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

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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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