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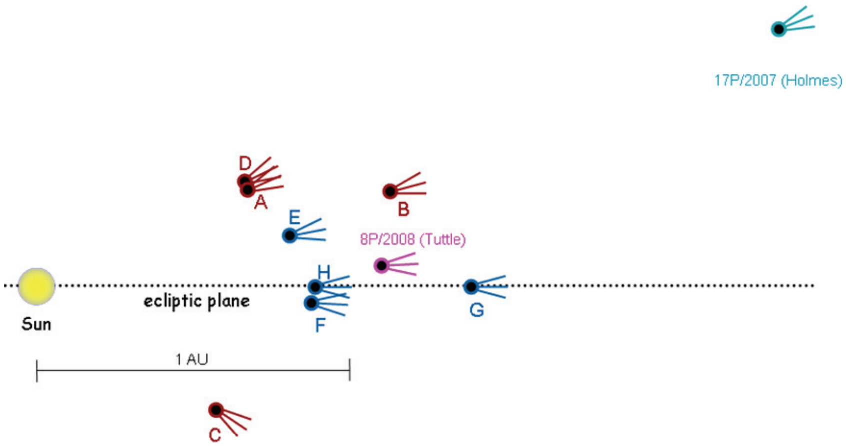
Cometary X-Ray Emission: Using Comets as Natural Solar Wind Probes



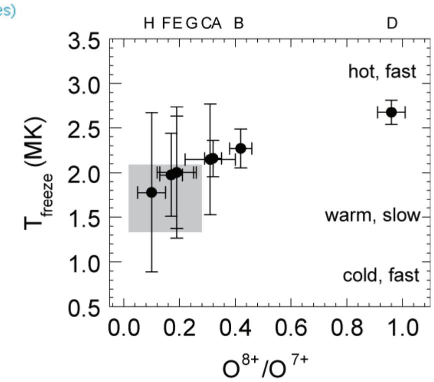


Figure 1 (left): Chandra comet survey. Indicated are the comet's heliocentric distance and the helioecliptic latitude during the observations. The color code indicates the spectral type. Letters refer to individual comets. Data of comets Tuttle and Holmes is work in progress.
Figure 2 (right): Spectrum-derived ionic oxygen ratios and corresponding freezing-in temperatures. The shaded area indicates the typical range of slow wind associated with coronal streamers.

Highly charged ions are amongst, if not the most, reactive species in the universe. When highly charged ions from the solar wind collide on neutral gas from comets or other sources, the ions become partially neutralized by capturing electrons into an excited state. These ions subsequently decay to the ground state by the emission of one or more photons in a process called charge exchange emission. The spectral shape of charge exchange emission depends on properties of both the neutral gas in the cometary atmosphere and the solar wind, and the subsequent emission can therefore be regarded as a fingerprint of the underlying interactions.

Based upon charge exchange cross sections measured in the lab, we developed a model to simulate cometary X-ray spectra. The model involved charge exchange of solar wind bare or H-like C, N, and O ions with cometary H, O, and H_2O species. We used this model to analyze the body of 10 comets observed by Chandra since its launch in 1999 (Figure 1). Our comparative study suggested the existence of at least three different spectral classes that were characterized by three distinct signatures: the combined fluxes of the carbon and nitrogen emission below 500 eV, the OVII emission, and the OVIII emission. This is illustrated in Figure 2, where the ratio between the OVIII and OVII fluxes is plotted as a function of the inferred freezing-in temperature. Most observations are within or near to the streamer-associated range of oxygen freeze-in temperatures. Four comets interacted with a wind significantly hotter than typical streamer winds. By comparing our data with archival ACE and SOHO data, we were able to link these spectral differences to different solar wind states, as such identifying comets interacting with (I) fast, cold wind, (II), slow, warm wind, and (III) disturbed, fast, hot winds associated with interplanetary coronal mass ejections (see Figure 2).

What seems to be missing in our survey is a comet that interacted with the polar, high-latitude solar wind. A number of comets have been observed at relatively high latitude, but all of them encountered a 'hot', disturbed wind. The surprisingly faint X-ray spectrum of the recently observed comet Holmes might be our first comet to interact with polar wind.

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Submitted by D. Bodewits (NASA/GSFC), D.J. Christian (Queen's University Belfast), M. Torney (U. of Strathclyde), M. Dryer (NOAA/SWPC), C.M. Lisse (JHU/APL), K. Dennerl (Max-Planck Institut für extraterrestriche Physik), T.H. Zurbuchen (U. of Michigan), S.J. Wolk (Harvard-Smithsonian Center for Astrophysics) A.G.G.M. Tielens (NASA/Ames) and R. Hoekstra (KVI - U. of Groningen). Comments or questions can be submitted to dennis.bodewits@nasa.gov. For an archive of earlier ACE News items see http://www.srl.caltech.edu/ACE/ACENews_Archives.html.