SEMICLASSICAL GRAVITATIONAL COLLAPSE AND AVOIDANCE OF SINGULARITIES

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Introduction. General Relativity (GR) predicts that, under standard conditions for normal matter, when gravity prevails over other forces, a space-time singularity must form [1]. On the other hand singularities are not expected to occur in the real universe as they may lead to pathological problems for the causal structure of the space-time. Several recent studies suggest that there may be mechanisms that prevent the formation of singularities and that these are likely to be related to quantum correction to GR that appear in the strong field regime. We considered some mathematical toy models describing complete gravitational collapse of a massive cloud that classically lead to the formation of a singularity. In order to fully characterize the final stages of collapse we would then need to use a theory of quantum-gravity which we do not possess yet. On the other hand semi-classical approaches are possible and they provide valuable hints at how gravity behaves in such extreme conditions [2].

Results. We have studied a well-known toy model for gravitational collapse where Einstein's equations can be fully solved. This is the so called Oppenheimer-Snyder model which describes a spherical, non-rotating, cloud of non-interacting particles that collapses under its own weight [3]. We found that semi-classical corrections, as inspired by some approaches to loop quantum gravity, avoid the formation of the singularity and lead to a bouncing behavior for the cloud [4].

Conclusions. Our results are in agreement with what has been found by using different approaches to the quantum regime of the final fate of collapse [5]. These results may have important implications for astrophysics. Classically it is believed that black holes must inevitably form from the complete collapse of sufficiently massive stars. These results suggest the possibility that the black hole horizon may be a transient phenomenon and that exotic compact remnants may result as leftovers from the collapse of massive stars.

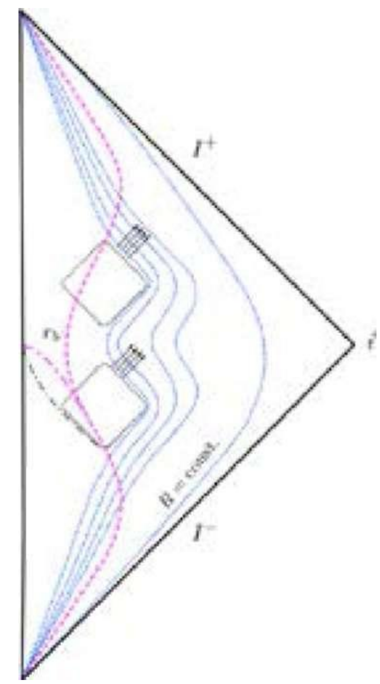

Figure 1. Penrose diagram for the collapse and bounce scenario described in [4].

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