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Neutrino and gamma-ray production from proton-proton interactions in binary-driven hypernovae

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We estimate the neutrino emission from the decay chain of the π-meson and μ-lepton, produced by proton-proton inelastic scattering in energetic ($E_{\rm iso} \geq 10^{52}$ erg) long gamma-ray bursts (GRBs), within the type I binary-driven hypernova (BdHN) model. The BdHN I progenitor is a binary system composed of a carbon-oxygen star ($\rm CO_{core}$) and a neutron star (NS) companion. The $\rm CO_{core}$ explosion as supernova (SN) triggers a massive accretion process onto the NS. For short orbital periods of few minutes, the NS reaches the critical mass, hence forming a black hole (BH). Recent numerical simulations of the above scenario show that the SN ejecta becomes highly asymmetric, creating a \textit{cavity} around the newborn BH site, due to the NS accretion and gravitational collapse. Therefore, the electron-positron ($e^{\pm}$) plasma created in the BH formation, during its isotropic and self-accelerating expansion, engulfs different amounts of ejecta baryons along different directions, leading to a direction-dependent Lorentz factor. The protons engulfed inside the high-density ($\sim 10^{23}$ particle/cm^3) ejecta reach energies in the range $1.24 \leq E_p \leq 6.14$~GeV and interact with the unshocked protons in the ejecta. The protons engulfed from the low density region around the BH reach energies $\sim$ 1~TeV and interact with the low-density (~ 1 particle/cm^3) protons of the interstellar medium (ISM). The above interactions give rise, respectively, to neutrino energies $E_\nu \leq 2$ GeV and $10 \leq E_\nu \leq 10^3$ GeV, and for both cases we calculate the spectra and luminosity.

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