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Eccentric binary black hole surrogate models for the gravitational waveform andremnant properties: comparable mass, nonspinning case

We develop new strategies to build numerical relativity surrogate models for eccentric binary black hole systems, which are expected to play an increasingly important role in current and future gravitational-wave detectors. We introduce a new surrogate waveform model, **NRSur2dq1Ecc**, using 47 nonspinning, equal-mass waveforms with eccentricities up to 0.2 when measured at a reference time of 5500M before merger. This is the first waveform model that is directly trained on eccentric numerical relativity simulations and does not require that the binary circularizes before merger. The model includes the (2,2), (3,2), and (4,4) spin-weighted spherical harmonic modes. We also build a final black hole model, **NRSur2dq1EccRemnant**, which models the mass, and spin of the remnant black hole. We show that our waveform model can accurately predict numerical relativity waveforms with mismatches ~0.001, while the remnant model can recover the final mass and dimensionless spin with errors smaller than $\approx 0.0005M$ and≈ 0.002 respectively. We demonstrate that the waveform model can also recover subtle effects like mode-mixing in the ringdown signal without any special ad-hoc modeling steps. Finally, we show that despite being trained only on equal-mass binaries, **NRSur2dq1Eccc** an be reasonably extended up to mass ratio $q \approx 3$ with mismatches ~0.01 for eccentricities smaller than ~0.05 as measured at a reference time of 2000M before merger. The methods developed here should prove useful in the building of future eccentric surrogate models over larger regions of the parameter space.

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