Supernova Neutrino Light Curves from Cooling of High/Low-Mass Proto-Neutron Stars

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We present the model spectra of neutrinos emitted from proto-neutron star (PNS) cooling. So as to obtain the time evolution of neutrino spectra, quasi-static evolutionary calculations of PNS cooling are performed. The masses of the PNS models are chosen to reflect recent observations of high-mass and low-mass pulsars in binary systems. For each, we adopt two initial conditions with high- and low-entropy profiles. The details of these models are described in our paper [1]. These data are open for use in any scientific research, provided that our paper is referenced in your publication.

The names of data files are as below:

- `spectobHmaxS.data`: $M_b = 2.35 M_\odot$ ($M_{\rm NS,g} = 2.05 M_\odot$), High initial entropy
- `spectobHminS.data`: $M_b = 1.29 M_\odot$ ($M_{\rm NS,g} = 1.20 M_\odot$), High initial entropy
- `spectobLmaxS.data`: $M_b = 2.35 M_\odot$ ($M_{\rm NS,g} = 2.05 M_\odot$), Low initial entropy
- `spectobLminS.data`: $M_b = 1.29 M_\odot$ ($M_{\rm NS,g} = 1.20 M_\odot$), Low initial entropy

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†`nuLC` stands for *neutrino-light curve*, which is neutrino analogue of the light curves of supernovae. The `nuLC` collaboration began in 2017 aiming to build a methodology to derive supernova and neutron star physics out of supernova neutrinos. Through the combined efforts of theoretical and experimental researchers, the collaboration is constructing a real data analysis framework for supernova neutrinos that will be observed in the near future.

where M_b is the baryon mass of PNS and $M_{\rm NS,g}$ is the gravitational mass of the remnant neutron star. The format of these data is the same with that of Supernova Neutrino Database [2], except that the number of energy bin is increased from 20 to 25. The data are arranged as follows:

$$
\begin{array}{llllllll}
t_0 \\
E_0 & E_1 & \frac{\Delta N_{1,\nu_e}(t_0)}{\Delta E_1} & \frac{\Delta N_{1,\bar{\nu}_e}(t_0)}{\Delta E_1} & \frac{\Delta N_{1,\nu_x}(t_0)}{\Delta E_1} & \frac{\Delta L_{1,\nu_e}(t_0)}{\Delta E_1} & \frac{\Delta L_{1,\bar{\nu}_e}(t_0)}{\Delta E_1} & \frac{\Delta L_{1,\nu_x}(t_0)}{\Delta E_1} \\
E_1 & E_2 & \frac{\Delta N_{2,\nu_e}(t_0)}{\Delta E_2} & \frac{\Delta N_{2,\bar{\nu}_e}(t_0)}{\Delta E_2} & \frac{\Delta N_{2,\nu_x}(t_0)}{\Delta E_2} & \frac{\Delta L_{2,\nu_e}(t_0)}{\Delta E_2} & \frac{\Delta L_{2,\bar{\nu}_e}(t_0)}{\Delta E_2} & \frac{\Delta L_{2,\nu_x}(t_0)}{\Delta E_2} \\
\dots \\
E_{24} & E_{25} & \frac{\Delta N_{25,\nu_e}(t_0)}{\Delta E_{25}} & \frac{\Delta N_{25,\bar{\nu}_e}(t_0)}{\Delta E_{25}} & \frac{\Delta N_{25,\nu_x}(t_0)}{\Delta E_{25}} & \frac{\Delta L_{25,\nu_e}(t_0)}{\Delta E_{25}} & \frac{\Delta L_{25,\bar{\nu}_e}(t_0)}{\Delta E_{25}} & \frac{\Delta L_{25,\nu_x}(t_0)}{\Delta E_{25}} \\
\\
t_1 \\
E_0 & E_1 & \frac{\Delta N_{1,\nu_e}(t_1)}{\Delta E_1} & \frac{\Delta N_{1,\bar{\nu}_e}(t_1)}{\Delta E_1} & \frac{\Delta N_{1,\nu_x}(t_1)}{\Delta E_1} & \frac{\Delta L_{1,\nu_e}(t_1)}{\Delta E_1} & \frac{\Delta L_{1,\bar{\nu}_e}(t_1)}{\Delta E_1} & \frac{\Delta L_{1,\nu_x}(t_1)}{\Delta E_1} \\
\dots
\end{array}
$$

where t_n [s] is a time measured from the onset of the computation and E_k [MeV] is a neutrino energy. Note that, E_k is defined on the interface between k-th and $(k+1)$-th energy bins while $E_0 = 0$ MeV. For k-th energy bin, $\frac{\Delta N_{k,\nu_i}(t_n)}{\Delta E_k}$ [/s/MeV] and $\frac{\Delta L_{k,\nu_i}(t_n)}{\Delta E_k}$ [erg/s/MeV] are differential neutrino number flux and differential neutrino luminosity, respectively, where $\nu_x = (\nu_\mu + \bar{\nu}_\mu + \nu_\tau + \bar{\nu}_\tau)/4$. Thus, the luminosity of $\bar{\nu}_e$ [erg/s] is given by

$$L_{\bar{\nu}_e}(t_n) = \sum_{k=1}^{25} (E_k - E_{k-1}) \times \frac{\Delta L_{k,\bar{\nu}_e}(t_n)}{\Delta E_k}, \tag{1}$$

and the number luminosity of $\bar{\nu}_e$ [/s] is given by

$$N_{\bar{\nu}_e}(t_n) = \sum_{k=1}^{25} (E_k - E_{k-1}) \times \frac{\Delta N_{k,\bar{\nu}_e}(t_n)}{\Delta E_k}. \tag{2}$$

Therefore the mean energy of emitted $\bar{\nu}_e$ at the time t_n is given by

$$\langle E_{\bar{\nu}_e}(t_n)\rangle = \frac{L_{\bar{\nu}_e}(t_n)}{N_{\bar{\nu}_e}(t_n)} \times \frac{\mathrm{MeV}}{1.6022 \times 10^{-6}\ \mathrm{erg}}. \tag{3}$$

If you find some strange problem, please contact us. We would appreciate it very much if you could give us comments or suggestions on our data. The correspondence address is

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References

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[2] K. Nakazato, K. Sumiyoshi, H. Suzuki, T. Totani, H. Umeda, and S. Yamada, Astrophys. J. Supp. **205** (2013) 2, arXiv:1210.6841 [astro-ph.HE]
`http://asphwww.ph.noda.tus.ac.jp/snn/`