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Integrable Hidden Structures in the Dynamics of Perturbed Black Holes

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In this talk we discuss the presence of integrable hiddenstructures in the dynamics of perturbed non-rotating black holes (BHs). This can also be considered as a seed for a wider program of an effective identification of "slow"and "fast"degrees of freedom (DoFs) in the (binary) BH dynamics, following a wave-mean flow perspective. The slow DoFs would be associated with a nonlinear integrable dynamics, on which the fast ones propagate following an effective linear dynamics. BH perturbation theory offers a natural ground to test these properties. Indeed, the decoupling of Einstein equations into wave master equations with a potential provides an instance of such splitting into (frozen) slow DoFs (background potential) over which the linear dynamics of the fast ones (perturbation master functions) evolve. It has been recently shown that these wave equations possess an infinite number of symmetries that correspond to the flow of the infinite hierarchy of Korteweg-de Vries (KdV) equations. Starting from these results, we talk about the presence of integrable structures in BH perturbation theory, first in Cauchy slices and then in hyperboloidal foliations. This second step introduces a splitting of the master equation into bulk and boundary contributions, unveiling an underlying structural relation with the slow and fast DoFs. This insight represents a first step to establish the integrable structures associated to the slow DoFs as bulk symmetries of the dynamics of perturbed BHs.

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