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Running Newton Coupling, Scale Identification and Black Hole Thermodynamics

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We discuss the quantum improvement of black hole solutions in the context of asymptotic safety. The Newton coupling in this formulation depends on an energy scale, which must be identified with some length scale in order to study physical consequences to black holes. However, no physical principle has so far been known for the identification. Here we propose that the consistency of the first law of thermodynamics is the principle that should determine physically sensible scale identification, at least close to the horizon. We show that this leads to a natural solution that the Newton coupling should be a function of the horizon area and find a universal formula for the quantum entropy, which agrees with the standard Bekenstein-Hawking entropy for constant Newton coupling, for Kerr black holes and other higher-dimensional black holes. This suggests that the Newton coupling is a function of the area at fixed radius near the horizon, and also away to infinity, where the quantum effects may not be so important.

Presenter: OHTA, Nobuyoshi