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ORIGINAL ARTICLE

Propagation of H and He cosmic ray isotopes in the Galaxy: astrophysical and nuclear uncertainties

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Abstract Observations of light isotopes in cosmic rays provide valuable information on their origin and propagation in the Galaxy. Using the data collected by the AMS-01 experiment in the range ∼0.2–1.5 GeV nucleon^{-1}, we compare the measurements on ^{1}H, ^{2}H, ^{3}He, and ^{4}He with calculations for interstellar propagation and solar modulation. These data are described well by a diffusive-reacceleration model with parameters that match the B/C ratio data, indicating that He and heavier nuclei such as C–N–O experience similar propagation histories. Close comparisons are made within the astrophysical constraints provided by the B/C ratio data and within the nuclear uncertainties arising from errors in the production cross section data. The astrophysical uncertainties are expected to be dramatically reduced by the data upcoming from AMS-02, so that the nuclear uncertainties will likely represent the most serious limitation on the reliability of the model predictions. On the other hand, we find that secondary-to-secondary ratios such as ^{2}H/^{3}He, ^{6}Li/^{7}Li or ^{10}B/^{11}B are barely sensitive to the key propagation parameters and can represent a useful diagnostic test for the consistency of the calculations.

Keywords Cosmic rays · Acceleration of particles · Nuclear reactions, nucleosynthesis, abundances

1 Introduction

Secondary Cosmic Ray (CR) isotopes such as ^{2}H, ^{3}He and Li–Be–B are believed to be produced as a results of nuclear interactions primary CRs such as ^{1}H, ^{4}He or C–N–O with the gas nuclei of the interstellar medium (ISM). The secondary CR abundances depend on the intensity of their progenitors nuclei, their production rate and their transport in the turbulent magnetic fields (Strong et al. 2007). Secondary to primary ratios such as ^{2}H/^{4}He, ^{3}He/^{4}He or B/C are used to study the CR propagation processes in the Galaxy. The B/C ratio is widely used to determine the key parameters of propagation models. In fact the B/C ratio is measured by several experiments between ∼100 MeV and ∼1 TeV of kinetic energy per nucleon. The CR propation physics is also connected with the indirect search of dark matter particles. In this context the CR propagation models, once tuned to agree with the B/C ratio, are used to compute the secondary production for other rare species such as $\bar{p}$ or $\bar{d}$, that provides the *astrophysical background* for the search of new physics signals (Donato et al. 2008; Evoli et al. 2011; Salati et al. 2010). Clearly, understanding the CR propagation processes is crucial for modeling both the CR signal and the background. Furthermore, these studies assume that all the CR species experience the same propagation effects in their journey throughout the ISM (Putze et al. 2010; Trotta et al. 2011). It is therefore important to test the CR propagation with nuclei of different mass-to-charge ratios. This issue of the *universality* of CR propagation histories was also studied in Webber (1997) and, recently, in Coste et al. (2012).

In this work we use the recent AMS-01 observations for the ^{2}H/^{4}He and ^{3}He/^{4}He ratios and compare them with the expected ratios based on interstellar and heliospheric propagation calculations. The aim of this work is to determine whether the AMS-01 observations are consistent with the propagation calculations derived from heavier nuclei (mainly from B/C data). This consistency is inspected within two classes of model uncertainties: the *astrophysical uncertainties*, which are related to the knowledge of the CR

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