Energy-momentum tensor and metric near the Schwarzschild sphere

Valentina Baccetti[1], Robert B. Mann[2,3], Sebastian Murk[1*] and Daniel R. Terno[1]

[1]Department of Physics and Astronomy, Macquarie University, Sydney NSW 2109, Australia
[2]Department of Physics and Astronomy, University of Waterloo, Waterloo, Ontario, Canada
[3]Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada
[*] sebastian.murk@mq.edu.au

Astrophysical black holes [1, 2, 3] - compact, superdense objects produced by gravitational collapse - are a common presence in the observable universe. Given the unique nature of their formation, they provide an ideal laboratory for the study of potential deviations from the standard predictions made by Einstein's theory of general relativity. Accretion discs and gravitational waves allow to probe their exterior geometry up to distances $r \gtrsim 2M$, where M denotes the gravitational mass. All currently available data is consistent with having the Schwarzschild and Kerr-Newman solutions of classical general relativity as asymptotic final states of the collapse [2, 4]. Nevertheless, it is unclear if, when, and how astrophysical black holes develop any of the horizons and/or singularities predicted by general relativity [3, 5].

We investigate [6] the implications of the formation of trapped spacetime regions in finite time of a distant observer using a self-consistent semiclassical approach with spherical symmetry. We obtain the limiting form of the energy-momentum tensor near the Schwarzschild radius and derive the general form of the spherically symmetric metric for both its growth and shrinking. The metric depends only on the radius and its rate of change. The null energy condition is violated, and the Schwarzschild radius is timelike during both the growth and shrinking stage. We present arguments that the required amount of negative energy density is incompatible with the standard analysis of black hole evaporation.

1. References

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