471E-1	6.800E+4	1.160E+0	
	1.481E-1	6.750E+4	7.590E-1	
	1.488E-1	6.720E+4	5.250E-1	
	1.497E-1	6.680E+4	4.490E-1	
	1.506E-1	6.640E+4	4.060E-1	
	1.517E-1	6.590E+4	3.480E-1	
	1.524E-1	6.560E+4	3.140E-1	
	1.534E-1	6.520E+4	2.830E-1	
	1.543E-1	6.480E+4	2.300E-1	
35 [10]		(T = 300 K)		Similar to above except for a sample
Tomiki, T.,	1.361E-1	7.350E+4	1.030E+1	of Harshaw optical-quality plate.
et al.,	1.368E-1	7.310E+4	7.960E+0	
1969	1.376E-1	7.270E+4	6.170E+0	
	1.391E-1	7.190E+4	5.690E+0	
	1.406E-1	7.110E+4	6.230E+0	
	1.422E-1	7.030E+4	6.830E+0	
	1.437E-1	6.960E+4	7.810E+0	
	1.451E-1	6.890E+4	7.840E+0	
	1.475E-1	6.780E+4	8.250E+0	
	1.484E-1	6.740E+4	7.590E+0	
	1.495E-1	6.690E+4	6.410E+0	
	1.502E-1	6.660E+4	5.410E+0	
	1.508E-1	6.630E+4	4.190E+0	
	1.517E-1	6.590E+4	2.850E+0	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
35 [10] (cont.)	1.527E-1	6.550E+4	2.210E+0	
	1.536E-1	6.510E+4	1.940E+0	
	1.543E-1	6.480E+4	1.500E+0	
	1.555E-1	6.430E+4	1.220E+0	
	1.580E-1	6.330E+4	8.680E-1	
	1.600E-1	6.250E+4	6.750E-1	
	1.613E-1	6.200E+4	6.770E-1	
36 [62] Nisar, M., Robin, S., 1974		(T = 300 K)		Single crystal of ultraviolet quality procured from the Harshaw Chemical Company; cleaved in vacuum of about 10^{-5} torr and studied without being exposed in air; the cleaved specimens were left in the experimental chamber for sometime until objectional fluorescent disappeared; reflectance measurements at 20° incidence were carried out and the absorption coefficients were determined with the method of Kramers-kronig transformation; data extracted from a figure.
	1.269E-1	7.881E+4	1.535E+5	
	1.255E-1	7.970E+4	5.008E+5	
	1.241E-1	8.060E+4	6.077E+5	
	1.227E-1	8.152E+4	6.597E+5	
	1.213E-1	8.244E+4	5.760E+5	
	1.174E-1	8.518E+4	3.928E+5	
	1.098E-1	9.111E+4	1.912E+5	
	1.081E-1	9.248E+4	1.429E+5	
	1.060E-1	9.430E+4	2.382E+5	
	1.045E-1	9.567E+4	2.945E+5	
	1.031E-1	9.702E+4	4.609E+5	
	1.007E-1	9.928E+4	8.746E+5	
	9.891E-2	1.011E+5	1.355E+6	
	9.804E-2	1.020E+5	1.425E+6	
	9.718E-2	1.029E+5	1.380E+6	
	9.551E-2	1.047E+5	9.807E+5	
	9.461E-2	1.057E+5	9.162E+5	
	9.302E-2	1.075E+5	7.672E+5	
	9.225E-2	1.084E+5	6.825E+5	
	9.149E-2	1.093E+5	6.580E+5	
	9.033E-2	1.107E+5	7.594E+5	
	8.749E-2	1.143E+5	1.103E+6	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
36 [62] (cont.)	8.681E-2	1.152E+5	9.514E+5	
	8.540E-2	1.171E+5	9.341E+5	
	8.285E-2	1.207E+5	7.600E+5	
	8.130E-2	1.230E+5	7.063E+5	
	7.924E-2	1.262E+5	3.727E+5	
	7.758E-2	1.289E+5	2.366E+5	
	7.645E-2	1.308E+5	2.399E+5	
	7.593E-2	1.317E+5	2.598E+5	
	7.541E-2	1.326E+5	2.249E+5	
	7.519E-2	1.330E+5	3.744E+5	
	7.468E-2	1.339E+5	1.462E+6	
	7.369E-2	1.357E+5	1.595E+6	
	7.321E-2	1.366E+5	1.454E+6	
	7.300E-2	1.370E+5	1.224E+6	
	7.220E-2	1.385E+5	1.105E+6	
	7.102E-2	1.408E+5	8.879E+5	
	7.037E-2	1.421E+5	5.001E+5	
	6.969E-2	1.435E+5	3.444E+5	
	6.925E-2	1.444E+5	3.067E+5	
	6.882E-2	1.453E+5	5.515E+5	
	6.840E-2	1.462E+5	6.174E+5	
	6.793E-2	1.472E+5	4.771E+5	
	6.752E-2	1.481E+5	6.699E+4	
	6.711E-2	1.490E+5	1.872E+3	
	6.693E-2	1.494E+5	2.347E+5	
	6.653E-2	1.503E+5	2.985E+5	
	6.592E-2	1.517E+5	2.383E+5	
	6.553E-2	1.526E+5	4.526E+5	
	6.477E-2	1.544E+5	1.191E+6	
	6.439E-2	1.553E+5	1.479E+6	
	6.431E-2	1.555E+5	1.546E+6	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
36 [62] (cont.)	6.402E-2	1.562E+5	1.445E+6	
	6.325E-2	1.581E+5	8.661E+5	
	6.309E-2	1.585E+5	7.371E+5	
	6.254E-2	1.599E+5	6.531E+5	
	6.184E-2	1.617E+5	6.158E+5	
	6.046E-2	1.654E+5	4.447E+5	
	5.981E-2	1.672E+5	4.265E+5	
	5.900E-2	1.695E+5	5.516E+5	
	5.794E-2	1.726E+5	1.308E+6	
	5.731E-2	1.745E+5	1.811E+6	
	5.672E-2	1.763E+5	1.976E+6	
	5.643E-2	1.772E+5	1.739E+6	
	5.559E-2	1.799E+5	1.666E+6	
	5.531E-2	1.808E+5	1.575E+6	
	5.488E-2	1.822E+5	1.534E+6	
	5.328E-2	1.877E+5	1.870E+6	
	5.277E-2	1.895E+5	1.993E+6	
	5.203E-2	1.922E+5	1.809E+6	
	5.128E-2	1.950E+5	1.997E+6	
	5.081E-2	1.968E+5	2.015E+6	
	5.025E-2	1.990E+5	2.261E+6	
	4.990E-2	2.004E+5	2.335E+6	
	4.921E-2	2.032E+5	2.111E+6	
	4.824E-2	2.073E+5	1.979E+6	
	4.679E-2	2.137E+5	1.536E+6	
	4.621E-2	2.164E+5	1.403E+6	
	4.545E-2	2.200E+5	1.244E+6	
	4.462E-2	2.241E+5	1.329E+6	
	4.425E-2	2.260E+5	1.371E+6	
	4.355E-2	2.296E+5	1.203E+6	
	4.338E-2	2.305E+5	1.014E+6	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
36 [62] (cont.)	4.237E-2	2.360E+5	8.422E+5	
	4.125E-2	2.424E+5	7.280E+5	
	4.042E-2	2.474E+5	6.062E+5	
	4.019E-2	2.488E+5	5.752E+5	
	3.970E-2	2.519E+5	6.174E+5	
	3.940E-2	2.538E+5	6.952E+5	
	3.885E-2	2.574E+5	5.952E+5	
	3.851E-2	2.597E+5	1.681E+6	
	3.798E-2	2.633E+5	5.725E+5	
	3.758E-2	2.661E+5	5.818E+5	
37 [60]		(T = 10 K)		Single crystal samples; freshly cleaved surfaces; near normal (10°) reflection spectrum obtained; absorption coefficients were determined with the Roessler method; data extracted from a figure.
Ganin, V. A.,	1.443E-1	6.930E+4	1.132E+5	
Karin, M. G.,	1.323E-1	7.560E+4	2.413E+5	
Sidorin, V. K.,	1.301E-1	7.684E+4	7.242E+5	
Sidorin, K. K.,	1.241E-1	8.056E+4	2.261E+6	
Starostin, N. V.,	1.205E-1	8.302E+4	3.687E+6	
Startsev, G. P.,	1.204E-1	8.306E+4	2.655E+6	
Shepilov, M. P.,	1.168E-1	8.558E+4	2.803E+6	
1975	1.103E-1	9.064E+4	2.547E+6	
	1.074E-1	9.313E+4	3.413E+6	
	1.032E-1	9.688E+4	4.529E+6	
	1.019E-1	9.813E+4	4.817E+6	
	1.007E-1	9.935E+4	6.190E+6	
	9.940E-2	1.006E+5	6.659E+6	
	9.814E-2	1.019E+5	6.189E+6	
	9.461E-2	1.057E+5	3.383E+6	
	9.242E-2	1.082E+5	3.969E+6	
	8.826E-2	1.133E+5	5.474E+6	
	8.636E-2	1.158E+5	6.046E+6	
	8.453E-2	1.183E+5	5.625E+6	

TABLE 9. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
37 [60] (cont.)	8.361E-2	1.196E+5	4.665E+6	
	8.271E-2	1.209E+5	4.432E+6	
	7.862E-2	1.272E+5	4.567E+6	
	7.639E-2	1.309E+5	5.008E+6	
	7.508E-2	1.332E+5	6.543E+6	
	6.789E-2	1.473E+5	6.208E+6	
	7.153E-2	1.398E+5	5.019E+6	
	7.092E-2	1.410E+5	4.849E+6	
	6.729E-2	1.486E+5	5.455E+6	
	6.726E-2	1.489E+5	4.877E+6	
	6.618E-2	1.511E+5	4.960E+6	
	6.562E-2	1.524E+5	5.001E+6	
	6.456E-2	1.549E+5	5.687E+6	
	6.402E-2	1.562E+5	5.004E+6	
	6.301E-2	1.587E+5	4.965E+6	
	6.203E-2	1.612E+5	5.283E+6	
	6.109E-2	1.637E+5	6.775E+6	
	6.098E-2	1.640E+5	4.995E+6	
	6.013E-2	1.663E+5	3.911E+6	
	5.672E-2	1.763E+5	4.423E+6	

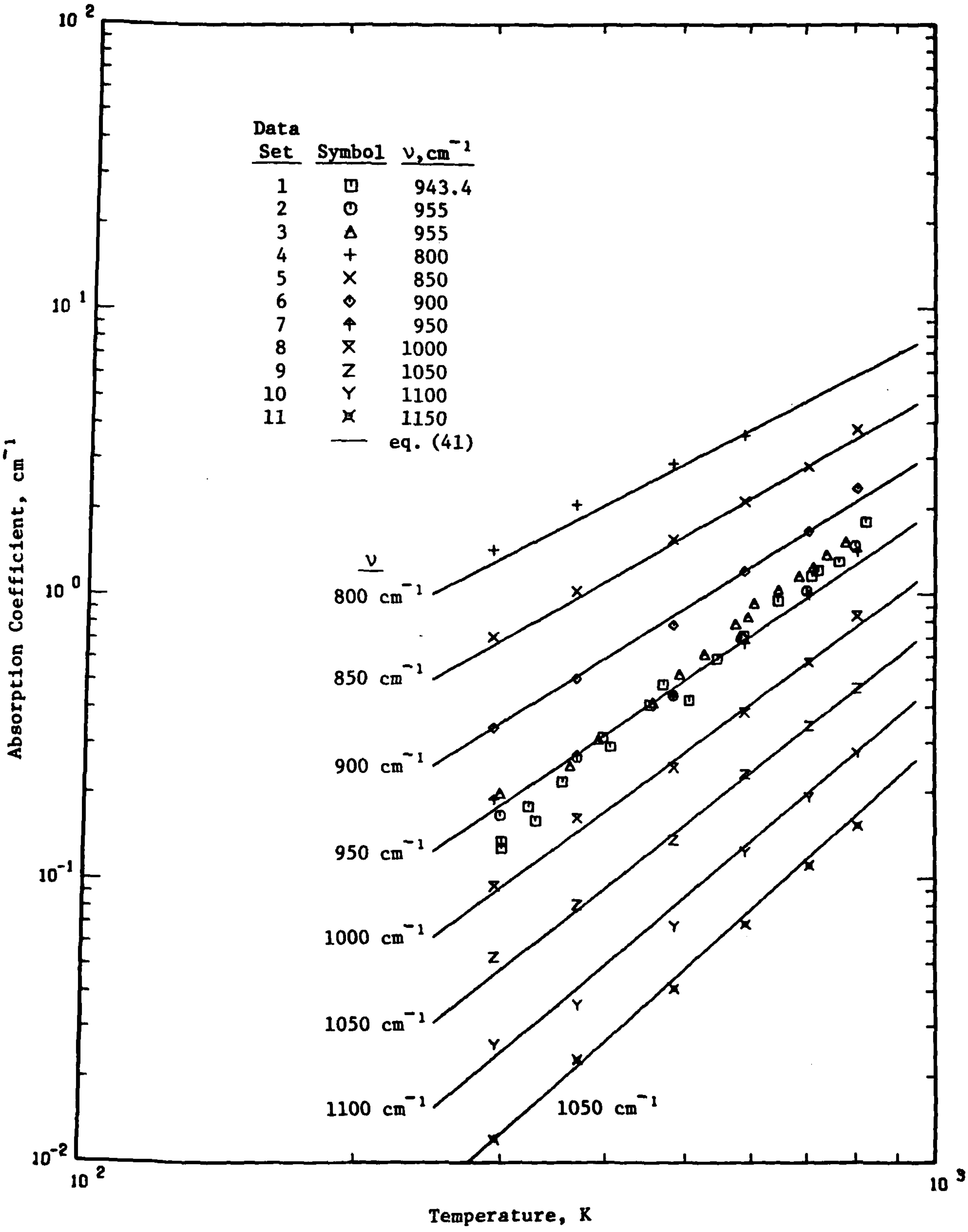

Figure 13. Absorption Coefficient of Barium Fluoride in the Multiphonon Region (Temperature Dependence)

TABLE 10. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (TEMPERATURE DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm^{-1}; Absorption Coefficient, α, cm^{-1}]

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
1 [61]	(ν = 943.4 cm^{-1})		Single crystal obtained from Hughes Research laboratory; sample thicknesses were so selected to provide adequate transmission over the temperature range of measurement and the absorption coefficients at room temperature agreed with values reported previously; absorption coefficients were determined with a simple laser transmission method using the relation where L is the thickness of the sample, τ the transmission, ρ the calculated single surface reflectivity, α the absorption coefficient; the laser power ranged from 2 to 4 watts; on recycling down to room temperature, the absorption level did not change; data extracted from a figure.
Chen, M.,	3.010E+2	1.280E-1	
Hass, M.,	3.010E+2	1.350E-1	
McGill, T. C.,	3.300E+2	1.600E-1	
1975	3.240E+2	1.790E-1	
	3.560E+2	2.200E-1	
	3.980E+2	3.140E-1	
	4.060E+2	2.910E-1	
	4.540E+2	4.080E-1	
	4.710E+2	4.830E-1	
	5.070E+2	4.240E-1	
	5.470E+2	5.930E-1	
	5.890E+2	7.150E-1	
	6.470E+2	9.470E-1	
	7.100E+2	1.160E+0	
	7.230E+2	1.210E+0	
	7.650E+2	1.300E+0	
	8.240E+2	1.790E+0	
2 [53]	(ν = 955 cm^{-1})		Single crystal samples cut from long rod of Optovac material on which previous room temperature measurements revealed no impurity bands in the frequency range of interest; samples of thicknesses 0.3 to 1.6 cm after polishing; direct spectrometer transmission method was used; absorption coefficients were
Lipson, H.,	3.000E+2	1.870E-1	
Bendow, B.,	3.700E+2	2.670E-1	
Skolnik, L.,	4.850E+2	4.420E-1	
Mitra, S.,	5.850E+2	7.000E-1	
Massa, N.,	7.000E+2	1.032E+0	
1976	8.000E+2	1.481E+0	

TABLE 10. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
2 [53] (cont.)			determined using a program which relates absorption, transmission, reflectivity and sample thickness, taking multiple internal reflections into account; data extracted from a figure.
3 [53]	(ν = 955 cm^{-1})		Similar to above except the method was laser calorimetry with laser power levels of 2 to 3 watt.
Lipson, H.,	3.000E+2	2.000E-1	
et al.,	3.630E+2	2.500E-1	
1976	3.930E+2	3.080E-1	
	4.580E+2	4.170E-1	
	4.930E+2	5.250E-1	
	5.280E+2	6.160E-1	
	5.760E+2	7.910E-1	
	5.960E+2	8.320E-1	
	6.060E+2	9.320E-1	
	6.480E+2	1.040E+0	
	6.860E+2	1.157E+0	
	7.130E+2	1.248E+0	
	7.400E+2	1.381E+0	
	7.800E+2	1.522E+0	
4 [53]	(ν = 800 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	1.434E+0	
et al.,	3.700E+2	2.064E+0	
1976	4.850E+2	2.872E+0	
	5.900E+2	3.612E+0	

TABLE 10. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
5 [53]	(ν = 850 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	7.090E-1	
et al.,	3.700E+2	1.025E+0	
1976	4.850E+2	1.559E+0	
	5.900E+2	2.121E+0	
	7.050E+2	2.806E+0	
	8.050E+2	3.791E+0	
6 [53]	(ν = 900 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	3.400E-1	
et al.,	3.700E+2	5.050E-1	
1976	4.850E+2	7.790E-1	
	5.900E+2	1.204E+0	
	7.050E+2	1.670E+0	
	8.050E+2	2.355E+0	
7 [53]	(ν = 950 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	1.900E-1	
et al.,	3.700E+2	2.720E-1	
1976	4.850E+2	4.380E-1	
	5.900E+2	6.710E-1	
	7.050E+2	1.000E+0	
	8.050E+2	1.411E+0	
8 [53]	(ν = 1000 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	9.400E-2	
et al.,	3.700E+2	1.630E-1	
1976	4.850E+2	2.460E-1	
	5.900E+2	3.840E-1	
	7.050E+2	5.760E-1	
	8.050E+2	8.370E-1	

TABLE 10. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF BARIUM FLUORIDE (TEMPERATURE DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	T	α	Specification and Remarks
9 [53]	(ν = 1050 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	5.300E-2	
et al.,	3.700E+2	8.100E-2	
1976	4.850E+2	1.370E-1	
	5.900E+2	2.330E-1	
	7.050E+2	3.440E-1	
	8.050E+2	4.680E-1	
10 [53]	(ν = 1100 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	2.600E-2	
et al.,	3.700E+2	3.600E-2	
1976	4.850E+2	6.800E-2	
	5.900E+2	1.240E-1	
	7.050E+2	1.930E-1	
	8.050E+2	2.760E-1	
11 [53]	(ν = 1150 cm^{-1})		Same as above.
Lipson, H.,	2.950E+2	1.200E-2	
et al.,	3.700E+2	2.300E-2	
1976	4.850E+2	4.100E-2	
	5.900E+2	6.900E-2	
	7.050E+2	1.110E-1	
	8.050E+2	1.530E-1	

4.4 Magnesium Fluoride, MgF_2

Magnesium fluoride is an anisotropic ionic crystal having a rutile structure. It has a large forbidden gap and hence it is transparent in the UV and is used as an optical material in this spectral region. It is of particular interest in vacuum UV spectroscopy because of its use as a reflective coating for mirrors and gratings. It has been found that a MgF_2 layer of suitable thickness, evaporated onto aluminum, retards oxidation of the aluminum and greatly increases the reflectance in the vacuum UV. The application of MgF_2 to an aluminum-surfaced replica grating results in a much improved efficiency down to 0.11 μm.

The crystal can be grown in vacuum using the Stockbarger technique. Large specimens with weight over 2 kg and diameter of about 10 cm are available. MgF_2 is a uniaxial positive crystal and is transparent from 0.11 to 7.5 μm. When used as a reflector, it is highly polarizing for wavelengths less than 0.124 μm. The absorption coefficient in the high-transparent infrared region 0.3–5 μm was found to be in the order of 10^{-4} cm^{-1}, compatible with the other alkaline earth fluorides. It is therefore considered among the window materials for chemical lasers. Available data on the absorption coefficient of MgF_2 are rather scanty and mostly were measured at 300 K as shown in Figures 14, 15, and 16 and in Table 11.

Stierwalt et al. [69] determined the absorption coefficient for a polycrystalline sample (Irtran 1) at three temperatures, 333, 393 and 453 K. The transmission method was used with an infrared spectrophotometer. In two spectral regions, 5.5-6.5 μm and 7.2-7.7 μm, the absorption coefficient values at different temperatures do not show any difference in their graphical presentation as shown in Figures 14 and 15. It appears that the sample they used is either quite impure or that a large number of defects were introduced in the manufacturing process. Only in the region between 7.2 and 7.7 μm, the spectrum shows some intrinsic features.

Rupprecht [45] reported optical constants for commercially available, hot-pressed, polycrystalline MgF_2 using spectral transmittance measurements. Motivated by the large discrepancies between the measured results and predictions from classical dispersion theory, he found that only by replacing the constant damping term in the classical equation by an exponentially varying frequency-dependent term, can reasonable agreement be obtained with dispersion theory. He found that the absorption index of MgF_2 varies with frequency according to the relation $\kappa(\nu)=\kappa_0$ exp $(^-\nu/\nu_0)$, where κ_0=30.9 and ν_0=103.9 cm^{-1}. After converting his absorption indices to absorption coefficients and plotting them together with those of other measurements, his data set exhibits a steeper slope as shown in Figure 15.

Similar to other fluorides, MgF_2 is highly transparent in the visible and near infrared regions and has low refractive indices at the chemical laser wavelengths. Deutsch [32], using the differential technique, measured absorption coefficients in the wavelength region from 5 to 8 μm, for radiation propagating along the c-axis. Although MgF_2 has a different crystal structure from that of other fluorides, the observed absorption coefficients decrease exponentially with increasing wavenumber as in the case of all the other fluorides. Absorption at several wavelengths in this region was also measured by Hordvik and Schlossberg [40] and Hordvik and Skolnik [42]. Their results show close agreement with those of Deutsch though the orientation of the samples they studied was not specified. It is noted from Figure 15 that the collective data can be best described with an exponential expression established by Deutsch [32], eq. (9) using the parameters given in Table 4.

Absorption coefficients at laser wavelengths 3.8 and 2.7 μm were given by Harrington et al. [48], Hordvik and Schlossler [40] and Hordvik and Skolnik [42]. It should be noted that in Figure 15, what is plotted at 3.8 and 2.7 μm are the total absorption of Harrington et al., as well as the separated bulk and surface absorptions from [40,42]. Clearly, the bulk absorption at 3.8 μm is intrinsic as predicted from the exponential relation, eq. (9). Hordvik and Skolnik also reported the absorption at 0.488 μm as indicated in Figure 14. The magnitude of value, 10^{-4} cm^{-1}, is the typical absorption observed in the transparent region.

In the ultraviolet region, the absorption spectrum was studied by Fabre et al. [58], Williams et al. [65], Stephan et al. [59], Hanson et al. [64], and Thomas et al. [66], whose results are plotted in Figures 14 and 16 and tabulated in Table

11. Their main concern was to investigate the spectral structures and the factors that give rise to these structures in the spectrum. Thus all the available data are for the ultraviolet wavelength region below 0.2 μm. Unlike the other fluorides, the absorption edge of MgF_2 was not systematically studied. Neither the Urbach rule was established nor the available data were adequate to carry out such analysis. Presently, reliable data in the absorption edge are still in need.

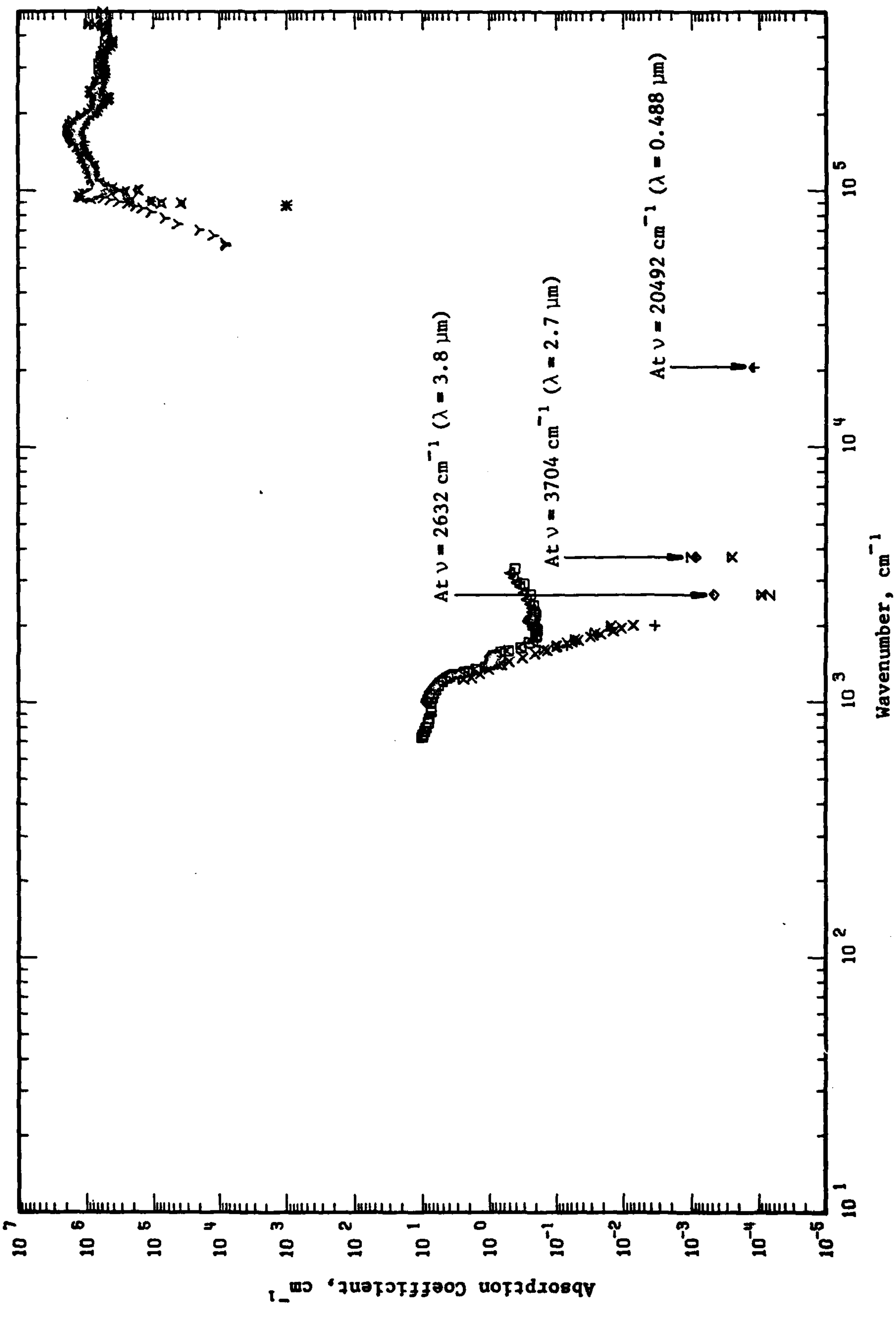

Figure 14. Absorption Coefficient of Magnesium Fluoride (Wavenumber Dependence)

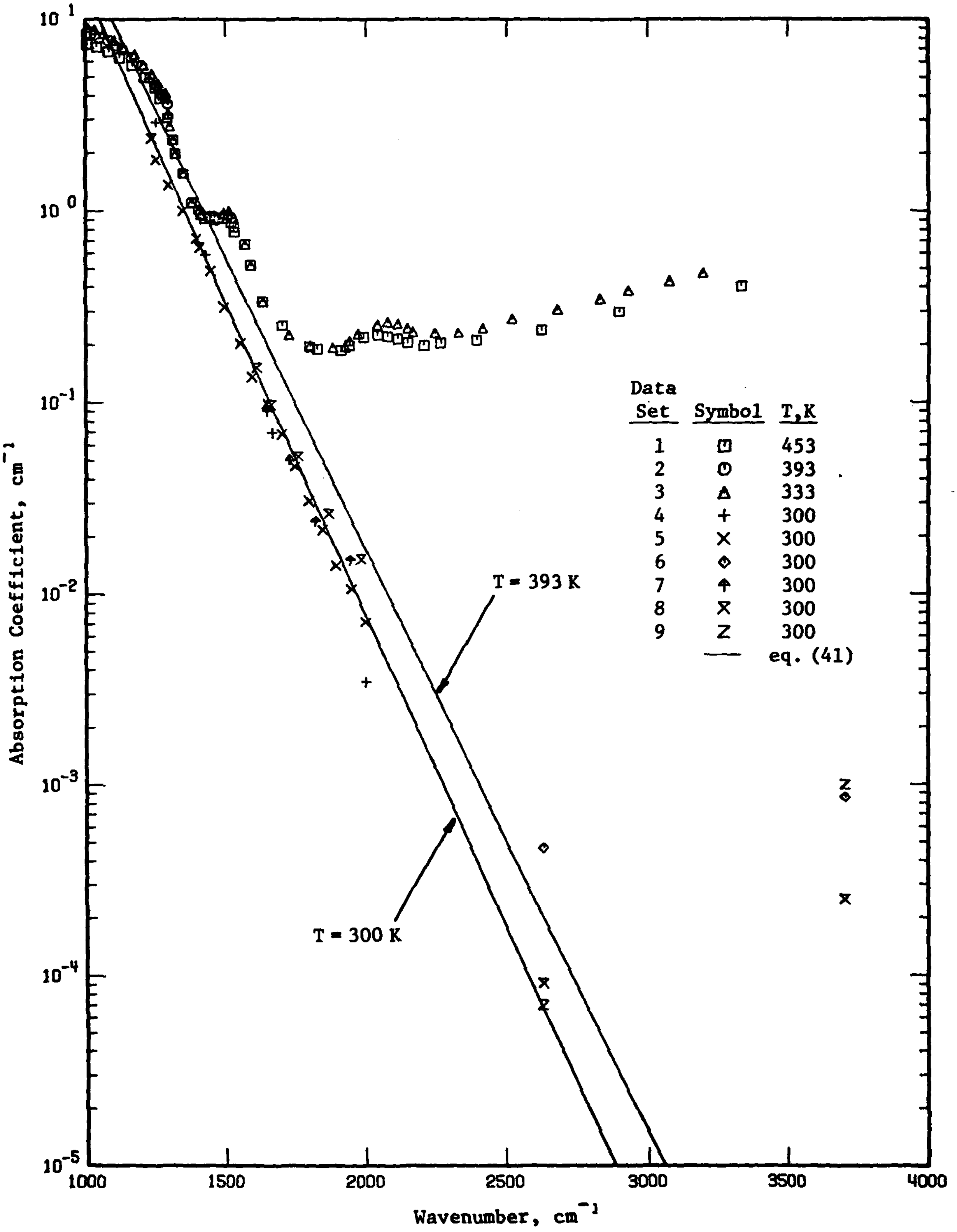

Figure 15. Absorption Coefficient of Magnesium Fluoride in the Multiphonon Region (Wavenumber Dependence)

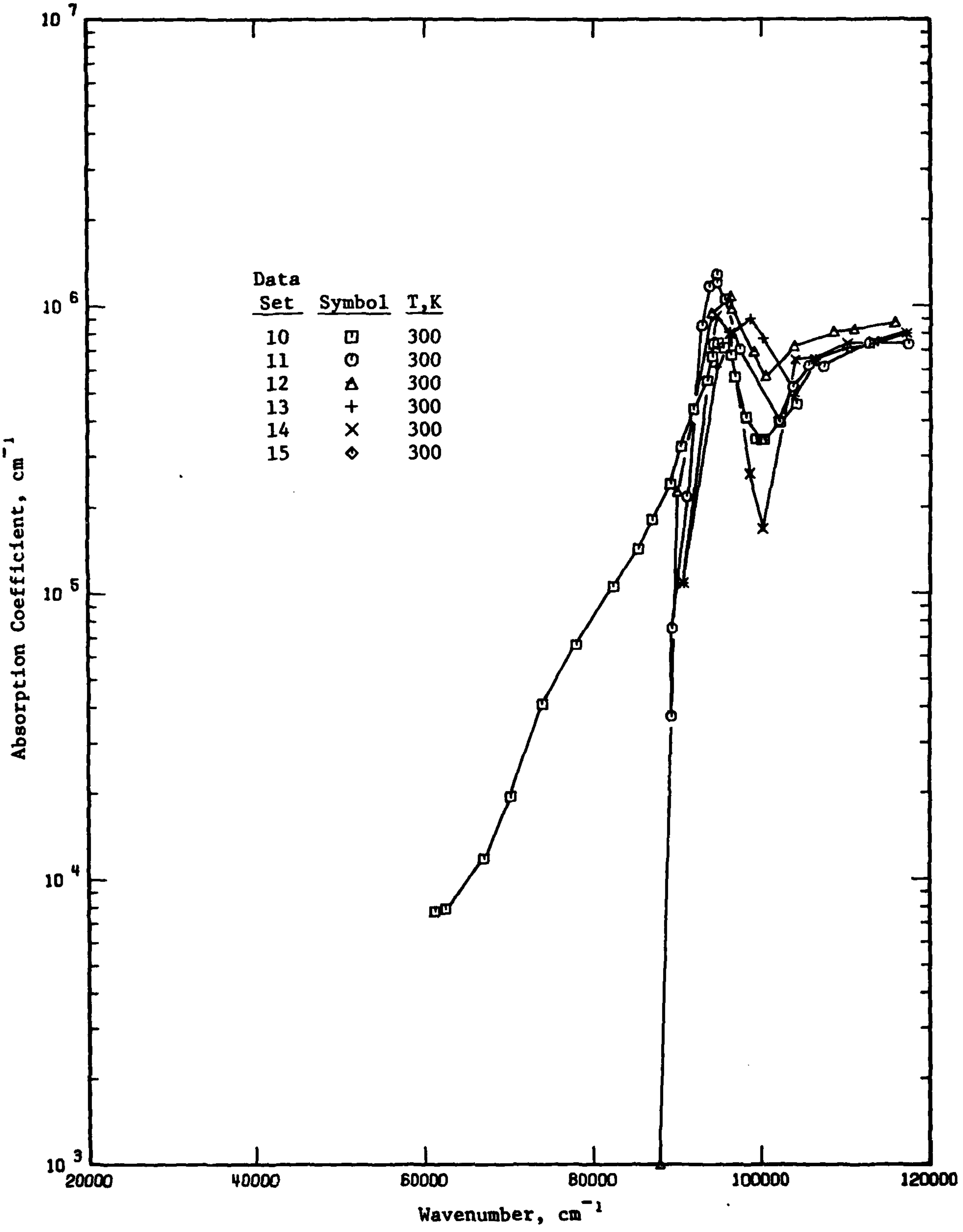

Figure 16. Absorption Coefficient of Magnesium Fluoride in the Urbach Tail Region (Wavenumber Dependence)

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE)

[Temperature, T, K; Wavelength, λ, μm; Wavenumber, ν, cm^{-1}; Absorption Coefficient, α, cm^{-1}]

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [69]		(T = 453 K)		Hot-pressed magnesium fluoride (Irtran 1); plate specimen of 2 mm thick; transmission methode was used with a spectrophotometer; data taken from a figure; in the spectral ranges 5.8-6.5 μm and 7.2-7.7 μm, the values of absorption coefficient measured at different temperatures are the same.
Stierwalt, D. L.,	3.000E+0	3.333E+3	4.040E-1	
Bernstein, J. B.,	3.450E+0	2.899E+3	2.970E-1	
Kirk, D. D.,	3.810E+0	2.625E+3	2.370E-1	
1983	4.180E+0	2.392E+3	2.120E-1	
	4.420E+0	2.262E+3	2.040E-1	
	4.540E+0	2.203E+3	1.980E-1	
	4.660E+0	2.146E+3	2.040E-1	
	4.740E+0	2.110E+3	2.150E-1	
	4.820E+0	2.075E+3	2.210E-1	
	4.900E+0	2.041E+3	2.240E-1	
	5.020E+0	1.992E+3	2.180E-1	
	5.150E+0	1.942E+3	1.980E-1	
	5.230E+0	1.912E+3	1.870E-1	
	5.470E+0	1.828E+3	1.900E-1	
	5.550E+0	1.802E+3	1.950E-1	
	5.870E+0	1.704E+3	2.510E-1	
	6.120E+0	1.634E+3	3.360E-1	
	6.280E+0	1.592E+3	5.180E-1	
	6.360E+0	1.572E+3	6.660E-1	
	6.530E+0	1.531E+3	7.770E-1	
	6.570E+0	1.522E+3	8.680E-1	
	6.690E+0	1.495E+3	9.060E-1	
	6.770E+0	1.477E+3	9.060E-1	
	6.850E+0	1.460E+3	8.930E-1	
	7.010E+0	1.427E+3	9.050E-1	
	7.090E+0	1.410E+3	9.570E-1	
	7.250E+0	1.379E+3	1.100E+0	
	7.420E+0	1.348E+3	1.560E+0	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
1 [69] (cont.)	7.580E+0	1.319E+3	1.980E+0	
	7.620E+0	1.312E+3	2.340E+0	
	7.740E+0	1.292E+3	3.050E+0	
	7.910E+0	1.264E+3	3.860E+0	
	8.030E+0	1.245E+3	4.380E+0	
	8.270E+0	1.209E+3	4.970E+0	
	8.590E+0	1.164E+3	5.710E+0	
	8.920E+0	1.121E+3	6.290E+0	
	9.240E+0	1.082E+3	6.750E+0	
	9.610E+0	1.041E+3	7.130E+0	
	9.930E+0	1.007E+3	7.340E+0	
	1.050E+1	9.524E+2	7.440E+0	
	1.090E+1	9.174E+2	7.440E+0	
	1.160E+1	8.621E+2	7.970E+0	
	1.200E+1	8.333E+2	8.190E+0	
	1.260E+1	7.937E+2	8.780E+0	
	1.300E+1	7.692E+2	9.290E+0	
	1.340E+1	7.463E+2	9.820E+0	
	1.370E+1	7.299E+2	1.010E+1	
2 [69]		(T = 393 K)		Similar to above.
Stierwalt, D. L.,				
et al.,	6.530E+0	1.531E+3	8.210E-1	
1963	6.570E+0	1.522E+3	9.180E-1	
	6.610E+0	1.513E+3	9.440E-1	
	6.690E+0	1.495E+3	9.440E-1	
	6.850E+0	1.460E+3	9.310E-1	
	6.930E+0	1.443E+3	9.310E-1	
	7.050E+0	1.418E+3	9.440E-1	
	7.130E+0	1.403E+3	1.010E+0	
	7.250E+0	1.379E+3	1.100E+0	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
2 [69] (cont.)	7.420E+0	1.348E+3	1.560E+0	
	7.580E+0	1.319E+3	1.980E+0	
	7.620E+0	1.312E+3	2.340E+0	
	7.740E+0	1.292E+3	3.600E+0	
	7.870E+0	1.271E+3	4.030E+0	
	7.990E+0	1.252E+3	4.500E+0	
	8.150E+0	1.227E+3	4.970E+0	
	8.350E+0	1.198E+3	5.710E+0	
	8.600E+0	1.163E+3	6.290E+0	
	8.840E+0	1.131E+3	6.940E+0	
	9.040E+0	1.106E+3	7.240E+0	
	9.240E+0	1.082E+3	7.760E+0	
	9.530E+0	1.049E+3	7.980E+0	
	9.690E+0	1.032E+3	8.200E+0	
	9.970E+0	1.003E+3	8.430E+0	
3 [69]		(T = 333 K)		Similar to above.
Stierwalt, D. L.,	3.130E+0	3.195E+3	4.710E-1	
et al.,	3.250E+0	3.077E+3	4.270E-1	
1983	3.410E+0	2.933E+3	3.820E-1	
	3.530E+0	2.833E+3	3.460E-1	
	3.730E+0	2.681E+3	3.050E-1	
	3.970E+0	2.519E+3	2.730E-1	
	4.140E+0	2.415E+3	2.440E-1	
	4.300E+0	2.326E+3	2.310E-1	
	4.460E+0	2.242E+3	2.310E-1	
	4.620E+0	2.165E+3	2.340E-1	
	4.660E+0	2.146E+3	2.440E-1	
	4.740E+0	2.110E+3	2.580E-1	
	4.820E+0	2.075E+3	2.620E-1	
	4.900E+0	2.041E+3	2.550E-1	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
3 [69] (cont.)	5.070E+0	1.972E+3	2.280E-1	
	5.150E+0	1.942E+3	2.090E-1	
	5.190E+0	1.927E+3	1.950E-1	
	5.310E+0	1.883E+3	1.930E-1	
	5.550E+0	1.802E+3	1.980E-1	
	5.790E+0	1.727E+3	2.240E-1	
	6.120E+0	1.634E+3	3.360E-1	
	6.280E+0	1.592E+3	5.180E-1	
	6.360E+0	1.572E+3	6.660E-1	
	6.530E+0	1.531E+3	9.180E-1	
	6.610E+0	1.513E+3	9.990E-1	
	6.690E+0	1.495E+3	9.710E-1	
	6.770E+0	1.477E+3	9.180E-1	
	6.930E+0	1.443E+3	9.180E-1	
	7.090E+0	1.410E+3	9.570E-1	
	7.130E+0	1.403E+3	1.010E+0	
	7.250E+0	1.379E+3	1.100E+0	
	7.420E+0	1.348E+3	1.560E+0	
	7.580E+0	1.319E+3	1.980E+0	
	7.620E+0	1.312E+3	2.340E+0	
	7.700E+0	1.299E+3	2.760E+0	
	7.740E+0	1.292E+3	3.180E+0	
	7.780E+0	1.285E+3	3.860E+0	
	7.790E+0	1.284E+3	4.090E+0	
	7.950E+0	1.258E+3	4.630E+0	
	8.110E+0	1.233E+3	5.180E+0	
	8.310E+0	1.203E+3	5.790E+0	
	8.510E+0	1.175E+	6.560E+0	
	8.800E+0	1.136E+3	7.140E+0	
	9.080E+0	1.101E+3	7.760E+0	
	9.410E+0	1.063E+3	8.440E+0	
	9.690E+0	1.032E+3	8.800E+0	
	9.930E+0	1.007E+3	9.040E+0	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
4 [45]		(T = 300 K)		Commercial hot-pressed polycrystalline; sample thickness ranging from about 1 cm to 10^{-3} cm with parallel and highly polished surfaces; transmittances were measure and absorption coefficients were determined according to eq. (18); it was found that absorption index, κ, and wavenumber are related by the expression $\kappa=\kappa_0\exp(-\nu/\nu_0)$, where $\kappa_0=30.9$ and $\nu_0=103.9$ cm^{-1}; data were calculated according to this equation; wavelength region was not given, 5 – 8 μm was assumed.
Rupprecht, G.,	5.000E+0	2.000E+3	3.436E-3	
1964	6.000E+0	1.667E+3	6.969E-2	
	7.000E+0	1.429E+3	5.903E-1	
	8.000E+0	1.250E+3	2.892E+0	
5 [32]		(T = 300 K)		Single crystals; obtained from the Harshaw Chemical Co.; typical sample dimensions 2.54 cm diameter and 2.54 cm thick; transmission measured with differential technique and absorption coefficient calculated by eq. (31); uncertainties of α in high transparent and low transparent regions are respectively about 10% and 3%; data taken from a figure; E-vector along c-axis.
Deutsch, T. F.,	5.000E+0	2.000E+3	7.100E-3	
1973	5.130E+0	1.949E+3	1.060E-2	
	5.280E+0	1.894E+3	1.400E-2	
	5.410E+0	1.848E+3	2.160E-2	
	5.560E+0	1.799E+3	3.070E-2	
	5.720E+0	1.748E+3	4.630E-2	
	5.880E+0	1.701E+3	6.860E-2	
	6.060E+0	1.650E+3	9.790E-2	
	6.260E+0	1.597E+3	1.361E-1	
	6.440E+0	1.553E+3	2.037E-1	
	6.680E+0	1.497E+3	3.141E-1	
	6.910E+0	1.447E+3	4.864E-1	
	7.170E+0	1.395E+3	7.145E-1	
	7.430E+0	1.346E+3	9.977E-1	
	7.720E+0	1.295E+3	1.358E+0	
	8.000E+0	1.250E+3	1.853E+0	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
6 [48]		(T = 300 K)		Commercial sample obtained from the Optovac Inc.; total absorption coefficient determined by the calorimeter method; data extracted from a table; temperature not given, 300 K assumed.
Harrington, J. A.	3.799E+0	2.632E+3	4.660E-4	
Bendow, B.,	2.700E+0	3.704E+3	8.610E-4	
Namjoshi, K. V.,				
Mitra, S. S.,				
Stierwalt, D. L.,				
1975				
7 [40]		(T = 300 K)		Crystal window sample of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic calorimetry was used to determine the absorption coefficients; CO_2, CO and Ar cw lasers were used; both surface and bulk losses were determined; bulk absorption data extracted from a table.
Hordvik, A.,	4.880E-1	2.049E+4	1.200E-4	
Schlossberg, H.,	5.246E+0	1.943E+3	1.500E-2	
1977	5.488E+0	1.822E+3	2.400E-2	
	5.782E+0	1.730E+3	5.000E-2	
	6.058E+0	1.651E+3	9.000E-2	
8 [42]		(T = 300 K)		Standard commercial quality crystals; obtained in finished form from the A. Meller Company; sample size of 5 x 12.5 mm surface and 10 mm thick; the photoacoustic technique was used to determine the absorption coefficients; the *HF/DF* laser used in the measurement was operated multiline for both HF and DF measurements; typical laser power of 300 mW was adequate for the measurements; digitized bulk absorption data were given; values at other wavelengths were taken from a figure.
Hordvik, A.,	2.700E+0	3.704E+3	2.500E-4	
Skolnik, L.,	3.800E+0	2.632E+3	9.100E-5	
1977	5.045E+0	1.982E+3	1.510E-2	
	5.350E+0	1.869E+3	2.618E-2	
	5.685E+0	1.759E+3	5.200E-2	
	6.010E+0	1.664E+3	9.727E-2	
	6.200E+0	1.613E+3	1.514E-1	
	7.097E+0	1.409E+3	6.427E-1	
	8.104E+0	1.234E+3	2.393E+0	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
9 [42]		(T = 300 K)		Similar to above except for surface absorption; the letter "S" follow the absorption value denotes the loss per surface.
Hordvik, A.,	2.700E+0	3.704E+3	1.000E-3	
et al.,	3.800E+0	2.632E+3	7.000E-5	
1977				
10 [58]		(T = 300 K)		Thin film specimens of various thickness on sustrate of known reflectivity; the resultant reflectance as a function of sample thickness observed and absorption coefficient was determined; data extracted from a curve which best fit the experimental data.
Fabre, D.,	9.600E-2	1.042E+5	4.555E+5	
Romand, J.,	9.790E-2	1.021E+5	3.941E+5	
Vodar, B.,	9.970E-2	1.003E+5	3.428E+5	
1964	1.000E-1	1.000E+5	3.418E+5	
	1.006E-1	9.940E+4	3.435E+5	
	1.018E-1	9.823E+4	4.086E+5	
	1.032E-1	9.690E+4	5.662E+5	
	1.037E-1	9.643E+4	6.738E+5	
	1.046E-1	9.560E+4	7.136E+5	
	1.054E-1	9.488E+4	7.440E+5	
	1.060E-1	9.434E+4	7.362E+5	
	1.061E-1	9.425E+4	6.656E+5	
	1.068E-1	9.363E+4	5.483E+5	
	1.087E-1	9.200E+4	4.370E+5	
	1.106E-1	9.042E+4	3.238E+5	
	1.122E-1	8.913E+4	2.397E+5	
	1.150E-1	8.696E+4	1.803E+5	
	1.171E-1	8.540E+4	1.427E+5	
	1.214E-1	8.237E+4	1.056E+5	
	1.281E-1	7.806E+4	6.573E+4	
	1.351E-1	7.402E+4	4.093E+4	
	1.424E-1	7.022E+4	1.941E+4	
	1.491E-1	6.707E+4	1.180E+4	
	1.600E-1	6.250E+4	7.854E+3	
	1.633E-1	6.124E+4	7.695E+3	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
11 [65]		(T = 300 K)		Single crystal obtained from Alpha Inorganics, Inc.; density of 3.13 gm cm^{-3}; mechanically polished using 0.5 μm grit until no scratches were seen under 200 x microscope; rotation of the sample through 90° about an axis along the direction of the incident light produced no change in the observed reflectance; reflectance measurements made at 20°, 70° and 75° angle of incidence; absorption coefficients were determined using the Fresnels equations; data extracted from a figure.
Williams, M. W.,	1.120E-1	8.930E+4	3.706E+4	
MacRae, R. A.,	1.119E-1	8.937E+4	7.525E+4	
Arakawa, E. T.,	1.097E-1	9.118E+4	2.166E+5	
1967	1.076E-1	9.298E+4	8.565E+5	
	1.065E-1	9.389E+4	1.167E+6	
	1.055E-1	9.479E+4	1.284E+6	
	1.054E-1	9.485E+4	1.204E+6	
	1.045E-1	9.569E+4	1.056E+6	
	1.026E-1	9.750E+4	7.082E+5	
	9.804E-2	1.020E+5	3.987E+5	
	9.634E-2	1.038E+5	5.218E+5	
	9.470E-2	1.056E+5	6.198E+5	
	9.311E-2	1.074E+5	6.156E+5	
	8.865E-2	1.128E+5	7.402E+5	
	8.518E-2	1.174E+5	7.374E+5	
	8.203E-2	1.219E+5	8.331E+5	
	8.143E-2	1.228E+5	8.393E+5	
	8.026E-2	1.246E+5	8.344E+5	
	7.800E-2	1.282E+5	8.763E+5	
	7.692E-2	1.300E+5	9.621E+5	
	7.536E-2	1.327E+5	1.056E+6	
	7.435E-2	1.345E+5	1.146E+6	
	7.241E-2	1.381E+5	1.139E+6	
	6.969E-2	1.435E+5	1.183E+6	
	6.757E-2	1.480E+5	1.323E+6	
	6.477E-2	1.544E+5	1.488E+6	
	6.365E-2	1.571E+5	1.536E+6	
	6.188E-2	1.616E+5	1.602E+6	
	6.120E-2	1.634E+5	1.665E+6	
	6.086E-2	1.643E+5	1.697E+6	

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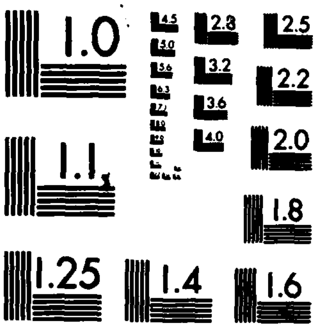
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5.0
5.6
6.3
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3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
11 [65] (cont.)	5.924E-2	1.688E+5	1.744E+6	
	5.770E-2	1.733E+5	1.743E+6	
	5.540E-2	1.805E+5	1.513E+6	
	5.152E-2	1.941E+5	1.139E+6	
	5.013E-2	1.995E+5	9.201E+5	
	4.838E-2	2.067E+5	8.079E+5	
	4.715E-2	2.121E+5	7.411E+5	
	4.634E-2	2.158E+5	7.239E+5	
	4.502E-2	2.221E+5	7.144E+5	
12 [59]		(T = 300 K)		Single crystal; no details on the sample were given; reflection spectra at incident angles of 20°, 45°, 60° and 70° were obtained; absorption coefficients were determined using Fresnel Formulae; data extracted from a figure.
Stephan, G.,	2.614E-2	3.825E+5	4.070E+5	
Le Calvez, Y.,	2.665E-2	3.753E+5	4.060E+5	
Lemonier, J. C.,	2.744E-2	3.644E+5	4.340E+5	
Robin, S.,	2.838E-2	3.524E+5	4.920E+5	
1969	2.878E-2	3.475E+5	5.510E+5	
	2.898E-2	3.451E+5	5.510E+5	
	2.938E-2	3.404E+5	5.350E+5	
	3.034E-2	3.296E+5	5.340E+5	
	3.173E-2	3.152E+5	5.460E+5	
	3.223E-2	3.103E+5	5.760E+5	
	3.298E-2	3.032E+5	5.440E+5	
	3.406E-2	2.936E+5	5.130E+5	
	3.434E-2	2.912E+5	5.430E+5	
	3.492E-2	2.864E+5	5.120E+5	
	3.613E-2	2.768E+5	5.400E+5	
	3.676E-2	2.720E+5	5.700E+5	
	3.795E-2	2.635E+5	6.880E+5	
	3.831E-2	2.610E+5	7.030E+5	
	3.883E-2	2.575E+5	6.570E+5	
	3.937E-2	2.540E+5	5.970E+5	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
12 [59] (cont.)	3.975E-2	2.516E+5	5.660E+5	
	4.014E-2	2.491E+5	6.110E+5	
	4.117E-2	2.429E+5	8.200E+5	
	4.137E-2	2.417E+5	8.650E+5	
	4.198E-2	2.382E+5	8.040E+5	
	4.323E-2	2.313E+5	4.730E+5	
	4.369E-2	2.289E+5	4.430E+5	
	4.415E-2	2.265E+5	4.730E+5	
	4.513E-2	2.216E+5	5.620E+5	
	4.587E-2	2.180E+5	5.610E+5	
	4.719E-2	2.119E+5	6.500E+5	
	4.946E-2	2.022E+5	7.540E+5	
	5.099E-2	1.961E+5	8.730E+5	
	5.233E-2	1.911E+5	1.082E+6	
	5.299E-2	1.887E+5	1.067E+6	
	5.365E-2	1.864E+5	1.021E+6	
	5.368E-2	1.863E+5	1.126E+6	
	5.444E-2	1.837E+5	1.246E+6	
	5.513E-2	1.814E+5	1.201E+6	
	5.587E-2	1.790E+5	1.185E+6	
	5.708E-2	1.752E+5	1.350E+6	
	5.787E-2	1.728E+5	1.379E+6	
	5.824E-2	1.717E+5	1.319E+6	
	5.907E-2	1.693E+5	1.259E+6	
	5.945E-2	1.682E+5	1.229E+6	
	5.988E-2	1.670E+5	1.258E+6	
	6.035E-2	1.657E+5	1.318E+6	
	6.211E-2	1.610E+5	1.258E+6	
	6.309E-2	1.585E+5	1.317E+6	
	6.353E-2	1.574E+5	1.257E+6	
	6.402E-2	1.562E+5	1.167E+6	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
12 [59] (cont.)	6.605E-2	1.514E+5	1.181E+6	
	6.707E-2	1.491E+5	1.151E+6	
	6.766E-2	1.478E+5	1.195E+6	
	6.930E-2	1.443E+5	1.150E+6	
	7.047E-2	1.419E+5	1.150E+6	
	7.168E-2	1.395E+5	1.089E+6	
	7.289E-2	1.372E+5	1.059E+6	
	7.418E-2	1.348E+5	1.058E+6	
	7.553E-2	1.324E+5	1.058E+6	
	7.764E-2	1.288E+5	9.980E+5	
	7.905E-2	1.265E+5	9.670E+5	
	8.217E-2	1.217E+5	9.660E+5	
	8.299E-2	1.205E+5	9.060E+5	
	8.636E-2	1.158E+5	8.750E+5	
	9.009E-2	1.110E+5	8.300E+5	
	9.208E-2	1.086E+5	8.140E+5	
	9.625E-2	1.039E+5	7.240E+5	
	9.950E-2	1.005E+5	5.730E+5	
	1.009E-1	9.915E+4	6.930E+5	
	1.037E-1	9.647E+4	9.780E+5	
	1.038E-1	9.636E+4	1.083E+6	
	1.063E-1	9.410E+4	9.470E+5	
	1.111E-1	9.002E+4	2.260E+5	
	1.138E-1	8.784E+4	1.000E+3	
13 [64]		(T = 300 K)		Single crystal obtained from Alpha
Hanson, W. F.,	6.263E-2	1.597E+5	1.531E+6	Inorganics, Inc.; polished with 0.5
Arakawa, E. T.,	6.049E-2	1.653E+5	1.653E+6	μm grit until no scratches were
Williams, M. W.,	5.849E-2	1.710E+5	1.788E+6	seen under 200 x magnification;
1972	5.511E-2	1.815E+5	1.670E+6	cleaned by washing with alcohol and
	5.345E-2	1.871E+5	1.514E+6	then suspended in the saturated vapor

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
13 [64] (cont.)	5.124E-2	1.952E+5	1.170E+6	above a boiling alcohol bath and immediately transferred into the reflectance chamber; reflectance was measured at 12 angles of incidence from 20° to 75°; absorption coefficients were determined by a two-parameter least-squares fit to Fresnels equations; data extracted from a figure.
	5.020E-2	1.992E+5	8.861E+5	
	4.733E-2	2.113E+5	7.275E+5	
	4.509E-2	2.218E+5	7.163E+5	
	4.397E-2	2.274E+5	7.030E+5	
	4.351E-2	2.298E+5	6.382E+5	
	4.321E-2	2.315E+5	6.167E+5	
	4.106E-2	2.435E+5	6.915E+5	
	4.039E-2	2.476E+5	7.032E+5	
	3.851E-2	2.597E+5	6.233E+5	
	3.735E-2	2.677E+5	5.887E+5	
	3.584E-2	2.790E+5	6.030E+5	
	3.388E-2	2.952E+5	6.380E+5	
	3.238E-2	3.089E+5	6.405E+5	
	3.002E-2	3.331E+5	5.944E+5	
	2.655E-2	3.766E+5	5.206E+5	
	2.436E-2	4.105E+5	4.895E+5	
	2.380E-2	4.202E+5	4.911E+5	
	2.322E-2	4.306E+5	5.032E+5	
	2.313E-2	4.323E+5	5.058E+5	
	2.292E-2	4.363E+5	5.702E+5	
	2.284E-2	4.379E+5	7.374E+5	
	2.263E-2	4.419E+5	9.052E+5	
	2.250E-2	4.444E+5	5.199E+5	
	2.222E-2	4.500E+5	5.050E+5	
	2.202E-2	4.540E+5	5.095E+5	
	2.153E-2	4.645E+5	5.000E+5	
	2.127E-2	4.702E+5	5.058E+5	
	2.102E-2	4.758E+5	5.232E+5	
	2.056E-2	4.863E+5	5.708E+5	
	2.023E-2	4.944E+5	5.560E+5	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
13 [64] (cont.)	1.962E-2	5.097E+5	4.836E+5	
	1.917E-2	5.218E+5	4.865E+5	
	1.879E-2	5.323E+5	4.642E+5	
	1.805E-2	5.540E+5	3.585E+5	
	1.715E-2	5.831E+5	6.595E+5	
	1.669E-2	5.992E+5	5.836E+5	
	1.642E-2	6.089E+5	5.635E+5	
	1.610E-2	6.210E+5	4.589E+5	
	1.574E-2	6.355E+5	5.119E+5	
	1.499E-2	6.669E+5	3.662E+5	
14 [66] Thomas, J., Stephan, G., Lemonnier, J. C., Nisar, M., Robin, S., 1973		(T = 300 K)		Single crystal obtained from Harshaw Chemical Co.; disc specimen with optical axis parallel to the polished faces; reflectances were measured every 5° (from 25° to 55°) for the positions of optical axis perpendicular and parallel to the plane of incidence and for the position of the plane of incidence perpendicular and parallel to the grating lines of the monochromator; absorption coefficients were determined by the least-squares fit to the Fresnels formulae; data for ordinary ray extracted from a figure.
	1.102E-1	9.075E+4	1.083E+5	
	1.056E-1	9.473E+4	6.142E+5	
	1.038E-1	9.631E+4	8.097E+5	
	1.014E-1	9.866E+4	9.013E+5	
	9.980E-2	1.002E+5	7.704E+5	
	9.615E-2	1.040E+5	4.862E+5	
	9.398E-2	1.064E+5	6.509E+5	
	9.074E-2	1.102E+5	7.148E+5	
	8.826E-2	1.133E+5	7.349E+5	
	8.532E-2	1.172E+5	8.014E+5	
	8.313E-2	1.203E+5	8.377E+5	
	8.000E-2	1.250E+5	9.000E+5	
	7.716E-2	1.296E+5	9.954E+5	
	7.402E-2	1.351E+5	1.069E+6	
	7.158E-2	1.397E+5	1.104E+6	
	6.925E-2	1.444E+5	1.090E+6	
	6.711E-2	1.490E+5	1.052E+6	
	6.506E-2	1.537E+5	1.029E+6	
	6.254E-2	1.599E+5	1.147E+6	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
14 [66] (cont.)	6.105E-2	1.638E+5	1.253E+6	
	5.882E-2	1.700E+5	1.282E+6	
	5.531E-2	1.808E+5	1.100E+6	
	5.283E-2	1.893E+5	1.061E+6	
	5.136E-2	1.947E+5	1.043E+6	
	4.995E-2	2.002E+5	9.281E+5	
	4.883E-2	2.048E+5	8.493E+5	
	4.706E-2	2.125E+5	6.757E+5	
	4.572E-2	2.187E+5	6.184E+5	
15 [66]		(T = 300 K)		Similar to above except for the extraordinary ray.
Thomas, J.,	1.102E-1	9.075E+4	1.083E+5	
et al.,	1.056E-1	9.473E+4	9.225E+5	
1973	1.038E-1	9.631E+4	7.988E+5	
	1.014E-1	9.866E+4	2.604E+5	
	9.980E-2	1.002E+5	1.674E+5	
	9.615E-2	1.040E+5	6.495E+5	
	9.398E-2	1.064E+5	6.509E+5	
	9.074E-2	1.102E+5	7.411E+5	
	8.826E-2	1.133E+5	7.477E+5	
	8.532E-2	1.172E+5	8.014E+5	
	8.313E-2	1.203E+5	7.651E+5	
	8.000E-2	1.250E+5	7.633E+5	
	7.716E-2	1.296E+5	9.009E+5	
	7.402E-2	1.351E+5	9.387E+5	
	7.158E-2	1.397E+5	1.089E+6	
	6.925E-2	1.444E+5	1.176E+6	
	6.711E-2	1.490E+5	1.197E+6	
	6.506E-2	1.537E+5	1.178E+6	
	6.254E-2	1.599E+5	1.224E+6	
	6.105E-2	1.638E+5	1.253E+6	

TABLE 11. EXPERIMENTAL DATA ON THE ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE (WAVELENGTH DEPENDENCE) (continued)

Data Set [Ref.] Author(s), year	λ	ν	α	Specification and Remarks
15 [66] (cont.)	5.882E-2	1.700E+5	1.322E+6	
	5.531E-2	1.808E+5	1.079E+6	
	5.283E-2	1.893E+5	9.920E+5	
	5.136E-2	1.947E+5	8.785E+5	
	4.995E-2	2.002E+5	7.596E+5	
	4.883E-2	2.048E+5	6.768E+5	
	4.706E-2	2.125E+5	6.517E+5	
	4.572E-2	2.187E+5	6.184E+5	

4.8. Color Centers in Alkaline Earth Fluorides

For a perfect and pure crystal its open windows are in principle clear and faultless but in practice there rarely exists a substance without impurities and defects. Imperfections reveal themselves as various absorptions, complicating the absorption spectrum of the pure host substance. Some of the absorptions are located in the open windows of the host substance thus degrading the applicabilities of the substance. Unfortunately, defects responsible for these undesirable absorptions are easily created simply by irradiation of photons of low energies such as visible light of appropriate frequencies, x-rays, and γ-rays. High energy particles such as electron, neutron and proton produce the same damages as x-rays. Exposure to these radiations are in general unavoidable in an ordinary operation of optical devices. For absorption in the visible wavelength region, the result is the coloration of the substance and thus the name "color center". Various absorption centers are assigned to designate various imperfections. Each of the centers of a given host substance has its unique spectral location thus a unique signature of the imperfection.

Color centers in the alkaline earth fluorides have been the object for extensive research for many years. It has been found that the most commonly observed ones are F and M bands which are located in the wavelength region between 0.175 and 0.8 μm. Furthermore, the color centers of alkaline earth fluorides are far more stable than those of alkali halides. Once the centers are formed, neither thermal nor photochemical bleaching can effectively remove the coloration. Although the subject of color centers is beyond the scope of present work it is briefly included here because the centers may significantly contribute to the extrinsic absorption in that portion of the transparent region. Among a handful published material, we selected the work of Messner and Smakula [85] and depicted their graphic presentation in Appendix A. Of the five bands in CaF_2 and SrF_2, and the nine in BaF_2, three bands (marked with arabic numerals in the graphs) could be correlated to an Ivey relation [86]: λ_m = const.d^n, where λ_m is the spectral position of absorption peak, d is the inter ionic distance, and n=3.85.

4.6. Impurities Contributing Extrinsic Absorption

After reviewing the existing data, we now have a clear picture of the absorption spectra of alkaline earth halides in the transparent region. They are all similar to that given in Figure 1. In the transparent region, absorption due to traces of impurities and imperfections may be of critical importance in laser applications. The question "What are the impurities that contribute most significantly to the absorption coefficient observed at the wavelengths of interest?" Search for the important impurities was motivated since the development of high-power lasers, as a result most of the studies were concentrated at wavelengths 2.7, 3.8, 5.3 and 10.6 μm.

Nominally pure commercial crystals are commonly observed to contain molecular-anion impurities, such as the metaborate ion (BO_2^-) and the carbonate ion (CO_3^{2-}), using conventional absorption spectroscopy. The hydroxyl ion (OH^-) is especially difficult to remove during purification, and may account for the higher absorption observed at 2.7 μm compared to that at 3.8 and 5.3 μm. These anion impurities, along with divalent metal cation impurities, are most likely present in small concentrations even in specially purified laser window materials since less than one part per million of certain anions can result in the presently observed extrinsic absorption. Flannery and Spark [87] performed a thorough study of possible impurities and displayed their results in correlation charts to allow either the identification of impurities to avoid at a given wavelength or the selection of a wavelength at which impurity absorption is likely to be small. These charts are given in Appendix B.

4.7 Refractive Index

Measurement on the refractive index of alkaline earth halides dates back to 1871, when Stefan [70] determined the refractive indices of a fluorite prism for solar lines B, D, and F. Since then, a large amount of data for CaF_2 in the transparent region has been contributed by a number of investigators, among them are Martens [71], Paschen [72], and Malitson [73]. They used either the deviation method or interferometry in their experiments. Refractive index data of strontium fluoride did not appear in the literature until 1927 when Thilo [74] reported the refractive index of SrF_2 for a single wavelength 0.589 μm. Subsequent measurements were reported by Smakula [75], Kaiser [43], and Dickinson [76]. The story for BaF_2 is similar to that for SrF_2. The major contributor to the data is Malitson [77]. The reason for such late attention was simply the difficulties of crystal growing. Refractive index data for MgF_2 came even later than that of SrF_2 and BaF_2. The first reported data set was that of Rood [78] in 1949. Subsequent measurement were reported by Hall [79], Duncanson [80], and by Eastman Kodak Co. [81].

Li [82], in 1978, reduced the then available experimental data on the refractive index to a common temperature, 293 K, and after careful evaluation and analysis adopted the Sellmeier type dispersion equation to represent the refractive index of alkaline earth halides at 293 K in addition to the proposed equations for the temperature coefficient. Tables 12 and 13, and Figures 17 and 18 summarize equations and the corresponding plots. Values of n and dn/dt in the transparent wavelength region have been calculated based on these equations and tables are presented in Ref. [82].

Table 12. Dispersion Equations of CaF_2, SrF_2, BaF_2, and MgF_2

Material	Wavelength Temperature	Equation
CaF_2	0.15–12.0 μm 293 K	$n^2 = 1.33973 + \frac{0.69913\ \lambda^2}{\lambda^2 - (0.09374)^2} + \frac{0.11994\ \lambda^2}{\lambda^2 - (21.18)^2} + \frac{4.35181\ \lambda^2}{\lambda^2 - (38.46)^2}$
SrF_2	0.15–14.0 μm 293 K	$n^2 = 1.33973 + \frac{0.720\ \lambda^2}{\lambda^2 - (0.09566)^2} + \frac{0.066\ \lambda^2}{\lambda^2 - (26.03)^2} + \frac{3.94\ \lambda^2}{\lambda^2 - (45.60)^2}$
BaF_2	0.15–15.0 μm 293 K	$n^2 = 1.33973 + \frac{0.81070\ \lambda^2}{\lambda^2 - (0.10065)^2} + \frac{0.19652\ \lambda^2}{\lambda^2 - (29.87)^2} + \frac{4.52469\ \lambda^2}{\lambda^2 - (53.82)^2}$
MgF_2	0.15–10.0 μm 293 K	$n^2 = 1.27620 + \frac{0.60967\ \lambda^2}{\lambda^2 - (0.08636)^2} + \frac{0.00800\ \lambda^2}{\lambda^2 - (18.0)^2} + \frac{2.14973\ \lambda^2}{\lambda^2 - (25.0)^2}$ for ordinary ray,
	0.15–10.0 μm 293 K	$n^2 = 1.25385 + \frac{0.66405\ \lambda^2}{\lambda^2 - (0.08504)^2} + \frac{1.08987\ \lambda^2}{\lambda^2 - (22.2)^2} + \frac{0.18159\ \lambda^2}{\lambda^2 - (24.4)^2} + \frac{2.12272\ \lambda^2}{\lambda^2 - (40.6)^2}$ for extraordinary ray,
	1.0–10.0 μm 293 K	$n^2 = 1.79079 + \frac{0.10822\ \lambda^2}{\lambda^2 - (0.16733)^2} + \frac{2.78138\ \lambda^2}{\lambda^2 - (25.54)^2}$ for IRTRAN 1.

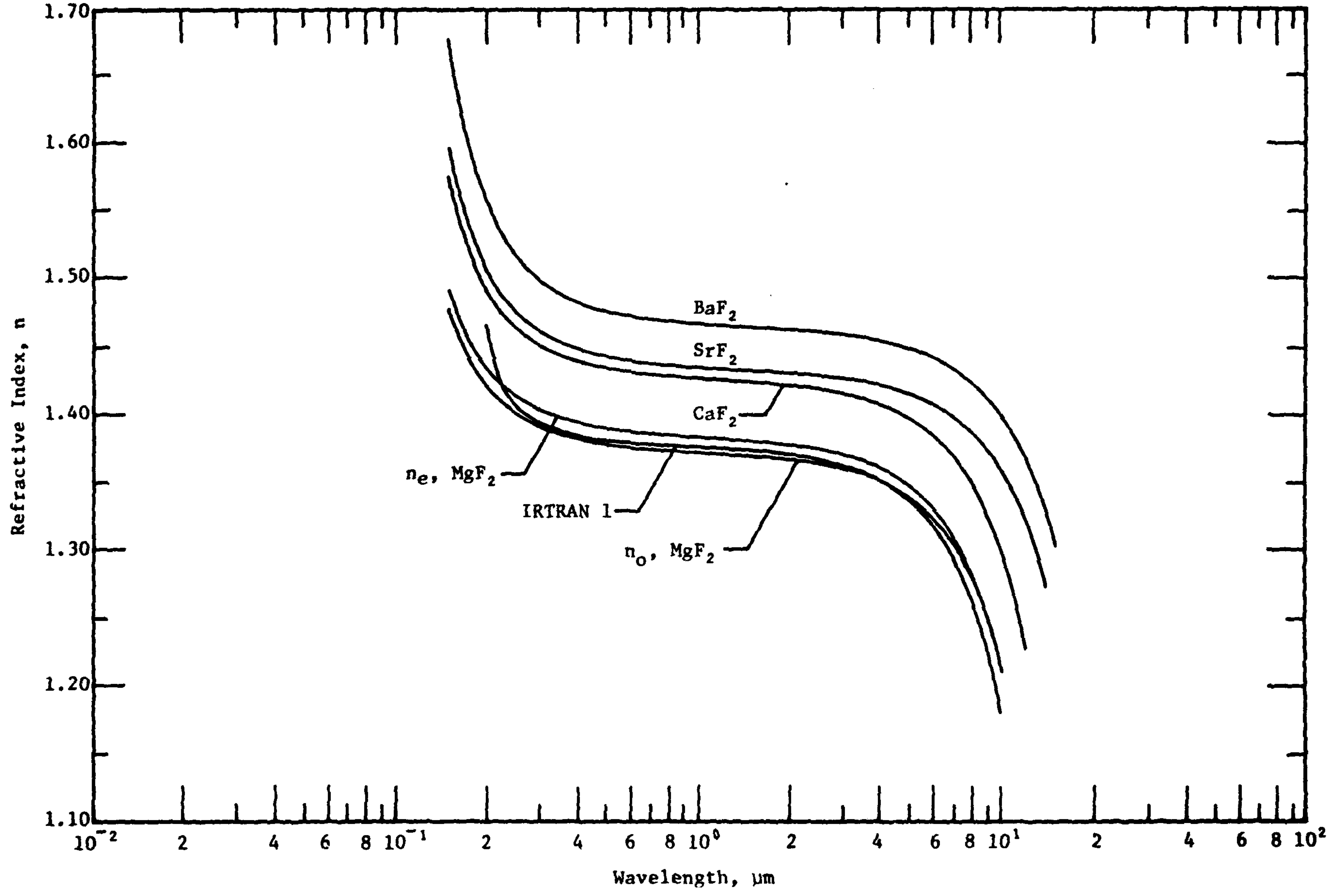

Figure 17. Refractive Index of Alkaline Earth Halides (Wavelength Dependence)

Table 13. The dn/dT Equations of CaF_2, SrF_2, and BaF_2

Material	Equation
CaF_2	$2n\frac{dn}{dT} = -16.6 - 57.3(n^2 - 1) + \frac{44.9\ \lambda^4}{(\lambda^2 - 0.09374^2)^2} + \frac{151.54\ \lambda^2}{\lambda^2 - (38.46)^2} + \frac{1654.6\ \lambda^4}{(\lambda^2 - 38.46^2)^2}$
SrF_2	$2n\frac{dn}{dT} = -28.0 - 55.2(n^2 - 1) + \frac{50.0\ \lambda^4}{(\lambda^2 - 0.09566^2)^2} + \frac{198.1\ \lambda^2}{\lambda^2 - 45.6^2} + \frac{1980.8\ \lambda^4}{(\lambda^2 - 45.6^2)^2}$
BaF_2	$2n\frac{dn}{dT} = -8.18 - 59.4(n^2 - 1) + \frac{31.0\ \lambda^4}{(\lambda^2 - 0.1036^2)^2} + \frac{225.0\ \lambda^2}{\lambda^2 - 53.82^2} + \frac{1660.8\ \lambda^4}{(\lambda^2 - 53.82^2)^2}$

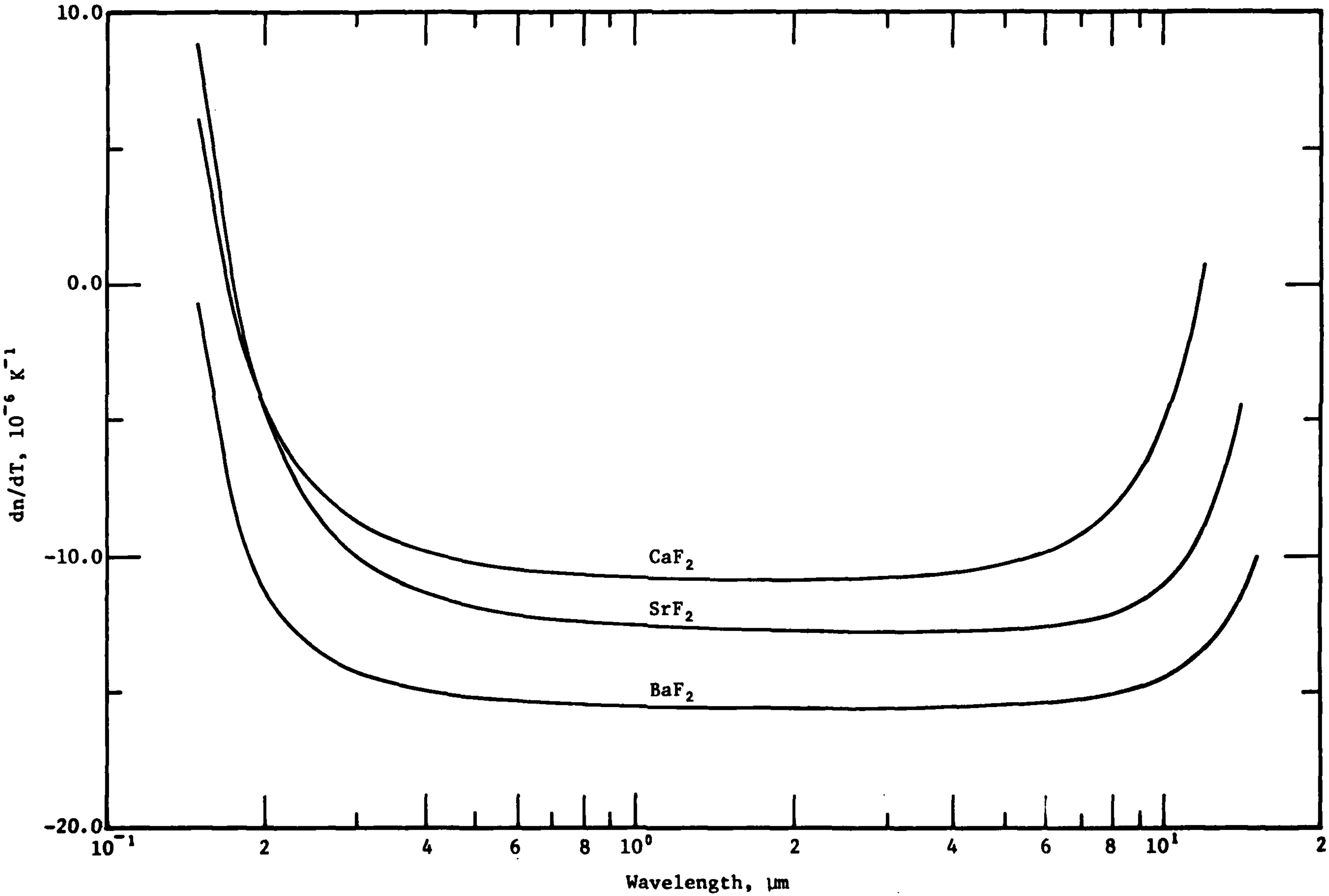

Figure 18. Temperature Coefficient of Refractive Index of Alkaline Earth Halides (Wavelength Dependence)

5. DATA ANALYSIS

Absorption in the infrared region is of current interest because of its application in windows for high-power infrared lasers. The total absorption at a given frequency can be attributed to processes involving phonons, defect modes due to impurities, vacancies, and surface contaminations. A number of observations have been made to investigate the frequency and temperature dependence of the intrinsic multiphonon absorption. It has been found that the exponential dependence of the absorption coefficient on frequency holds for a number of optical materials at room temperature [32].

Although considerable efforts were made in finding expressions to relate the absorption coefficient with frequency and temperature, the results were not quite satisfactory. The main reasons of such discordance are: (i) inadequacy in the characterization of the specimen under investigation, (ii) inability of elimination of the unwanted extrinsic contributions, (iii) unavailability of equipment for determination of low absorption, (iv) insufficiency of reliable data over wide frequency and temperature ranges. It is well known that impurities, heat treatment, surface polishing are the major factors that contribute to the total observed absorption. However, these very important pieces of information are generally missing or vaguely mentioned partly due to unawareness on the part of investigators and partly due to the inadequacy of the facilities used. As a result, correct assignment of errors is not possible.

Surface contamination is known to contribute to absorption and is usually in the range from 10^{-5} to 10^{-3} cm^{-1} per surface. At high absorption levels, the effect of surface absorption is insignificant. At low absorption levels, $\alpha < 10^{-3}$ cm^{-1}, surface absorption and absorption due to stubborn impurities, hydroxyl and oxygen containing radicals, may predominate the bulk absorption, resulting in difficulties in the determination of the instrinsics. Additional errors are introduced into the data when they must be read off from inadequate graphs.

As a result of the combination of the above considerations, the errors in data are estimated in general at 3 to 10% in the high absorption range for $\alpha > 0.1$ cm^{-1}. At low absorptions, errors increase with decreasing absorption. At very low absorption (10^{-4} cm^{-1} or lower) errors may exceed 100%. As a consequence, intrinsic behavior is only revealed in the high absorption range, while at low levels, the extrinsics usually predominate and mask the intrinsics. Only by utilizing appropriate method, can the intrinsics and extrinsics be separated.

In special applications, particularly in the area of lasers, high temperature (> 300) absorption coefficients are usually needed. It is unfortunate that absorption coefficients are rarely measured at elevated temperatures. In the case of alkaline earth halides, the only known systematic measurement of absorption coefficient as a function of frequency and temperature was made by Lipson et al. [53] for CaF_2, SrF_2 and BaF_2. As their values are mostly in the high absorption range (see Figures 3, 7 and 11) and are well behaved, it is likely that their results do represent the intrinsic absorptions in the corresponding frequency regions.

5.1. Typical Trends in Data

Typical trends in experimental data (room temperature or higher) can be clearly seen in the figures of Section 4 where frequency-dependent absorption coefficients are plotted in semi-log scale and temperature dependent absorption coefficients are plotted in log-log scale. Data sets in both figures appear as straight lines in corresponding plots. The implication of this straight-line behavior is that the absorption coefficient is related to frequency and temperature, respectively, in the form of $\alpha(\nu) \sim \exp(-A\nu)$ at a given temperature and $\alpha(T) \sim T^{A'}$ at a given frequency where A and A' are constants for each of the lines.

The exponential dependence of absorption coefficient on frequency is not only observed in the multiphonon region, but is also observed in the Urbach tail region.

5.2. Formulation of Model

A straight line in a semi-log plot of log α vs. ν indicates an exponential relation of the form

$$\log \alpha = \log \alpha_0 - 0.43429A(\nu+B) \qquad (38)$$

where A is related to the slope of the line in the semi-log plot at a given temperature, and α_0 and B are arbitrary constants corresponding to the corrdinates of an arbitrary reference point on the line. Therefore three constants are required to define a straight line in the semi-log representation.

A careful study on Figures 3, 7 and 11 will reveal that the slopes of the lines are varying with temperature. This means that α_0 and B are also varying with temperature unless there exists a pair of values that is common to all of the lines for a given material. This requirement places a restriction that all the lines must converge to a common point (B, α_0). To see whether this point could be found, a graphical extrapolation was made by drawing straight lines through corresponding data sets and extending to a region where they tend to meet. Indeed, we did find a definite point of convergence for each of the materials, CaF_2, SrF_2 and BaF_2. Since data are available at various temperatures, the existence of such a point of convergence provides a reliable clue that α_0 and B are constants for a given material and that only the slope, A, varies with temperature, i.e.,

$$\log \alpha = \log \alpha_0 - 0.43429(\nu+B)A(T). \qquad (39)$$

To find the functional relation of A and T, we have made use of the fact that the plot of α versus T is a straight line in the log-log scale. To meet this condition we are limited to the consideration of the expression

$$A(T) = C(D - \log T), \tag{40}$$

where C and D are constants for a given material. Combining eqs. (38) to (40) leads to the following empirical equation which represents the absorption coefficient as a function of frequency and temperature:

$$\alpha(\nu,T) = \alpha_0 \exp[-a(\nu+b)(c-\log T)] \tag{41}$$

where α_0, a, b and c are constants for a given material. At a given temperature this equation is reduced to the well known form of $\alpha(\nu) \sim \exp(-a'\nu)$ and at a given frequency, $\alpha(T) \sim T^{b'}$, where a' and b' are constants.

It is interesting to point out that eq. (41) is analogous to the Urbach rule in the ultraviolet absorption edge. Similar to the terms used by Tomik and Miyata for the Urbach tail, the pair of constants, α_0 and b in eq. (41) defines the "cross over point" where the curves of α versus ν at various temperature converge and the factor a(c-log T) is defined as the "steepness" of the lines. The physical meaning of these parameters remains to be ascertained.

5.3. Numberical Data Fitting for CaF_2, SrF_2, BaF_2

Numberical values of the constants, α_0, a, b and c can be determined through least-squares fitting of the experimental data to eq. (41). Needless to say the reliability of the constants depends upon the availability of experimental data and their accuracies. Review of the available data as discussed in Section 4 indicated that data fitting can be made for CaF_2, SrF_2 and BaF_2. As the errors in the data are in the range of 10%, therefore the uncertainty in the results of such fitting is about 10%.

The least-square calculation was performed on the equation:

$$\log \alpha = \log \alpha_0 - 0.43429a(\nu+b)(c-\log T) \qquad (42)$$

The first approximate values of a and c were evaluated by holding α_0 and b fixed at their graphically determined values. The final values of the constants were then determined by allowing free adjustment of all four constants. The results of the best fit are shown in Table 14.

Table 14. The Parameters of Equation (41)

Crystal	$\log \alpha_0$	a ,cm	b, cm^{-1}	c
CaF_2	3.0834	0.005251	−383.92	4.4498
SrF_2	2.9169	0.006577	−360.56	4.3288
BaF_2	2.8507	0.007349	−327.67	4.2873

Comparison of the experimental data and the values calculated from eq. (41) can be seen in Figures 3, 5, 7, 9, 11, and 13 where the calculated ones are shown as solid lines. The agreement is convincingly good.

5.4. Prediction of Key Parameters for MgF_2

As it was noticed in Section 4, the existing data for MgF_2 are insufficient for least-squares calculations in which both frequency and temperature are treated as independent variables. In order to utilize the existing data of the material and yet give some meaningful calculations for MgF_2, we have to reduce the number of unknown constants in eq. (41). We have observed positive evidence that enabled us in the determination of the constants in eq. (41).

Comparing eq. (41) with Deutsch's representation, eq. (9), we can see that $1/\nu_0 \sim a(c-\log T)$. At a given temperature, say room temperature, the factor $(c-\log T)$ is a constant and therefore $1/\nu_0 \sim a$. In the case of alkali halides we have found that this is the case for LiF, NaCl, KCl and KBr for which the values of a are obtained from data fitting calculations. Furthermore, we found that the frequency, ν_{Lo}, of the longitudinal optical mode of the fundamental phonon is also proportional to ν_0. It was noted that the parameter ν_0 is related to the molecular weight, M, of the corresponding material as discussed in Ref. [84]. This implies that both 1/a and ν_{Lo} are also individually related to M in a similar manner. Listed in Table 15 are the values of ν_0, a, 1/a, M and 1/M and ν_{Lo} of the concerned materials. In this list, the values in parentheses are those predicted graphically as discussed below.

Figure 19 shows the plots for ν_{Lo}, 1/a and ν_0 versus 1/M. It is seen that all the lines are parallel to each other and the points for LiF, NaCl and KBr on the 1/a vs. 1/M plot precisely define a straight line. The value of a for KCl was thus predicted [84]. Since both alkali halides and alkaline earth halides are ionic crystals and have absorption spectra of same nature, it was expected that the behaviour of alkali halides in Figure 19 may also hold for alkaline earth halides. It was

Table 15. The Values of ν_0, a, M and ν_{Lo} of the Crystals

Crystal	ν_0 cm^{-1}	a cm	1/a cm^{-1}	M g/mole	1/M mole/g	ν_{Lo} cm^{-1}
LiF	153.2	0.002237	447.03	26	0.0385	673
NaCl	56.0	0.00591	169.20	58.5	0.0171	271
KCl	50.8	(0.00700)	(142.86)	74.5	0.0134	212
KBr	39.1	0.00886	112.87	120	0.0083	166
MgF_2	143.8	(0.004184)	(239)	62.3	0.0161	617
CaF_2	93.6	0.005251	190.44	78.0	0.0128	482
SrF_2	90.4	0.006577	152.05	125.6	0.0080	395
BaF_2	75.9	0.007349	136.07	175.3	0.0057	344

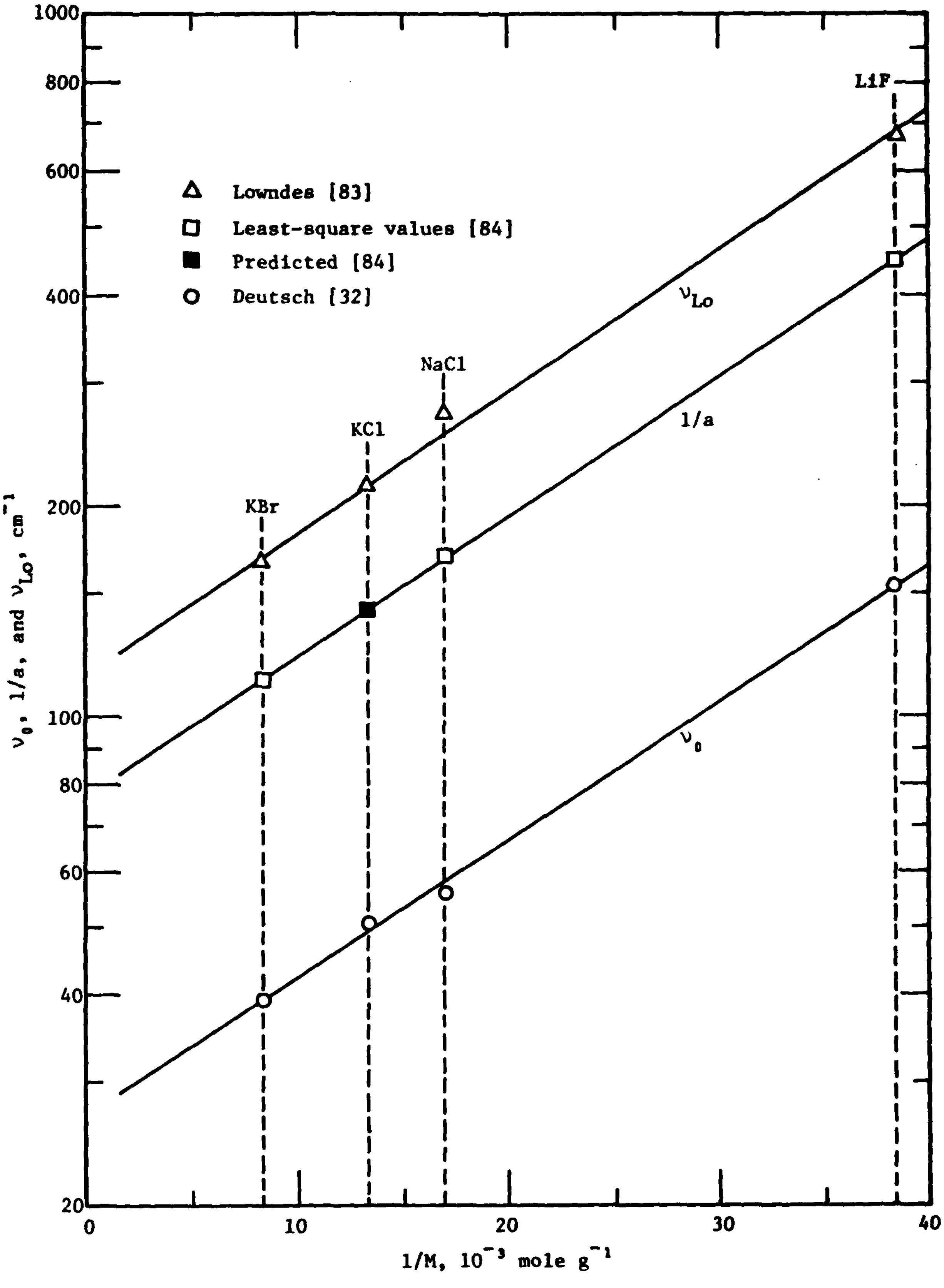

Figure 19. Semi-Log Plots of ν_0, 1/a, ν_{Lo} of Alkali Halides as a Function of 1/M

indeed found to be the case as shown in Figure 20. All the three lines are parallel to each other and the value of a for MgF_2 is predicted. Furthermore, Figure 20 reveals that in the case of CaF_2 the value of ν_0 determined by Deutsch appears to be too low. The reason for such a discrepancy is that data available to Deutsch was limited. Lower value of ν_0 means a more steep slope of the line in the semi-log plot. The fact that the value of ν_0 for CaF_2 should be higher is not only revealed in Figure 20, but also is supported by the data of Hordvik and Skolnik [42] and Lipson et al. [53].

For MgF_2, reliable frequency-dependent data are available only at room temperature. Although data sets of Stierwalt et al. [69] were measured at higher temperatures, they are not useful in the determination of the constants of eq. (41) because the data sets are for a polycrystalline material and the sample is apparently impure as shown in Figures 14 and 15. As a result, we have to rely on the room-temperature data to estimate the constants.

From a careful examination on the constants found for CaF_2, SrF_2 and BaF_2, we can observe some clues regarding the variation of the constants α_0, b and c from material to material. First, we see that all three constants are either higher for lighter compound or are approximately the same. Second we see that the values of $\log \alpha_0$ is roughly proportional to the values of 1/M. From these clues we can estimate the approximate values of $\log \alpha_0$ and c for MgF_2 to initiate a least-squares calculation using room

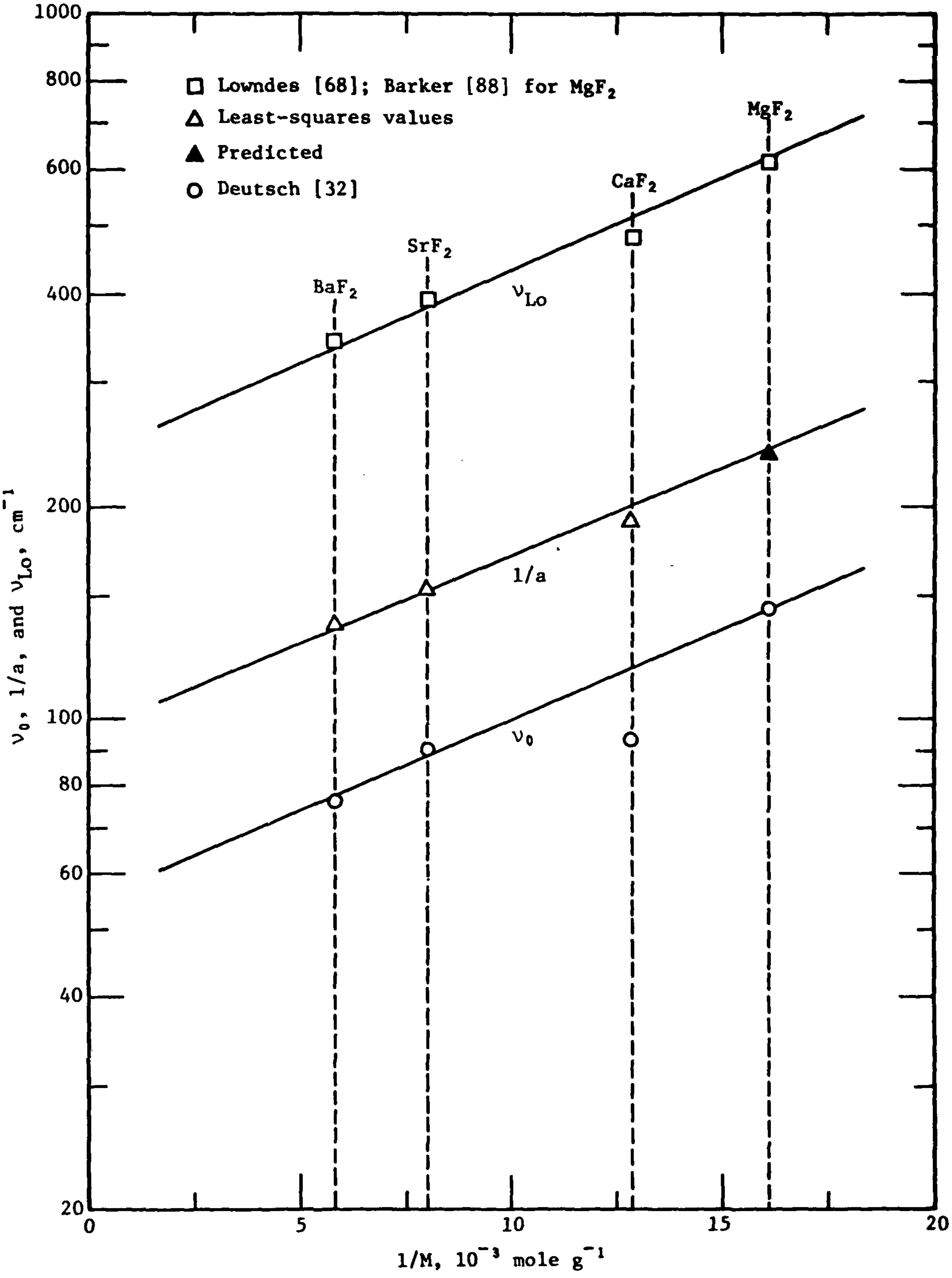

Figure 20. Semi-Log Plots of ν_0, 1/a, ν_{Lo} of Alkaline Earth Halides as a Function of 1/M

temperature data. The initial estimated values of log a_0 and c were respectively 3.186 and 4.519. Through a trial and error process, by alternatively holding one of the two at appropriate fixed values, we found that log α_0 = 3.1877, c = 4.2901, and b = -377.29. With the previously determined value of a, the absorption spectra of MgF_2 are fully described. It is interesting to point out that log α_0 is almost exactly proportional to 1/M as shown in Figure 21. Comparing the values of c for the various materials, we can see that c appears to be approximately a constant, a situation similar to that observed for the case of alkali halides [84].

5.5. Recommended Values of Absorption Coefficient

Equation (41) is formulated to describe the absorption coefficient as a function of frequency and temperature in the multiphonon absorption region and in the temperature region where $T \geq 300$ K. Uncertainties in the calculated values are of the order of 10%. In the case of MgF_2, this uncertainty is applicable to room temperature only. At higher temperatures, a higher uncertainty should be assigned and the resulting values should be considered as provisional because limited data were available in the determination of the constants in eq. (41).

Recommended and provisional values were calculated using eq. (41) and are presented in Tables 16 to 19. For visual demonstration, Figures 22 to 29 are provided to show the "crossover point" and the calculated absorption spectra at various temperatures and frequencies.

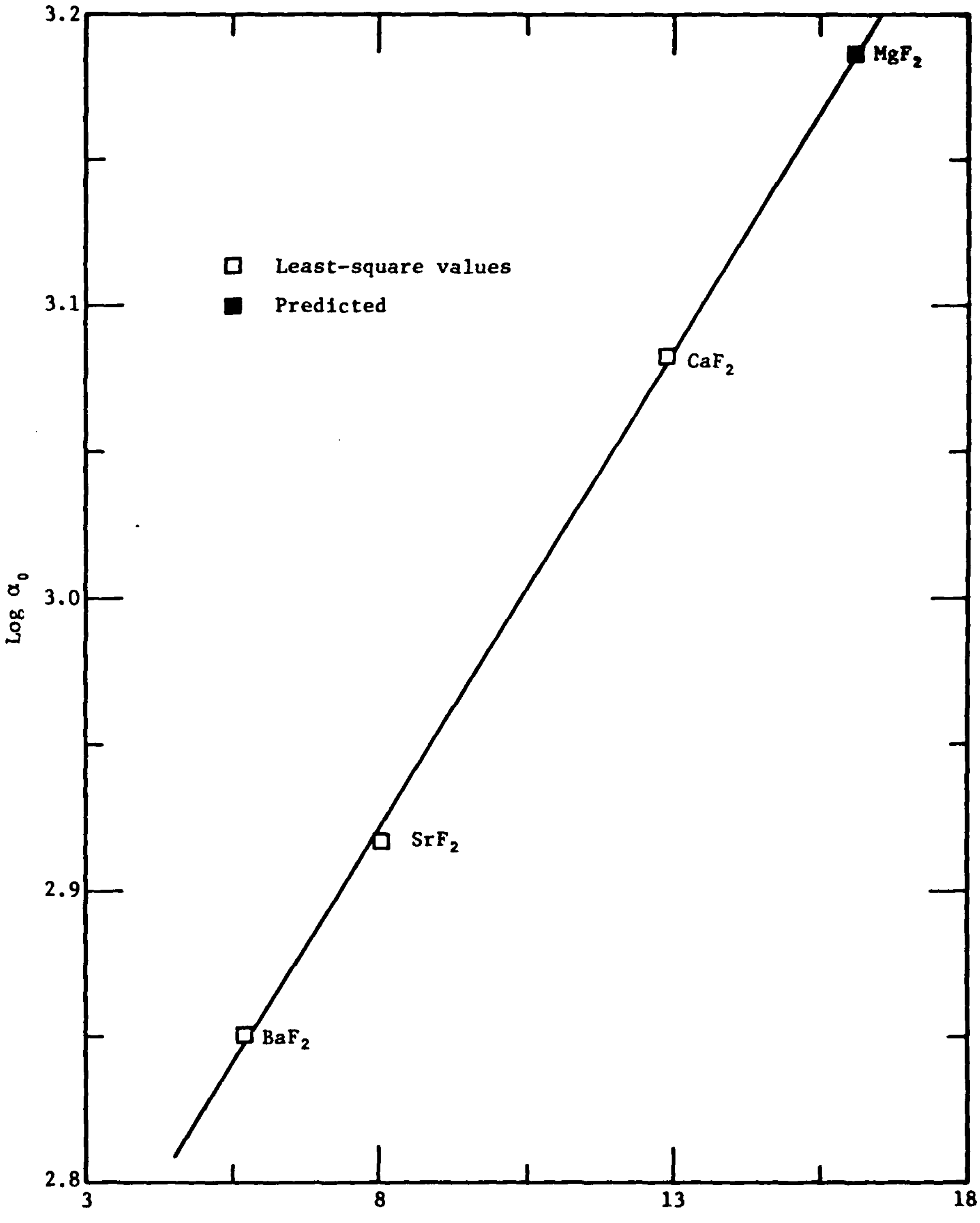

Figure 21. Log α_0 Versus 1/M

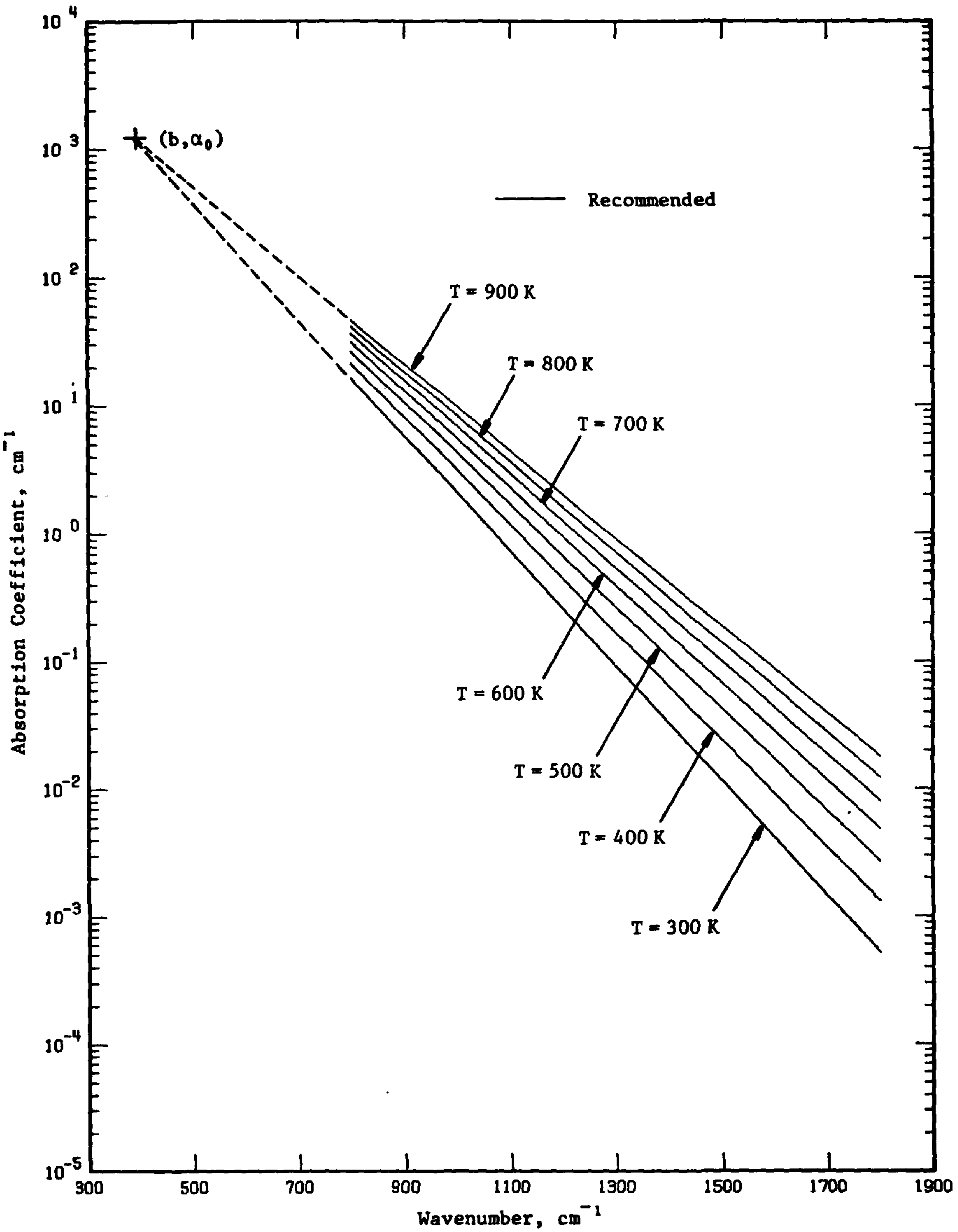

Figure 22. Calculated Absorption Spectra of Calcium Fluoride (Wavenumber Dependence)

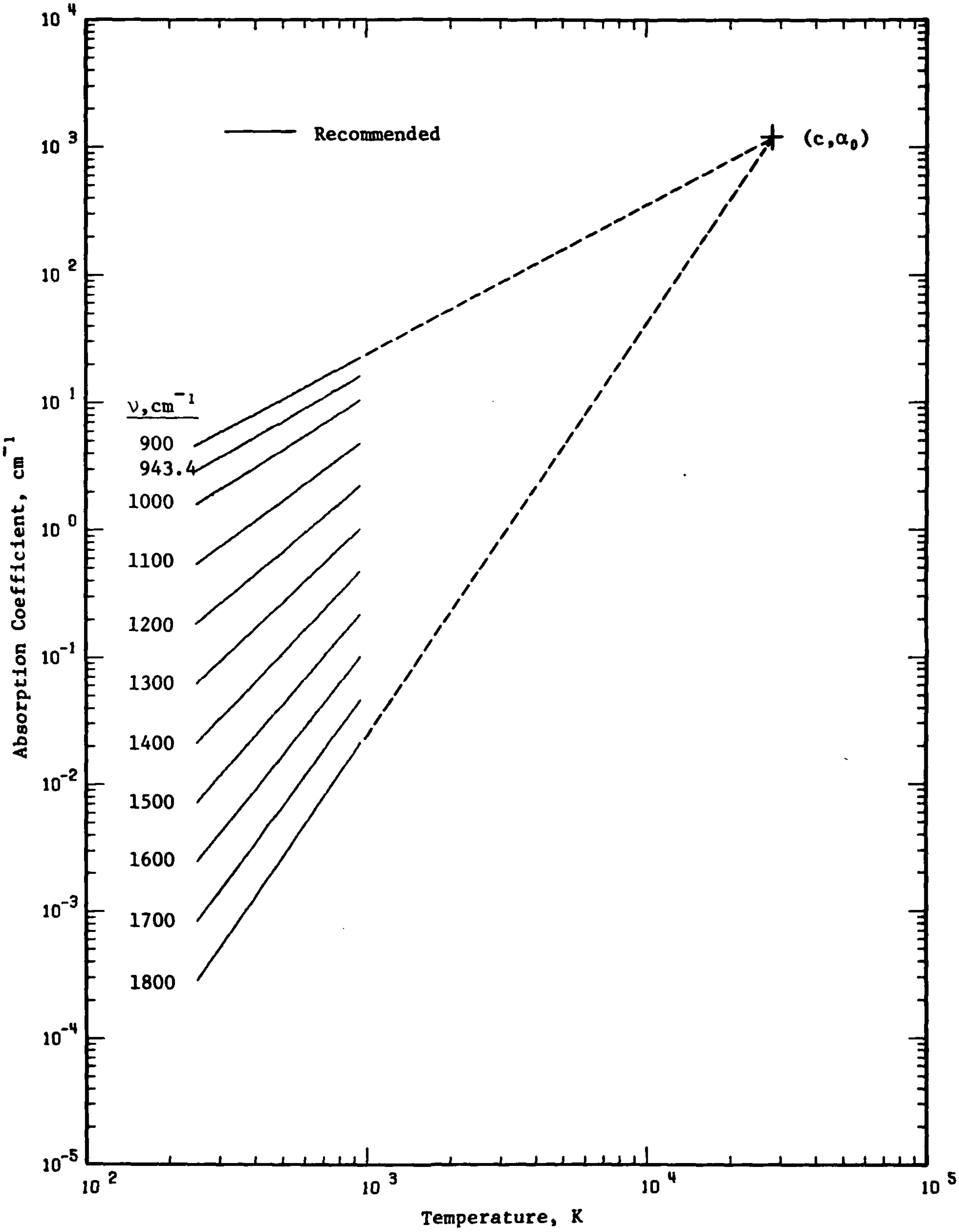

Figure 23. Calculated Absorption Spectra of Calcium Fluoride (Temperature Dependence)

TABLE 16. RECOMMENDED VALUES ON THE INFRARED ABSORPTION COEFFICIENT OF CALCIUM FLUORIDE [a]

[WAVENUMBER, ν, CM^{-1}; TEMPERATURE, T, K; ABSORPTION COEFFICIENT, α, CM^{-1}]

WAVENUMBER, CM^{-1}	TEMPERATURE, K							
	300	300[b]	400	500	600	700	800	900
8.000E+02	1.628E+01		2.139E+01	2.643E+01	3.142E+01	3.637E+01	4.128E+01	4.617E+01
8.500E+02	9.698E+00		1.317E+01	1.669E+01	2.026E+01	2.387E+01	2.751E+01	3.117E+01
9.000E+02	5.777E+00		8.105E+00	1.054E+01	1.306E+01	1.566E+01	1.833E+01	2.105E+01
9.500E+02	3.442E+00	3.5E+00	4.990E+00	6.656E+00	8.422E+00	1.028E+01	1.221E+01	1.421E+01
1.000E+03	2.051E+00	2.0E+00	3.072E+00	4.203E+00	5.430E+00	6.743E+00	8.135E+00	9.599E+00
1.050E+03	1.222E+00	1.2E+00	1.891E+00	2.654E+00	3.501E+00	4.425E+00	5.420E+00	6.481E+00
1.100E+03	7.278E-01	6.7E-01	1.164E+00	1.676E+00	2.257E+00	2.903E+00	3.611E+00	4.377E+00
1.150E+03	4.336E-01	4.7E-01	7.167E-01	1.058E+00	1.455E+00	1.905E+00	2.406E+00	2.955E+00
1.200E+03	2.583E-01	2.8E-01	4.412E-01	6.684E-01	9.384E-01	1.250E+00	1.603E+00	1.996E+00
1.250E+03	1.539E-01	1.8E-01	2.716E-01	4.221E-01	6.050E-01	8.203E-01	1.068E+00	1.348E+00
1.300E+03	9.168E-02	1.1E-01	1.672E-01	2.665E-01	3.901E-01	5.383E-01	7.115E-01	9.100E-01
1.350E+03	5.462E-02	5.6E-02	1.029E-01	1.683E-01	2.515E-01	3.532E-01	4.740E-01	6.145E-01
1.400E+03	3.254E-02	3.9E-02	6.337E-02	1.063E-01	1.622E-01	2.318E-01	3.158E-01	4.149E-01
1.450E+03	1.939E-02	2.1E-02	3.901E-02	6.712E-02	1.046E-01	1.521E-01	2.104E-01	2.802E-01
1.500E+03	1.155E-02	1.1E-02	2.402E-02	4.238E-02	6.741E-02	9.980E-02	1.402E-01	1.892E-01
1.550E+03	6.880E-03	5.1E-03	1.479E-02	2.676E-02	4.346E-02	6.548E-02	9.340E-02	1.278E-01
1.600E+03	4.099E-03	3.4E-03	9.103E-03	1.690E-02	2.802E-02	4.297E-02	6.223E-02	8.627E-02
1.650E+03	2.442E-03		5.604E-03	1.067E-02	1.807E-02	2.820E-02	4.146E-02	5.825E-02
1.700E+03	1.455E-03		3.450E-03	6.740E-03	1.165E-02	1.850E-02	2.762E-02	3.934E-02
1.750E+03	8.667E-04		2.124E-03	4.256E-03	7.511E-03	1.214E-02	1.840E-02	2.656E-02
1.800E+03	5.164E-04		1.307E-03	2.688E-03	4.843E-03	7.967E-03	1.226E-02	1.794E-02
1.850E+03	3.076E-04		8.049E-04	1.697E-03	3.122E-03	5.227E-03	8.169E-03	1.211E-02
1.887E+03	2.097E-04	4.2E-04	5.621E-04	1.208E-03	2.256E-03	3.827E-03	6.049E-03	9.058E-03
1.900E+03	1.833E-04		4.955E-04	1.072E-03	2.013E-03	3.430E-03	5.443E-03	8.178E-03
2.632E+03	9.334E-08	6.2E-05	4.079E-07	1.281E-06	3.261E-06	7.187E-06	1.425E-05	2.607E-05

[a] INTRINSIC VALUES WERE CALCULATED ACCORDING TO EQ.(41) WITH UNCERTAINTIES ABOUT ±10 PERCENT.

[b] VALUES IN THIS COLUMN, SELECTED FROM REF.[32,42,51,52], ARE THE BULK ABSORPTION COEFFICIENTS WHICH ARE EITHER THE LOWEST REPORTED OR THOSE USED TO DEFINE THE CONSTANTS IN EQ.(41). UNCERTAINTIES IN THESE VALUES ARE ABOUT ±10 PERCENT. EXPERIMENTAL DATA OBTAINED AT WAVENUMBER HIGHER THAN 1600 CM^{-1} TEND TO BE CONSIDERABLY HIGHER THAN THE RECOMMENDED VALUES DUE TO IMPURITIES AND SURFACE ABSORPTION.

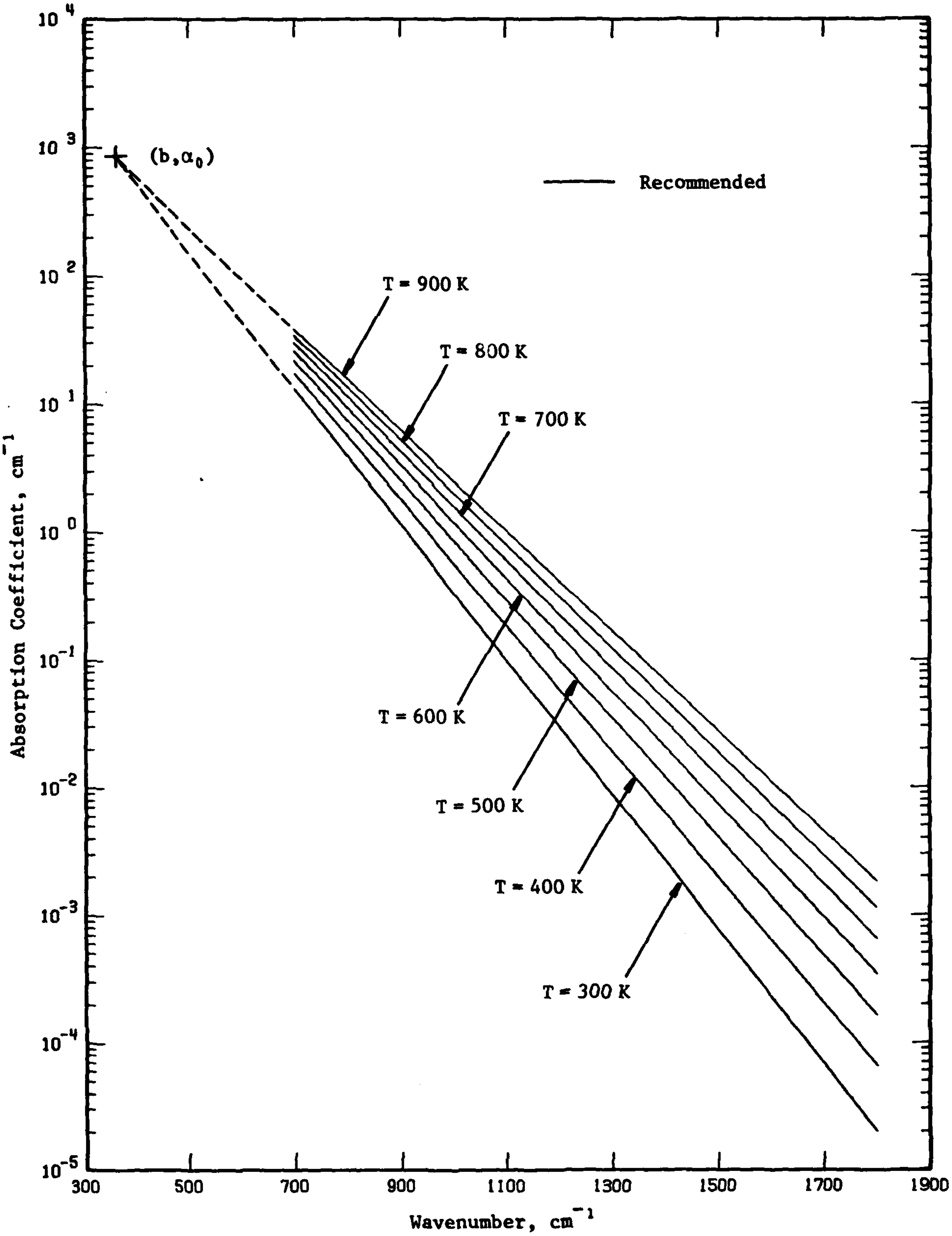

Figure 24. Calculated Absorption Spectra of Strontium Fluoride (Wavenumber Dependence)

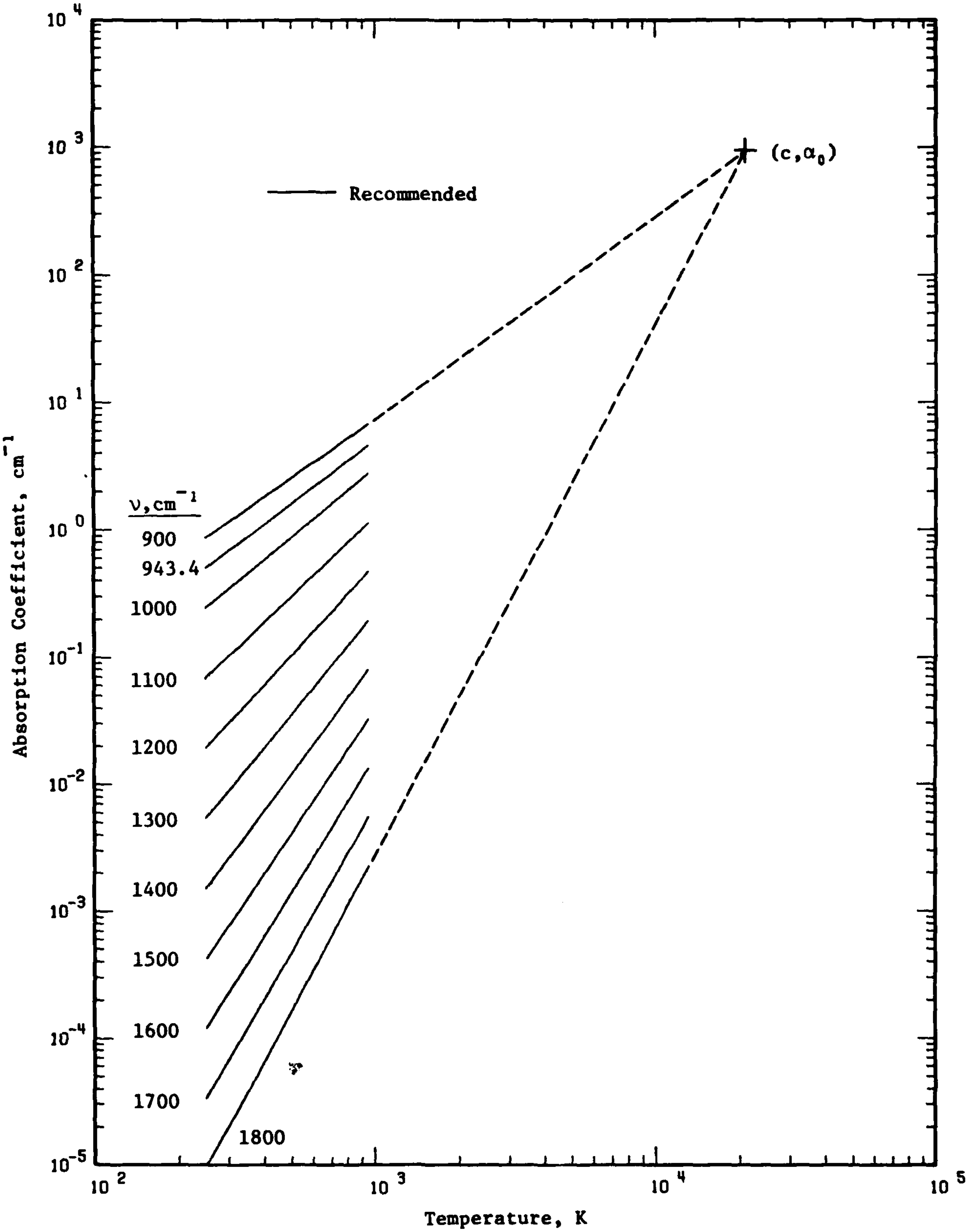

Figure 25. Calculated Absorption Spectra of Strontium Fluoride (Temperature Dependence)

TABLE 17. RECOMMENDED VALUES ON THE INFRARED ABSORPTION COEFFICIENT OF STRONTIUM FLUORIDE[a]

[WAVENUMBER, ν, CM^{-1}; TEMPERATURE, T, K; ABSORPTION COEFFICIENT, α, CM^{-1}]

WAVENUMBER, CM^{-1}	TEMPERATURE, K							
	300	300[b]	400	500	600	700	800	900
7.000E+02	1.323E+01		1.749E+01	2.171E+01	2.591E+01	3.009E+01	3.424E+01	3.839E+01
7.500E+02	7.197E+00		9.911E+00	1.270E+01	1.556E+01	1.847E+01	2.143E+01	2.443E+01
8.000E+02	3.915E+00		5.617E+00	7.433E+00	9.344E+00	1.134E+01	1.341E+01	1.554E+01
8.500E+02	2.129E+00	2.0E+00	3.183E+00	4.349E+00	5.611E+00	6.961E+00	8.390E+00	9.891E+00
9.000E+02	1.158E+00	1.1E+00	1.804E+00	2.545E+00	3.370E+00	4.273E+00	5.250E+00	6.294E+00
9.500E+02	6.300E-01	6.2E-01	1.023E+00	1.489E+00	2.024E+00	2.623E+00	3.285E+00	4.005E+00
1.000E+03	3.427E-01	3.2E-01	5.795E-01	8.711E-01	1.215E+00	1.611E+00	2.055E+00	2.549E+00
1.050E+03	1.864E-01	1.8E-01	3.284E-01	5.097E-01	7.298E-01	9.887E-01	1.286E+00	1.622E+00
1.100E+03	1.014E-01	1.0E-01	1.861E-01	2.982E-01	4.383E-01	6.070E-01	8.047E-01	1.032E+00
1.150E+03	5.515E-02	5.5E-02	1.055E-01	1.745E-01	2.632E-01	3.726E-01	5.035E-01	6.567E-01
1.200E+03	3.000E-02	2.7E-02	5.979E-02	1.021E-01	1.581E-01	2.288E-01	3.151E-01	4.179E-01
1.250E+03	1.632E-02	1.5E-02	3.389E-02	5.973E-02	9.493E-02	1.404E-01	1.972E-01	2.659E-01
1.300E+03	8.875E-03	1.0E-02	1.920E-02	3.495E-02	5.701E-02	8.621E-02	1.234E-01	1.692E-01
1.350E+03	4.827E-03		1.088E-02	2.045E-02	3.423E-02	5.293E-02	7.719E-02	1.077E-01
1.400E+03	2.626E-03		6.169E-03	1.197E-02	2.056E-02	3.249E-02	4.830E-02	6.852E-02
1.450E+03	1.428E-03		3.496E-03	7.001E-03	1.235E-02	1.995E-02	3.022E-02	4.360E-02
1.500E+03	7.769E-04		1.981E-03	4.096E-03	7.415E-03	1.225E-02	1.891E-02	2.775E-02
1.550E+03	4.226E-04		1.123E-03	2.397E-03	4.453E-03	7.518E-03	1.183E-02	1.766E-02
1.600E+03	2.298E-04		6.364E-04	1.402E-03	2.674E-03	4.615E-03	7.404E-03	1.124E-02
1.650E+03	1.250E-04		3.607E-04	8.205E-04	1.606E-03	2.833E-03	4.633E-03	7.149E-03
1.700E+03	6.800E-05		2.044E-04	4.801E-04	9.644E-04	1.739E-03	2.899E-03	4.549E-03
1.750E+03	3.699E-05		1.159E-04	2.809E-04	5.791E-04	1.068E-03	1.814E-03	2.895E-03
1.800E+03	2.012E-05		6.566E-05	1.644E-04	3.478E-04	6.555E-04	1.135E-03	1.842E-03
1.887E+03	6.974E-06	4.1E-05	2.445E-05	6.468E-05	1.432E-04	2.805E-04	5.020E-04	8.390E-04

[a] INTRINSIC VALUES WERE CALCULATED ACCORDING TO EQ.(41) WITH UNCERTAINTIES ABOUT ±10 PERCENT.

[b] VALUES IN THIS COLUMN, SELECTED FROM REF.[32,40,47,52,53], ARE THE BULK ABSORPTION COEFFICIENTS WHICH ARE EITHER THE LOWEST REPORTED OR THOSE USED TO DEFINE THE CONSTANTS IN EQ.(41). UNCERTAINTIES IN THESE VALUES ARE ABOUT ±10 PERCENT. EXPERIMENTAL DATA MEASURED AT WAVENUMBERS HIGHER THAN 1300 CM^{-1} TEND TO BE HIGHER THAN THE RECOMMEDED VALUES DUE TO IMPURITIES AND SURFACE CONTAMINATION [40,53].

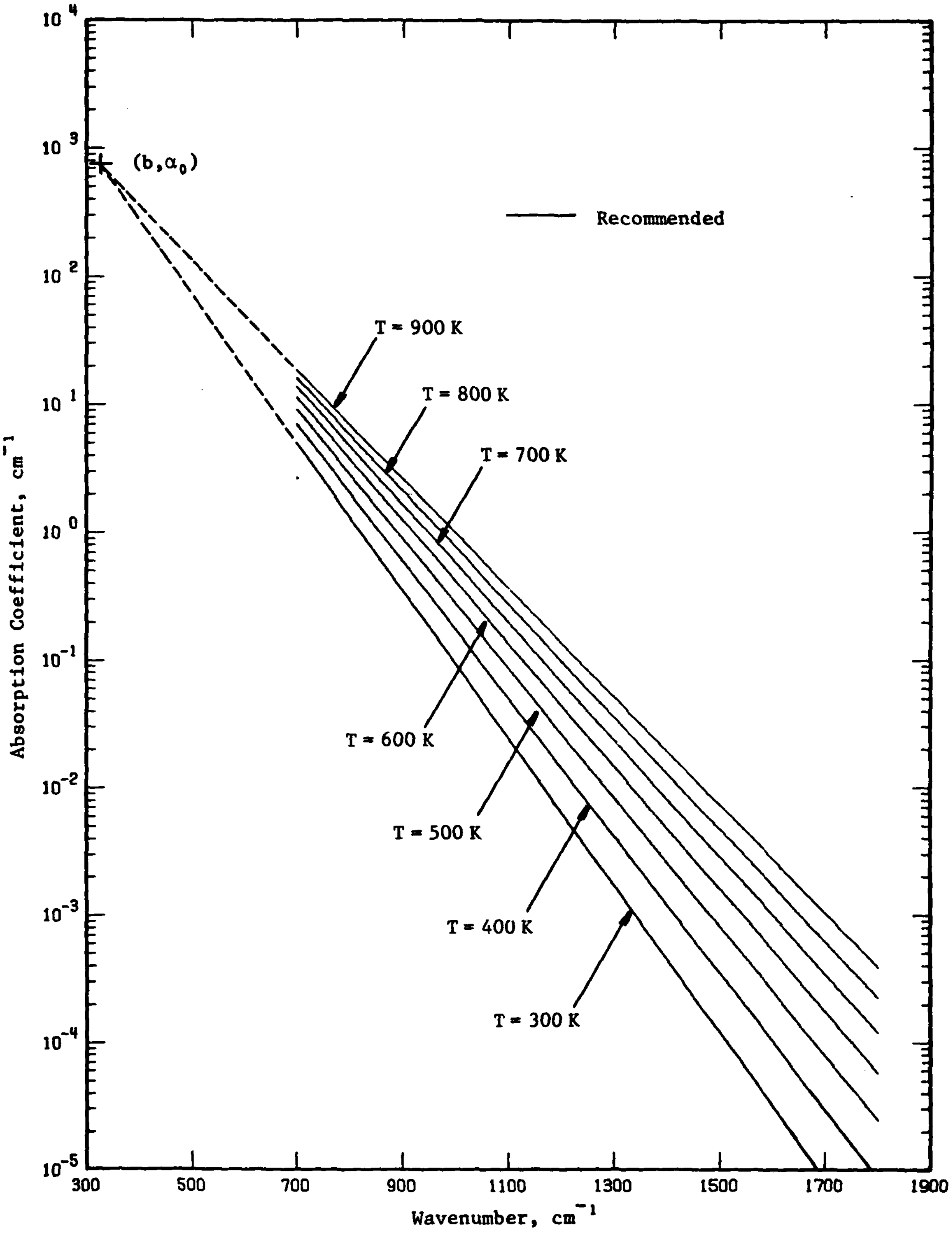

Figure 26. Calculated Absorption Spectra of Barium Fluoride (Wavenumber Dependence)

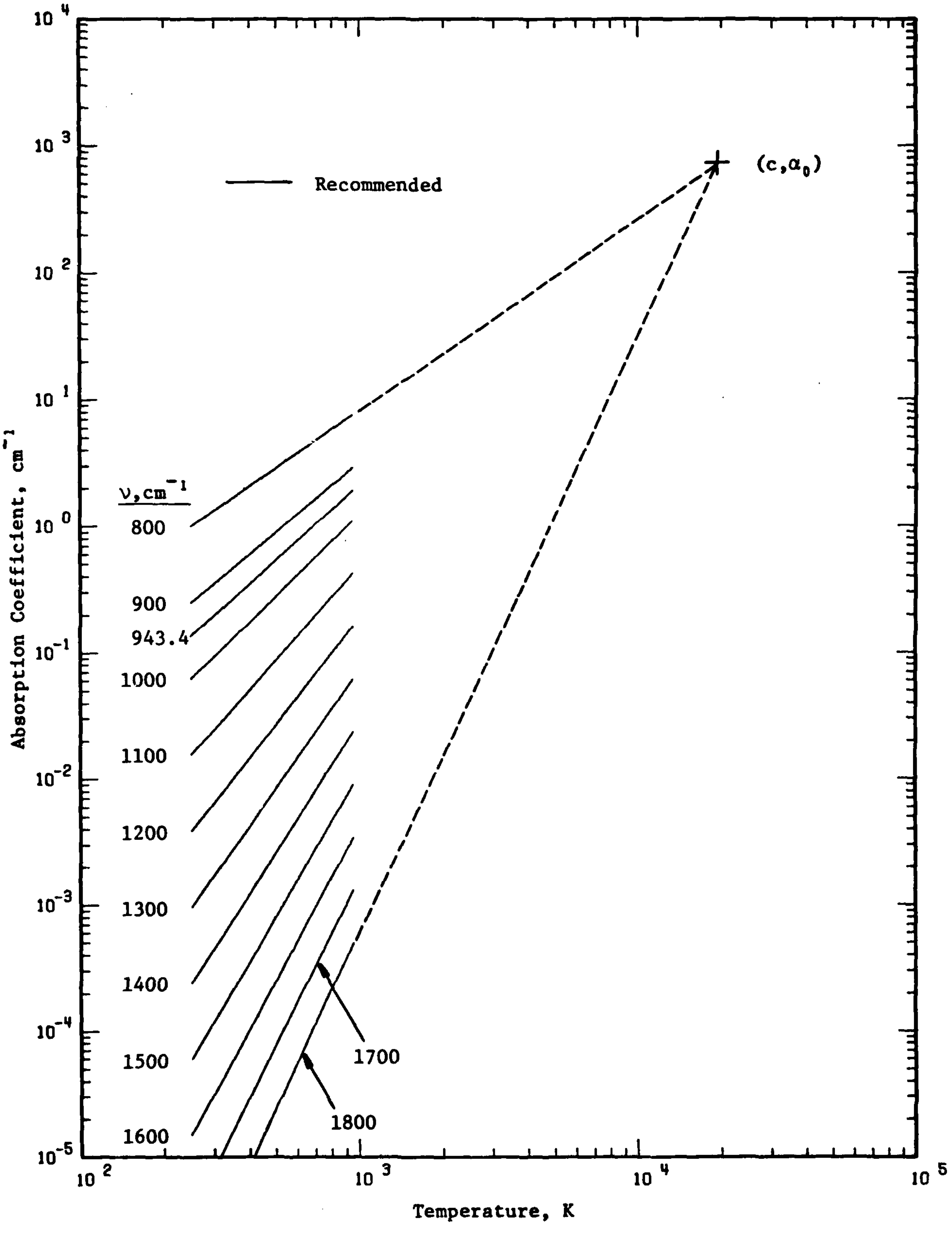

Figure 27. Calculated Absorption Coefficient of Barium Fluoride (Temperature Dependence)

TABLE 18. RECOMMENDED VALUES ON THE INFRARED ABSORPTION COEFFICIENT OF BARIUM FLUORIDE[a]

[WAVENUMBER, ν, CM⁻¹; TEMPERATURE, T, K; ABSORPTION COEFFICIENT, α, CM⁻¹]

WAVENUMBER, CM⁻¹	TEMPERATURE, K							
	300	300[b]	400	500	600	700	800	900
7.000E+02	5.007E+00		7.048E+00	9.188E+00	1.141E+01	1.370E+01	1.606E+01	1.847E+01
7.500E+02	2.575E+00	2.4E+00	3.794E+00	5.126E+00	6.554E+00	8.067E+00	9.658E+00	1.132E+01
8.000E+02	1.324E+00	1.4E+00	2.043E+00	2.859E+00	3.764E+00	4.749E+00	5.808E+00	6.936E+00
8.500E+02	6.807E-01	6.5E-01	1.100E+00	1.595E+00	2.162E+00	2.795E+00	3.492E+00	4.250E+00
9.000E+02	3.500E-01	3.1E-01	5.920E-01	8.899E-01	1.242E+00	1.645E+00	2.100E+00	2.604E+00
9.500E+02	1.800E-01		3.187E-01	4.965E-01	7.131E-01	9.686E-01	1.263E+00	1.596E+00
1.000E+03	9.255E-02	8.7E-02	1.716E-01	2.770E-01	4.096E-01	5.701E-01	7.593E-01	9.777E-01
1.050E+03	4.759E-02	4.8E-02	9.237E-02	1.545E-01	2.352E-01	3.356E-01	4.566E-01	5.990E-01
1.100E+03	2.447E-02	2.4E-02	4.973E-02	8.619E-02	1.351E-01	1.976E-01	2.746E-01	3.670E-01
1.150E+03	1.258E-02	1.0E-02	2.677E-02	4.809E-02	7.759E-02	1.163E-01	1.651E-01	2.249E-01
1.200E+03	6.470E-03	6.9E-03	1.441E-02	2.683E-02	4.457E-02	6.845E-02	9.928E-02	1.378E-01
1.250E+03	3.327E-03		7.759E-03	1.496E-02	2.560E-02	4.029E-02	5.970E-02	8.444E-02
1.300E+03	1.711E-03		4.177E-03	8.348E-03	1.470E-02	2.372E-02	3.590E-02	5.174E-02
1.350E+03	8.796E-04		2.249E-03	4.657E-03	8.443E-03	1.396E-02	2.159E-02	3.170E-02
1.400E+03	4.523E-04		1.211E-03	2.598E-03	4.849E-03	8.218E-03	1.298E-02	1.942E-02
1.450E+03	2.326E-04		6.517E-04	1.449E-03	2.785E-03	4.838E-03	7.805E-03	1.190E-02
1.500E+03	1.196E-04		3.509E-04	8.086E-04	1.600E-03	2.848E-03	4.693E-03	7.292E-03
1.550E+03	6.149E-05		1.889E-04	4.511E-04	9.187E-04	1.676E-03	2.822E-03	4.468E-03
1.600E+03	3.162E-05		1.017E-04	2.517E-04	5.276E-04	9.867E-04	1.697E-03	2.738E-03
1.650E+03	1.626E-05		5.474E-05	1.404E-04	3.030E-04	5.808E-04	1.020E-03	1.678E-03
1.700E+03	8.359E-06		2.947E-05	7.832E-05	1.741E-04	3.419E-04	6.136E-04	1.028E-03

[a] INTRINSIC VALUES WERE CALCULATED ACCORDING TO EQ.(41) WITH UNCERTAINTIES ABOUT ±10 PERCENT.

[b] VALUES IN THIS COLUMN, SELECTED FROM REF.[32,53], ARE THE BULK ABSORPTION COEFFICIENTS WHICH ARE EITHER THE LOWEST REPORTED OR THOSE USED TO DEFINE THE CONSTANTS IN EQ.(41). UNCERTAINTIES IN THESE VALUES ARE ABOUT ±10 PERCENT. EXPERIMENTAL DATA MEASURED AT WAVENUMBERS HIGHER THAN 1200 CM⁻¹ TEND TO BE MUCH HIGHER THAN THE CALCULATED VALUES DUE TO EXTRINSIC ABSORPTIONS [40].

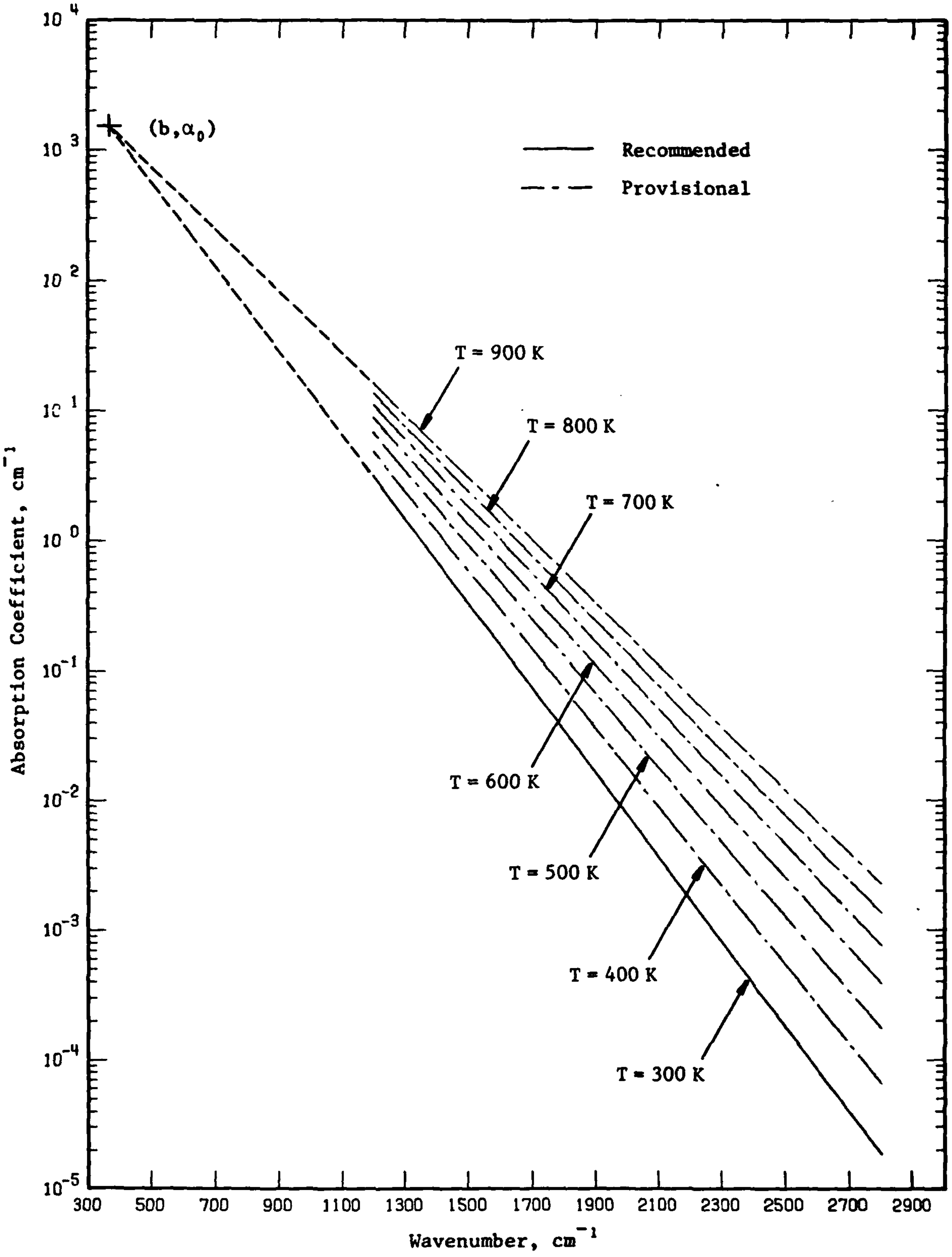

Figure 28. Calculated Absorption Spectra of Magnesium Fluoride (Wavenumber Dependence)

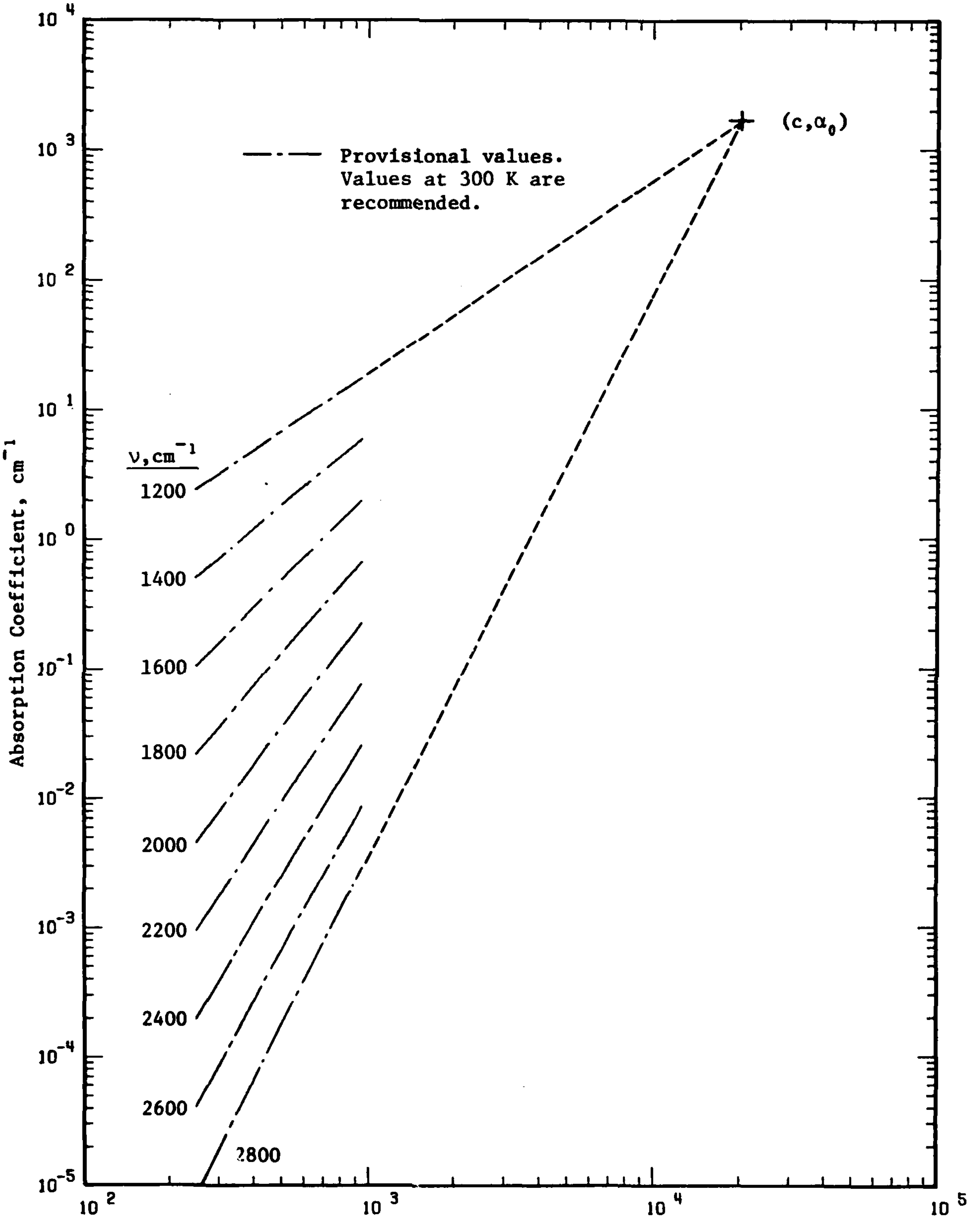

Figure 29. Calculated Absorption Spectra of Magnesium Fluoride (Temperature Dependence)

TABLE 19. RECOMMENDED VALUES ON THE INFRARED ABSORPTION COEFFICIENT OF MAGNESIUM FLUORIDE[a]

[WAVENUMBER, ν, CM^{-1}; TEMPERATURE, T, K; ABSORPTION COEFFICIENT, α, CM^{-1}]

WAVENUMBER, CM^{-1}	TEMPERATURE, K							
	300	300[b]	400	500	600	700	800	900
1.200E+03	3.168E+00		4.852E+00	6.753E+00	8.849E+00	1.112E+01	1.355E+01	1.614E+01
1.250E+03	2.175E+00	1.9E+00	3.419E+00	4.855E+00	6.467E+00	8.240E+00	1.017E+01	1.223E+01
1.300E+03	1.493E+00	1.4E+00	2.409E+00	3.491E+00	4.726E+00	6.106E+00	7.624E+00	9.273E+00
1.350E+03	1.025E+00	1.0E+00	1.697E+00	2.509E+00	3.454E+00	4.525E+00	5.718E+00	7.029E+00
1.400E+03	7.039E-01	7.1E-01	1.196E+00	1.804E+00	2.524E+00	3.353E+00	4.289E+00	5.328E+00
1.450E+03	4.833E-01	4.8E-01	8.427E-01	1.297E+00	1.845E+00	2.485E+00	3.217E+00	4.039E+00
1.500E+03	3.318E-01	3.1E-01	5.938E-01	9.324E-01	1.348E+00	1.841E+00	2.412E+00	3.061E+00
1.550E+03	2.278E-01	2.0E-01	4.184E-01	6.704E-01	9.853E-01	1.365E+00	1.809E+00	2.321E+00
1.600E+03	1.564E-01	1.4E-02	2.948E-01	4.819E-01	7.201E-01	1.011E+00	1.357E+00	1.759E+00
1.650E+03	1.074E-01	9.8E-02	2.077E-01	3.465E-01	5.263E-01	7.494E-01	1.018E+00	1.333E+00
1.700E+03	7.375E-02	6.9E-02	1.464E-01	2.491E-01	3.846E-01	5.553E-01	7.634E-01	1.011E+00
1.750E+03	5.063E-02	4.8E-02	1.031E-01	1.791E-01	2.811E-01	4.115E-01	5.725E-01	7.661E-01
1.800E+03	3.476E-02	3.1E-02	7.267E-02	1.287E-01	2.054E-01	3.050E-01	4.294E-01	5.807E-01
1.850E+03	2.387E-02	2.2E-02	5.120E-02	9.256E-02	1.501E-01	2.260E-01	3.221E-01	4.402E-01
1.887E+03	1.810E-02	1.5E-02	3.957E-02	7.260E-02	1.192E-01	1.813E-01	2.606E-01	3.590E-01
1.900E+03	1.639E-02		3.608E-02	6.654E-02	1.097E-01	1.675E-01	2.415E-01	3.337E-01
1.950E+03	1.125E-02	1.1E-02	2.542E-02	4.784E-02	8.019E-02	1.241E-01	1.812E-01	2.529E-01
2.000E+03	7.726E-03	7.1E-03	1.791E-02	3.439E-02	5.860E-02	9.196E-02	1.359E-01	1.917E-01
2.050E+03	5.304E-03		1.262E-02	2.472E-02	4.283E-02	6.815E-02	1.019E-01	1.453E-01
2.100E+03	3.642E-03		8.893E-03	1.778E-02	3.130E-02	5.050E-02	7.643E-02	1.102E-01
2.150E+03	2.501E-03		6.266E-03	1.278E-02	2.287E-02	3.742E-02	5.733E-02	8.350E-02
2.200E+03	1.717E-03		4.415E-03	9.187E-03	1.672E-02	2.773E-02	4.299E-02	6.330E-02
2.250E+03	1.179E-03		3.111E-03	6.605E-03	1.222E-02	2.055E-02	3.225E-02	4.798E-02
2.300E+03	8.093E-04		2.192E-03	4.748E-03	8.929E-03	1.523E-02	2.419E-02	3.637E-02
2.350E+03	5.557E-04		1.545E-03	3.414E-03	6.526E-03	1.129E-02	1.814E-02	2.757E-02
2.400E+03	3.815E-04		1.088E-03	2.454E-03	4.769E-03	8.363E-03	1.360E-02	2.090E-02
2.450E+03	2.620E-04		7.669E-04	1.764E-03	3.485E-03	6.198E-03	1.020E-02	1.584E-02
2.500E+03	1.799E-04		5.404E-04	1.268E-03	2.547E-03	4.593E-03	7.653E-03	1.201E-02
2.550E+03	1.235E-04		3.808E-04	9.119E-04	1.862E-03	3.403E-03	5.740E-03	9.101E-03
2.600E+03	8.479E-05		2.683E-04	6.556E-04	1.360E-03	2.522E-03	4.305E-03	6.899E-03
2.632E+03	6.665E-05	9.1E-05	2.144E-04	5.308E-04	1.113E-03	2.082E-03	3.581E-03	5.778E-03
2.650E+03	5.822E-05		1.890E-04	4.713E-04	9.943E-04	1.869E-03	3.229E-03	5.229E-03
2.700E+03	3.997E-05		1.332E-04	3.389E-04	7.266E-04	1.385E-03	2.422E-03	3.964E-03

[a] INTRINSIC VALUES WERE CALCULATED ACCORDING TO EQ.(41) WITH UNCERTAINTIES ABOUT ±10 PERCENT. VALUES AT TEMPERATURES OTHER THAN 300 K ARE PROVISIONAL VALUES.

[b] VALUES IN THIS COLUMN, SELECTED FROM REF.[32,42], ARE THE BULK ABSORPTION COEFFICIENTS WHICH ARE EITHER THE LOWEST REPORTED OR THOSE USED TO DEFINE THE CONSTANTS IN EQ.(41). UNCERTAINTIES IN THESE VALUES ARE ABOUT ±10 PERCENT. VALUES LOWER THAN 1.0E-04 CARRY HIGHER UNCERTAINTIES UP TO ±50 PERCENT.

6. SUMMARY OF RESULTS AND CONCLUSIONS

The purpose of the present study is to survey and compile the available data on the absorption coefficient of alkaline earth halides and to generate recommended values on the absorption coefficient in the infrared region through data evaluation and analysis. In this study we have seen that the absorption spectra of alkaline earth halides are of same nature and of similar configuration as that typified in Figure 1.

Low absorption coefficients at laser wavelengths are of particular interest in laser applications. Unfortunately laser wavelengths are located near the multiphonon absorption region. Factors that introduce extrinsic absorptions into this region will therefore increase the absorption at laser wavelengths. For this reason, numerous investigations were conducted in this region, but the results are still less than satisfactory.

Based on the considerations stated above, the present work is naturally focused in the multiphonon absorption region. We have developed an equation that describes the absorption coefficient as a function of both frequency and temperature. As a counterpart of the Urbach rule for the uv absorption edge, we have established an expression for the infrared absorption edge. These expressions are of the same form and the parameters in the corresponding equations are similar. Compared with Deutsch's expression, we have extended the dependence of the absorption coefficient to include the temperature in addition to frequency. It is worthwhile to point out that the equation formulated in this work is of the same type as it was found for alkali halides [84]. Correlation techniques used for alkali halides are equally applicable in the present work. Through our correlation, we have confidence to propose that the constants in eq. (9) established by Deutsch for CaF_2 should be modified.

Many theoretical studies have attempted to provide an understanding of the absorption mechanisms in the infrared absorption edge. Except at very low temperatures, spectra obtained in this region are featureless and have large uncertainties. Thus little conclusion can be drawn. In order to provide useful information for theoretical studies, high-accuracy measurements should be carried out over wide wavelength and temperature ranges.

It should be emphasized that the present work does not resolve the discrepancies between the available data sets, it simply establishes the most probable values, of stated uncertainty, of the absorption coefficient that a pure crystal may have. Furthermore, the proposed predictive eq. (41) can be considered valid only to the reported accuracy and within the region of experimental data it is based on. In general, extrapolation of the equation for use outside of this region is not advised for quantitative results. Finally, the type of analysis presented here assumes the model is an absolutely correct representation of the data at hand, which is not generally true since the model is an oversimplification of the true behavior of matter. However, for practical purposes, based upon the experimental data from several sources, and within the usable region of the data, we believe that eq. (41) is valid for calculation of the absorption coefficient in the given wavelength and temperature regions. It is important to point out that the rule established in the present work is for the temperature region $T \geqq 300$ K.

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APPENDIX A

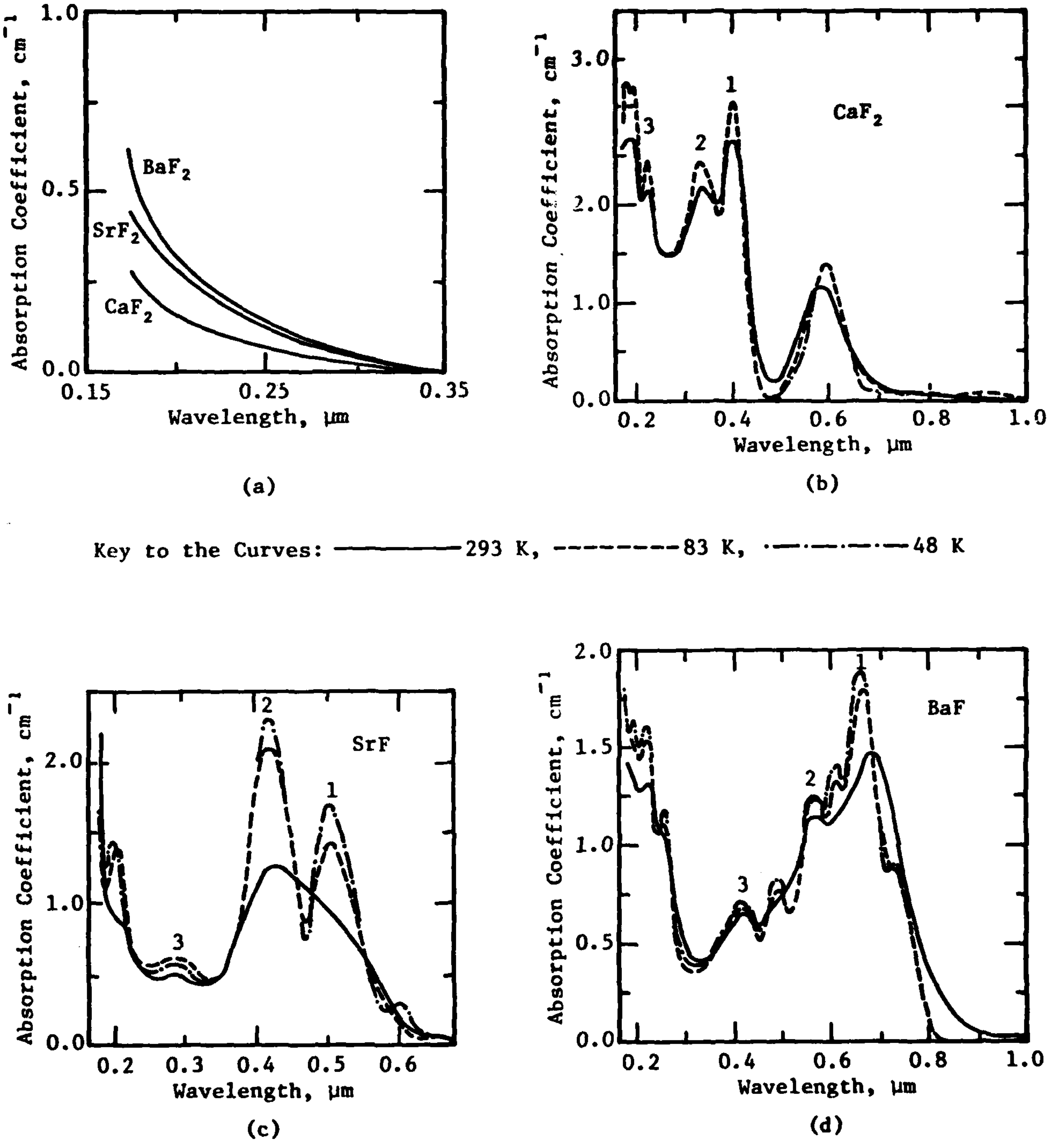
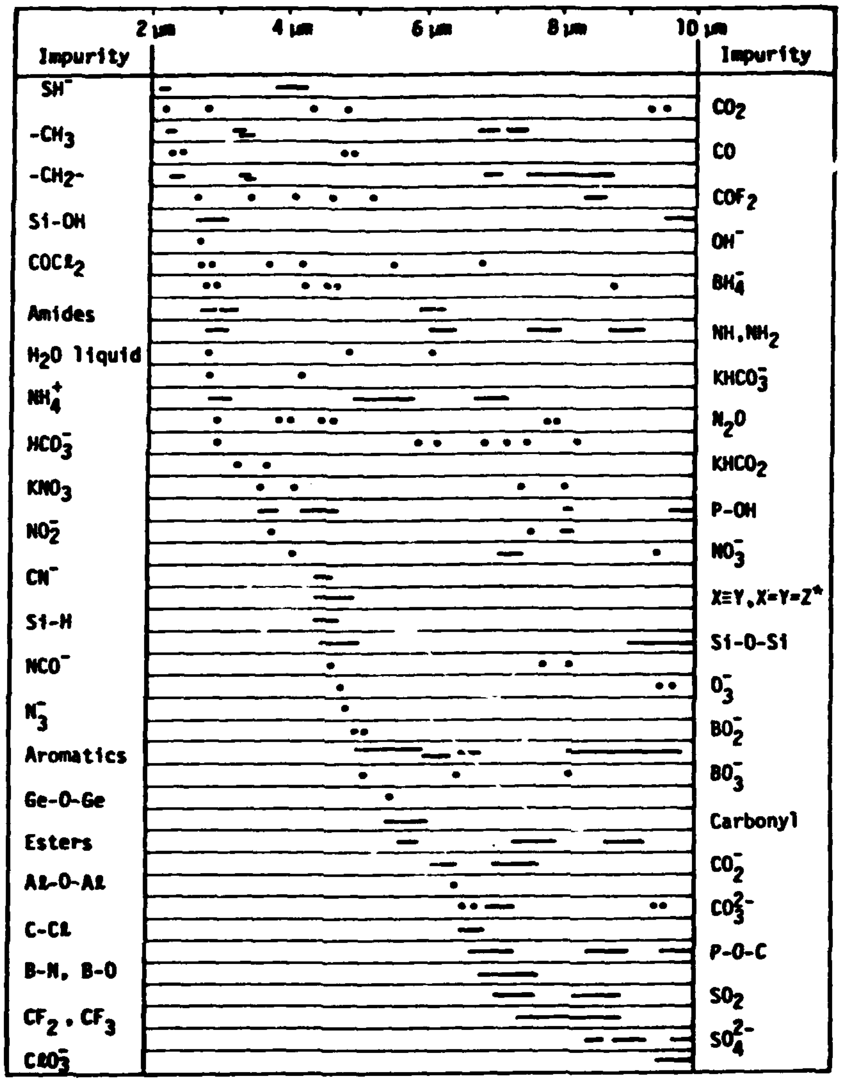


Figure A1. Absorption Coefficient of Colored Alkaline Earth Fluorides (After Messner and Smakula [85]). (a) Uncolored Pure Crystals; (b), (c), and (d) are Colored at Room Temperature by 3-Mev Electrons of 10^6 Rad Dose. Peak Labeled with the Same Arabic Number are Related by the Ivey's Expression.

APPENDIX B



*X,Y = C,N; Z = C,N,O,S: X≡Y means C≡C, C≡N, etc.

Figure B1. Correlation chart showing the absorption lines between 2 and 10 μm of some chemical bonds, molecular ions, radicals, and compounds. Key: • peak positions; —— range of peak positions in various materials.

Figure B2. Correlation chart showing the absorption lines between 0.5 and 15 µm of some chemical bonds, molecular ions, radicals, and compounds.

- • peak positions
- —— range of peak positions in various materials

Absorption strength:

S strong
M medium
W weak
V variable

Absorption line width:

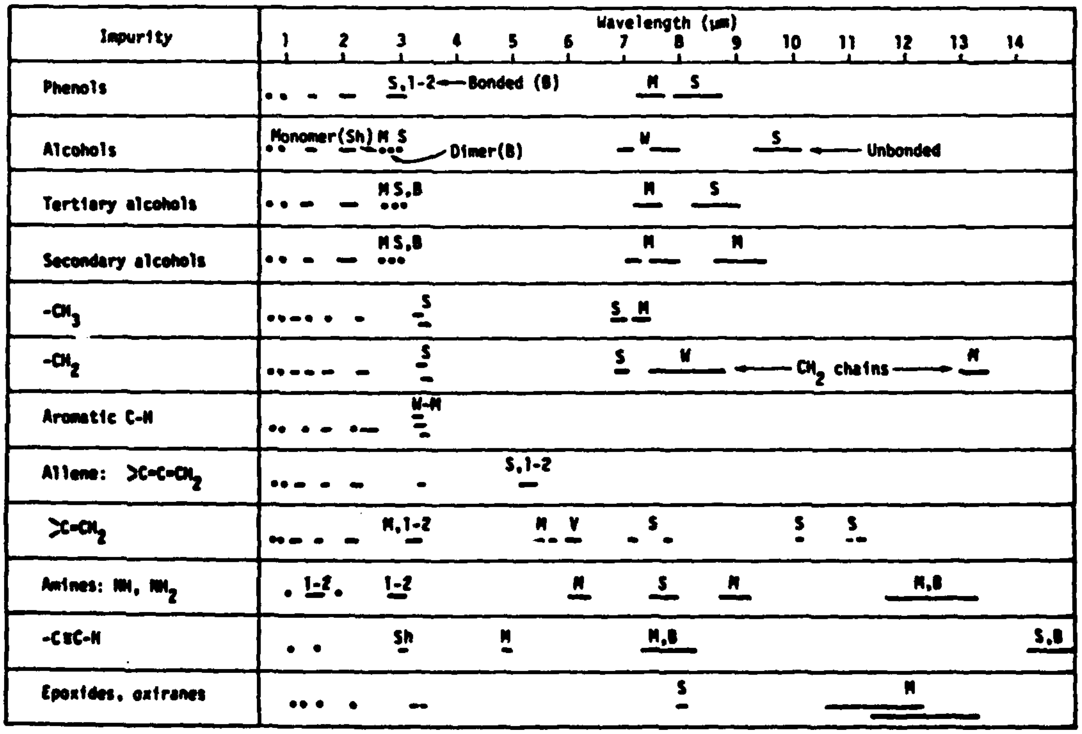
B broad
Sh sharp

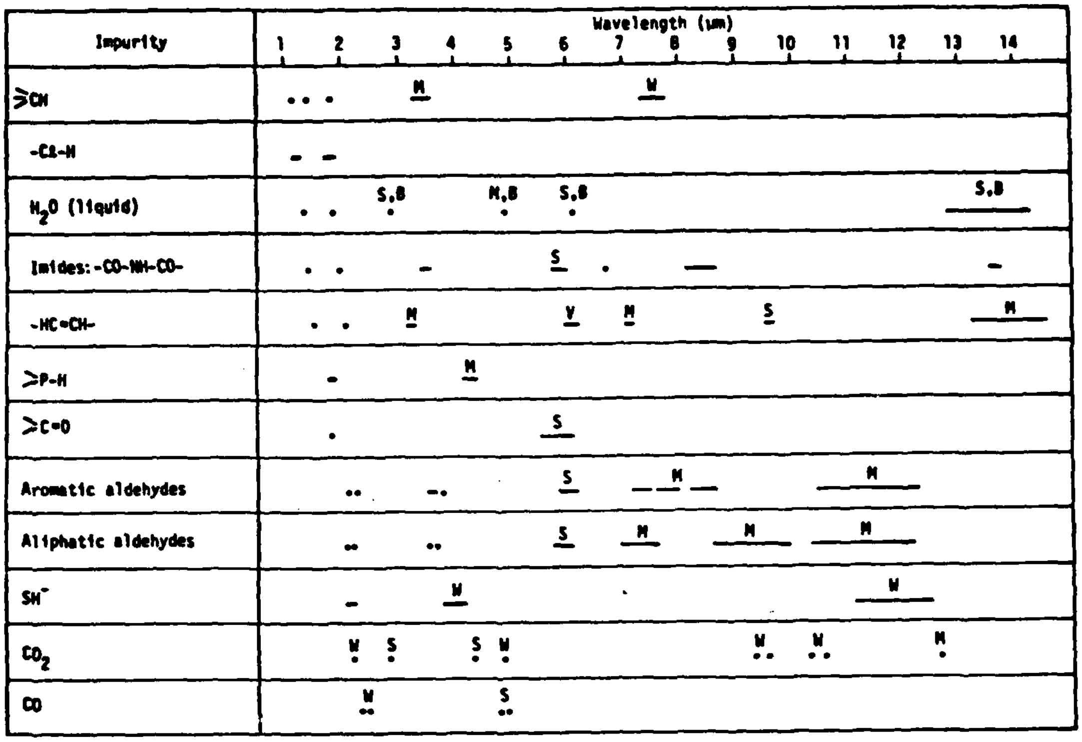
Numbers associated with an absorption band indicate the number of peaks occurring within that band.

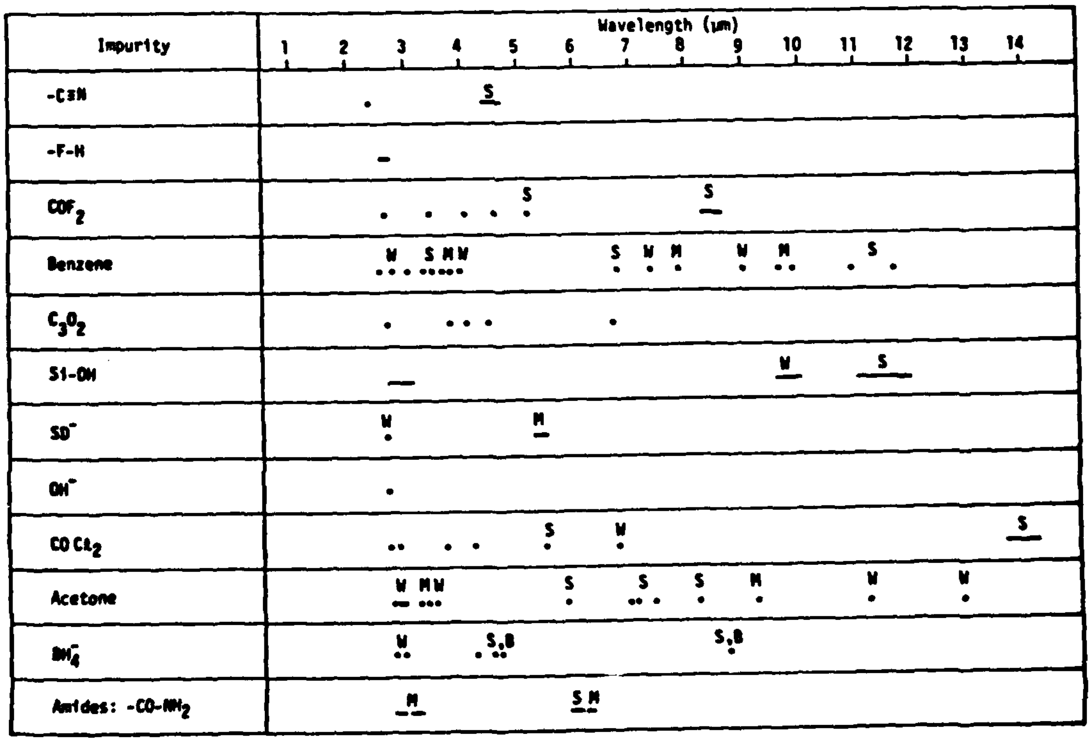
If several designations apply to one peak, they are separated by commas.

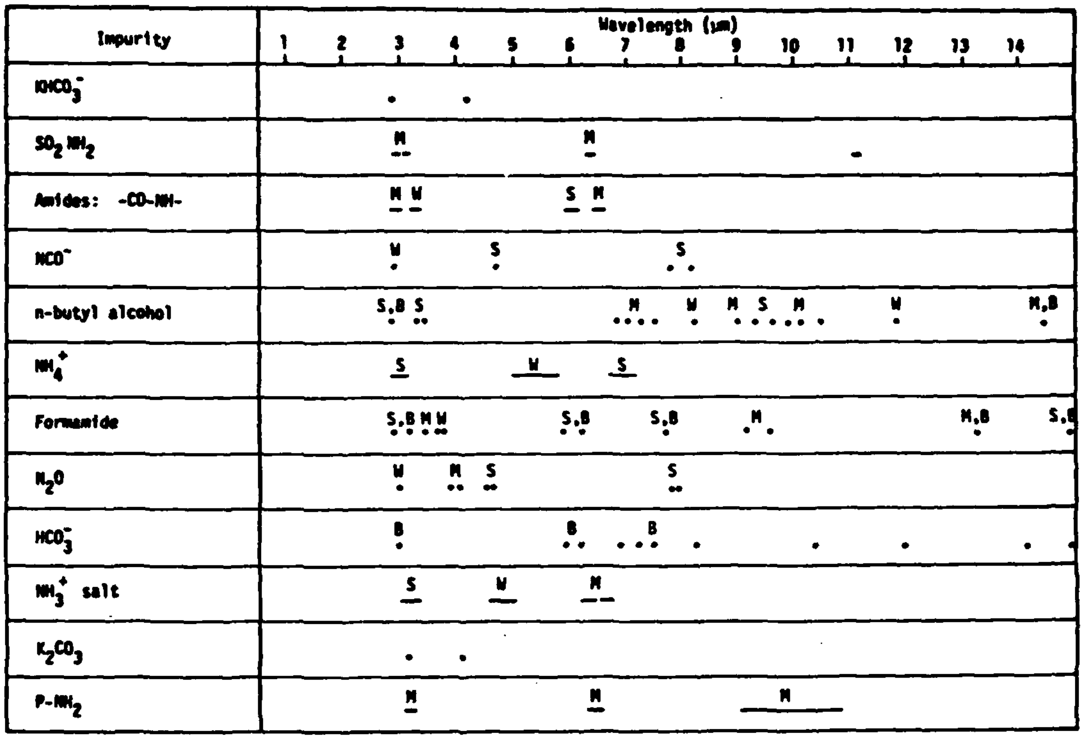
If a designation applies to two adjacent peaks, it may be written between them.

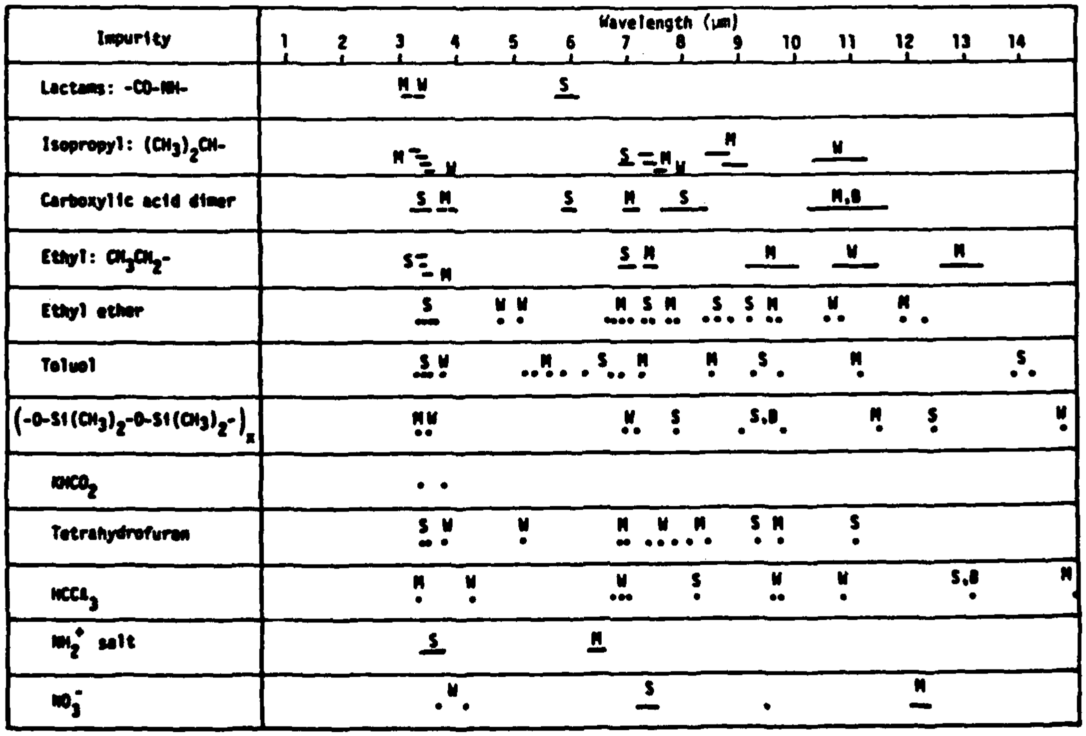
aliph. = aliphatic
arom. = aromatic
Me = metal atom.

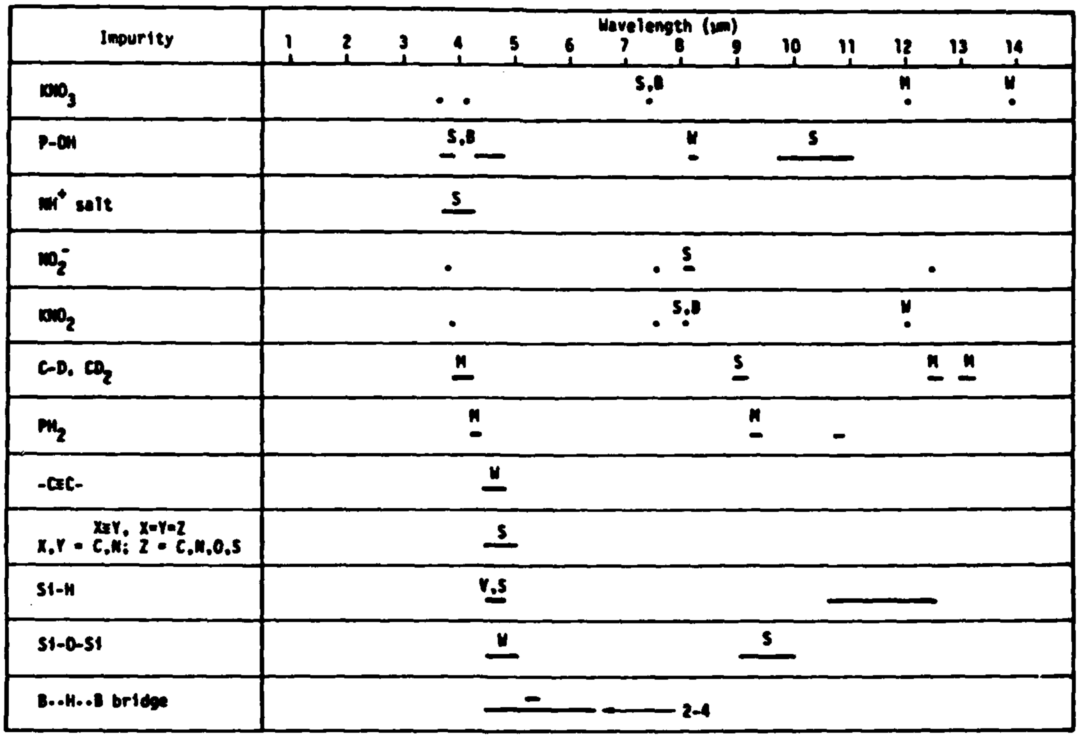


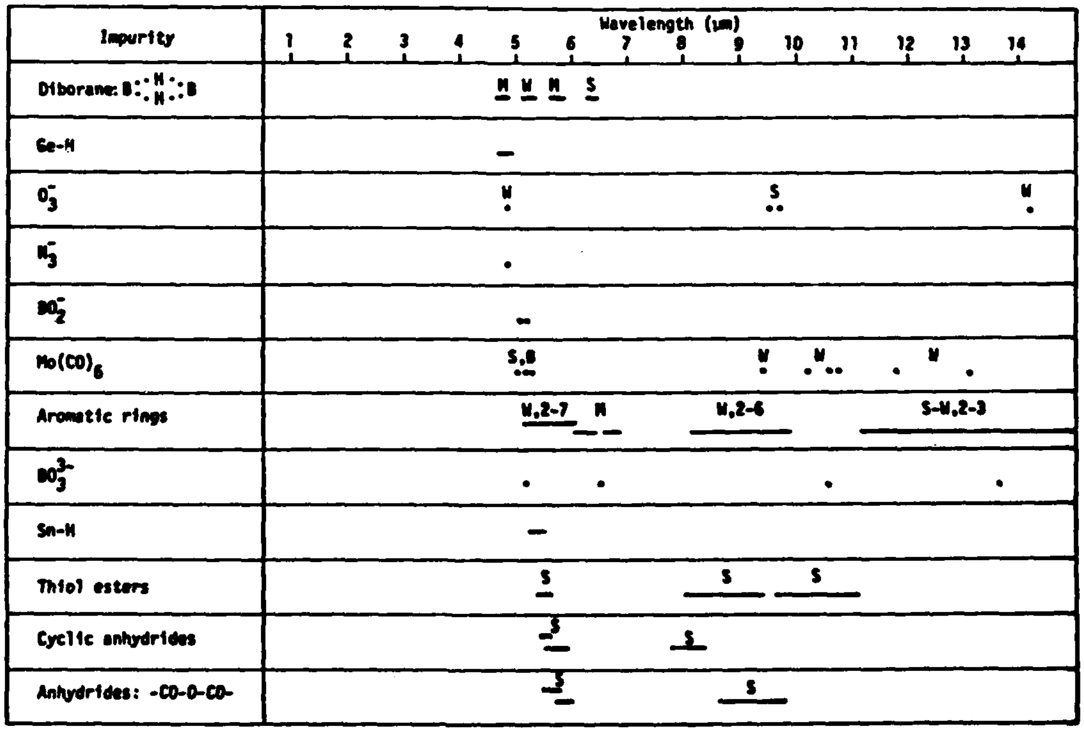

Impurity
Wavelength (µm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
≥CH M W
-Cl-H
H2O (liquid) S,B M,B S,B S,B
Imides: -CO-NH-CO- S
-HC=CH- M V M S M
≥P-H M
≥C=O S
Aromatic aldehydes S M M
Aliphatic aldehydes S M M M
SH⁻ W W
CO2 W S S W W W M
CO W S

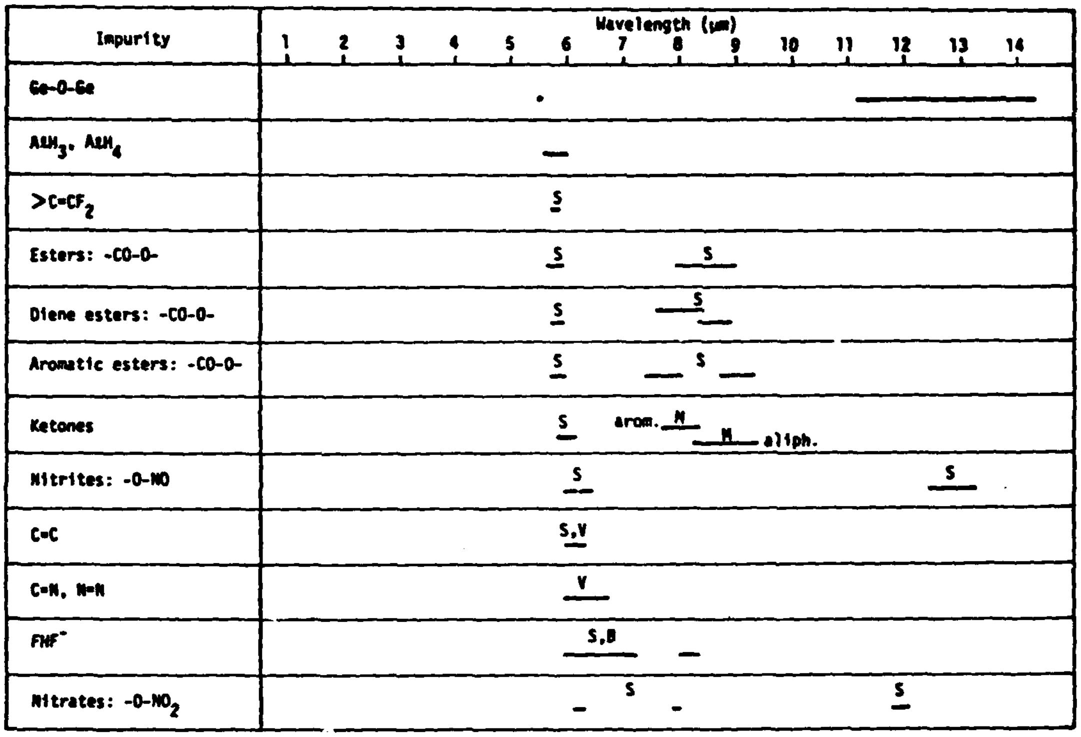

Impurity
Wavelength (µm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
-C≡N S
-F-H
COF2 S S
Benzene W S M W S W M W M S
C3O2
Si-OH W S
SD⁻ W M
OH⁻
COCl2 S W S
Acetone W M W S S S M W W
BH4⁻ W S,B S,B
Amides: -CO-NH2 M S M

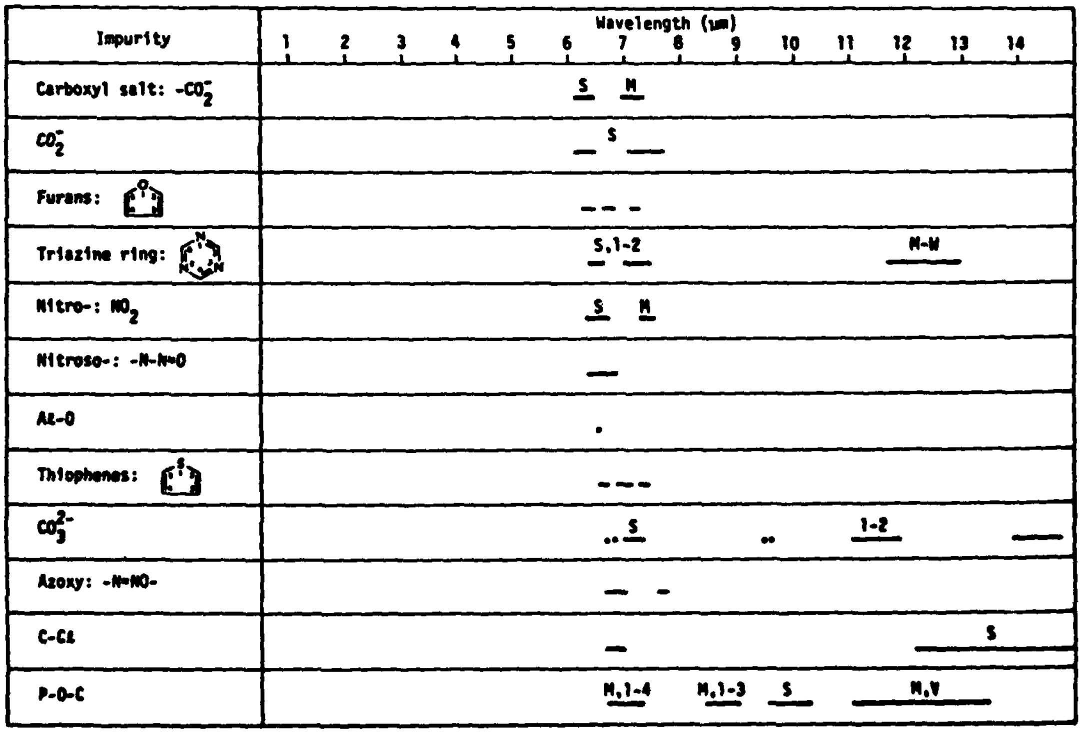

Impurity
Wavelength (μm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
$KHCO_3^-$
SO_2NH_2 M M
Amides: -CO-NH- M W S M
NCO^- W S S
n-butyl alcohol S,B S M W M S M W M,B
NH_4^+ S W S
Formamide S,B M W S,B S,B M M,B S,B
N_2O W M S S
HCO_3^- B B B
NH_3^+ salt S W M
K_2CO_3
$P-NH_2$ M M M

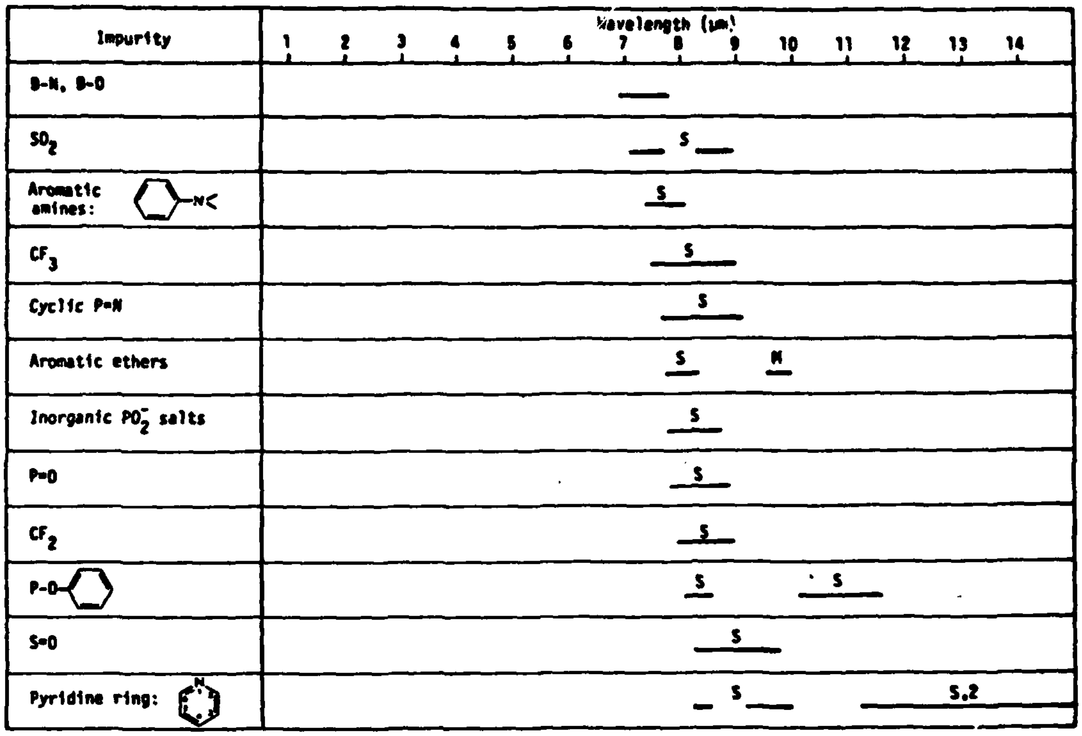

Impurity
Wavelength (μm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Lactams: -CO-NH- M W S
Isopropyl: $(CH_3)_2CH-$ M W S M W M W
Carboxylic acid dimer S M S M S M,B
Ethyl: CH_3CH_2- S M S M M W M
Ethyl ether S W W M S M S S M W M
Toluol S W M S M M S M S
$(-O-Si(CH_3)_2-O-Si(CH_3)_2-)_x$ M W W S S,B M S W
$KHCO_2$
Tetrahydrofuran S W W M W M S M S
$HCCl_3$ M W W S W W S,B M
NH_2^+ salt S M
NO_3^- W S M

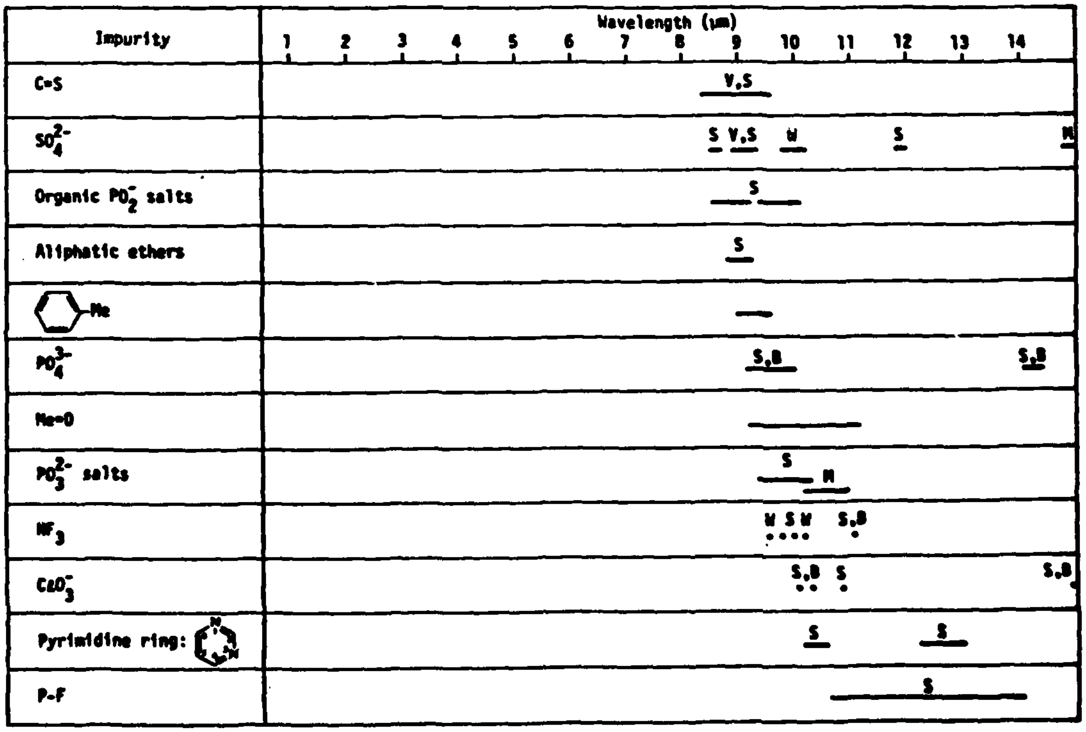

Impurity
Wavelength (μm)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
KNO_3
S,B
M
W
P-OH
S,B
W
S
NH^+ salt
S
NO_2^-
S
KNO_2
S,B
W
C-D, CD_2
M
S
M
M
PH_2
M
M
-C≡C-
W
X≡Y, X=Y=Z
X,Y = C,N; Z = C,N,O,S
S
Si-H
V,S
Si-O-Si
W
S
B··H··B bridge
2-4

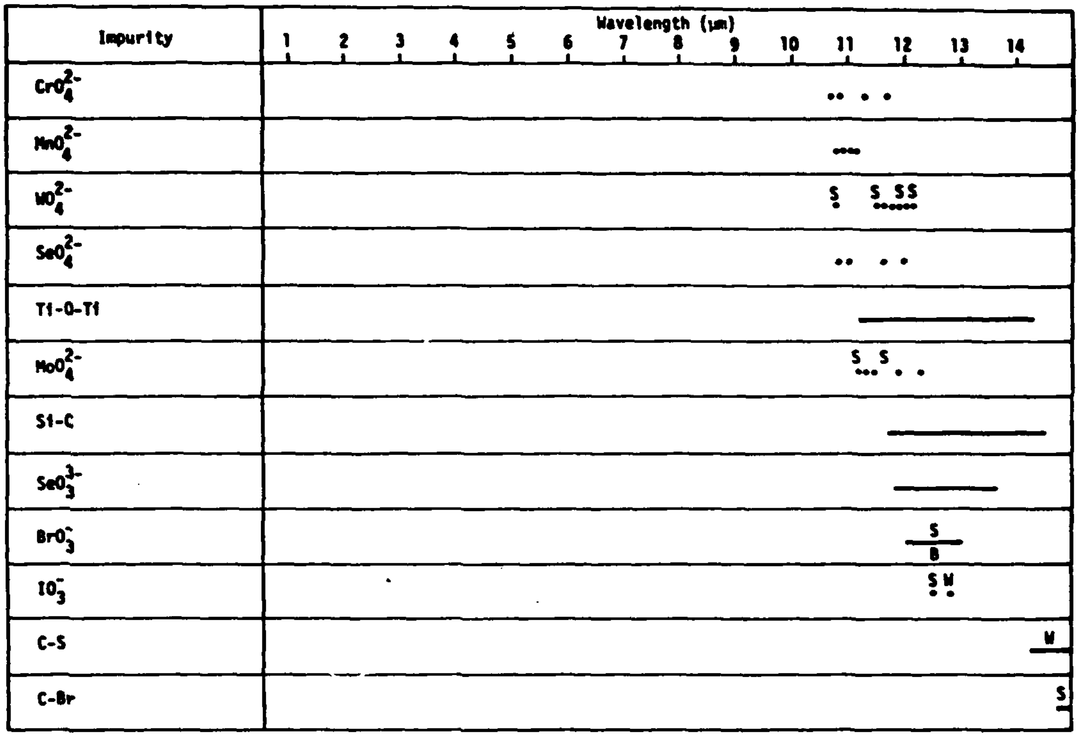

Impurity
Wavelength (μm)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Diborane: B:·H·:B
M
W
M
S
Ge-H
O_3^-
W
S
W
N_3^-
BO_2^-
$Mo(CO)_6$
S,B
W
W
W
Aromatic rings
W,2-7
M
W,2-6
S-W,2-3
BO_3^{3-}
Sn-H
Thiol esters
S
S
S
Cyclic anhydrides
S
S
Anhydrides: -CO-O-CO-
S
S


Impurity
Wavelength (µm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Ge-O-Ge
AlH_3, AlH_4
$>C=CF_2$
S
Esters: -CO-O-
S S
Diene esters: -CO-O-
S S
Aromatic esters: -CO-O-
S S
Ketones
S arom. M M aliph.
Nitrites: -O-NO
S S
C=C
S,V
C=N, N=N
V
FHF^-
S,B
Nitrates: $-O-NO_2$
S S


Impurity
Wavelength (µm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Carboxyl salt: $-CO_2^-$
S M
CO_2^-
S
Furans:
Triazine ring:
S,1-2 M-W
Nitro-: NO_2
S M
Nitroso-: -N-N=O
Al-O
Thiophenes:
CO_3^{2-}
S 1-2
Azoxy: -N=NO-
C-Cl
S
P-O-C
M,1-4 M,1-3 S M,V


Impurity
Wavelength (μm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
B-N, B-O
SO_2
S
Aromatic amines:
N<
S
CF_3
S
Cyclic P=N
S
Aromatic ethers
S
M
Inorganic PO_2^- salts
S
P=O
S
CF_2
S
P-O-
S
S
S=O
S
Pyridine ring:
N
S
S,2


Impurity
Wavelength (μm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
C=S
V,S
SO_4^{2-}
S
V,S
W
S
M
Organic PO_2^- salts
S
Aliphatic ethers
S
-Me
PO_4^{3-}
S,B
S,B
Me=O
PO_3^{2-} salts
S
M
NF_3
W S W
S,B
ClO_3^-
S,B
S
S,B
Pyrimidine ring:
N
N
S
S
P-F
S


Impurity
Wavelength (μm)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
CrO_4^{2-}
MnO_4^{2-}
WO_4^{2-}
S
S
S S
SeO_4^{2-}
Ti-O-Ti
MoO_4^{2-}
S
S
Si-C
SeO_3^{3-}
BrO_3^-
S
B
IO_3^-
S W
C-S
W
C-Br
S