Contribution ID: **33** Type: **Talk**

Greybody factors as robust gravitational observables: insights into post-merger signals and echoes from ultracompact objects

Tuesday 27 May 2025 09:48 (12 minutes)

The quasinormal mode spectrum plays a crucial role in modeling post-merger ringdown signals in binary coalescences, encompassing both black holes and ultracompact horizonless objects. However, quasinormal modes are highly sensitive to small deformations of the system and only describe the linear response within a limited and imprecisely defined timeframe after the merger. Motivated by a recently discovered connection between greybody factors and post-merger black hole signals, we study the robustness of greybody factors as gravitational observables, furnishing a complementary approach to quasinormal modes. We show that greybody factors are stable under small perturbations and unaffected by specific ambiguities that undermine the reliability of the quasinormal modes. We demonstrate that greybody factors play a significant role in characterizing also the signals emitted by wormholes and other horizonless ultracompact objects. The greybody factors of ultracompact objects exhibits both low-frequency resonances and high-frequency, (quasi-)reflectionless scattering modes. We show that these high-frequency (quasi-)reflectionless scattering modes, rather than low-frequency resonances, are directly responsible for the echoes observed in the time-domain response of ultracompact objects or black holes surrounded by matter fields localized at large distances. Our study is focused both on non-rotating and rotating solutions.

Based on: https://arxiv.org/abs/2406.01692, https://arxiv.org/abs/2501.16433, forthcoming works.

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Session Classification: Observational Science (OSB)

Track Classification: Observational Science (OSB): Div1