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Neutrino Emission upon Black Hole Formation in Core Collapse Supernovae

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When a core-collapse supernova fails to explode or barely exploded, i.e., unable to unbind most of the stellar envelope, the associated proto-neutron star is expected to eventually implode into a black hole. In this scenario, the neutrino luminosity spectrum will then see an abrupt end as a result of the engulfment of the luminous core and the increasing gravitational redshift. The dynamics of this violent cut-off is, however, not fully explored and, as a result, is usually treated by considering only specific trajectories. In this study, we perform a fully general relativistic ray-trace study that outlines the potential effects of the highly curved spacetime on neutrino emissions and the resulting signature of black hole formation. The effect of the rotation of the black-hole-forming progenitor is also investigated based on the Kerr metric. Following that, we explored, via more detailed hydrodynamical simulations and accounting for flavour oscillation, the delaying effects of neutrino interactions with the accreting matter flows, which can potentially convolve with the signatures of black hole formation.

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