

Title :

Galactic molecular clouds as sources of secondary positrons

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Summary :

The recent data on cosmic ray positron flux measured near the Earth by the Alpha Magnetic Spectrometer (AMS-02) experiment extends to TeV energy. The recently observed data by AMS-02 clearly confirms that the positron flux rises with energy and shows a peak near a few hundred GeV. This rising positron flux cannot be explained by interactions of cosmic rays with interstellar hydrogen gas. Pulsars, dark matter and many other innovative physical scenarios have been studied to explain this rising of the positron flux, also known as positron excess. In this work, we have developed a model to show that secondary positrons produced inside Galactic Molecular Clouds (GMCs) can significantly contribute to the observed positron spectrum on Earth. Multi-wavelength data of GMCs were particularly useful in building this model. A very recent survey implemented the optical / IR dust extinction measurements to trace 567 GMCs within 4 kpc of Earth, residing in the Galactic plane. We have also used the updated catalog of GMCs reported in recent papers using all-Galaxy CO survey, distributed in the Galactic plane, to find the secondary positrons produced in them in interactions of cosmic rays with molecular hydrogen. Moreover, by analyzing the Fermi-LAT data, new GMCs have been discovered near the Galactic plane. We also include some of these GMCs closest to the Earth, where cosmic ray interactions produce secondaries. It has been speculated earlier that cosmic rays may be reaccelerated in some of the GMCs. We select 7 GMCs out of 567 GMCs recently reported, within 4 kpc of Earth, where reacceleration due to magnetized turbulence is assumed. We include a hardened component of secondary positrons produced from the interaction of reaccelerated CRs in those 7 GMCs. We use publicly available code DRAGON for our simulation setup to study CR propagation in the Galaxy and show that the observed positron spectrum can be well explained in the energy range of 1 to 1000 GeV by our self-consistent model. Data of proton, antiproton spectra and B/C and $^{10}\text{Be} / ^9\text{Be}$ ratios as well as electron, positron spectra and positron fraction measured by AMS-02 and PAMELA, are fitted by our model quite well. Further observations of the nearby GMCs by Fermi-LAT, HESS, HAWC, LHAASO, CTA etc, can eluminate on the possibility of GMCs being an important contributors to the observed CR spectra.

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