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Low-Energy Supernova Constraints on Millicharged Particles

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The hot and dense environment of the supernova core serves as an extraordinary factory for new feebly-interacting particles. Low-energy supernovae, a class of supernovae with low explosion energy, are particularly intriguing due to their stringent constraints on the energy transfer caused by new particles from the supernova core to the mantle. We investigate low-energy supernova constraints on millicharged particles by considering three production channels in the core: plasmon decay, proton bremsstrahlung, and electron-positron annihilation processes. We find that the electron-positron annihilation process, previously omitted in supernova studies on millicharged particles, is the dominant production channel in the high-mass region. By studying the energy deposition due to Coulomb scatterings with protons in the supernova mantle, we find that low-energy supernovae impose the most stringent constraints on millicharged particles in the mass range of ~(10–200) MeV, surpassing the energy loss limit from SN1987A by nearly one order of magnitude.

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