Energetic Particle Intensity Increases at Voyagers 1 and 2 during 2002–03

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Abstract

We summarize energetic particle data acquired during 2002–03 by the Low Energy Charged Particle (LECP) instruments on Voyagers 1 (V1) and 2 (V2). Our focus is the period ∼2002.5–2003.2, during which V1 and V2 saw markedly different intensity variations. During this period V1 moved from 85 to 88 AU, while at 34N° latitude, and V2 moved from 67 to 70 AU, while at 24S° latitude. Starting in mid-2002, particle intensities at V1 showed a large rapid increase that remained at highly elevated but variable levels until early 2003. The unique nature of the V1 increase and the absence of comparable structures in the V2 data suggest that the V1 event is associated with the heliospheric termination shock (TS).

1. Introduction

Several independent techniques predict that V1 is close to the TS [1]. Voyager instrument teams continue to monitor their data closely for possible signatures of activity upstream of the TS or of a TS crossing into the subsonic heliosheath plasma. This report is a brief overview of the recent LECP data from V1 and V2, with an emphasis on unusually intense energetic particle intensity variations at V1 during mid-2002 to early 2003. Angular distributions and ion composition data for this V1 "event" are summarized in companion papers [2,3].

2. Observations

Fig. 1 is a mission overview of V1 and V2 LECP data covering the period 1977.68 to 2003.36. Panel (a) shows 26-day averaged, inter-normalized count rates of protons >70 MeV, generally an admixture of galactic and anomalous cosmic rays. Panel (b) shows 10-day averaged intensities of ∼0.5–1.5 MeV protons, generally a composite of protons from solar activity (e.g., flares and coronal mass ejections) and from acceleration by transient and recurrent shocks (and possibly turbulence) in the outer heliosphere (the V1 trace is offset by 1000 for clarity). Important features in panel (b) include the ∼100-fold intensity increase of protons at V1 starting in mid-2002 and continuing to early 2003, and the absence of

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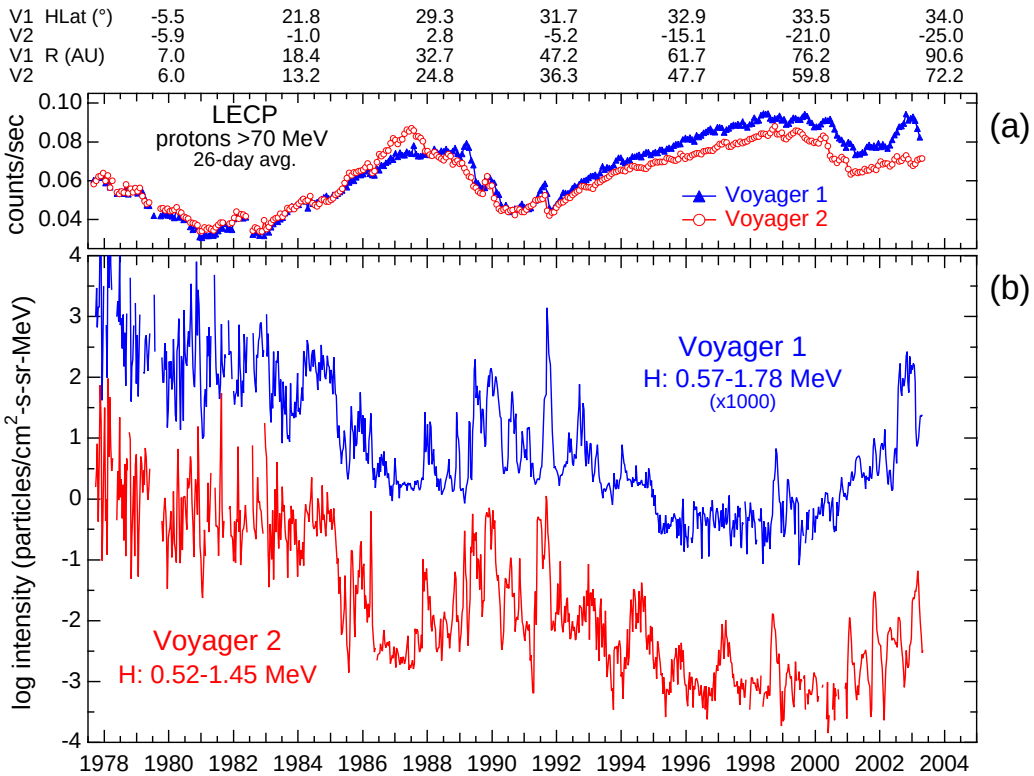

Fig. 1. (a) Cosmic ray protons >70 MeV, and (b) energetic protons ≈0.5–1.5 MeV observed at V1 and V2 during 1977.68 (1977/250) to 2003.36 (2003/132). Spacecraft helioradii (R) and heliographic latitudes (HLat) are indicated at the top

an earlier increase at V2 of comparable intensity (V2 is ∼18 AU sunward of V1). Note that the >70 MeV proton rate at V1 began to recover early in 2002, ∼2 solar rotations before the abrupt increase of the ∼0.5–1.5 MeV protons, and began to decline in early 2003 when the ∼0.5–1.5 MeV proton intensity decreased.

Fig. 2 shows the period 2001.5 to 2003.36 in greater detail. Panels (a) and (b) compare ∼0.5–1.5 MeV and ∼3–17 MeV proton intensities, respectively, at V1 and V2. The V2 data have been time shifted to the V1 helioradius using daily-averaged solar wind speeds from the Plasma Science (PLS) instrument on V2 (PLS on V1 has not operated properly since 1980). This time shift has been performed to indicate what V1 would be expected to observe, on a qualitative level, if structures at V2 were simply convected outward. Although this shift does not account for the ∼60° latitude difference between the two Voyagers or for temporal evolution over the ∼70-day convective delay, it does underscore the fact that the broad ∼0.5–0.6-year wide intensity increases seen at V1 during ∼2002.5–2003.2 did not propagate by V2 earlier.

The intense event at V1 in 2002–03 covered a broad range of ion energies,

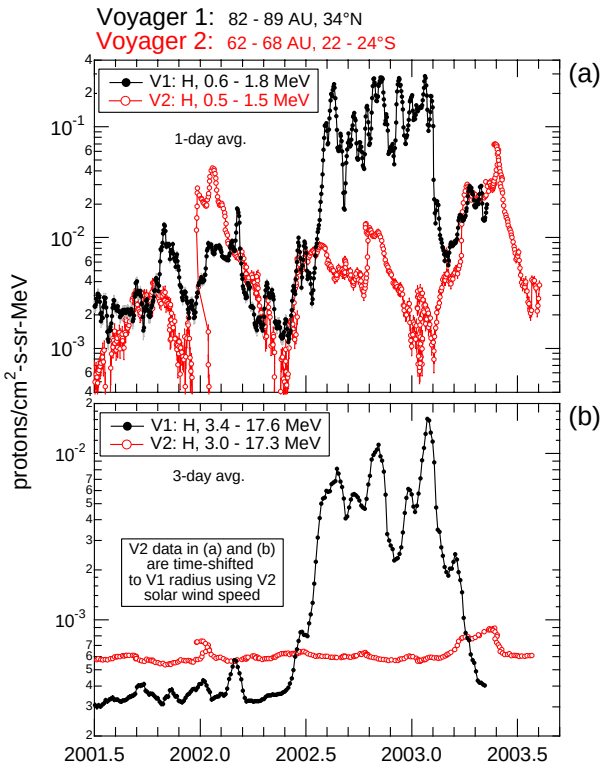

Fig. 2. Comparison of protons intensities (a) 0.5–15 MeV and (b) 3.0–17 MeV measured at V1 and V2 during 2001.5–2003.36. V2 data have been time-shifted to the V1 helioradius using measured V2 solar wind speed.

from at least 30 keV to a few tens of MeV/nuc [2,3], and also included enhanced levels of relativistic electrons. Fig. 3 shows 1-day averaged count rates for, from the top, electrons 0.35–1.5 MeV, protons 3.4–17.6 MeV, protons 0.57–1.78 MeV, and ions 53–85 keV. Note the highly variable, small-scale, impulsive (∼daily) and the medium-scale (∼26-day) structures that are superposed on the long-term (∼0.6-year) increase, and the close correspondence between such variations in the electron and proton traces. The small-scale, impulsive variations of ion and electron intensities over such a long time interval are unique to this event, compared to other events observed in the outer heliosphere by either V1 or V2. In addition, the ion intensities exhibit large, beam-like angular distributions with ions propagating outward away from the Sun along the presumed, nearly azimuthal heliospheric magnetic field [2].

3. Summary

We have compared LECP data from the V1 and V2 spacecraft during 2002–03 and emphasized the unusually intense and long-lived nature of the event

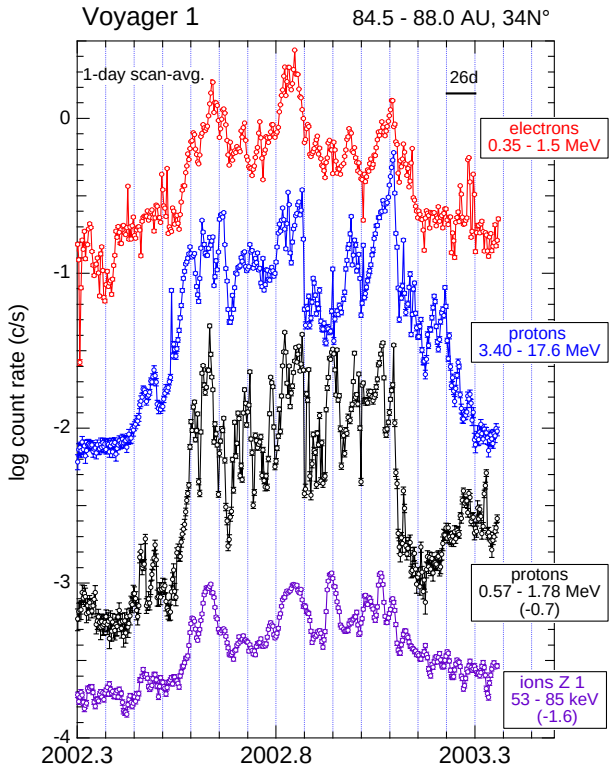

Fig. 3. From the top, one-day averaged count rates at V1 of 0.35–1.5 MeV electrons, 3.4–17.6 MeV protons, 0.57–1.78 MeV protons, and 53–85 keV ions. Vertical lines are spaced every 26 days.

observed at V1 during ∼2002.60–2003.36. Where do the observed ion and electron intensity variations, anisotropic angular distributions [2], and ion composition signatures originate? The question remains open, but at least two scenarios are being investigated. In one, V1 is in the near upstream region of the TS, and the observed event results from connection to the TS. In the other scenario, V1 is beyond the TS in mid-2002, and the particle intensity, anisotropy, and composition variations are indicative of conditions in the heliosheath [4]. This work was supported by the Voyager Interstellar Mission under NASA Grant NAG5-4365.

4. References

1. Stone E. 2001, Science 293, 55
2. Decker R. B., Krimigis S. M., Roelof E. C. 2003, Proc. ICRC2003
3. Hill M. E. et al. 2003, Proc. ICRC2003
4. Krimigis S. M. et al. 2003, in preparation