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Cosmic Ray Electron Transport and Radiation in the Inner Heliosphere and X-ray and Gamma-ray Observations of the Quiet Sun

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Fermi routinely observes gamma-rays from the quiet Sun (QS), i.e. when there is no flaring activity, and there are upper limits in X-ray regime from RHESSI. The gamma-rays are produced by Cosmic Ray (CR) protons (via pion production) and electrons via inverse Compton (IC) scattering of solar optical photons. This problem has received considerable attention. A possible source of the X-rays could be synchrotron emission by Cosmic Ray Electrons (CRes) which has not received much attention. Fluxes and spectra of CRs are observed at 1 AU, but calculation of QS radiation requires flux-spectrum of CRs from the Earth to the Sun. The common practice to this end is to use some phenomenological modulation procedure. This procedure may be useful for evaluation of the CRs variation in the outer (>1 AU) heliosphere, but the transport from one AU to the Sun requires a kinetic approach, because particle paths are determined by the large scale magnetic field. We address this transport using a Fokker-Planck equation including the effects of field convergence, scattering by turbulence and more important for CRes, the energy loss rate due to synchrotron and IC processes.

Several near Earth instruments have observed CRe spectra at 1 AU during quiet and active phase of the Sun. There are also many observations and subsequent models for the structure of the magnetic field in the inner heliosphere, which allow us to address the first and third processes fairly accurately. However, the second requires a knowledge of the energy density and spectrum of turbulence from 1 AU to the Sun. Up to recently these characteristics of the turbulence were measured around 1 AU, but Parker Solar Probe (PSP) has extended this knowledge to 0.17 AU, which can be extrapolated to the Sun using several reasonable models. In this talk we will present result on transport of CRes using a novel and simple version of Fokker Planck equation, and will present the spectral evolution of the CRes from 1 AU to the photosphere, for three models of the turbulence. The spectra at the photosphere can then be used to calculate, for the first time, the synchrotron spectrum and a more accurate IC spectrum, which when used in conjunction with gamma-ray and X-ray observations can constrain the transport processes and their parameters.

Track

Cosmic Rays

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