APPLICATION OF A SIMPLE 1-D PROPAGATING BARRIER MODEL TO THE ONSET OF COSMIC RAY MODULATION IN SOLAR CYCLES 20-23

I. G. Richardson (1), G. Wibberenz (2) and H. V. Cane (1)
(1) Laboratory for High Energy Astrophysics, Goddard Space Flight Center, Greenbelt, MD 20771, USA, (2) IEAP, University of Kiel, D-24118 Kiel, Germany.
`richardson@lheavx.gsfc.nasa.gov`/Fax: 301-286-1682

Recent work suggests a close association between the evolution of the solar magnetic field, as indicated by parameters such as the IMF and tilt angle, and cosmic ray modulations at 1 AU, on time-scales of $\sim$ 1 year. We investigate this relationship using a simple 1-dimensional model in which changes in the solar magnetic field propagate from the Sun and cause a change in the radial diffusion coefficient which is assumed to scale as some power of the IMF intensity. The recovery in the cosmic ray density as particles flow in behind this "propagating barrier" is modeled by a recovery time which physically is related to particle entry into the depleted regions of the heliosphere, partly by drift and perpendicular diffusion from higher latitudes. We find that the cosmic ray density for periods of $\sim$ 2 years following modulation onset can be modeled reasonably successfully. By determining the best fit between predictions of the model and the observed cosmic ray densities, the dependence of the diffusion coefficient on B and the recovery time may be inferred. The dependence on particle energy can also be investigated. A much longer recovery time is required in $\mathbf{A}< 0$ epochs ($\mathbf{A}$ is the solar global magnetic field direction) than when $\mathbf{A}> 0$ (e.g., $\sim$ 300 and $\sim$ 50 days respectively at neutron monitor energies). This difference is consistent with models of cosmic ray modulation including drifts, which indicate that particles can more easily gain entry to the inner heliosphere when they drift in over the poles in $\mathbf{A}> 0$ epochs than when they move along the current sheet at low latitudes in $\mathbf{A}< 0$ epochs. The longer recovery time in $\mathbf{A} < 0$ epochs helps to explain why a significant cosmic ray depression occurred at the maximum of solar cycle 20 even though the associated increase in magnetic field intensity was comparatively modest.