Naked Singularities and Quantum Gravity

Tomohiro Harada*
Department of Physics, Waseda University, Shinjuku, Tokyo 169-8555, Japan

Singularity theorems predict the existence of singularities in generic spacetime. Singularities formed in gravitational collapse may be covered by event horizon or can be seen by a distant observer. In fact, there can appear naked singularities in generic collapse of a dust ball.

For the forming naked singularity in the self-similar collapse of a dust ball, the radiated power P and $\hat{P}$ due to quantum effects for minimally and conformally coupled massless scalar fields, respectively, can be calculated as [1] $P \sim \hat{P} \sim \hbar(U_0 - U)^{-2}$ for $U_0 - U < M$, where U is the retarded time defined as $U \equiv T - R_*$ using the usual Schwarzschild coordinates. For the forming naked singularity in the collapse of dust with C^∞ initial data, the result is [2] $P \sim \hbar\nu_s^{1/2}(U_0 - U)^{-3/2}$, $\hat{P} \sim \hbar\nu_s(U_0 - U)^{-1}$ for $U_0 - U < \nu_s^{-1}$, where ν_s is some positive constant. For the above two cases, the power grows unboundedly as $U \to U_0$. In comparison, for the collapse to a black hole, the result is well known as a Hawking radiation.

Let us see the total radiated energy E and $\hat{E}$ until the moment $U_0 - U = t_{Pl} = \nu_{Pl}^{-1} = 10^{-43}$s. We can easily find [3] $E \sim \hat{E} \sim E_{Pl} = 10^{16}\mathrm{erg} = 10^{-5}\mathrm{g}$, for the self-similar dust; and $E \sim \hbar\nu_{Pl}\left(\nu_s/\nu_{Pl}\right)^{1/2} < E_{Pl}$, $\hat{E} \sim \hbar\nu_{Pl}\left[\left(\nu_s/\nu_{Pl}\right)\ln(\nu_{Pl}/\nu_s)\right] < E_{Pl}$, for the C^∞ dust.

It is also noted that the back reaction effect of the created partcles on the dynamics of the central region is not significant [4]. Therefore, whether the emission is enormous depends on the super Planckian physics. In this sense, a naked singularity can be a probe of quantum gravity. If the naked singularity emits a considerable amount of energy, it may be an astrophysical object, for example, a central engine of gamma ray bursts.

References

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*harada@gravity.phys.waseda.ac.jp