

III. PLASMA DYNAMICS

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A. CHANNELING AND COMPRESSION OF A PLASMA

The theoretical studies of the compression of a plasma beam in a slowly converging magnetic channel, reported in Quarterly Progress Report No. 52, page 21, have been extended to a model based on consideration of the motion of individual particles. If collisions are neglected, the particles are simply reflected from the walls of the channel and the depth of their penetration into the confining magnetic field defines a boundary layer between the plasma beam and the field. The width of this boundary layer, and the variation of the field and plasma density within it, can be calculated in terms of the density of the particles in the beam and v_o , the rms velocity component of the particles perpendicular to the wall of the channel. The value of v_o at any point in the channel depends upon the angle of spread of the beam, the angle at which the walls of the channel converge, and (because of multiple reflections from the walls) the shape of the channel at points upstream. If the channel converges slowly, these effects can be combined to derive an integral equation for the width of the channel and the plasma density as functions of distance downstream, if the external magnetic field is specified. This equation reduces to quite simple forms if certain terms can be neglected, and it is expected that the experiments will indicate which terms are small.

The velocity v_o is a measure of the "temperature" of the plasma beam and, because of multiple reflections of particles from the channel walls, it increases very rapidly as the plasma is compressed (analogously to a gas with a very large value of γ). The width of the boundary layer, therefore, increases rapidly with distance downstream, and it is expected that this increase will be easily measurable experimentally.

At high densities, scattering from collisions with neutral particles will also contribute to v_o , and hence to the growth of the boundary layer. An approximate calculation of this effect has been carried out, and we hope that it can be tested experimentally.

Apparatus for experimental verification of these theories is being constructed.

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