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TITLE: Computer Modeling of Pulsed CO_2 Lasers for Lidar Applications

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SIGNIFICANT ACCOMPLISHMENTS:

Allthough this modeling effort has only recently commenced, the experimental results obtained during the past year will enable a comparison of the numerical code output with experimental data to be made. This will ensure verification of the validity of the code. The measurements were made on a modified commercial CO_2 laser, the PSI LP-140. Results obtained included:-

1) Measurement of the pulse shape and energy dependence on gas pressure.

2) Determination of the intra-pulse frequency chirp due to plasma and laser induced medium perturbation effects. A simple numerical model showed quantitative agreement with these measurements. The pulse to pulse frequency stability was also determined.

3) The dependence of the laser transverse mode stability on cavity length. A simple analysis of this dependence in terms of changes to the equivalent fresnel number and the cavity magnification was performed.

4) An analysis of the discharge pulse shapes enabled the low efficiency of the laser to be explained in terms of poor coupling of the electrical energy into the vibrational levels. This analysis also provided estimates of the electron drift velocities and number densities.

5) The existing laser resonator code has been modified to allow it to run on the Cray XMP under the new operating system.

FOCUS OF CURRENT AND PLANNED RESEARCH:

A numerical model of a pulsed transversely excited (TE) CO_2 laser is being developed to enable the performance of such devices to be predicted prior to construction. This is of particular benefit to the LAWS contract where two contractors are providing alternative laser configurations.

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Although numerical models of TE CO_2 lasers have been used in the past these models have normally been constructed as several computer programs, each addressing a particular feature of the laser. Although a limited degree of feedback is available between these programs each is essentially a stand alone program and this lack of interaction between the modules resulted in limitations on the predicted output. This approach was necessitated by the considerable run time required by each of the programs. With the availability of much greater computing power, it has become possible to integrate all these modules into a single program where they can interact with one another.

The model addresses the transfer of stored electrical energy into the vibrational and rotational levels of the molecular gas species present in the laser gas and the subsequent conversion of the energy in these levels into the optical output pulse. The electrical to vibrational energy conversion will be modeled by solution of the Boltzmann equation with the inclusion of superelastic and electron-electron collision processes which are normally excluded from the simpler models. Additionally a multi-line multi-mode gain distribution will be used to determine the optical output as opposed to the normal single-line single-mode approximation. The inclusion of hot band contributions to the gain together with modeling of the gas thermodynamic effects will enable the frequency content and stability of the output pulse to be determined as well as the output amplitude and pulse shape.

The model will be verified by comparison with experimental results obtained within the laboratory and from the published literature.

<u>PUBLICATIONS:</u>

1) Jaenisch, H.M. & G.D. Spiers,"Modifications to the LP-140 Pulsed CO_2 Laser for Lidar Use", SPIE High Energy Lasers Conference, Los Angeles California, Jan. 24, 1991.

2) Spiers, G.D.,"Discharge Circuit Considerations for Pulsed CO_2 Lidars", To be presented at the OSA Coherent Laser Radar: Technology and Applications Topical Meeting, Snowmass Colorado, July 8-12, 1991.