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Heliospheric Transient Structures Associated with Short-Period Variations in the GCR Flux

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Abstract: Short-period variations in the integral GCR fluence ($\gtrsim 100$ MeV), often observed in neutron monitor data have also been seen by the High Sensitivity Telescope (HIST) aboard the Polar spacecraft. Although HIST was designed to measure radiation-belt electrons, it makes clean measurements of the integral GCR fluence when Polar is outside the radiation belts. These measurements show GCR variability on a variety of timescales including 0.1 mHz - 1 mHz. On August 20, 2006 a Forbush decrease observed at Polar was also seen at the INTEGRAL spacecraft. Data from Polar HIST and from INTEGRAL's Ge detector saturation rate (GEDSAT), which also measures the GCR background with a threshold of 200 MeV, show similar, coherent, short-period GCR variations at two very different locations within the Earth's magnetosphere. Comparing these variations from Polar and INTEGRAL to solar wind magnetic field and plasma conditions at the L1 Libration point sunward of the Earth reveal this coherency occurs when Earth is in close proximity to and inside a flux rope interplanetary CME (ICME). Inversion of the ICME magnetic field results in a flux rope axial orientation nearly parallel to the radial direction. This orientation is consistent with a grazing passage of the ICME with the Earth. New measurements from STEREO will enable detailed 3-D analyses of such solar wind disturbances along spatial scales on the same order of typical SEP and GCR proton gyroradii, which are needed to help determine the mechanism behind this short-period variability.

Introduction

Short-period variations in the integral GCR fluence, often observed in neutron monitor data have also been seen by the High Sensitivity Telescope (HIST) [1] aboard the Polar spacecraft. Although HIST was designed to measure radiation-belt electrons, it makes clean measurements of the integral GCR fluence when Polar is outside the radiation belts and above geomagnetic cutoff effects. These measurements show GCR variability on a variety of timescales including 0.1 mHz - 1 mHz.

On August 20, 2006 a Forbush decrease observed at Polar was also seen at the INTEGRAL [2] spacecraft during a very active time in the solar wind. Both Polar and INTEGRAL are Earth-orbiting satellites. Data from Polar HIST with a threshold of 100 MeV and from INTEGRAL's Ge detector saturation rate (GEDSAT), which measures the GCR background with a threshold of 200

MeV, show similar, short-period GCR variations in and around the Forbush decrease. Looking at the solar wind magnetic field and plasma conditions during this time reveals three interplanetary shocks present in the days leading up to and including the Forbush decrease. The first two shocks are driven by interplanetary coronal mass ejections (ICMEs) and the last one by a high-speed stream. The solar wind following these shocks and during the Forbush decrease are not particularly geoeffective.

The Forbush decrease, which begins at 1200 UT on August 20, 2006 is the largest intensity change during this active time, but there are many others on a variety of timescales. As an example, looking at more than 14 consecutive hours of INTEGRAL and Polar data on August 21, 2006 shows great similarities in the time history of the measurements made aboard the two satellites coupled with differences that must be due to GCR variability on a scale size of the order or less than their separation

distance. During this time, Polar passes through the southern polar region on open field lines at 6Re while INTEGRAL is near apogee at nearly 20 Re above the Earth in the northern hemisphere. Despite this separation of over 25 Re, many of the larger intensity fluctuations remain identical at both satellites. Autoregression and power spectral analyses have shown the data are not colored noise and that these fluctuations are statistically significant. Such analyses can be done with high confidence because both detectors aboard Polar and INTEGRAL have large geometric factors that generate high count rates on the order of 1000 particles per spin, ensuring rigorous, statistically significant samples.

Only minor differences exist between the magnetic field observed by ACE at the L1 Lagrangian point, approximately 225 Re sunward of the Earth, and Wind at nearly the same radial distance as ACE, but 100 Re on the dawn side of the Earth. Considering the average solar wind field strength during this time is 10 nT, an energetic proton incident at the INTEGRAL GEDSAT detector threshold of 200 MeV would have a gyroradius of 50 Re in the solar wind. This is a factor of two larger than the spacecraft separation between INTEGRAL and Polar.

The large solar wind magnetic field changes observed during this period caused by transient heliospheric structures in the interplanetary medium are believed to play a role in these short-period GCR variations. New measurements from STEREO [3] will soon enable detailed 3-dimensional analyses of such solar wind transients along spatial scales on the same order of typical SEP and GCR proton gyroradii, which are needed to help determine the mechanism behind this short-period variability.

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