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Symmetric integration of the 1+1 Teukolsky equation on hyperboloidal foliations of Kerr spacetimes

Wednesday, 5 July 2023 14:00 (20 minutes)

This talk outlines a fast, high-precision time-domain solver for scalar, elec- tromagnetic, and gravitational perturbations on hyperboloidal foliations of Kerr space- times. Time-domain Teukolsky equation solvers have typically used explicit methods, which numerically violate Noether symmetries and are Courant-limited. These re- strictions can limit the performance of explicit schemes when simulating long-time extreme mass ratio inspirals, expected to appear in the LISA band for 2-5 years. We outline work on using symmetric (exponential, Padé, or Hermite) integrators, which are uncon- ditionally stable and known to preserve certain Noether symmetries and phase-space volume. For linear hyperbolic equations, these implicit integrators can be cast in ex- plicit form, making them well-suited for long-time evolution of black hole perturba- tions. The 1+1 modal Teukolsky equation is discretized in space using polynomial collocation methods and reduced to a linear system of ordinary differential equations coupled via mode-coupling arrays and discretized differential operators. We use a matricization technique to cast the mode-coupled system in a form amenable to a method-of-lines framework, simplifying numerical implementation and enabling efficient parallelization on CPU and GPU architectures. We present tests of our numerical code on late-time tails of Kerr spacetime perturbations in the sub-extremal and extremal cases.

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