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Estimating the Neutrino Flux from X-ray Bursts

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Type I X-ray bursts are thermonuclear explosions on the surface of accreting neutron stars in low-mass X-ray binaries. They are highly energetic (sim 10^38 erg) events and so can release energy in the form of neutrinos. The neutrino flux released during an X-ray burst comes primarily from beta-decays. Using KEPLER, a 1D implicit hydrodynamics code that calculates the full nuclear reaction network, we have measured the neutrino fluxes of type I bursts for a range of initial conditions. We find that neutrino losses are between 6 times10^-5 (low hydrogen fraction) and 0.185 (high hydrogen fraction), of the total energy per nucleon, Qnuc. We also find a dependence on the neutrino flux with metallicity of the accreted fuel. Recent literature often uses the approximation formula Qnuc=1.6+4 Xb,mathrmMeV/mathrm{nucleon} where Xb is the average hydrogen mass fraction of the ignition column to estimate Qnuc and hence fuel composition. We find this expression is a very poor fit (rms = 0.4..) to the KEPLER predictions. We attribute the discrepancy to the assumption of 35% energy loss due to neutrinos during the rp and alpha p processes in this expression, however, it is only at beta-decays that sim35 of energy is lost due to neutrino emission, and beta-decays do not contribute much to the total energy. Using total measured burst energies from KEPLER for a range of initial conditions, we have determined a new approximation formula, Qnuc=0.93+7.41bar-1.88\barX^2, with a root mean square error (RMS) value of 0.07 MeV/nucleon, compared to the old relation that has an RMS value of 0.47 MeV/nucleon.

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