Quiet-time low-energy protons in the outer heliosphere

K. Kecskeméty (1), Yu.I. Logachev (2), and M.A. Zeldovich (2)

(1) KFKI Research Institute for Particle and Nuclear Physics, H-1525 Budapest, POB 49, Hungary

(2) Skobeltsyn Institute of Nuclear Physics, Moscow State University, 119992 Moscow, Russia

Radial variations of low-energy ($\sim$1-8 MeV) quiet-time fluxes of protons are examined at heliocentric distances of 2-85 AU during low solar activity periods using Voyager 1-2 (LECP, CRS) and Ulysses (LET) data. Our attention is focused on the solar cycle minima of 1985-1987 and 1995-1997. The comparison with fluxes obtained near the Earth (IMP-8) during similarly quiet periods indicates that the fluxes are the lowest between 2 to 3 AU and exhibit a positive gradient out to about 20 AU. The fluxes going outwards tend do decrease again reaching a shallow minimum near 50 AU, then rise again where the contribution of anomalous protons becomes significant, especially above 6 MeV. The value of mean free path of the particles estimated from the gradients suggests a tendency to decrease when approaching the termination shock. The energy spectra also display considerable changes with heliocentric distance: in the 1-8 MeV interval the characteristic negative slope with exponent –2 to –3 gradually decreases outwards and the spectra become nearly flat at 50 AU and even positive at places, finally reaching a small negative value again. The latitude variation, primarily based on Ulysses data suggest that the fluxes decrease towards higher latitudes on both hemispheres, however, streamer belt low-flux data are very scarce due to contamination from solar events during the fast latitude scans. The interpretation of the gradients in terms of various the possible sources is discussed.