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THEORETICAL STUDIES OF SOLAR-PUMPED LASERS

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By

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SUMMARY

The paper "Kinetic Modeling of an IBr Solar Pumped Laser," by W. L. Harries and W. E. Meador, has appeared in Space Solar Power Review, Vol. 4, pp 189-202, 1983. The paper was accepted in June 1983 but, due to delays at Pergammon Press, the issue did not appear until December 1984.

A paper "Criteria for the Evaluation and Comparison of Laser Solar Energy Converter Systems," by W. L. Harries, was submitted to the AIAA Journal of Propulsion and Power.

The work for the period July 1984 to January 1985 can be divided under these headings:

1) Continued Investigations of Black-Body Solar Pumped Lasers;

2) Computer analyses of Polymerization using Lasers;

3) Investigations of metallic sodium as a laser medium.

INVESTIGATIONS OF BLACK-BODY SOLAR PUMPED LASERS

The report for January 1984 to July 1984 (PTR 84-4) had an analysis of a CO_2 black-body pumped laser. The power output of the laser was estilated both as a function of time (computer graphic solutions) and under steady state conditions (analytic solutions). A considerable amount of experimental data on such lasers was available from the work of R. J. Insuik and W. H. Christiansen, IEEE J. Quantum Electronics, QE-20, 622 (1984). In

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addition, R. J. Insuik had also very kindly made available her Ph.D. thesis. Our analysis had included the new effect of the heating of the gases which filled the lower laser level.

Qualitative agreement had been obtained between theory and experiment for steady output power versus gas pressure and different black-body temperature; however, the theory indicated much too high an output at low pressures. The agreement between power output and black-body temperature was fair, and the analysis also correctly showed a drop in power as the gas temperature increased. There was lack of agreement between the analytical results and the outputs for different gas mixtures of CO_2, He, Ar. Hence, the analytical results were considered preliminary and tentative.

The analysis suffers the disadvantage that the rate coefficients and absorption cross sections are not well known. Diffusion to the walls had been included already, and a new assumption was made that there was a finite probability that a collision of a particle in the upper laser level with the wall resulted in the particle being transferred to the lower laser level $CO_2(001) \rightarrow CO_2(100)$. This seemed to reduce the output at low pressures to agree with the experiment. The effect of using larger values of the absorption cross section was tried. This had the effect, as had been suggested by Insuik, of absorption in the outer gas layers of the laser at higher gas pressures. Despite improved agreement at the "standard pressure," however, the effect of varying the gas ratios still showed a discrepancy between theory and experiment. The investigation continues.

COMPUTER ANALYSES OF POLYMERIZATION USING LASERS

This investigation was strictly not part of studies of solar energy

conversion using lasers, but the techniques used in computer graphic solutions of several time dependent simultaneous equations could be immediately applied, and were used in several instances.

INVESTIGATIONS OF METALLIC SODIUM AS A LASER MEDIUM

The possibility of using metallic vapors as laser media was still studied because such lasers would operate at high temperatures, and this would reduce the weight of the radiator. Accordingly, experimental measurements are being made of the absorption of visible light in sodium vapor to obtain cross sections as functions of wavelength for the transitions $X \rightarrow A$, $X \rightarrow B$, and $X \rightarrow C$. The experiments, performed in a heat pipe arrangement, are done in a higher temperature regime than those found in the literature, and are continuing.

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