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ERROR IN $R_{\nu}$

We recently discovered an error in the leakage calculations which incorrectly used $\log_{10}$ instead of $\log$ in the analytic form of the zeroth-order Fermi integral. The integral was used to compute number loss rates in the diffusive regime, as in Equation (A34) in Rosswog & Liebendörfer (2003). The effect of the error was to artificially suppress neutrino number emission rates, $n_{\nu}$, in the optically thick regions of the simulations by a factor of approximately $\log_{10} e \sim 0.5$. It had no direct effect on the energy emission rates, $n_{\nu}Q_{\nu}$. Below we estimate the effect of our error on the average electron fraction, $\langle Y_{e}\rangle$, and average neutrino energies, $\langle E_{\nu}\rangle$.

EFFECT ON $\langle Y_{e}\rangle$

From comparisons of a disk simulation (different from this one, but also experiencing significant diffusive neutrino losses) computed with and without the error, we conclude that $\langle Y_{e}\rangle$ was not significantly affected. This is expected. For most of its life the disk is in a quasi-equilibrium state with respect to the charged-current reactions. In this regime the timescale for a local change in $Y_{e}$ (set by $\tau_{\nu} - \tau_{\text{Ree}}$) is much shorter than for changes in density and temperature. A small difference in the rate of change of $Y_{e}$ does not affect this hierarchy of timescales, and the disk’s $\langle Y_{e}\rangle$ is simply set by its density and temperature. For further description of this comparison see Foucart et al. (2016, Section II.C).

In addition, the neutrino-driven evolution of the dynamical outflows was dominated by free-streaming neutrino losses, so that the effect of the error was negligible also on our estimate of the ejecta $\langle Y_{e}\rangle$.

EFFECT ON $\langle E_{\nu}\rangle$

The only significant effect of this error on our findings was that our estimates of the average neutrino energies were artificially high. This is because the total number-averaged energies were calculated from $\langle E_{\nu}\rangle = \int d^{3}x \int d^{3}x R_{\nu}Q_{\nu}$, and the error suppressed $R_{\nu}$ by a factor of 2 (at most) while leaving $Q_{\nu}$ unchanged.

Here we recalculate the neutrino energies at several times late in the simulation. Figure 1 corrects the bottom panel of Figure 12 from the published version of this paper. The sentence interpreting that figure on p. 13 should now read: “The average energy per neutrino, given by $L_{\nu}/R_{\nu}$, averaged in time over the disk evolution is about 7, 9, and 14 MeV for $\nu_{e}$, $\bar{\nu}_{e}$, and $\nu_{x}$ neutrinos, respectively;
the average neutrino energies are not constant, but decrease for $\nu_e$ and $\bar{\nu}_e$ at a rate of about 0.5 MeV per 10 ms. The brief increase in $\langle E_{\nu_e} \rangle$ is a transient effect of the transition of that species’ emission from an epoch dominated by diffusion to one dominated by free-streaming.”

CONCLUSION

This code error led us to report average neutrino energies that were erroneously high for a leakage model. See Figure 1 for a correction. It had an insignificant effect on the hydrodynamics and composition evolution.

REFERENCES

Foucart, F., Haas, R., Duez, M. D., et al. 2016, PhRD, 93, 044019