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ORIGINAL ARTICLE

Dynamical evolution of an unstable gravastar with zero mass

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Abstract Using the conventional gravastar model, that is, an object constituted by two components where one of them is a massive infinitely thin shell and the other one is a de Sitter interior spacetime, we physically interpret a solution characterized by a zero Schwarzschild mass. No stable gravastar is formed and it collapses without forming an event horizon, originating what we call a massive non-gravitational object. The most surprise here is that the collapse occurs with an exterior de Sitter vacuum spacetime. This creates an object which does not interact gravitationally with an outside test particle and it may evolve to a point-like topological defect.

Keywords Gravastar · Black hole

1 Introduction

Gravastars were proposed as an alternative model to black holes by Mazur and Motola (2001). In their original form, they consisted of five layers: an internal core, $0 < R < R_1$ (where R denotes the radius of the star), described by the de Sitter universe, an intermediate thin layer of stiff fluid, $R_1 < R < R_2$, an external region, $R > R_2$, described by the Schwarzschild solution, and two infinitely thin shells, appearing, respectively, on the hypersurfaces $R = R_1$ and $R = R_2$ (Mazur and Mottola 2001, 2004). The intermediate layer substituted the region where both horizons (of de Sitter and of Schwarzschild) should be present. Later, Visser and Wiltshire (2004) simplified this model, reducing to three the number of regions. The first work to consider gravastar solutions with de Sitter exterior were analyzed in Carter (2005). In this work we will use the same kind of exterior spacetime (Chan et al. 2009b). In recent works, two of us showed that gravastars do not substitute black holes (Rocha et al. 2008a, 2008b; Chan et al. 2009a, 2009b; Chan and da Silva 2010; Chan et al. 2011). Instead of, they can coexist. In these studies were analyzed the stability of many gravastar's configurations. Now we are interested in a particular case, with zero Schwarzschild mass, which implies in a non-gravitational object. This structure is possible since the gravitational mass depends on the trace of the energy momentum tensor, instead of the energy density only. As the inner region is filled by dark energy, there is an equilibrium between the repulsive gravitational mass (the inner region) and the attractive one (the thin shell). This kind of objects has also been studied by two of us, in the case of a charged shell (Chan and da Silva 2010). In addition, we know that topological defects are extended solutions from Field Theory when the vacuum structure is topologically nontrivial. In three spatial dimensions one can have either point-like defects (monopoles), line-like defects (strings) or membrane-like defects (domain walls). So, the object that we study here is similar to a point-like topological defect, since the de Sitter vacuum solution does not describe all the spacetime. It is the aim of this work to

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