Numerical relativity reaching into post-Newtonian territory: a compact-object binary simulation spanning 350 gravitational-wave cycles.

MARK SCHEEL, California Institute of Technology, BELA SZILAGYI, Jet Propulsion Laboratory, California Institute of Technology, JONATHAN BLACKMAN, California Institute of Technology, TONY CHU, Princeton University, LAWRENCE KIDDER, Cornell University, HARALD PFEIFFER, Canadian Institute for Theoretical Astrophysics, University of Toronto, ALESSANDRA BUONANNO, Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam, Germany, YI PAN, University of Maryland, ANDREA TARACCHINI, Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam, Germany, SXS COLLABORATION — We present the first numerical-relativity simulation of a compact-object binary whose gravitational waveform is long enough to cover the entire frequency band of advanced gravitational-wave detectors such as LIGO, Virgo and KAGRA, for mass ratio 7 and total mass as low as 45.5\(M_{\odot}\). We find that effective-one-body models, either uncalibrated or calibrated against substantially shorter numerical-relativity waveforms at smaller mass ratios, reproduce our new waveform remarkably well, with a loss in detection rate due to modeling error smaller than 0.3%. In contrast, post-Newtonian inspiral waveforms and existing phenomenological inspiral-merger-ringdown waveforms display much greater disagreement with our new simulation. The disagreement varies substantially depending on the specific post-Newtonian approximant used.

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Date submitted: 09 Jan 2015
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