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Fate of an infalling Passenger at the Cauchy Horizon of a Reissner-Nordström Black Hole

Ever since Penrose & Simpson contradicted Novikov's prediction that an infalling passenger would emerge into an asymptotically flat universe, there have been a continued interest in predicting the fate of an infalling passenger near the Cauchy horizon (CH) of a Reissner-Nordström (RN) black hole. Poisson & Israel observed that the CH singularity becomes stronger upon considering the backscattered particles in addition to highly blueshifted infalling massless particles. However, their analysis did not reveal if the singularity is strong enough to destroy the infalling passenger. On the other hand, Ori showed that the tidal forces are not strong enough and the particle separation remain finite leading to the possibility of extension of spacetime beyond the CH. This unresolved issue has maintained the motivation of researchers until recent times.

In this work, we consider a massive scalar field in the RN geometry to mimic the dynamics of the infalling passenger. This results in two coupled differential equations, namely, the Einstein field equation and the Klein-Gordon equation in this background. To study the behavior of the mass function and the scalar field near the CH, we develop a perturbative method to solve the coupled dynamical equations.

Our detailed analysis shows that the otherwise well-behaved mass function exhibits a very rapid and unbounded growth, behaving with the advanced time as $v^{-\alpha}$ with α ranging from 0.09 to 0.13, upon approaching the CH. In addition, we find that even though the scalar field is well behaved outside the CH, it exhibits abrupt and rapid fluctuations with infinite jumps near the CH, and it completely vanishes beyond the CH. This indicates complete destruction of an infalling passenger as well as no possibility of extension of spacetime beyond the CH, confirming Penrose's prediction. Consequently, our findings do not agree with theories predicting weak singularity at the CH.

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