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Accelerated motion in general relativity: fate of the singularity

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Abstract Under general relativity, the paths of accelerated test particles are taken into account. It is examined whether such accelerations have any influence on the 'singularity' of the spacetime. The Raychaudhuri equation for the congruence of the time-like curves describing the paths of the accelerated particles is considered to calculate a few physical attributes. It is shown that if the acceleration of the test particles exceeds a particular value, then the congruences of the accelerated time-like curves do not encounter any singularity although the usual energy conditions are violated or modified. It is shown further that in the curved spacetime of general relativistic framework one may generate a system of transformations that is a generalization of the Rindler coordinates related to accelerated frame in the flat Minkowski spacetime. To show the influence of the acceleration of test particle on singularity of a particular spacetime the Schwarzschild spacetime is considered. Taking tidal deviation related acceleration term, it is shown that the acceleration may attain a specific value for which the modified Kretschmann scalar vanishes in a spherical neighbourhood of the singularity and thus the Schwarzschild singularity disappears. In the context of singularity as 'geodesic incompleteness' of the spacetime manifold it is also proved that prescribing an appropriate acceleration term on the maximal geodesic defined in a finite interval one may extend it up to infinite proper time and hence the spacetime becomes singularity free. Such results hold at the price of violating the usual energy conditions.

1 Introduction

The general relativity explaining the gravity in the true sense is so successfully that it has a wide range of applications in the precise measurement of planetary motions, galactic and extra-galactic phenomena and also the evolution of the universe in the stationary as well as dynamical spacetime continuum. In the framework of that elegant theory there exists a situation while the causality breaks down and that is nothing but the singularity. It is supposed to be a condition in which the gravity is so intense that spacetime itself breaks down catastrophically; although that is not the only way to define a singularity.

In 1955 Penrose [1] proposed the idea of singularity in terms of incompleteness of spacetime manifold subject to certain conditions including the existence of trapped surface. In 1970 Hawking and Penrose [2] developed the 'singularity theorem' interpreting the gravitational singularity in the Big Bang situation. The singularities may be evident in all the black hole spacetime and in all the cosmological solutions that do not have a scalar field energy or a cosmological constant. In this article we concentrate on the spacelike singularity at which the spacetime curvature blows up. The blow up ratio of the curvature during gravitational collapse have been studied in details [3,4]. As the curvature is associated with gravity the curvature singularity corresponds to infinite gravity and there exist a number of possibilities of how such infinitely strong gravity manifests itself.

Now a pertaining question is whether that singularity lasts forever or there may be some way by which it is completely destroyed. We are strongly motivated by the event of black hole evaporation interpreting that if the entire black hole gets evaporated then its singularity must be diminished by some manner before the evaporation process is completed. We identify that the accelerated particles having some suitable value of acceleration may destroy the spacetime singularity.

The acceleration may be incorporated in the special relativity characterized by Minkowski spacetime. In 1973 Misner et al. [5] analyzed the accelerated motion in the framework of special relativity. Although, in general, the special relativity deals with inertial frame of reference, but that is

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