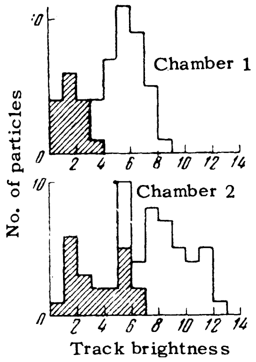

FIG. 4. Distribution of particles in track brightness: Hatched area–particles with range > 60 g/cm² Pb (π mesons with minimum ionization); blank area–particles whose range after passing through the chamber is 7-20 g/cm² Cu (protons with a mean ionizing ability ≈ $3.5 \times I_{min}$).

brightnesses increased by ≈ 13 times, but the ratio of brightnesses dropped to ≈ 2.0, which indicated a transfer to a regime of saturation (the operating regime for most spark chambers), where tracks of particles with different ionization are not distinguished by brightness.

Up to this time, as far as we know, there has been only a single observation in a spark chamber of track brightness differentiation produced by ionization: In the decay of Λ particles in a multilayer spark chamber, Cronin [1] observed that protons had a greater brightness than π mesons. However, this observation, interesting in itself, does not indicate the possibility of measuring ionization in a spark chamber. In this case the important circumstance was that the protons and π mesons passed through the chamber strictly simultaneously, and the energy of the high voltage pulse was divided in accordance with the ionization of the particles (the tracks created conducting channels with different resistance). Here the spark chamber, in the operating regime used, did not give a difference in brightness for solitary tracks with different ionization.

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1)Strictly speaking, a connection between track structure and ionization density follows just from the dependence of the number of bunches on the high-voltage pulse delay time. In this experiment the conditions of the discharge development were held constant (gas composition, and height and length of the high-voltage pulse were not changed) and only the initial conditions connected solely with the ionization density of the particle track at the time of arrival of the high-voltage pulse were varied.

2)Of course, increasing the delay is not the best way of decreasing the bunch density in the tracks. The same effect can be obtained by shortening the high voltage pulse. In the present experiment this was not an important matter.

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UNIVERSAL INSTABILITY IN A POTASSIUM PLASMA

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IT has been shown by a number of authors [1-6] that a plasma with an inhomogeneous density distribution in a magnetic field can be unstable against the so-called universal instability. The instability can develop in a low-density plasma (mean free path greater than the dimensions of the system) and in a dense plasma.

The instability leads to the excitation of waves that are essentially perpendicular to the magnetic field but with a finite component along the field; the characteristic frequencies are given by

$$\omega = k_y (cT/eH)\, n'/n, \tag{1}$$

where k_y is the component of the wave vector perpendicular to the magnetic field, T is the temperature in energy units, H is the magnetic field, n is the plasma density and n′ is the density gradient.

In a bounded plasma, in which k_y is determined by the circumference of the plasma cylinder, only those frequencies will be excited for which $m\lambda = 2\pi R$, where λ is the wavelength and R is the radius of the plasma cylinder. The growth rate is inversely proportional to k_z for small densities and k_z^2 for high densities (k_z is the component of the wave vector parallel to the magnetic field). [6] It then follows that long wavelengths are the most unstable.

We have carried out experiments in a device in which a plasma is produced by thermal ionization of potassium vapor on a tungsten plate heated to 2000°K. In this device the plasma forms a cylinder bounded at the ends by hot plates. The magnetic field is along the axis of the cylinder. The plasma density is a maximum at the center and falls off in the radial direction. The plasma density is essentially zero at a value of r equal to the radius of the plate. In the present device the radius of the plate $R = 2$ cm, and the distance between plates $L = 36$ cm. The measurements were carried out at plasma densities ranging from 1×10^8 to 5×10^{11} cm^{-3} and magnetic fields from 600 to 1600 Oe.

Over the entire range of density and magnetic fields that have been investigated it is observed that oscillations are excited with frequencies of 5—9, 15—18 and 20—28 kc/sec. In each case, at certain values of n and H we observe 3—4 peaks, with frequencies in the ratio 1 : 2 : 3 : 4. Oscillations of this kind have been recently observed by D'Angelo and Motley.[7]

The excitation of the oscillations is evidently not associated with the presence of electric sheaths at the edge of the hot tungsten plate. By varying the plate temperature and the neutral flux on the plate we have created conditions under which either electron or ion sheaths were produced near the surface of the plate. The oscillations were excited in all cases and no change was observed.

In accordance with theory the oscillations are excited in a low-density plasma $n \sim 10^8$—10^9 cm^{-3} (mean free path $l > L$) and in a dense plasma $n \sim 10^{10}$—10^{11} cm^{-3} ($l < L$).

The frequencies of the oscillations lie in the range given by Eq. (1). If we assume that $n'/n \sim 1/R$, $\lambda \sim R$, i.e., $k_y \sim 2\pi/R$, then with $T = 2000$°K, $H = 1000$ Oe, $R = 2$ cm we find $f = \omega/2\pi = 5$ kc/sec, in agreement with the observed frequencies.

The dependence of the oscillation frequency on magnetic field has been investigated. The measurements were carried out at densities $\sim 10^9$ cm^{-3}. In this case $l \sim L$, the collision frequency is small, and there is essentially no diffusion. As a result the plasma density and the radial density distribution are essentially independent of magnetic field, that is to say, n'/n and k_y remain constant while ω must vary as $1/H$. It has been verified that the frequency is reduced as the field increases for all three harmonics: the frequency varies as $1/H$.

Measurements of the phase shift of the oscillations in the azimuthal direction at points separated by 45°, 90°, and 180° indicate that what we observe is an azimuthal traveling wave with λ equal to a, a/2, a/3 correspondingly for the three harmonics ($a = 2\pi R$ is the circumferential length).

There is no phase shift along the axis of the plasma cylinder, i.e., the waves do not move in this direction. The amplitude of the oscillations varies along the column and is a maximum at the center, indicating the existence of a standing wave characterized by $\lambda/2 \sim L$. This amplitude distribution is observed at both low and high densities. The existence of a longitudinal wave with the longest wavelength available to the system is in accord with theory.

The results of this experiment are in agreement with theory and the observed instability can be identified with the "universal" instability of an inhomogeneous plasma in a magnetic field.

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