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Renormalization group analysis of the self-interacting axion cloud

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There are strong interests in considering ultra-light scalar fields (especially axion) around a rapidly rotating black hole because of the possibility of observing gravitational waves from axion condensate (axion cloud) around black holes. Motivated by this consideration, we propose a new method to study the dynamics of an ultra-light scalar field with self-interaction around a rapidly rotating black hole, which uses the dynamical renormalization group method. We find that for relativistic clouds, a saturation of the superradiant instability by the scattering of the axion due to the self-interaction does not occur in the weakly non-linear regime when we consider the adiabatic growth of the cloud from a single superradiant mode. This may suggest that an explosive phenomenon called the Bosenova may inevitably happen for relativistic axion clouds, at least once in its evolutionary history.

Author: OMIYA, Hidetoshi (Kyoto University)

Presenter: OMIYA, Hidetoshi (Kyoto University)

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