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Polarization Effects in Cosmic-Ray Acceleration by Cyclotron Auto-Resonance

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Abstract : Theoretical investigations, analytical as well as numerical, have shown that electrons can be accelerated to GeV energies by the process of cyclotron auto-resonance acceleration (CARA). In CARA, the particle would be injected along the lines of a uniform magnetic field aligned parallel to the direction of propagation of a plane-wave radiation field. Unfortunately, an accelerator based on CARA would be prohibitively too long and too expensive to build and maintain. However, the process stands a better chance of success near the polar cap of a compact object (such as a neutron star, a black hole or a magnetar) or in an environment created in the wake of a binary neutron-star or blackhole merger. Dynamics of the nuclides $_{1}H^{1}$, $_{2}He^{4}$, $_{26}Fe^{56}$, and $_{28}Ni^{62}$, in such astrophysical conditions, have been investigated by single-particle calculations and many-particle simulations. The investigations show that these nuclides can reach ZeV energies (1 ZeV = 10^{21} eV) due to interaction with super-intense radiation of wavelengths = 1 and 10 m and = 50 pm and magnetic fields of strengths at the mega- and giga-tesla levels. Examples employing radiation intensities in the range 10^{32}-10^{42} W/m^2 have been used. Employing a two-parameter model for representing the radiation field, CARA is analytically generalized to include any state of polarization, and the basic working equations are derived rigorously and in closed analytic form.

Keywords : compact objects, cosmic-ray acceleration, cyclotron auto-resonance, polarization effects, zevatron
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