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Multi-messenger signals from core-collapse supernovae

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Abstract. The next Galactic supernova is expected to bring great opportunities for the direct detection of gravitational waves, full flavor neutrinos, and multi-wavelength photons. To prepare for appropriate observations of these multi-messenger signals, we use a long-term numerical simulation of the core-collapse supernova and discuss detectability of the signals in different situations. By exploring the sequential multi-messenger signals of a nearby CCSN, we discuss preparations for maximizing successful studies of such an unprecedented stirring event.

Keywords. Galaxy: general, gravitational waves, neutrinos, supernovae: general

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Our supernova model is based on a long-term numerical simulation of the core-collapse supernova (CCSN) of a 17 $M_\odot$ red supergiant progenitor, which self-consistently models the multi-messenger signals expected in gravitational wave, neutrino, and electromagnetic messengers. In this article, we briefly summarize our findings because of page limitation. Refer to Nakamura *et al.* (2016) for details. The numerical code we employ for the CCSN simulation is essentially the same as found in Nakamura *et al.* (2015).

Galactic Center Supernovae. The neutrino signal from a CCSN occurring at the Galactic Center determines the time of core bounce to within several milliseconds. This high accuracy estimation of the bounce time allows the time window of GW analysis to be reduced, which greatly reduces the background noise. The neutrino signal also provides pointing information, which will facilitate optical followup.

Extremely Nearby Supernovae. This rare event would provide unique information. The pre-CCSN neutrino signals enable us to diagnose the core structure of the progenitor. A high-precision gravitational waveform reconstruction will tell us what happens deeply inside the core. Ceaseless monitoring of nearby massive stars listed in Nakamura *et al.* (2016) is essential not to miss the possible opportunities of such a rare event.

Extragalactic Supernovae. Next-generation neutrino detectors will have sensitivity to the neutrino burst from CCSN in nearby galaxies within a few Mpc. Within the horizon of next-generation detectors, the top 10 galaxies host more than 60% of the total CCSN rate, so the number of galaxies which need followup is rather limited. A list of nearby galaxies in Nakamura *et al.* (2016) will assist early followup by optical telescopes.

References

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