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Bayesian inference of binary black holes with inspiral-merger-ringdown waveforms using two eccentric parameters

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Orbital eccentricity is a crucial physical effect to unveil the origin of compact-object binaries detected by ground- and spaced-based gravitational-wave (GW) observatories. Here, we perform for the first time a Bayesian inference study of inspiral-merger-ringdown eccentric waveforms for binary black holes with non-precessing spins using two (instead of one) eccentric parameters: eccentricity and relativistic anomaly. We employ for our study the multipolar effective-one-body (EOB) waveform model SEOBNRv4EHM, and use initial conditions such that the eccentric parameters are specified at an orbit-averaged frequency. We show that this new parametrization of the initial conditions leads to a more efficient sampling of the parameter space. We also assess the impact of the relativistic-anomaly parameter by performing mock-signal injections, and we show that neglecting such a parameter can lead to significant biases in several binary parameters. We validate our model with mock-signal injections based on numerical-relativity waveforms, and we demonstrate the ability of the model to accurately recover the injected parameters. Finally, using standard stochastic samplers employed by the LIGO-Virgo-KAGRA Collaboration, we analyze a set of real GW signals observed by the LIGO-Virgo detectors during the first and third runs. We do not find clear evidence of eccentricity in the signals analyzed, more specifically we measure $e^{\mathrm{GW150914}}_{\mathrm{gw,\,10Hz}} = 0.08^{+0.09}_{-0.06}$, $e^{\mathrm{GW151226}}_{\mathrm{gw,\,20Hz}} = 0.05^{+0.05}_{-0.04}$, and $e^{\mathrm{GW190521}}_{\mathrm{gw,\,5.5Hz}} = 0.15^{+0.12}_{-0.12}$.

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