If the particle remains inside a thin tube of radius r_0 centred about Γ where r_0 is of the order of the characteristic distance of the field variation, then the particle is said to be confined and r_0 is called the 'plasma radius'.

By taking into account the expansion parameters a_0 (Larmor radius/plasma radius) and ε (plasma radius/mean radius of curvature) together, an adiabatic type theory can be developed, which takes finite Larmor radius effects into account in the basic periodic solution of the problem. The expansion parameter is in fact:

$$\varepsilon a_0 = \frac{\text{Larmor radius}}{\text{mean radius of curvature}}.$$

In the first-order approximation εa_0, the principal terms which appear only in the second-order approximation of the classical adiabatic theory (parameter a_0) are found.

The equations are no longer valid if the particle departs too far from the tube, but this case is not of interest since these particles are no longer confined.

The 'guiding centre' equations obtained are thus valid in the thin tube approximation, even if the Larmor radius is of the same order as the plasma radius.

The effect of singularities in the magnetic field at integral values of the rotational transform on the magnetic axis, can be studied, as well as the reflection of particles with low $v_{\parallel}$ due to a mirror effect of the toroidal field. Certain cases are completely integrable to this order, and provide a simple illustration of the phenomena.

Non-linear resonance effects at high power in a cylindrical plasma*

A. M. Messiaen and P. E. Vandenplas
Laboratoire de Physique des Plasmas, Ecole Royale Militaire,
Bruxelles 4, Belgium

A plasma column exhibits a main resonance and series of secondary resonances when a low power electromagnetic wave (with $\bar{E}_{\perp}$ axis and $\bar{B}_{\parallel}$ axis) is directed on it and when the density is varied by altering the discharge current. The corresponding phenomena are now investigated at high power (E-fields up to 10^4 Vm^{-1}). A luminosity curve gives an independent measurement of plasma density as a function of discharge current. When $E > 10^3$ Vm^{-1}, strong non-linear effects appear: deformation of the different resonance peaks and hysteresis, the corresponding luminosity curve exhibits kinks indicating greater perturbation of the average plasma density over a wider resonance domain. As the power increases, the kinks become plateaux indicating preferential absorption of energy at resonance and a tendency of the plasma to remain in a resonant state through h.f. ionization.

With high incident energy, the high amount of energy absorbed at resonance is sufficient to sustain the plasma in a resonant state in the absence of a d.c. discharge current. The absorbed h.f. energy remains practically constant as a function of increasing incoming energy when the plasma is self-sustained in one of its eigenmodes; the corresponding density also remains practically constant as indicated by the luminosity. When the incoming h.f. energy is decreased below a certain minimum, there is a jump to the next resonance characterized by a lower density.

* Presented by P. E. Vandenplas. Paper published in *Phys. Lett.* **25A**, 339 (1967).

Kinetic equations for microscopic turbulence*

D. Pfirsch, K. Elsässer and D. Biskamp
Max-Planck-Institut für Physik und Astrophysik, Munich
Federal Republic of Germany

Two types of kinetic equations for the homogeneous microscopic turbulence of a one-dimensional plasma are compared with each other. These are the usual quasilinear approach and a theory based on the Hamilton-Jacobi formalism. Both theories should yield the same results as long as particle trapping can be neglected. We estimate that this becomes important for times of the order of

$$T = \frac{1}{\omega_p} \cdot \frac{m^2 v_p (\Delta v_p)^3}{e^2 \phi^2}$$

* Presented by D. Pfirsch.

here v_p is a typical phase velocity in a reference system with vanishing group velocity and Δv_p is the range of phase velocities for the unstable modes. For times small compared to T the two theories agree, whereas for times of the order of T the Hamilton–Jacobi approach deviates from the quasi-linear theory in a way which can be interpreted as a relaxation effect.

Instability and anomalous diffusion of a weakly ionized magnetized radio-frequency plasma*

J. POLMAN
Philips Research Laboratories, N. V. Philips' Gloeilampenfabrieken
Eindhoven, Netherlands

THE influence of a magnetic field on the transverse diffusion of a weakly ionized radio-frequency hydrogen plasma has been investigated by measuring the density decay of the plasma along the magnetic field, directed parallel to the discharge tube (inner diameter 5 cm, length 200 cm). The plasma is created at one end of this tube. The axial decay length is inversely proportional to the square root of the transverse diffusion coefficient. The range of pressures used was 0·02–0·07 torr. At low values of the magnetic field ($\leqslant$50–70 G) the transverse diffusion coefficient behaves classically, while at higher fields the transverse diffusion becomes anomalous, its coefficient being independent of gas pressure and magnetic field. At the critical field B_{cr}, where anomalous diffusion begins, the plasma becomes unstable, showing oscillations with frequencies of about 100 kc/s and higher harmonics of this frequency. At higher fields the oscillations disappear in strong random fluctuations. B_{cr} is proportional to the square root of the gas pressure. An explanation of the above phenomena, based on the theory of the ion acoustic instability of a weakly ionized inhomogeneous plasma by Timofeev, can be given, from which the values of the critical field and the oscillation spectrum can be derived. The results of the diffusion coefficient measurements can be explained by introducing the turbulent mixing length concept in the theory of a plasma, subjected to ion acoustic instability.

* Presented by the author. Paper published in *Plasma Phys.* 9, 471 (1967); also available as a Thesis, University of Groningen, Natuurkundig Lab. der R.U., Groningen, Netherlands.

Fusion efficiency for revolving fields*

M. L. POOL, J. W. SNYDER, P. E. WEILER and P. POLISHUK
Ohio State University, Columbus, U.S.A.

IN A d.c. magnetic bottle a hydrogen plasma has been created by the magnetic and electric fields induced by two sets of four coils. One phase of a two-phase 4·0-MHz oscillator energizes two coils of each set, and the other phase energizes the other two coils. The strength of the magnetic bottle field is that required for ion-cyclotron resonance. Thomson scattering from a ruby laser beam indicates a particle density of 2×10^{13} cm^{-3} to date. The salient ability of the coil ensemble to (a) walk ions to the centre of the plasma and (b) to give them an energy corresponding to that in an orbit of a radius which is 5 per cent less than the radius of the vacuum chamber but no more energy, is corroborated.

An extension of this coil ensemble is proposed. Two such ensembles as above would be placed in the same magnetic bottle field and made to operate upon two parallel and continuously connected vacuum chambers. One coil ensemble would be energized at a cyclotron frequency of A and the other ensemble, properly phased, at a frequency of B, where $A/B = 3/2$. A mixture of deuterium and tritium would be admitted. The two cyclotronic beams would react in the connected regions of the chambers. Calculations indicate that for the two ion beams, each at the terminal energy of 44·5 keV and at regional densities of about 10^{15} cm^{-3}, an energy yield could be obtained which is equal to the energy inherent in the beams.

* Presented by M. L. POOL.
Work sponsored by a grant from the Air Force Office of Scientific Research, Washington D.C. and in part by the Air Force Flight Dynamics Laboratory.