IS THE RADIATIVE ELECTRON RECOMBINATION COEFFICIENT A FUNCTION OF MAGNETIC FIELD?*

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Considerable debate over the years has centered on whether the rate of diffusion of electrons transverse to a magnetic field in gaseous plasmas varies as B^{-1} or B^{-2}. A body of experience seemed to prove the former (1), while Boltzmann equation derivations predicted the latter (2). No derivation of the former was heretofore forthcoming, and so when a decade ago experiments around a plasma beam (3, 4) seemed to describe diffusion losses at a rate of B^{-2}, the process of Bohm diffusion (as it was called) seemed disproved.

Nevertheless the numerous and continuing references to anomalous losses and the offering of Bohm diffusion as an explanation have kept the concept alive. Recently the author believes he has succeeded in deriving the Bohm diffusion coefficient by distorted free-path considerations (5), and the question has therefore arisen as to why the beam experiments should have yielded the results they do. The difficulty may lie in the fact that the beam experiments, which measure the ratio of the diffusion coefficient to the recombination coefficient, require an unstated assumption that the recombination coefficient is constant in magnetic fields. With a fairly diligent search, the author has been unable to find any experimental substantiation of that assumption. In fact there seems to be no reference in the literature to any recombination experiments at all that have been conducted in strong B fields.

Since it is the low angular momentum overlap between plane waves and orbital wave functions which makes electronic recombination such an improbable process, the rapid decrease that electron cyclotron radii undergo in a magnetic field might be expected to improve this situation drastically, especially for recombination into Rydberg states. The quantum number of the Bohr orbit which has the same angular momentum as a cyclotron orbit in a field of *B* tesla is $n = 120B^{-1/3}$. It is highly suggestive, therefore, that the phenomenon is in fact unknown in ordinary discharge afterglow experiments, which, because they are conducted at moderate pressures (~1 torr) rarely permit states to exist much above $n = 20$ (below which B must be greater than 200 tesla to observe an effect) while the beam experiments, which were conducted between 10^{-6} and 10^{-3} torr, would have permitted states as high as $n = 200$, and could easily have been influenced at the 0.1 to 1 tesla fields employed.

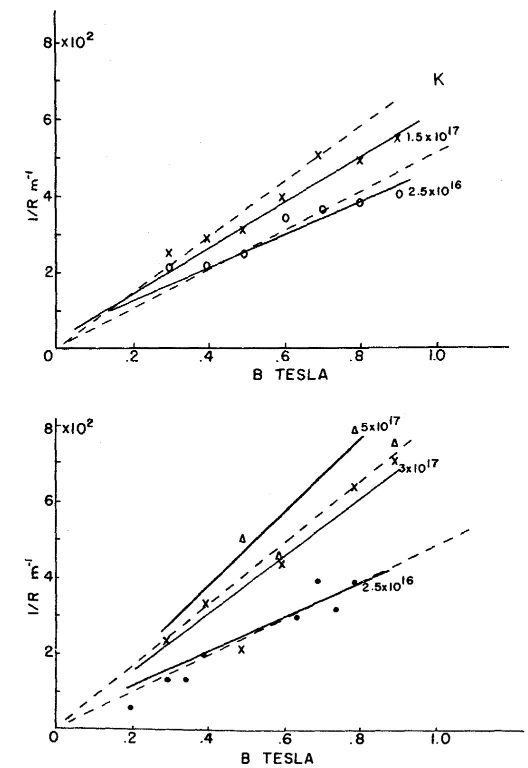

FIGURE 1. Reciprocal beam radii as a function of magnetic field. Solid lines are fitted to a single functional dependence of recombination upon magnetic field plus Bohm diffusion. Dashed lines are for Cowling diffusion and constant recombination. The dashed lines must pass through the origin. Labels on graphs are densities in m^{-3}.

*A revised version of this paper will appear in Physics Letters (Amsterdam).

Proc. Okla. Acad. Sci. 58: 114-115 (1978)

If the data of D'Angelo and Rynn on the change of radius of their plasma beams with magnetic field and gas density in Cs and K are fitted to the assumption that the recombination coefficient α varies with B, the results in Figure 1 are obtained with a single expression for all the data, showing that somewhat better overall agreement is found with the variable α theory than with the B^{-2} diffusion theory.

It is the purpose of this paper to emphasize that research should be directed to the possible dependence of recombination upon magnetic field.

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