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Cosmic Censorship: A study on the behaviour of regular black holes

The Weak Cosmic Censorship Conjecture (CCC) generally states that all singularities must be hidden behind the event horizon. Consequently, this conjecture forbids the destruction of event horizons in singular black holes, since their removal would expose naked singularities. Regular black holes, by contrast, contain no curvature singularities and are therefore not subject to the consequences of the cosmic censorship conjecture. As such it is not evident if there exists any mechanism which either prevents or permits the destruction of their event horizons. In this study, we investigate the possibility of removing the horizons of regular black holes, by considering a particular class known as *black bounces*. These geometries regularize the singular Kerr-Newman family by introduction of the real regularization parameter l and the mapping $r^2 \rightarrow r^2 + l^2$. To probe the stability of their event horizons, we employ a Wald-like *gedanken* experiment, whereby we attempt to have a black hole assimilate a test particle such that the resulting spacetime contains no event horizon. To facilitate our investigation, we introduce the concept of *saturation*, with which we are able to quantify the notions of extremality and near-extremality. This allows us to unify the treatment of both saturated and under-saturated regimes without the need for case-specific expressions or arguments. Within this framework, we find that the Kerr-Newman black bounce admits two distinct channels (I and II) for removal of the event horizon, in contrast to the single channel available to its singular counterpart. We demonstrate that both of these channels can, in principle, lead to destruction of the event horizon, however, only if the black hole is not at the point of extremality. Moreover, we show that a strict enforcement of the test particle conditions requires that the black hole reside near the brink of collapse in order to be susceptible to horizon removal. We conclude by comparing our findings to a similar analysis conducted on the regular Bardeen and Hayward black holes, upon which it is demonstrated that all three candidates exhibit similar behaviour in the context of horizon removal.

Author: VAN LOGGENBERG, Luan (Stellenbosch University)

Presenter: VAN LOGGENBERG, Luan (Stellenbosch University)