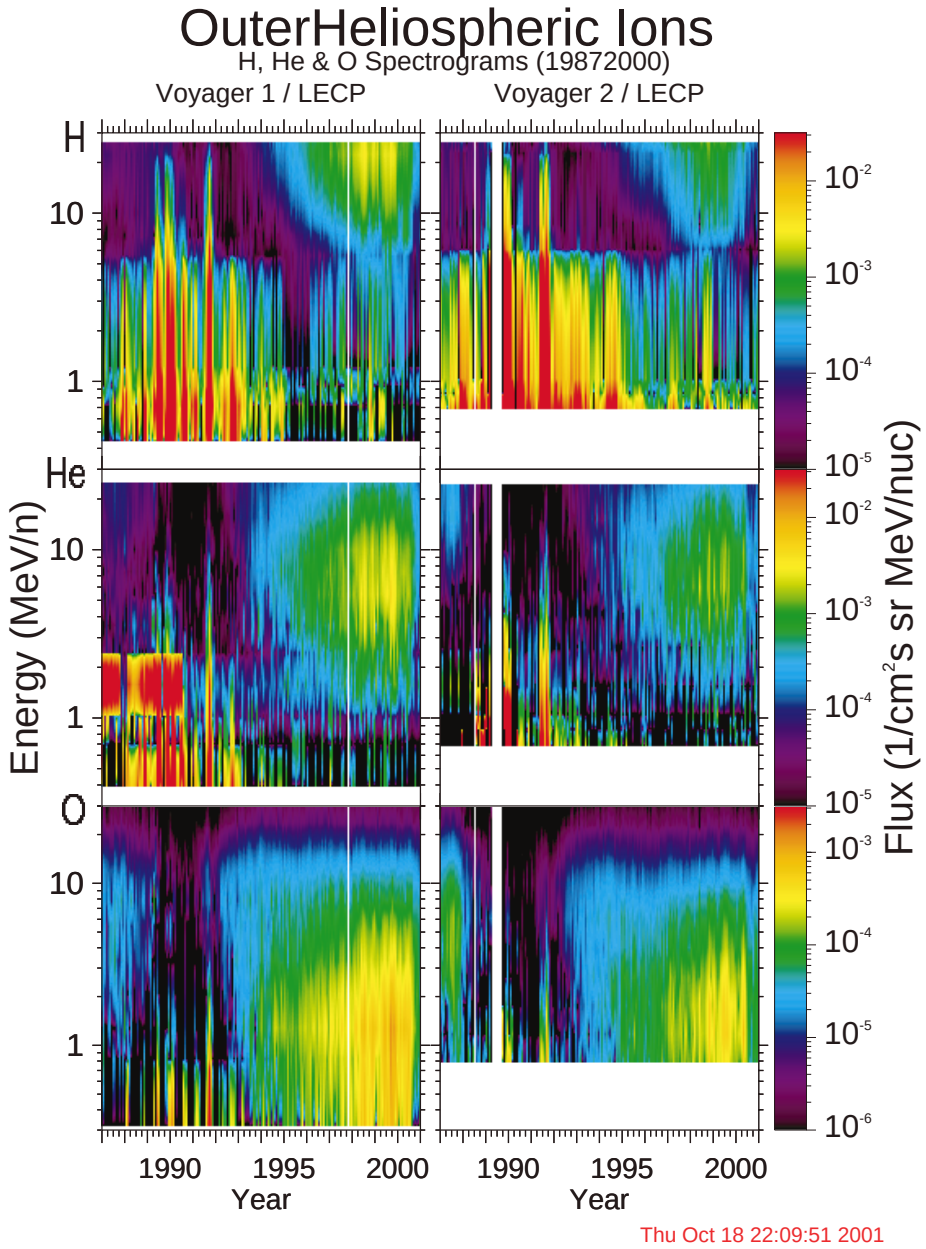

Spectrogram of ion intensity (1/cm^{2}s-sr-MeV/nucleon, color-scale) vs. kinetic energy (MeV/nucleon, vertical scale) and time (years, horizontal scale). The panels in the left and right columns show Voyager 1 and 2 observations, respectively. The panels in the top, middle, and bottom rows display H, He, and O ions, respectively.

Solar Cycle Changes in the Intensities of Anomalous Cosmic Rays and Solar Energetic Particles in the Outer Heliosphere at Voyager 1 & 2

Since before the space age it has been known that Solar activity (usually measured by the variations in the number of sunspots on the Sun) is anti-correlated with the intensity of cosmic rays (Forbush, 1954). The Voyager spacecraft, as they traveled to the distant heliosphere, returned measurements showing that this anticorrelation persists to at least 80 Astronomical Units from the Sun.

The intensity of solar energetic particles (SEPs) (and related, interplanetary-accelerated ions), which increases at solar maximum and decreases at solar minimum, is another measure of solar activity. Large SEP proton events at Voyager 1 occurred near the 1989 to 1991 solar maximum period (the predominantly red peaks from ~0.5 to 7 MeV in the upper left panel).

So called anomalous cosmic rays (ACRs), which are accelerated “pick up” ions, are also anticorrelated with solar activity. At characteristic energies these particles can be seen to increase in intensity as the level of solar activity subsides. For example, the green to yellow peaks near 1 MeV/nucleon, from ~1995 to 2000 in the bottom panels indicate the increase (or recovery) of ACR oxygen ions, as the intensity of SEPs subsides.

ACR O and He can be seen at both Voyager 1 & 2, with peak intensities at kinetic energies of ~1.3 and 6 MeV/nucleon. The peak intensity of ACR H is off the energy scale in the top two panels. The peak intensities of all three ACR species increase by about a factor of 100 from 1991 to 1999.

Contributed by Dr. Matthew E. Hill & Professor Douglas C. Hamilton, University of Maryland, Department of Physics, College Park, MD, for the Voyager 1 & 2 Low Energy Charged Particle instrument team.