Supplementary information for the letter: "Long-lived inverse chirp signals from core collapse in massive scalar-tensor gravity"

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Code tests – In order to test the the code for stellar collapse in massive scalar-tensor (ST) theory of gravity, we have repeated the convergence analysis displayed in Fig. 3 of [1] but now using a massive scalar field with $\mu = 10^{-14}$ eV and $\alpha_0 = 10^{-4}$ and $\beta_0 = -20$. We observe the same convergence between first and second order, in agreement with the first and second order schemes used in the code.

As a further test, we have evolved the 12 $M_\odot$ zero-age-main-sequence progenitor WH12 of the catalog of realistic pre-SN models [2] for the same μ, α_0 and β_0, employing a uniform grid with Δr inside $r = 40\,\text{km}$ and logarithmically increasing grid spacing up to the outer boundary at $1.8 \times 10^5\,\text{km}$. Convergence of $r\varphi$ extracted at $r_{\text{ex}} = 3 \times 10^9\,\text{cm}$ is tested with three different resolutions $\Delta r_1 = 250\,\text{m}$, $\Delta r_2 = 125\,\text{m}$, $\Delta r = 62.5\,\text{m}$ in the interior and a total number of $N_1 = 5\,000$, $N_2 = 10\,000$, $N_3 = 20\,000$ grid points, respectively, so that the differences between high, medium and low resolution are expected to scale with $Q_1 = 2$ for first and $Q_2 = 4$ for second-order convergence. This expectation is borne out by Fig. 1 where we study the convergence of the strong peak signal generated at core bounce at $t - r_{\text{ex}} \approx 38$ ms which dominates all our wave signals. The good agreement between the solid and dotted curves demonstrates convergence close to second order and implies a discretization error of about 6 % (3 %) for coarse (medium) resolution. In the simulations used for our study, we use $\Delta r = 166$ m and extend the outer grid to 9×10^5 km while keeping the resolution in the extraction zone unchanged.

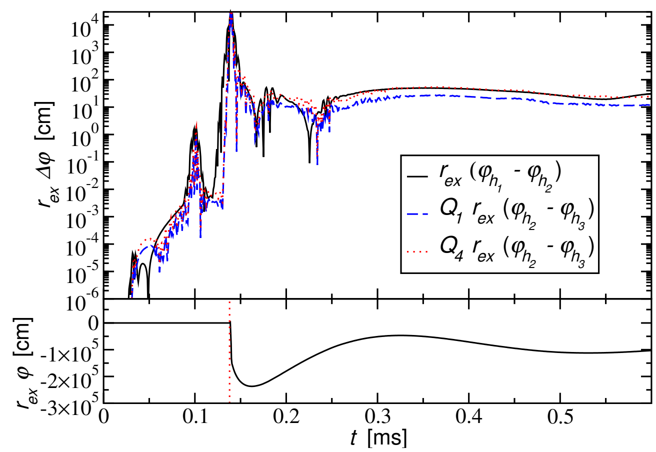

FIG. 1. Convergence of the wave signal at $r_{\text{ex}} = 3 \times 10^4$ km from a typical, strongly scalarized collapse of the WH12 profile with $\Gamma_1 = 1.3$, $\Gamma_2 = 2.5$, $\Gamma_{\text{th}} = 1.35$, $\alpha_0 = 10^{-4}$, $\beta_0 = -20$. The solid curve shows the difference of the coarse and medium resolution runs and is compared with that between medium and high resolution rescaled for first-order (dashed) and second-order (dotted curve) convergence factor. For reference, we show the signal $r_{\text{ex}}\varphi$ in the bottom panel where the vertical dotted line at $t - r_{\text{ex}} = 38\,\text{ms}$ marks the core bounce.

[1] D. Gerosa, U. Sperhake, and C. D. Ott, CQG **33**, 135002 (2016).
[2] S. E. Woosley and A. Heger, Phys. Rept. **442**, 269 (2007).