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NEW INFRARED LASER CONCEPTS

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Infrared laser concepts that have high efficiency or high power applications are being studied. As part of this interest, the possibilities of lasing homonuclear molecules such as H_2 or N_2 directly without the use of permanent dipole additives have been analyzed. Basically the idea is to produce an inversion in a gas by a high-pressure e-beam-stabilized electric discharge and then induce radiative transitions via collision partners or electric fields. Of the many molecular possibilities, H_2 has been chosen as a likely

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) candidate for such a laser because of its relatively short wavelength transitions (2.8μ) and easily achieved population inversion. Gain has been predicted over a bandwidth extending from 2.7μ to 10μ using the principle of collisionally induced dipole. The magnitude of the peak gain which occurs at 2.8μ is proportional to pressure squared and for a mixture of H_2 and Xe equals approximately 5%/meter at 50 atmospheres.

TECHNICAL PROGRAM

I. Collisionally Induced Laser

Summary

Infrared laser concepts that have high efficiency or high power applications are being studied. As part of this interest, the possibilities of lasing homonuclear molecules such as H_2 or N_2 directly without the use of permanent dipole additives have been analyzed. Basically the idea is to produce an inversion in a gas by a high-pressure e-beam-stabilized electric discharge and then induce radiative transitions via collision partners or electric fields. Of the many molecular possibilities, H_2 has been chosen as a likely candidate for such a laser because of its relatively short wavelength transitions (2.8μ) and easily achieved population inversion. Gain has been predicted over a bandwidth extending from 2.7μ to 10μ using the principle of collisionally induced dipole. The magnitude of the peak gain which occurs at 2.8μ is proportional to pressure squared and for a mixture of H_2 and Xe equals approximately 5%/meter at 50 atmospheres.

Technical Progress and Tasks

As part of the collisionally induced laser program the following tasks have been identified and have been studied during this period:

1. Dissociative recombination measurements of H_2-Xe mixtures: In order to insure that gain is observed @ 2.8μ, the continuum absorption due to electron-neutral bremsstrahlung must be small. This is expected to be the case after crowbaring the sustainer discharge and e-beam so that electron recombination will sizably reduce the electron concentration Preliminary measurements of this recombination in mixtures of H_2-AR,

N_2-AR, H_2-Xe at pressure from 5 to 10 atm and electron density of $10^{13}/cm^3$ to $10^{14}/cm^3$ have shown recombination rates which are satisfactorily fast and in good agreement with experimental results of others carried out at lower pressure. These measurements were carried out in a small scale e-beam device that was available and not the larger device being built and described below.

2. Aerodynamic disturbances: Measurements of any aerodynamic disturbances with time due to nonuniform discharge heating will be attempted using laser holography. The holographic appra̲teus using a Q switched ruby is almost complete and ready to be tested.

3. V-V rate measurement in H_2: The first measurements of v-v rates in H_2 will be attempted shortly. This information is necessary to accurately predict the rate of electrical pumping required. Measurements of v-v energy transfer rates will be obtained in vibrationally excited D_2 and HD. By absorbing a short pulse of HF laser radiation (≈1 joule in 30 nsec), the D_2 or HD molecules are excited to the first vibrational level. The v-v rates will be obtained by recording the time variation of the collision-induced spontaneous overtone emission radiation from different vibrational levels. The electrical discharge of the HF laser has been studied and is now operational. While still in the development stage, it appears that the laser is capable of 0.5 joule output suitable for the experiment. The high-pressure absorption cell for the D_2/HD-Xe mixtures has also been constructed. The cell has been vacuum checked.

4. Inverse Bremsstrahlung Measurements: Preliminary measurements were carried out in mixtures of N_2-Ar last fall. These important experiments of the continum absorption have been delayed until an enlarged e-beam

apparatus is completed.

5. Gain measurements at 2.8μ: An optical bridge and HF laser probe for 2.8μ has been constructed. The power supply for the sustainer is being reconstructed. A high pressure sustainer cell is available. Measurements of gain await completion of the e-beam appratus. The electron beam apparatus to be used for induced dipole laser experiments is being tested. Vacuum tests showed the chamber could be evacuated to pressures on the order of 10^{-5} torr, sufficient for electrical operation of the device. A comprehensive series of electrical tests using a variety of cold cathodes is being carried out presently. To date, about 3 amps/cm^2 (about 200 amps total) have been drawn thru the foil window at 180kv without arcing problems. We are concentrating at improving the efficiency of this device as well as increasing the voltage output.

II. V-V Pumped Balanced Laser Program

Summary

In the search for new lasers having the possibility of increased efficiency, the N_2-DCl and D_2-HCl molecular systems have also been analyzed as examples of possible v-v transfer lasers. Experimental aparatus in the form of a low pressure mixing laser setup was built and used as a means for preliminary study.

Tasks

After initially lasing both CO and CO_2 in the apparatus, attempts at lasing DCl and HCl were carried out in the previous year. Unfortunately these tests were not positive. During the latter part of 1974 lasing was reattempted (also using CO-CS_2 and N_2-CS_2) using better optics with the same result. Line reversal measurements of the vibrational energy in CS_2 were carried out and showed a vibrational temperature of about 600°K at best, which is too low for lasing. Thus it appears that v-v transfer in N_2-CS_2 and CO-CS_2 mixtures is too slow.