Abstract number: S3-73
TeV anisotropy
15 min. contributed talk

THE TRANSPORT OF COSMIC RAYS ACROSS MAGNETIC FIELDLINES

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The long residence times and small anisotropies of cosmic rays suggest that they are well confined and well scattered by the Galactic magnetic field. Due to the disk-like shape of the confinement volume, transport in the vertical direction, which is perpendicular to the mean Galactic magnetic field, is key to cosmic ray escape. It has long been recognized that this vertical transport depends both on the vertical component of the field lines themselves and on the extent to which the cosmic rays are tied to the field lines. In this paper, we use magnetic fields with very simple spatial and temporal structures to isolate some important features of cross field line transport. We show that even simple magnetic nonuniformities combined with pitch angle scattering can enhance cross field line transport by several orders of magnitude, while pitch angle scattering is unnecessary for enhanced transport if the field is chaotic. Nevertheless, perpendicular transport is much less than parallel transport in all the cases we study. We apply the results to confinement of cosmic rays in the Fermi bubbles.