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Pitch angle scattering of an energetic magnetized particle by a circularly polarized electromagnetic wave

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The interaction between a circularly polarized electromagnetic wave and an energetic gyrating particle is described [1] using a relativistic pseudo-potential that is a function of the frequency mismatch, a measure of the extent to which $\omega - k_z v_z = \Omega/\gamma$ is not true. The description of this wave-particle interaction involves a sequence of relativistic transformations that ultimately demonstrate that the pseudo potential energy of a pseudo particle adds to a pseudo kinetic energy giving a total pseudo energy that is a constant of the motion. The pseudo kinetic energy is proportional to the square of the particle acceleration (compare to normal kinetic energy which is the square of a velocity) and the pseudo potential energy is a function of the mismatch and so effectively a function of the particle velocity parallel to the background magnetic field (compare to normal potential energy which is a function of position). Analysis of the pseudo-potential provides a means for interpreting particle motion in the wave in a manner analogous to the analysis of a normal particle bouncing in a conventional potential well. The wave-particle interaction is electromagnetic and so differs from and is more complicated than the well-known Landau damping of electrostatic waves. The pseudo-potential profile depends on the initial mismatch, the normalized wave amplitude, and the initial angle between the wave magnetic field and the particle perpendicular velocity. For zero initial mismatch, the pseudo-potential consists of only one valley, but for finite mismatch, there can be two valleys separated by a hill. A large pitch angle scattering of the energetic electron can occur in the two-valley situation but fast scattering can also occur in a single valley. Examples relevant to magnetospheric whistler waves are discussed. Extension to the situation of a distribution of relativistic particles is presented in a companion talk [2].

[1] P. M. Bellan, Phys. Plasmas 20, Art. No. 042117 (2013)

[2] Y. D. Yoon and P. M. Bellan, JGR 125, Art. No. e2020JA027796 (2020)