Twin LIGO/Virgo Detections of a Viable Gravitationally-Lensed Black Hole Merger

arxiv.org/abs/1901.03190

We identify a binary black hole (BBH) merger that appears to be multiply lensed by an intervening galaxy. The LIGO/Virgo events GW170809 and GW170814 have indistinguishable waveforms separated by 5 days, and overlap on the sky within the 90\% credible region. Their strain amplitudes are also similar, implying a modest relative magnification ratio, as expected for a pair of lensed gravitational waves. The phase of the two events is also consistent with being the same, adding more evidence in support of both events originating from the same BBH merger. The difference in the published inferred distances of each event can then be interpreted as following from their different magnifications. The observed chirp masses of both events are also similar, as expected for a pair of lensed events, with a common detected value of $29.1^{+1.3}_{-1.0}M_{\odot}$, lying at the peak of the observed distribution of chirp masses. We infer this case is a prototypical example of a lensed event that supports our lensing prediction \cite{Broadhurst2018} according to which, cosmologically distant, magnified BBH comprise most of the LIGO/Virgo events with chirp masses enhanced above $\simeq 15M_{\odot}$ by the cosmological expansion. From our predictions we estimate an intrinsic, unlensed, chirp mass of $\simeq 10-12 M_\odot$, with a source redshift in the range $0.9<z<2.5$. We also outline a joint analysis over all baseline permutations that can stringently test our lensing interpretation of these two events. More generally, lensed events effectively multiply the number of baseline permutations and motivates the use of more interferometers for round the clock coverage of all repeat events of a given source, in order to maximise the orbital details and sky localization of lensed BBH sources.

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