Gun Injection into a Microwave Plasma

by

J. C. Sprott

May, 1970

PLP 364

Plasma Studies
University of Wisconsin

It has been suggested that one could fill a toroidal multipole to very high densities by rapid pulsed gun injection. This note describes measurements made two years ago in which a gun plasma was injected into a background microwave plasma of variable density in the toroidal octupole. The results lead to a pessimistic conclusion concerning the feasibility of such a filling scheme.

The microwave plasma was produced by a 144 μsec pulse of 9 GHz radiation. The density was varied by changing the microwave power up to the maximum of 100kW. The background gas pressure was 5×10^{-5} torr. The gun plasma was injected 500 μsec after the microwave pulse. The ion saturation current to a probe on the B=0 axis was measured just before gun injection $[I_1(500)]$ and 100 μsec after gun injection $[I_1 + I_2(600)]$. The results are shown in fig. 1. The upper diagonal line shows the result that would be expected if the injection process were unaltered, and the probe read the sum of the ion saturation currents for the two plasmas. The lower diagonal line shows the expected result if none of the gun injected plasma were trapped. At very low microwave plasma densities, gun injection is not affected. As the background density is increased, the total density appears to decrease. At very high microwave densities, the total density approaches the value expected for no gun injection.

The total number of particles in the machine, N, changes according to the equation

$$\frac{dN}{dt} = \Phi_{in} A_{in} - \Phi_{out} A_{out} = \frac{n_2 E_2 A_2}{B} - \frac{n_1 E_1 A_1}{B} ,$$

where n_2, E_2, and A_2 are the injected density, electric field, and the area of the flux surface through which injection occurs. n_1 is the background density, E_1 is the average circumferential electric field away from the injection port, and A_1 is the area of the wall. Since $\nabla \times \vec{E} = 0$ at peak magnetic field,

$$E_2 \omega = E_1 2\pi R = V,$$

where ω is the width of the injection port. Substituting gives

$$\frac{dN}{dt} = (n_2 - n_1) \frac{V\ell}{B} ,$$

where ℓ is the length of a field line near the wall. This simple argument suggests that for the injected density greater than the background density ($n_2 > n_1$), the density can be built up, but for large background densities, as much plasma is expelled as is injected.

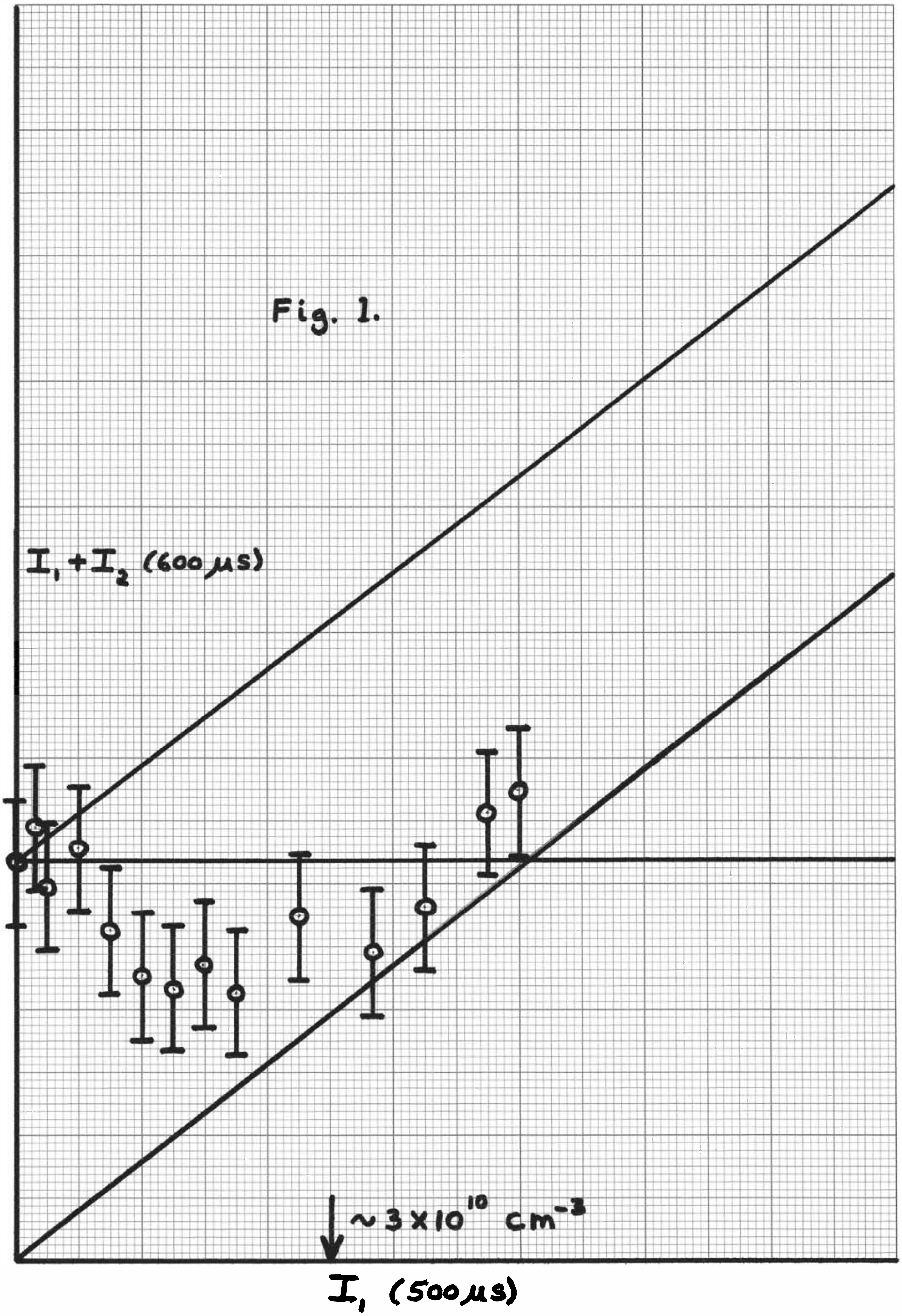

Fig. 1.