Seminar

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Institute for Plasma Research

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Title: Charged particle dynamics in an elliptically polarized electromagnetic wave and a uniform axial magnetic field

Speaker: Dr. Shivam Kumar Mishra
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Date: 14th March 2024 (Thursday)

Time: 11:00 AM

Venue: Seminar Hall, IPR

Abstract

The relativistic motion of a charged particle placed in an electromagnetic wave is a problem of fundamental interest and is of relevance for investigating the interaction of intense radiation with matter. It is well known that the motion of the charged particle in the electromagnetic wave does not leads to any net energy gain by the charged particle over a period of time [1]. The net energy gain can be achieved by applying an external magnetic field along the wave propagation direction [2]. Therefore, an analytical study of the charged particle dynamics in the presence of an elliptically polarized electromagnetic wave and a uniform axial magnetic field, is performed. It is found that for $\frac{g\omega_0}{\omega'} = \pm 1$ maximum energy gain occurs respectively for linear and circular polarization; $\omega_0$and ω' respectively being the cyclotron frequency of the charged particle in the external magnetic field and Doppler-shifted frequency of the wave seen by the particle, and $g = \pm 1$ respectively correspond to right and left-handedness of the polarization. An explicit solution of the governing equation is obtained in terms of particle position or laboratory time, for the resonant energy gain in a circularly polarized electromagnetic wave. These explicit position- or time-dependent expressions are useful for better insight into various phenomena, viz., cosmic ray generation, microwave generation, plasma heating, and particle acceleration, etc. Furthermore, it has been shown that the quantum effect on the net energy gain by the charged particle becomes significant in the domain where the radiation-reaction force exceeds the Lorentz force.

Reference:

1 L. D. Landau and E. M. Lifshitz. The Classical Theory of Fields. Butterworth-Heinemann, 4 edition, Jan 1980.

2 AA Kolomenskii and AN Lebedev. In Doklady Akad. Nauk SSSR, volume 145, page 1259. Lebedev Inst. of Physics, Moscow, 1962.