Physical aspects of naked singularity explosion
– *How does a naked singularity explode?* –

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It is known that several models of gravitational collapse end in naked singularities from regular initial data. Among these models the most fully studied one is the spherically symmetric inhomogeneous dust collapse, which is described by the Lemaître-Tolman-Bondi (LTB) solution. It is expected that the quantum effects analogous to Hawking radiation play an important role in the final stage of the collapse. From the consideration of a quantized massless scalar field on the classical background of such collapse, it was found that the outgoing quantum flux diverges in the approach to the Cauchy horizon. The expectation value of the quantum stress tensor of the massless scalar field on the classical background of spherical dust collapse has recently been examined for its exact expression in a 2D model. I and T. Harada have recently investigated the behavior of this value in detail [1]. The results obtained in this research are as follows.

We have investigated the expectation value of the quantum stress tensor for the massless scalar field on the 2D self-similar spherical dust collapse. From the numerical integration for the null geodesic equations we obtain the junction relation between the inside and the outside null coordinates. Using this relation we have investigated exact behaviors of the expectation value of the quantum stress tensor in detail. At first, to confirm the insignificance of the back reaction in the semiclassical treatment, we calculate the energy density around the center. The energy density of quantum field is kept considerably smaller than that of the background dust field. It can be said that quantum gravitational effects are more important than the back reaction in the whole course of the collapse.

We can depict the inside behavior in the naked singularity explosion as follows. As the dust collapse proceeds the quantum field flows inward and the positive energy is accumulated in the center surrounded by slightly negative energy. At the naked singularity formation this gathered positive energy is converted to the diverging outgoing flux. The negative energy envelope flows inward crossing the Cauchy horizon. The diverging outgoing flux emerges from the stellar surface and propagates along the Cauchy horizon.

There is energy balance relation between ingoing and outgoing flux at the Cauchy horizon similar to the Hawking radiation. However this balance is not long-standing like the Hawking radiation but instantaneous. The ingoing negative flux diverges at the central naked singularity, which is balanced with the outgoing diverging flux along the Cauchy horizon. If we take into account the backreaction and a theory of quantum gravity, we could expect that the outgoing flux would be milder and have longer time duration than the naked singularity explosion, which is emitted divergingly in less than a Planck time.

References

[1] H. Iguchi and T. Harada, in preperation

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