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MOLECULAR AND CHEMICAL LASER SYSTEMS.(U)
JUL 77 J R WIESENFELD, G J WOLGA DAHC04-74-G-0120
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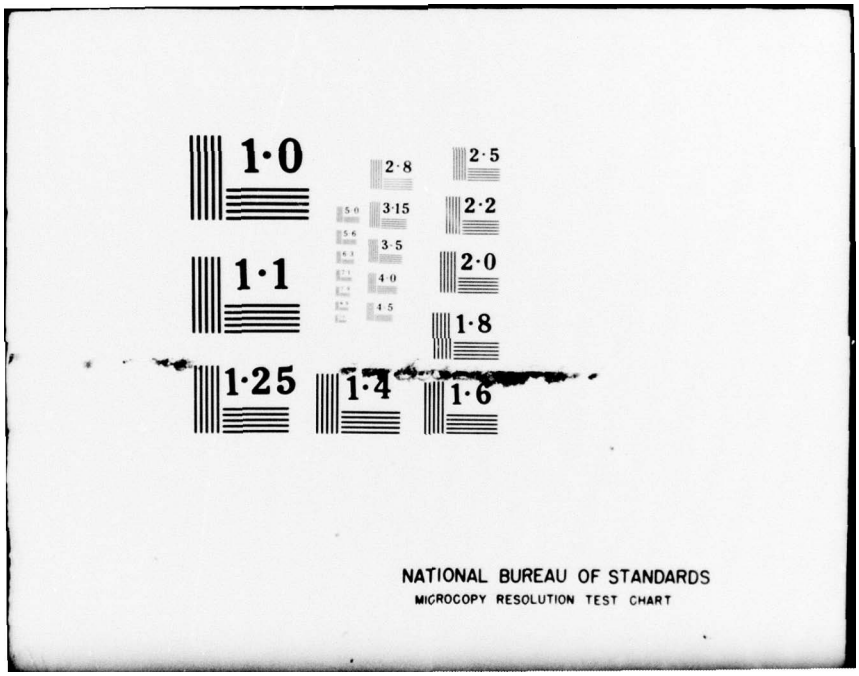
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MOLECULAR AND CHEMICAL LASER SYSTEMS

FINAL REPORT

JOHN R. WIESENFELD
GEORGE J. WOLGA

July 25, 1977

U. S. ARMY RESEARCH OFFICE

CONTRACT/GRANT NUMBER

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Electronic to Vibrational Energy Transfer: $O_2(^1\Delta g) \rightarrow HF(v)$
Iodine atom lasers
Chemical reactions pumping iodine atom lasers
Spontaneous mode locking in iodine atom lasers

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

The work performed under the above referenced grants included:

a) Experimental study of the reaction system

$$O + HI \rightarrow OH + I \text{ or } I^*$$

$$O_2(^1\Delta g) + I(^2P_{3/2}) \rightleftarrows O_2(^3\Sigma_g) + I^*(^2P_{1/2})$$

in a flow system. Measurements of optical gain at the I atom laser

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20. ABSTRACT (continued)

wavelength of 1.315 microns indicated an optical loss of 3-8% across the transverse flow laser channel.

(b) Parametric studies were made on a variety of compounds suitable for photodissociative pumping of I atom lasers.

(c) Spontaneous mode locking was observed and experimentally studied in a photolytically pumped I atom probe laser.

(d) Electronic to vibrational energy transfer between $O_2^*(^1\Delta g)$ and HF leading to the vibrational excitation of HF to levels v=1 and v=2 was observed and studied. Evidence was provided that the transfer occurs from $O_2(^1\Delta g)$ rather than from $O_2(^1\Sigma^+ g)$.

FOREWORD

The work completed under the subject grants lies mainly in two areas: studies related to iodine atom lasers; studies of electronic to vibrational energy transfer. Four publications accurately summarize the work completed. Since these publications have all appeared in recognized journals and have been discussed in prior reports we shall not reconsider them at length in this final report. We shall, however, summarize each distinct study and reference the appropriate publication.

A. Production of Electronically Excited Iodine Atoms, ($I^2P_{1/2}$) Following Injection of HI into a Flow of Discharged Oxygen

The emission from the transition $I^*(5\,^2P_{1/2}) \rightarrow I(5\,^2P_{3/2})$ at 1.315μm following injection of HI into a microwave-discharged He/O_2 flow was studied. Relative $I^*(5\,^2P_{1/2})$ emission intensities were recorded as a function of HI and O_2 flow rates and as a function of time after injection. Pulsed gain measurements using an iodine photodissociation laser as a source showed that the ratio $N_I*/(N_I + N_I*) \cong 0.15 - 0.25$, is less than that required for population inversion. This observation was discussed in terms of known chemical processes involving $O(^3P)$, HI, $O_2(^1\Delta g)$ and iodine atoms.

Reference: R. J. Pirkle, J. R. Wiesenfeld, C. C. Davis, G. J. Wolga, and R. A. McFarlane, IEEE Jn. Quant. Elect., Vol. QE-11, No. 10, p. 834, October 1975.

B. Output Mode Spectra, Comparative Parametric Operation, Quenching, Photolytic Reversibility, and Short-Pulse Generation in Atomic Iodine Photodissociation Lasers

The advantages and disadvantages of the atomic iodine photodissociation laser for high-energy operation were considered. Laser excitation by both slow and fast flashlamps was investigated; in slow flash excitation, self-mode-locking occured frequently and the output-mode characteristics of the laser operated in this way were studied. The comparative performance of different parent materials for photodissociation was investigated in the fast flash mode of excitation. This mode of excitation gave higher energy laser output and efficiency and less pyrolysis

of the parent material. These observations, and the photolytic reversibility characteristics of different materials in repetitively photolyzed operation, were discussed in the light of the most recently available kinetic data: i-C_3F_7I is the material of choice for laser operation. Finally, limits to the ability of atomic iodine photodissociation laser/amplifier(s) systems to generate and amplify short duration, high-energy pulses set by intralevel relaxation effects and coherent interactions were discussed.

Reference: C. C. Davis, R. J. Pirkle, R. A. McFarlane and G. J. Wolga, IEEE Jn. Quant. Elect., Vol. QE-12, No. 6, p. 334, June 1976.

C. Self-Mode-Locking of an Iodine Photodissociation Laser

The observation of self-mode-locking of an iodine photodissociation laser was reported. Typical laser output had the form of a train of fully or partially mode-locked relaxation spikes. Simultaneous oscillation in at least eight longitudinal modes and locking of both longitudinal and transverse modes was observed.

Reference: R. J. Pirkle, C. C. Davis, and R. A. McFarlane, *Journal of Applied Physics*, Vol. 46, p. 4083, 1975.

D. Observation of E-V Energy Transfer from $O_2(a'\Delta g)$ to HF

Infrared emission from HF(v=1) and HF(v=2) was observed when HF was added to a discharged mixture of oxygen and helium. A first order dependence of HF(Δv=1) emission on $O_2('\Delta g \rightarrow {}^3\Sigma_g^-)$ emission was observed. This suggested that the energy transfer occurred directly from $O_2('\Delta g)$ rather than from $O_2('\Sigma_g^+)$. Transfer from the latter specie would have resulted in a second order dependence of $[HF^+]$ on $[O_2\ '\Delta g]$. E→V transfer from $O_2('\Delta g)$ to HCl was not observed. This suggested that the larger energy defect for the transfer to HCl was important. In addition the transfer to HCl would have required a Δv=3 transition in HCl which suggests that such transitions are less probable than are Δv=2 transitions as took place in HF.

Reference: S. Madronich, J. R. Wiesenfeld and G. J. Wolga, Chemical Physics Letters, Volume 46, No. 2, p. 267, 1 March 1977.