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A New Gravitational-wave Signature from Standing Accretion Shock Instability in Supernovae

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We present results from fully relativistic three-dimensional core-collapse supernova simulations of a non-rotating 15{M} Ź star using three different nuclear equations of state (EoSs). From our simulations covering up to ~350 ms after bounce, we show that the development of the standing accretion shock instability (SASI) differs significantly depending on the stiffness of nuclear EoS. Generally, the SASI activity occurs more vigorously in models with softer EoS. By evaluating the gravitational-wave (GW) emission, we find a new GW signature on top of the previously identified one, in which the typical GW frequency increases with time due to an accumulating accretion to the proto-neutron star (PNS). The newly observed quasi-periodic signal appears in the frequency range from ~100 to 200 Hz and persists for ~150 ms before neutrino-driven convection dominates over the SASI. By analyzing the cycle frequency of the SASI sloshing and spiral modes as well as the mass accretion rate to the emission region, we show that the SASI frequency is correlated with the GW frequency. This is because the SASI-induced temporary perturbed mass accretion strikes the PNS surface, leading to the quasi-periodic GW emission. Our results show that the GW signal, which could be a smoking-gun signature of the SASI, is within the detection limits of LIGO, advanced Virgo, and KAGRA for Galactic events.
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