

Particle production in curved spacetime

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Abstract. Particle production in curved spacetime has been discussed through the method of complex time WKB approximation. We consider Dirac equation in non-flat spacetime to understand particle production as particle–antiparticle rotation. The method is also generalized to understand particle production through parametric resonance. To understand the method of CWKB we consider particle production in Kasner spacetime as an example.

Keywords. Particle production; Robertson–Walker spacetime; parametric resonance.

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1. Introduction

The Dirac equation in curved spacetime is of considerable interest in astrophysics and cosmology. Previous investigations in this direction are due to Fock [1], Tetrode [2], Schrödinger [3] and McVittie [4]. A general discussion of the $m = 0$ neutrino case was given by Brill and Wheeler [5].

In astrophysics and cosmology the pair creation in expanding universes has been of considerable interest for several reasons. The choice of quantum vacuum is a very delicate object in curved spacetime and it greatly affects the calculations leading to pair creation. The works in this direction are due Chimento and Mollerach [6], Audretsch and Schäfer [7], Castagnino and Mazzitelli [8], Biswas and Guha [9], Biswas *et al* [10], Guha *et al* [11] and Biswas *et al* [12]. Calculation of pair creation and others related to has also been carried by Lotze [13], Barut and Duru [14], Biswas *et al* [15], Sahni [16], Barut and Singh [17] and many others.

In astrophysics the study of Dirac equation has gained importance in strange matter calculations as well as in neutron star calculations [18], with and without magnetic field. In cosmology the effect of particle production has some physical considerations, mainly in the study of damping and avoidance of initial singularity. A study of pair creation of spin $\frac{1}{2}$ particles (massive and massless) in Robertson–Walker universes was made by Parker [19], Lotze [13] and recently by Biswas *et al* [11, 12]. In the so called back-reaction problem, the effect of particle production back on the metric has not been incorporated successfully so far. Fischetti, Hartle and Hu [20], Anderson [21] tried to solve the back-reaction problem but the effect of particle production is not directly involved in the calculations. Ford [22] tried to stress the importance of particle production in solving the back-reaction