XX. INTERACTION OF LASER RADIATION WITH PLASMAS AND NONADIABATIC MOTION OF PARTICLES IN MAGNETIC FIELDS*

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RESEARCH OBJECTIVES

1. Nonadiabatic Motion of Charged Particles

We have nearly completed our study of nonadiabatic trapping in mirror systems and in so doing have verified and extended our original work on single-particle orbits and orbit stability. Particles are lost from these systems by resonant interactions with the weak perturbing field very much as ions and electrons are scattered by interaction with whistler waves in the Van Allen belts. The analogy will be pursued. The scattering matrix can be evaluated by techniques akin to those used in the quasi-linear analysis of plasma-wave interactions. We are thus in a position to check experimentally some of the predictions of quasi-linear theory. Some preliminary results suggest that effects neglected in quasi-linear theory may not be negligible, after all. We shall concentrate a large fraction of our work on nonadiabatic interaction on this question during the coming year.

The experiment involving nonadiabatic injection is progressing at the expected rate. We have injected a beam and attained approximately 10 transits of the system and are nearly ready to begin studying loss mechanisms in more detail.

L. M. Lidsky, D. J. Rose, J. F. Clarke, R. W. Moir

2. Mechanisms of the Hollow-Cathode Arc

The principal mechanisms suspected of being present in the hollow-cathode arc will be studied in situ. These mechanisms are: thermionic emission, field emission, secondary electron emission by ions, photons, and metastable atoms, and various cumulative processes (such as ionization of excited atoms). The objective is quantitative understanding of the importance of the various mechanisms, and of the operation of the arc itself.

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3. Interaction of Coherent Radiation and Plasmas

Work on laser-plasma interactions continues, along the following general lines:

(i) The scattering of infrared (10.62-μ) radiation from plasma with electron density

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$\approx 10^{14}$ cm^{-3} will permit accurate measurement of the fluctuation spectrum and wave-damping mechanisms in the plasma. The experiment, which was started in 1965, continues, an N_2-CO_2 laser having been constructed for the purpose. As a secondary interesting goal, the coherent scattered spectrum from a low-pressure gas will also be measured with the use of this apparatus.

(ii) Scattering of laser radiation from an electron beam, in better geometrical arrangements than hitherto available, will be completed.

D. J. Rose, L. M. Lidsky, A. A. Offenberger, M. A. Samis

4. Plasma-Laser Science and Technology

Under this heading are included gaseous electronics, plasma physics, and technological aspects of devices that are likely to be of interest as gas lasers. We shall continue work of this nature which was started in 1965. In particular, an approximate self-consistent theory of the high-power argon gas laser is being put together. The theory takes account of radial flow, radial space charge, ionization in the axial electric field, power balance per unit volume, and axial resistivity. An experiment is under way to study the effects of various cathodes for such lasers, and the beneficial effects to be expected from achieving high radial heat transfer from the capillary column.

D. J. Rose, D. E. Crane, W. T. Hebel

5. Photoionization and Other Phenomena

An experiment to observe the effects of photoionization of excited states, by using a focused pulsed laser, will be reactivated. Briefly, the experiment has to do with ionizing most of the excited states in a small volume deep inside a plasma, a task that can be accomplished with relative ease. Thus a small excess density perturbation is created, whose dissipation rate and other characteristics can be studied. Information about density of excited states and local-particle transport coefficients in the plasma is expected to be obtained.

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