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1/3

Damping coefficient of vibrating electrons

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Abstract—A Druyvesteyn distribution is substituted for the assumed Maxwellian distribution in the derivation of the damping coefficient of vibrating electrons. The consequences are discussed.

INTRODUCTION

IN BOTH the Eccles–Larmor and the Appleton–Hartree equations for the refractive index of an ionized medium, the collision frequency ν is introduced as a parameter in the damping coefficient g in the differential equation of vibrating electrons. The expression used

$$g = m\nu \tag{1}$$

is based on the simplifying assumption that the velocity distribution follows a Maxwellian law, such that the number of particles, whose mean velocity lies in the neighbourhood of

$$v = \frac{-jE_0 e}{m\omega}\{1 - \exp[-j\omega(t - t_1)]\}\exp(j\omega t)$$

at time t (t_1 being the instant of their last collisions), is given by

$$N = \frac{N_0}{\tau}\exp\left(-\frac{t - t_1}{\tau}\right)dt_1 \tag{2}$$

where N_0 = total number of particles considered;
τ = average time interval between collisions;
ω = angular frequency of wave;
$j = \sqrt{-1}$.

In a more general context, LOEB (1955) suggests that the Maxwellian law be replaced by a Druyvesteyn law. One reason given is that as a result of several investigations, the Maxwellian law is now believed to be incompatible with a *velocity-independent* mean free path, whereas the Druyvesteyn law initially postulates this independence.

ANALYSIS

Prescinding for the present from the hidden implications and limitations of this law, and with the sole view of studying the differences between the two laws in their relation to the Appleton–Hartree equation, a Druyvesteyn distribution is here postulated. Expression (2) then becomes

$$N = \frac{N_0}{\tau}\exp\left[-\frac{(t - t_1)^2}{\tau^2}\right]dt_1. \tag{3}$$