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The origin of low effective spins in LIGO/Virgo binary black hole mergers

All of the ten LIGO/Virgo binary black hole (BH-BH) merger detections to date have low values for their effective spins. There are only three potential explanations of this fact. If BH spin magnitudes are large then (i) both BH spin vectors must lie in/near orbital plane or (ii) BH spins are pointing in opposite directions. Or (iii) BH spin magnitudes are small.

We test the third hypothesis within the framework of classical binary evolution scenario of the formation of BH-BH mergers. We test three models of angular momentum transport in massive stars: Geneva model (mildly efficient transport), MESA model (efficient transport) and Fuller model (super-efficient transport) to calculate natal BH spins. We allow for binary evolution to increase BH spins through accretion. We also account for potential spin-up of stars through tidal interactions. Additionally, we update calculation of stellar-origin BH masses, we include revised star formation history in Universe and we account for metallicity evolution of star forming gas (and not stars as it was done before) across cosmic time.

We find that we can match simultaneously observed BH-BH merger rate density, BH masses and effective spins. Models with efficient angular momentum transport are favored. It appears that the gas chemical composition (higher at a given redshift that this of stars) better reproduces LIGO/Virgo merger rate estimate. The mass loss during pair-instabilty pulsation supernovae that limits BH mass is possibly overestimated if BH mass is allowed to exceed 50 Msun. Although, the overall current population of LIGO/Virgo ten BH-BH mergers do not indicate existence of such massive BHs, one particular merger (GW170729) may possibly host a BH more massive than 50 Msun.

If in fact angular momentum transport in massive stars is efficient, then any observation of highly spinning BH would indicate either very effective tidal spin up of a BH progenitor star (e.g., homogeneous evolution, high-mass X-ray
binary formation through case A mass transfer), significant accretion process in a BH history (e.g., low/intermediate-mass X-ray binary), or a BH formation through merger of two BHs (e.g, in a dense stellar cluster).

Serdecznie zapraszam,
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