Contribution ID: **147** Type: **Oral**

Perturbing the perturbed: Quasi-normal mode instability in asymptotically de Sitter black holes

In this talk, we aim to address the question of whether the quasi-normal modes, which represent the characteristic frequencies associated with perturbed black hole spacetimes and are central to the stability of these black holes, are themselves stable. We begin by presenting a general method for transforming to a hyperboloidal coordinate system in both asymptotically flat and asymptotically de Sitter spacetimes. We shall discuss how such a coordinate system effectively captures the dissipative boundary conditions, resulting in a non-self-adjoint differential operator. To fully understand the behaviour of a non-self-adjoint operator, we must study both the spectrum and the *pseudo-spectrum* of such an operator. We shall therefore introduce and explain the relevance of the notion of pseudo-spectrum in black hole physics. We then study the spectrum and the pseudo-spectrum of asymptotically de Sitter black holes numerically using spectral methods. Our analysis demonstrates how external perturbations to the scattering potential cause the quasi-normal modes to deviate from their unperturbed values. Additionally, we also highlight the implications of the instability observed in the fundamental quasi-normal mode on issues like the validity of the strong cosmic censorship conjecture.

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Session Classification: Classical & Quantum Gravity

Track Classification: Classical & Quantum Gravity