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Improved Gauge Conditions and Evolution Techniques for Puncture Black Hole Simulations ZACHARIAH ETIENNE, NASA Goddard Space Flight Center, University of Maryland, and West Virginia University, JOHN BAKER, NASA Goddard Space Flight Center, VASILEIOS PASCHALIDIS, STUART SHAPIRO, University of Illinois at Urbana-Champaign, BERNARD KELLY, NASA Goddard Space Flight Center — Robust spacetime gauge conditions are critically important to the stability and accuracy of numerical relativity (NR) simulations involving puncture black holes. Most of the NR community continues to use the highly-robust—though nearly decade-old—"moving-puncture gauge conditions" for such simulations. We present improved gauge conditions and evolution techniques that reduce constraint violations by more than an order of magnitude on adaptive-mesh refinement (AMR) grids. It has been found that high-frequency waves propagating away from puncture black holes (e.g., in binary systems) cross progressively lower levels of refinement until they become under-resolved and reflect off an AMR boundary, leading to noisy gravitational waveforms. Such noise does not converge away cleanly with increasing resolution, effectively setting a hard upper limit on waveform accuracy using puncture techniques at computationally feasible resolutions. We demonstrate that our improved puncture gauge conditions reduce this noise by nearly an order of magnitude, and point to possible directions for future improvements.

Zachariah Etienne
NASA Goddard Space Flight Center,
University of Maryland, and West Virginia University

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