Solar and Interplanetary Ions near Earth

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The interplanetary medium is host to a variety of plasma phenomena. However, the vast scale of the Solar System, and the large dynamic range of interplanetary particle and field fluxes, make the interpretation of single-point plasma and field observations a challenging task. Decades of ground-based measurements, and a quarter century of satellite observations, have aided in identifying the signatures of distinct plasma acceleration mechanisms. For example, particle-producing solar flares show up most dramatically as a large increase in the flux of 1-50 MeV protons, with similar enhancements for other ionic species and for electrons. We examine this region of the plasma spectrum in great detail for both individual and group characteristics of flare-accelerated ion populations. In addition, the same techniques will be applied to the study of other classes of interplanetary ion flux.

Data for this study come from the Charged Particle Measurement Experiment (CPME) aboard the Earth-orbiting IMP 7 and IMP 8 satellites. Solid state detectors measure protons, alpha particles, and $Z > 2$ nuclei over a series of kinetic energy passbands. Detailed analysis of the raw data allows us to construct approximate differential energy spectra for protons (0.5-200 MeV), alphas (1.0-32. MeV/nuc), and medium (CNO) nuclei (1.0-4.0 MeV/nuc).

Using an array of satellite and ground-based monitoring data in conjunction with CPME data, we have identified particle producing flares occurring between September 1972 and June 1978. Event-averaged spectra and abundance ratios are studied for statistical trends. Among the results:

1) The average proton spectrum tends to be harder for flares with larger total proton output. Alphas and medium nuclei do not show this trend.

2) Crossplots of event proton flux vs. alpha flux at equal energy per nucleon demonstrate that, while the main trend shows a slight increase of P/a with event size, there is a distinct group of flares which have unusually large P/a ratios. Examination of individual events shows that most are associated with the second in a series of closely spaced particle flares. This finding suggests that the region near the flare site itself may be the origin of this compositional anomaly.

3) Crossplots of medium nuclei vs. proton flux emphasize the isolated class of "Z-rich" flares: particle flares with high medium nuclei content.

Application of our analysis techniques to the quiet interplanetary background flux yields results that are generally consistent with other studies. Unusual "bumps" on the observed proton and alpha spectrum are most likely contamination features from the so-called "anomalous component." We finally study non-flare periodic or corotating flux enhancements. The typical event-averaged ion spectra of these events differ in shape and extent from flare particle spectra. Time-series plots of simultaneous magnetic field , solar wind, and CPME ion flux data demonstrate the dominant role of the IMF sector structure in organizing non-flare flux enhancements. In fact, our study uncovers a class of corotating events which are enriched in $Z > 2$ ions, and which are closely associated with the passage of IMF sector boundaries. We show that this class of enhancements, known as sector ion clouds (SIC), include as a subset many of the "Z-rich" flare events. The origin of this compositional feature will be the topic of future studies.