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Modeling of the production of the observed primary positrons by the nearest bow shock pulsar PSR J0437-4715

The origin of antiparticles – positrons and antiprotons – as detected by the observatories PAMELA and AMS-02 is a topical issue due to their discussed relation to the dark matter annihilations/decays. On the other hand, the observed excess of positrons can be explained by a contribution from the near-Earth pulsars once these are driving a bow shock into the interstellar medium. In this case both the positrons injected by the pulsar and the background cosmic ray (CR) nuclei are re-accelerated by the bow shock which forms the spectra of both leptons and nuclei. The nearest pulsar PSR J0437-4715 located at distance ˜160 pc has a bow shock detected by the Hubble Space Telescope. It can be considered as a natural source of positrons and re-accelerate primary and secondary CRs including antiprotons. The re-acceleration model may help to explain the observed similarities in their spectra. The moderate spin-down power of PSR J0437-4715 ˜6x10(33) erg/s allows it to produce very high energy (VHE) leptons. This was confirmed by an accurate kinetic modeling of lepton acceleration in between its pulsar wind termination shock and bow shock that allowed us to reproduce both the multiwavelength spectra and observed structure of its pulsar wind nebula in the far ultraviolet and X-ray bands. Using the results of this simulation for accurate normalization of the produced lepton flux and the modern models of particles transport in the local interstellar medium, we calculate the spectra of positrons and electrons produced by PSR J0437-4715 at the Earth and confront them to the near-Earth fluxes of positrons and electrons detected by PAMELA and AMS-02. We discuss a possible contribution into the observed near-Earth CR from some other nearby sources.
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