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Parametric resonant acceleration of particles by gravitational waves

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Abstract. We study the resonant interaction of charged particles with a gravitational wave propagating in the non-empty interstellar space in the presence of a uniform magnetic field. It is found that this interaction can be cast in the form of a *parametric resonance* problem which, besides the main resonance, allows for the existence of many secondary ones. Each of them is associated with a non-zero resonant width, depending on the amplitude of the wave and the energy density of the interstellar plasma. Numerical estimates of the particles' energization and the ensuing damping of the wave are given.

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1. Introduction

Despite the numerous efforts to detect gravitational waves, there is no convincing evidence for their existence (Thorne 1987). This is due to the fact that not only is their amplitude very small (Smarr 1979), but it is highly possible that some kind of damping mechanism operates on them as they travel through space (Esposito 1971, Macedo and Nelson 1983, Papadopoulos and Esposito 1985). This damping may originate in the interaction of the gravitational wave with the interstellar matter (Macedo and Nelson 1990, Varvoglis and Papadopoulos 1992).

In a recent paper (Kleidis *et al* 1993, which hereafter is referred to as paper I) the problem of the interaction of a charged particle with a gravitational wave, in the presence of a uniform magnetic field, has been modelled as a Hamiltonian dynamical system. The corresponding analysis was carried out for various directions of propagation of the wave with respect to the magnetic field. It was found that, in the oblique propagation, diffusive acceleration of the particle, as a result of secular energy transfer from the wave, could lead to damping.

The most important results, however, were derived from the parallel propagation case where the dynamical system is trapped at an exact resonance between the Larmor frequency of the particles and the frequency of the wave. In this case a *phase lock* situation appears (see Menyuk *et al* 1987), leading to an *infinite* acceleration of the particle and, consequently, to a non-trivial damping of the wave. The zero probability problem of the exact resonance was considered inappropriate in a more recent paper (Kleidis *et al* 1995, which hereafter is referred to as paper II), by considering that the propagation of the gravitational wave takes place in a space filled with plasma, which results in a dispersion of the wave (Grishchuk

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