PRODUCTION OF TWO TEMPERATURES IN AN IONIZED GAS IN A MAGNETIC FIELD

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WE consider an ionized gas in which the ionic temperature is assumed given. The energy radiated by the electrons per unit time by virtue of cyclotron radiation is:

$$(dE_e/dt)_c = -\frac{E_{e\perp}}{t_c} = -(4e^4H^2/3c^5m_e^3)\,E_{e\perp}. \qquad (1)$$

Here e is the charge of the electron, H is the magnetic field, m_e is the mass of the electron and $E_{e\perp}$ is the electron energy due to motion in the transverse magnetic field. In order-of-magnitude terms, the energy radiated in a time t_c is equal to the energy of the electrons. The frequency of the cyclotron motion is $\nu \sim eH/m_e$; in what follows it will be assumed that the gas is transparent in this frequency region. This condition is rather stringent; given characteristic dimensions, we assume either a highly rarified gas or high values of the magnetic field and ionic temperature.

If the electrons radiate a significant part of their energy in a time short compared to the relaxation time t_{eq} of the electronic and ionic components of the gas, i.e., if $t_{eq} > t_c$, it can be shown that the electronic temperature will differ considerably from the ionic temperature.

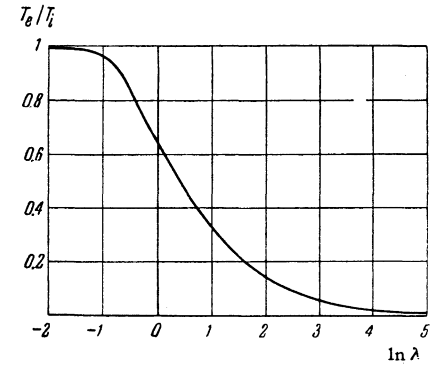
The relaxation time for the electronic component is[1]

$$t_r = m_e^{1/2}(3kT_e)^{3/2}/8\cdot 0.714\,\pi n_e e^4 \ln\Lambda. \qquad (2)$$

Here T_e is the kinetic temperature of the electrons, n_e the number of electrons per unit volume and $\ln\Lambda$ is the Coulomb logarithm. It will be assumed that $t_c \gg t_r$ so that the electron gas is characterized by a Maxwellian distribution. Thus, the Spitzer formula[1] can be used in analyzing the exchange of energy between the electron gas and the ion gas:

$$\left[\frac{dE_e}{dt}\right]_i = \frac{E_i - E_e}{\alpha t_{eq}}$$
$$= (E_i - E_e)\left[\left(\frac{3\alpha m_e m_i k^{3/2}}{8\pi^{1/2} n_i Z^2 e^4 \ln\Lambda}\left(\frac{T_e}{m_e} + \frac{T_i}{m_i}\right)^{3/2}\right]^{-1} \qquad (3)$$

Here m_i is the ion mass, Z is the charge of the ion and n_i is the number of ions per unit volume.



The factor α takes account of the retardation of the relaxation process because of the magnetic field, $\alpha \sim 3$.

In the quasi-stationary state we can equate (1) and (3). Whence the following expression is obtained for the ratio $T_e/T_i = \theta$:

$$\lambda^2 = \frac{(1/\theta - 1)}{\theta^3(1 + m_e/m_i\theta)},\quad \lambda = \frac{\alpha k^{2/3} m_i}{3(2\pi)^{1/2} c^5 m_e^{7/2} Z^2 \ln\Lambda}\,\frac{T_i^{2/3} H^2}{n_i} \qquad (4)$$

The condition $t_c \gg t_r$ is equivalent to the inequality $\lambda \ll 10^6$ in which case $m_e/\theta m_i \ll 1$, so that Eq. (4) can be simplified: $\lambda = \theta^{-5/2}(1-\theta)$. The function $\theta = \theta(\lambda)$ is given in the figure. At large values of λ it is apparent that $\theta = \lambda^{-2/5}$. Thus, the difference in temperatures for the ionic component and the electronic component can become very large.

[1] Spitzer. Physics of Fully Ionized Gases, Interscience, New York (1955).

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INVESTIGATION OF K_{e3}-DECAY WITH THE EMISSION OF A GAMMA PHOTON

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THE spectra of π mesons and electrons produced in K_{e3} decay have been investigated by a number of authors.[1-3] An important contribution to these spectra is due to the K_{e3} decay with the emission of a hard γ photon. Hence we investigate this process in this paper: