charge and momentum. They fell on the metal wall of the chamber and emitted light at the points of impact; this could be observed through a glass plate which had been fixed on the opposite side of the chamber with soft 'Araldite'. The position of protons and hydrogen molecular ions was always well defined on the chamber wall, and their deflexion due to magnetic field, thus determined, agreed within probable error of measurements with our theoretical calculations.

The field of the electromagnet was calibrated with a Grassot's fluxmeter within the pole pieces and outside, extending to the copper canal and the side walls of the analyser. The chamber, together with the accelerating column, was evacuated by a fast oil pump backed by a Kinney pump through a 'Freon' cold trap, and the pressure inside it was kept as low as 10^{-6} mm mercury during the experiments.

At an incident ion energy of 360 keV and with a suitable fixed magnetic field, well-defined spots could be seen on the metal wall of the analyser. These were due to singly and multiply charged copper ions, such as Cu^{+}, Cu^{2+}, Cu^{3+}, Cu^{4+} and Cu^{5+}, which were emitted from the canal surface by fast protons and molecular hydrogen ions. The spots due to Cu^{2+} ions overlapped with those due to incident ions causing their emission, but all other spots were well separated from one another, indicating that there was no appreciable energy spread among the emitted ions belonging to a particular group and entering the analyser. The energy and momentum of these ions, as calculated from the deflexion they experienced in the magnetic field, were in agreement, within experimental error, with equations (1) and (2). Copper ions carrying more than five charges were not detected within the energy range of the incident ions investigated. At an energy of 100 keV of the incident ions there were three spots, at 200 keV five, while at 360 keV all the aforementioned species of charges appeared. This made us believe that the efficiency of emission of ions and the multiplicity of their charge rise with energy of the incident beam.

We were not able to detect any ions of impurities which, it was suspected, might be present in the discharge tube of the radiofrequency ion source, and hence we believe that all the emitted Cu ions were due to single bi-particle elastic collisions of protons and hydrogen molecular ions with Cu atoms lying on the surface of the canal. There is some uncertainty as to the nature of one or two rather faint spots which occurred in the momentum spectrum (which was spread over a length of 10–11 cm). The only plausible explanation that we can offer is that they were formed due to multiply charged ions the positive charge of which was degraded during their flight in the trajectories in the magnetic field from the canal to the collector plate. No attempt was made to detect whether complex particles[3], for example of any compound of copper, were emitted in these experiments from copper surface. If they were, they overlapped with Cu ions.

The incident beam current on the copper canal and the thick metal disk which held it in position varied between 30 and 40 μamp, while the energy of the incident ions ranged between 100 keV and 360 keV in these experiments.

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GEOPHYSICS

Role of Plasma Instabilities in Auroral Phenomena

RECENTLY it was proposed that plasma instabilities are responsible for the auroral precipitation of particles trapped inside the magnetosphere[1]. The entire event would be a two-step process, one which takes particles inside the magnetosphere and one which dumps the trapped particles. Responsible for the second step would be plasma micro-instabilities of the type outlined by Krall and Rosenbluth[2].

Against this view is the fact that the number of particles and the amount of energy contained inside the radiation belts are barely sufficient to supply one auroral event[3]. Moreover, micro-instabilities are not the most suitable ones for explaining gross plasma motion and can be inhibited by a number of factors[4], such as the presence of a shear in the magnetic field.

The necessity of overcoming these objections leads one to look for plasma macroscopic instabilities which exist in collisionless régimes and do not respect the constraint that particles move together with the lines of magnetic field. Instabilities of this nature may be suitable for explaining the first step, as they would allow potential energy stored in the magnetic field of the thermalized solar wind to be transferred into kinetic energy. This process could occur inside the magnetopause or on the corresponding nightside.

In order to avoid having to consider the trapping and dumping phase, it is proposed that the instability excites plasma waves and then accelerates particles according to a pattern of the type considered by Stix[5].

Although at the present stage it is difficult to identify one definite type of plasma instability as being responsible for the auroral process, I would mention that two classes of macroscopic collisionless instabilities have been investigated[6,7]. One of them[7] is related to the appearance of an electric field parallel to the lines of the magnetic field, so that the 'frozen-in law' does not hold, due to anisotropic pressure and ion gyro radius effects. The driving factor is a spatial gradient of the longitudinal electron pressure or a gradient of the density together with transverse pressure gradients. In the case when the equilibrium magnetic field has no shear, the growth rate of the instability is of the order:

$$\gamma \approx k \frac{p'_{e\parallel}}{\Omega \rho}$$

where k is the wave number transverse to the magnetic field, $p'_{e\parallel}$ the transverse gradient of the longitudinal electron pressure, ρ the mass density and Ω the ion gyrofrequency. Assuming typically that: $p'_{e\parallel}/\rho \approx v^2_{the}/R$, $R \approx 10^9$ cm, $v_{the} \approx 4\times 10^7$ cm/sec, $B \approx 10^{-3}$ gauss, $k \approx 10^{-7}$ cm^{-1}, we obtain $\gamma \approx 10^{-1}$ sec^{-1}. For shorter wavelengths, that is $k \approx 10^{-5}$ cm^{-1}, the growth time becomes 10^{-1} sec, which seems to be consistent with the duration of burst of auroral X-rays observed recently[8].

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