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The impact of the circumstellar magnetic field on the observed gamma-ray spectrum from supernova remnants

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Supernova remnants (SNRs) are widely believed to be one of the main candidates for the origin of Galactic cosmic rays. Very-high-energy gamma-ray emission observed from a number of SNRs suggests that particles are indeed accelerated to high energies by shock in remnants. However, it is extremely difficult to discriminate which particles are responsible for this emission as both protons (through hadronic interactions and subsequent pion decay) and electrons (through inverse Compton scattering on ambient photon fields) can potentially generate gamma-ray photons. The recent detection of the abrupt cut-off at lower energies in the gamma-ray spectra of two SNRs, IC 443 and W44, with the Fermi-LAT provided strong evidence that cosmic-ray protons are indeed accelerated in SNRs based on the interpretation of this cutoff as a characteristic pion-decay feature. However, it can be shown that certain spatial or temporal variability of the ambient medium can result in similar spectral features in the leptonic scenario adding another uncertainty to the determination of the emitting process. SNRs created in core-collapse explosions expand inside the stellar wind bubble blown up by a progenitor star. The magnetic field in the wind medium follows a 1/r profile with high values at the surface of the star, e.g. 1-10 G for red supergiants. This means that at the early stages of its evolution the remnant interacts with a very strong magnetic field, which results in a synchrotron cooling feature in the electron spectrum, which in turn shows up in the gamma-ray spectrum as a break at similar energies as a pion-decay signature. In this work, we study how the circumstellar magnetic field might modify the resulting spectrum of electrons and subsequent gamma-ray spectrum.

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