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Jung-Tsung Li (UCSD): Neutrino Burst-Generated Gravitational Radiation From Collapsing Supermassive Stars

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We estimate the gravitational radiation signature of the electron/positron annihilation-driven neutrino burst accompanying the asymmetric collapse of an initially hydrostatic, radiation-dominated supermassive object suffering the Feynman-Chandrasekhar instability.
An object with a mass $5 \times 10^4 M_\odot < M < 5 \times 10^5 M_\odot$, with primordial metallicity, is an optimal case with respect to the fraction of its rest mass emitted in neutrinos as it collapses to a black hole: lower initial mass objects will be subject to scattering-induced neutrino trapping and consequently lower efficiency in gravitational radiation generation; while higher masses will not get hot enough to radiate significant neutrino energy before producing a black hole.
The optimal case collapse will radiate several percent of the star's rest mass in neutrinos and, with an assumed small asymmetry in temperature at peak neutrino production, produces a characteristic linear memory gravitational wave burst signature.
The timescale for this signature, depending on redshift, is ~ 1 s to 10 s, optimal for proposed gravitational wave observatories like DECIGO.
Using the response of that detector, and requiring a signal-to-noise ratio SNR > 5, we estimate that collapse of a $\sim 10^5 M_\odot$ supermassive star could produce a neutrino burst-generated gravitational radiation signature detectable to redshift z
$lesssim 3$.
With the envisioned ultimate DECIGO design sensitivity, we estimate that the linear memory signal from these events could be detectable with SNR > 5 to z
$lesssim 15$.

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