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Destroying Kerr-Sen black holes

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By neglecting the self-force, self-energy, and radiative effects, it has been shown that an extremal or near-extremal Kerr-Newman black hole can turn into a naked singularity when it captures charged and spinning massive particles. A straightforward question then arises: do charged and rotating black holes in string theory possess the same property? In this paper we apply Wald's gedanken experiment, in his study on the possibility of destroying extremal Kerr-Newman black holes, to the case of (near-)extremal Kerr-Sen black holes. We find that feeding a test particle into a (near-)extremal Kerr-Sen black hole could lead to a violation of the extremal bound for the black hole.

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I. INTRODUCTION

According to the cosmic censorship hypothesis, all physical singularities due to gravitational collapse are hidden behind an event horizon [1,2]. This hypothesis, which implies that no naked singularity occurs in our Universe, is formulated in weak and strong versions [2]. The weak cosmic censorship conjecture (WCCC), which has relevance to the work presented in this paper,[1] effectively postulates that the singularities due to gravitational collapse cannot influence points near the future null infinity $\mathcal{I}^+$. For example, in the case of collapsing stars the hypothesis says that the singularity resulting from this process must be hidden behind an event horizon. However, due to the lack of solid evidence that a black hole candidate is really a black hole, the possibility of a naked singularity's existence is worth considering. Related to this consideration, it is interesting to note that one can observationally differentiate naked singularities from black holes through the characteristics of their gravitational lensings [3].

In the Einstein-Maxwell theory, several investigations on the WCCC violation have been carried out in the literature. For example, in his groundbreaking work [4] Wald showed that it is impossible to turn an extremal Kerr-Newman black hole into a naked singularity by letting the black hole capture a test particle having large angular momentum and electric charge compared to its energy. Later on, the problem of WCC violation was revisited by many authors; for example in [5] Hubeny showed that overcharging a near-extremal Reissner-Nordstrom (RN) black hole is possible by injecting a charged test particle into the black hole, and in [6] Jacobson and Sotiriou showed that a near-extremal Kerr black hole can be overspun by a test particle with angular momentum.

Quite recently Saa *et al.* in [7] showed that, by neglecting the backreaction effect, destroying a near-extremal Kerr-Newman black hole is possible by a test particle with electric charge and angular momentum. In their analysis, the particle's energy is kept linear in the equation related to the extremality, and the overextremization of Kerr-Newman black holes cannot be performed once the black holes are in the extremal condition. Later on, Gao *et al.* showed in [8] that, by neglecting the radiative and self-force effects, destroying an extremal Kerr-Newman black hole with a test particle is possible if the linear approximation of the particle's energy is not taken into account. However, due to the narrow range of the particle's energy, which leads to the violation of the black hole's extremality bound, taking the radiative and self-force effects [9–11] into account could be a cure to the problem of producing a naked singularity from a black hole.

Several studies in the literature about the possibility of cosmic censorship violation in charged and/or rotating black holes are also worth mentioning. In [12], the authors studied the possibility of violating WCCC in the case of a black hole that interacts with fields instead of test particles. The possibility of producing a naked singularity in a Kerr-Newman background by letting a neutral spinning body fall into an extremal RN black hole was discussed in [13]. Keeping up to the linear order in the test particle parameters, extremal black holes can at most remain extremal in a variety of scenarios [14]. Including the cosmological constant in studies of WCCC violation of black holes was considered in [15]. Very recently, a nonperturbative test of cosmic censorship with a stream of charged null dust in the theory as discussed in the present paper was performed in [16], where the authors showed that some energy conditions prevent the formation of a naked singularity in the future.

In the low energy limit of string field theory, there is a known rotating charged black hole solution, namely, the Kerr-Sen black hole [17]. It has physical properties which

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[1]The weak censorship conjecture deals with the asymptotically flat spacetime [2], which is a feature in Kerr-Sen geometry.

