



Contribution ID: 551

Type: Oral Presentation

An investigative numerical modelling study of galactic deuterons in the heliosphere

Friday 11 July 2025 10:00 (20 minutes)

The observation of galactic cosmic ray (GCR) deuteron at the Earth has been done precisely with the PAMELA and AMS02 space detectors and reported from July 2006 to September 2014 and from May 2011 to April 2021, respectively. These observations span time frames that include solar maximum and both minimum modulation conditions in the $A > 0$ and $A < 0$ magnetic field cycles at rigidities between ~ 0.75 GV and ~ 19.5 GV. A surprise from AMS02 observation was that current available GALPROP calculated deuteron local interstellar spectra (LIS) are unable to reproduce the deuteron observations at rigidities above ~ 5 GV, and thus challenging the status quo regarding their origin in the galaxy. In this study a comprehensive 3D numerical model and a set of diffusion and drift coefficients, previously applied to a number of cosmic ray nuclei, together with a newly estimated LIS for deuterons, are used to simulate the modulation of deuterons from July 2006 to April 2021. The modelling results will be compared to observations made by PAMELA and AMS-02 detectors. This study will illustrate and discuss the effects due to different LISs and those caused by the main modulation mechanisms on deuteron modulation at the Earth. Furthermore, differences between the modulation of protons and deuterons at the Earth will be uncovered and highlighted.

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Session Classification: Astrophysics & Space Science