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ANALYSIS OF SOLAR FLUX DATA FOR STRATCOM VIIA

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Contract Monitor: Jagir S. Randhawa

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US Army Electronics Research and Development Command
Atmospheric Sciences Laboratory
White Sands Missile Range, N.M. 88002

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20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

Ozone overburden values and dissociation rates are developed and a single scatter flux model compared to observed conditions using data obtained with a balloon-borne spectrometer which responds to the UV solar flux between 2000 Å and 3200 Å.

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INTRODUCTION

Samplings of the UV solar flux have been accomplished using an instrument designed to make continuous scans over a range of 1200 Å.[1] A complete description of the instrument and its theory of operation were given in an earlier report [Barlow and Jensen, 1976].

A total of four balloon flights have been made with the instrument. Results of the first two flights are discussed in the report by Jensen and Montierth (1976). The fourth flight of the instrument was made on the STRATCOM-VIII-a balloon during September 1977. Only the analysis of the data obtained during the third flight (September 1976) will be considered in this paper.

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[1] angstrom (Å) = 10^{-10} meters.

RESULTS

The UV scatter experiment flown on STRATCOM-VII-a yielded a considerable amount of information on the structure of the UV scatter flux at altitudes up to 39 km for the wavelength region from 2000 Å to 3200 Å. Figure 1 gives the look geometry for the instrument. Figure 2 shows a sample scan of the output after the data is decoded, calibrated and assembled into a final data file.

The method of analysis used to obtain the ozone overburden, dissociation rates and comparison of the theoretical single scatter flux to the observed data is essentially the same as the procedure outlined in the Interim Report [Jensen and Montierth, 1976]. The procedure followed to calculate the ozone overburden values has been changed, however. The method used in the earlier effort to obtain the ozone overburden was to consider the following expression:

$$\frac{I_{calc(\lambda 1)}}{I_{calc(\lambda 2)}} + M = \frac{I_{mea(\lambda 1)}}{I_{mea(\lambda 2)}} \qquad (1)$$

where the radiative transfer model described in the report referenced above and outlined in appendix A is used to produce the flux value at each wavelength and gives the ratio on the left side of expression #1. The total ozone is then varied to force the value of M to become arbitrarily small. This ozone profile used in the model to produce the comparison is then integrated to obtain the ozone overburden. This procedure is repeated for a number of ratios within a scan of data and a weighted average taken of the overburden. Use of this technique results in some uncertainties as the levels of total ozone obtained by forming ratios using different wavelength points within a single data scan produce variations of a factor of 2 or 3. This difference in the ozone overburden is possibly caused by the difficulty in resolving the differences between respective data resulting in the vacillating levels of the ratios, and thus the total ozone content.

The procedure presently used to obtain the ozone overburden values is to extract the data from a scan where single scatter theory can be expected to hold. The reduced set of data points is matched as closely as possible to the corresponding theoretical curve using the sum of the squared-differences between the theoretical and measured values as the fit criterion. The shape of the theoretical curve is changed by adjusting the ozone level used in the radiative transfer model and then normalizing the output with the measured data at a point. Using only the shape of the flux curve for obtaining the ozone overburden results in values which are not dependent on an absolute instrument calibration, but which require only good measurement of relative values. Figures 3, 4, and 5 show measured data with calculated flux values. The ozone overburden is also shown on each figure. Figure 6 shows the sensitivity of the shape of the scatter flux curve to modification of the ozone overburden. Illustrated are the theoretical curve shown in Figure 5 and curves with ±20% ozone superimposed and normalized to the same point.

This method of generating the ozone overburden provides good results at present, and can certainly be improved upon as the effort continues. Resolving such difficulties as how the shape of the ozone profile in addition to the total content affects the calculated values, specifically at large zenith angles, will enable us to improve upon the ozone overburden values obtained.

The dissociation rates are calculated by evaluating the terms in the following expression:

$$J_{Total} = J_a + \sum_{i=0}^{n} J_i \qquad (2)$$

where:

J_a = ALBEDO TERM

$J_o = \int I(\lambda)\sigma(\lambda)d\lambda$

$J_1 = \iint I(\lambda w)\sigma(\lambda)dw$

J_a is the term due to albedo, J_o is the term due to direct solar flux, J_1 is the term due to primary scattering, and other terms due to higher order scatter. Because the data obtained does not provide sufficient samplings at enough different pointing directions to perform the integration on the J_1 term, the model is used to interpolate the flux values between points where data exist. Using the values of the terms as presently defined gives the following result:

$$\frac{J_1}{J_1 + J_o} \quad X\ 100\% \ \stackrel{\sim}{\sim}\ 10\%$$

There is some uncertainty in this value (between $\stackrel{\sim}{\sim}$ 6% - 14%) and an effort is being made to resolve it.

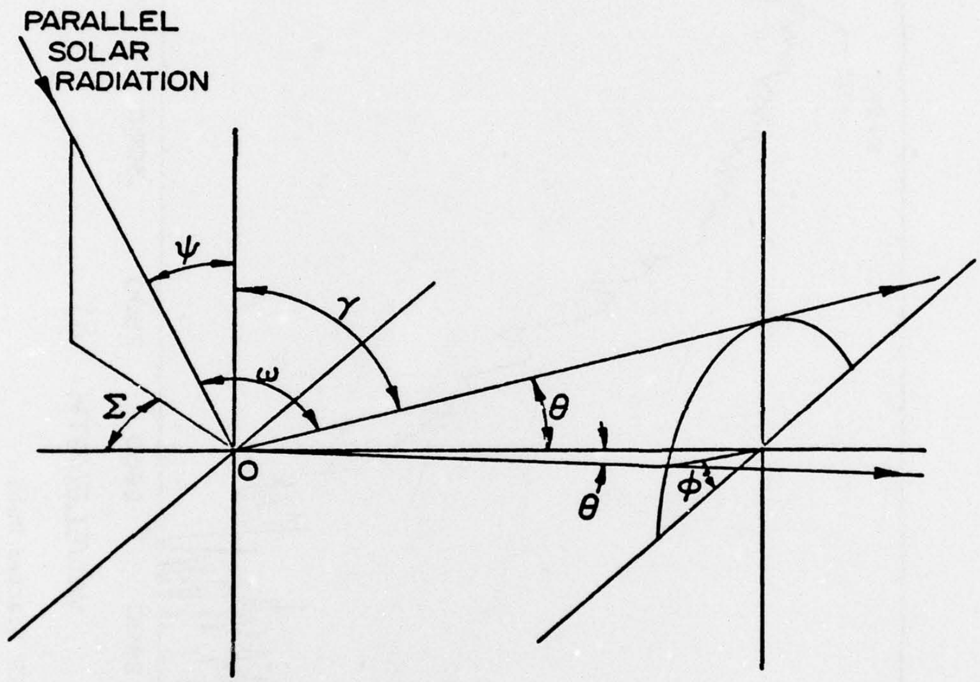

Figure 1. Spectrometer Look Geometry

where

ψ = solar zenith angle

φ = mirror scan angle (15° increments)

γ = look zenith angle

θ = mirror tilt angle

ω = scatter angle

o = spectrometer slit location

Σ = solar azimuth angle

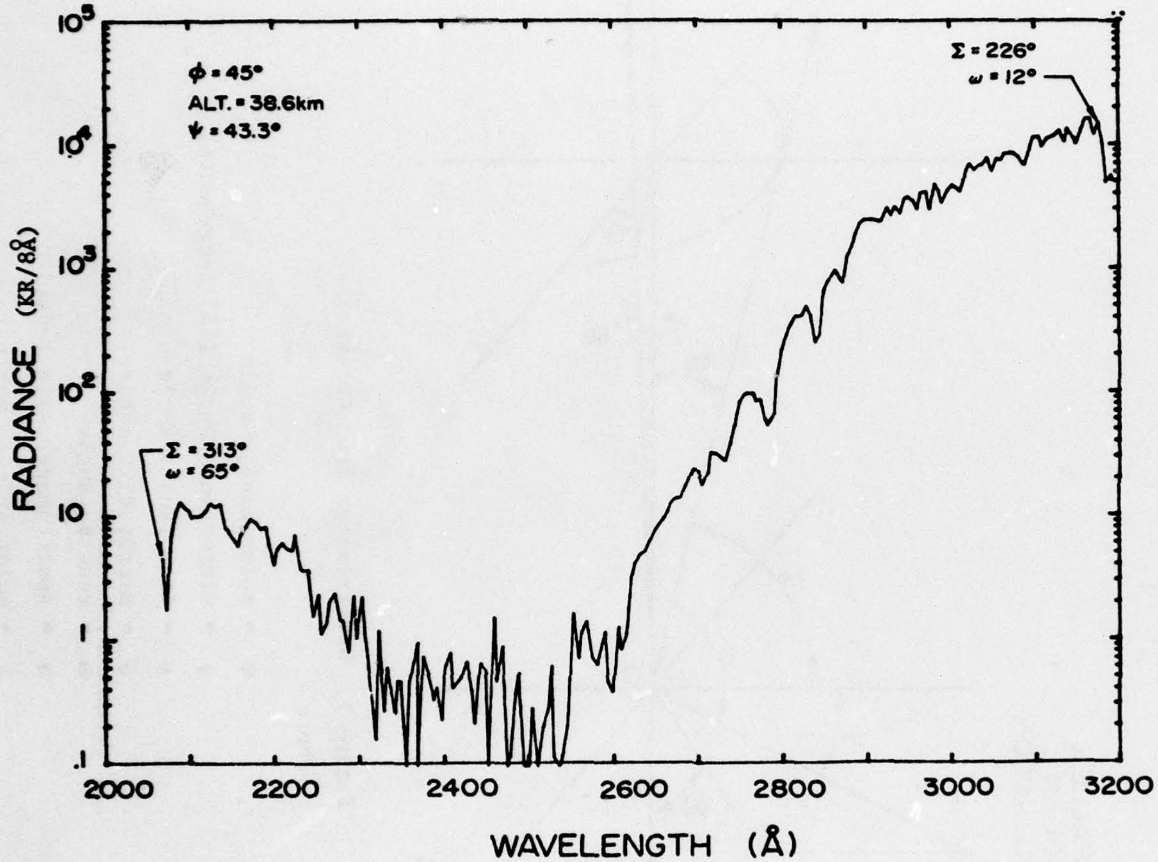

Figure 2. Sample UV Scatter Data

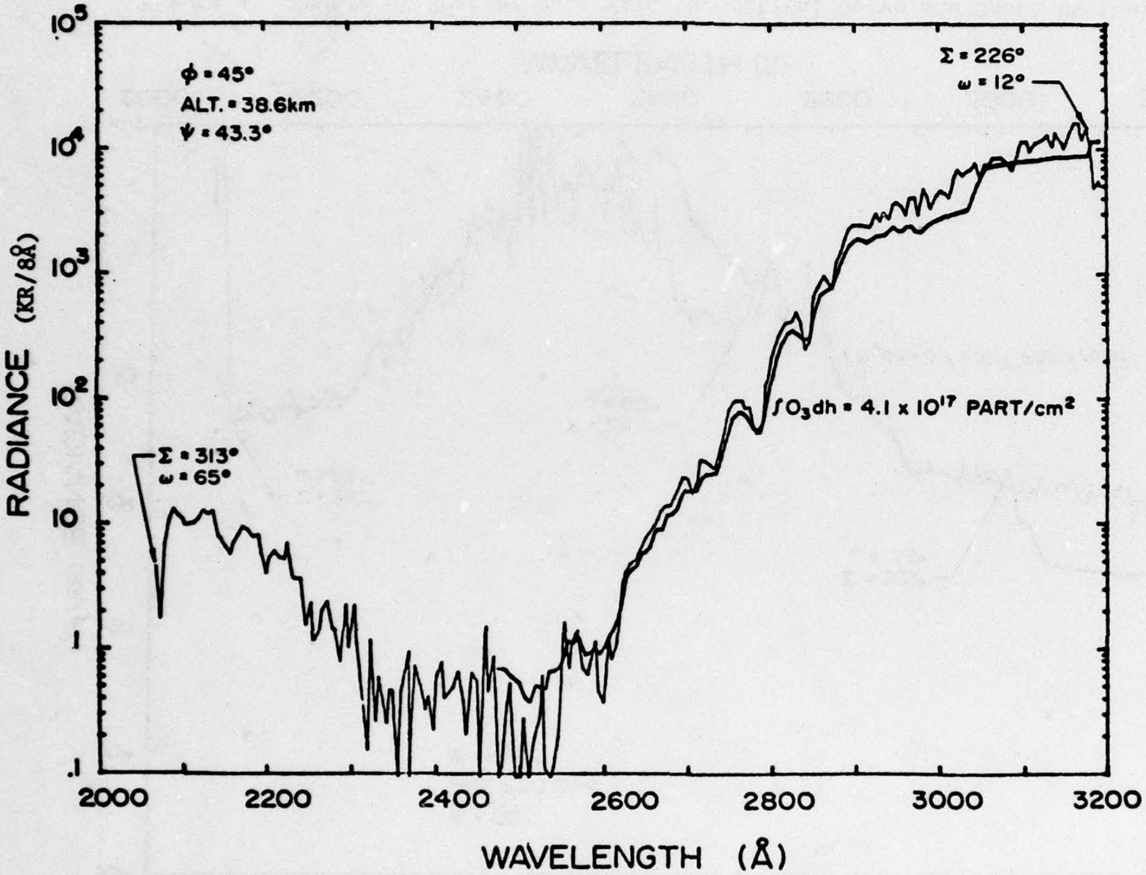

Figure 3. Sample UV Scatter Data With Theoretical Curve and Ozone Overburden ($\phi = 45^{o}$)

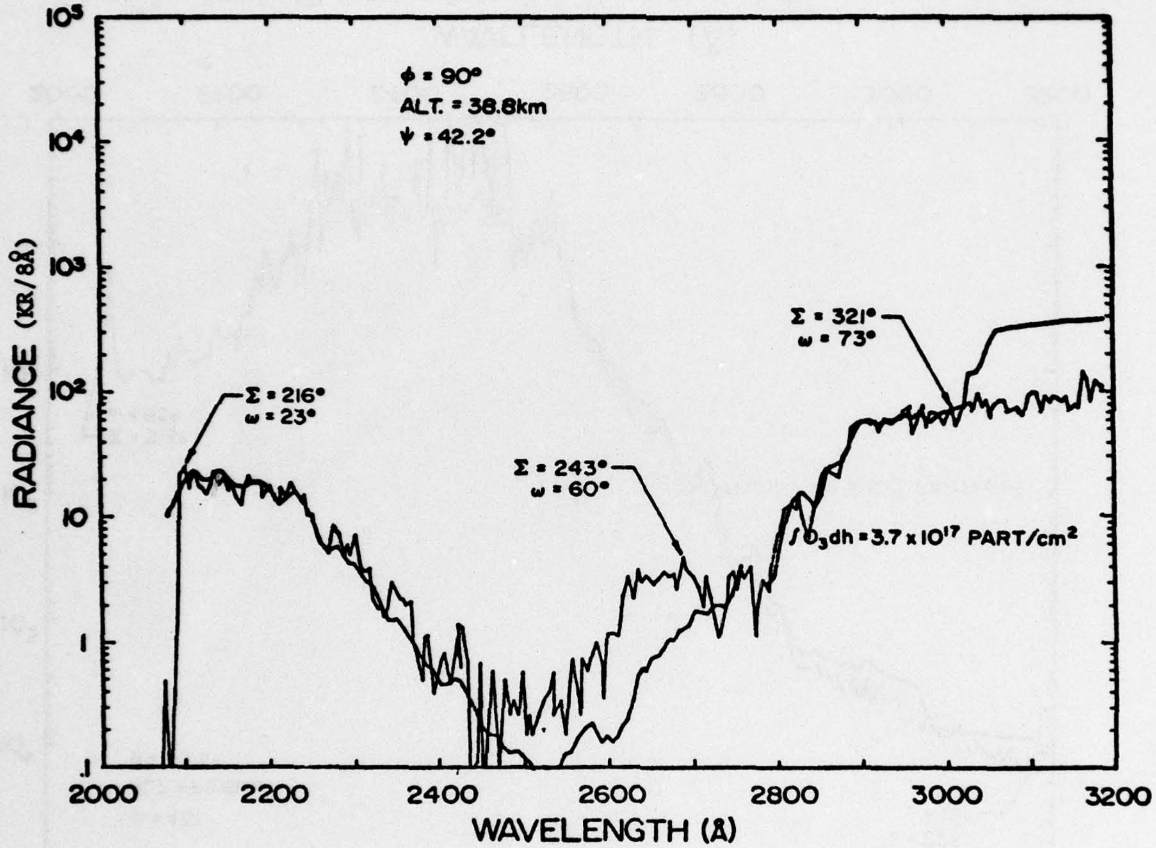

Figure 4. Sample UV Scatter Data With Theoretical Curve and Ozone Overburden ($\phi = 90^{\circ}$)

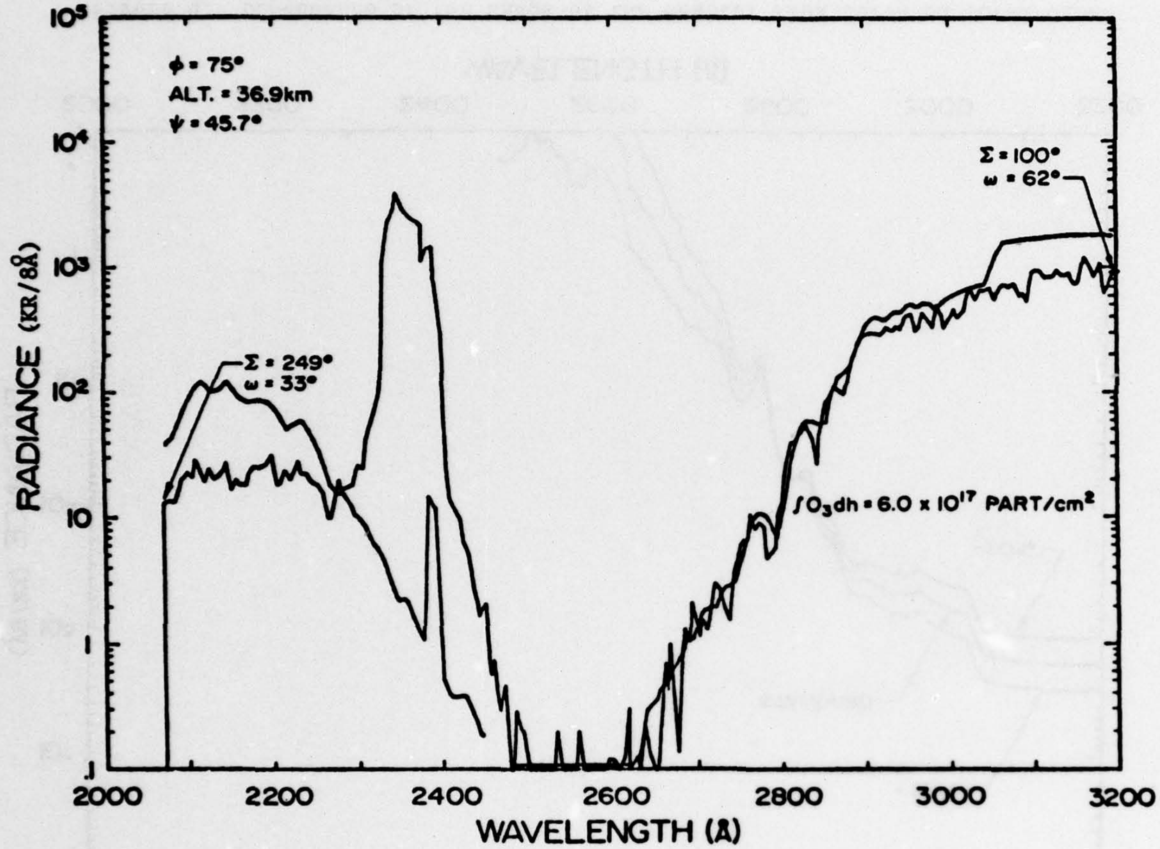

Figure 5. Sample UV Scatter Data With Theoretical Curve and Ozone Overburden (ϕ = 75°)

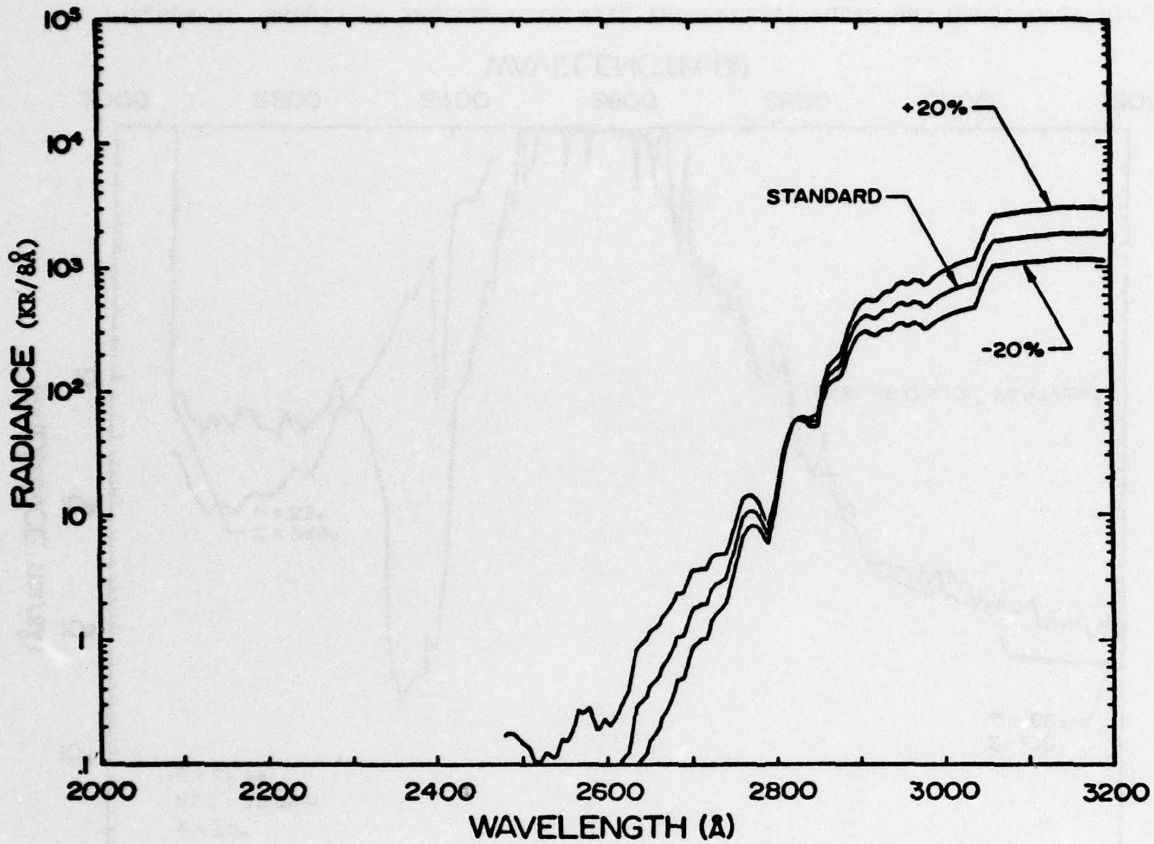

Figure 6. Dependence of the Shape of the Scatter Flux Curve on Total Ozone

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Barlow, A.R., and L.L. Jensen, Solar Ultraviolet Spectrometer, *Final Report*, 38 pp., Contract No. DAAD07-75-C-0107, Space Science Laboratory, Utah State University, Logan, January 1976.

Jensen, L.L. and K. Montierth, Analysis and Evaluation of Solar Flux Data and Recommended Modifications for the Solar Spectrometer, *Interim Technical Report*, 20 pp., Contract No. DAEA18-76-C-0040, May 1976.

APPENDIX A

RADIATIVE TRANSFER MODEL

The radiative transfer model incorporates primary rayleigh scatter, absorption terms due to O_3 and O_2 and the attenuation of the signal along paths S_1 and S_2 due to the scattering of light out of these paths (see Figure A-1 for the integration geometry and Figure 1 for the look geometry of the instrument). The number of photons the instrument sees can be formulated in the following fashion:

$$I_{instrument} = \int_0^\infty I'(s,\lambda)A(s,\lambda)\sigma_{\omega\lambda}n(s)\Delta\omega' dV$$

where

$$I'(s,\lambda) = I_\infty(\lambda)e^{-\int_s^\infty \sigma_{O_3}[O_3] + \sigma_{O_2}[O_2] + \sigma_R'[M]\, ds_2}$$

and

$$A(s,\lambda) = e^{-\int_0^s \sigma_{O_3}[O_3] + \sigma_{O_2}[O_2] + \sigma_R'[M]\, ds_2}$$

$$\sigma_R' = \int \sigma_{\omega\lambda}\, d\omega$$

Where $\sigma_{\omega\lambda}$ is the angular rayleigh scattering cross section and has the form $\sigma_{\omega\lambda} = (1 + \cos^2\omega)\sigma_{R(\lambda)}$.

By consideration of Figure A-1 we can also obtain the following relationships:

$$dV = D^2 ds_1 \Delta\omega$$

$$\Delta\omega' = \frac{A}{D^2}$$

Thus the number of photons which the instrument sees reduces to the following expression:

$$I_{ins} = \int_0^\infty I'(s,\lambda)A(s,\lambda)\sigma_{\omega\lambda}\, n(s)A\Delta\omega ds_1$$

The computer model developed evaluates the above expression taking into consideration the instrument look geometry shown in Figure 1.

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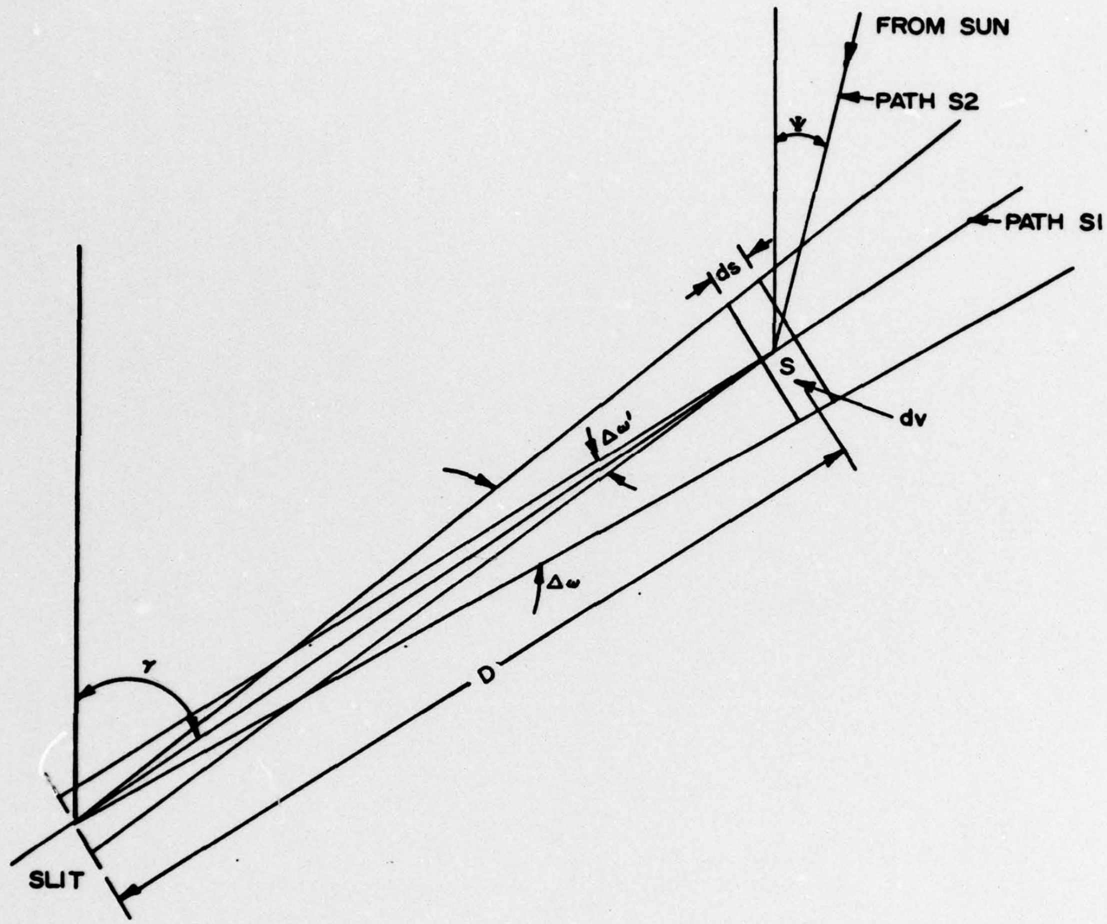

Figure A-1. Geometry Used For Integration