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On the shape and properties of the global heliosphere over the Solar Cycle with Voyager/LECP ions and Cassini/INCA ENAs

Konstantinos Dialynas (1), Stamatios Krimigis (1,2), Donald Mitchell (2), Robert Decker (2), and Edmond Roelof (2)

(1) Office for Space Research and Technology, Academy of Athens, Athens 10679, Greece , (2) Johns Hopkins University Applied Physics Laboratory, Space Department, Laurel, MD, United States (tom.krimigis@jhuapl.edu)

Voyager 1 (V1) and Voyager 2 (V2) have crossed the termination shock in 2004 (V1) and 2007(V2) and traversing the Heliosheath (HS) in the upstream (nose) hemisphere, while the Ion and Neutral Camera (INCA) on Cassini enables Energetic Neutral Atom (ENA) images of the celestial sphere that place the local ion measurements by each Voyager in a global context. We present an analysis of 5.2-55 keV ENA global images of the HS and 28-53 keV in-situ ions over an 11-year period (2003-2014) that corresponds to the declining phase of solar cycle 23 (SC23) and onset of SC24. The measurements reveal a coherent decrease and recovery between ENA in the global heliosphere and in-situ ions at V1/V2 during this time period, in overlapping energy bands, establishing that the HS ions are the source of >28 keV ENA. The similarity in the overall appearance of the images throughout the INCA energy range (5.2-55 keV), reveals that the source of ENAs at <30 keV (i.e. below the V1,2 ion threshold) is also the HS. The consistency between >5.2 keV ENA and ion variations with the Solar Sunspot Numbers (SSN) and solar wind parameters indicates that the Heliosphere responds promptly, within $\sim$2-3 years, to outward propagating solar wind changes in both the nose and anti-nose (tail) directions following the Solar Cycle (SC) phases. A detailed latitudinal examination of the global ENA emissions, verifies that the peak intensities between the nose and anti-nose directions are nearly similar, the power law ENA spectral index (γ) is largely the same near the equator in both the nose and anti-nose directions and displays similar spatial dependence with latitude. The totality of the ENA and in situ ion observations, together with the V1 measurement of a $\sim$0.5 nT interstellar magnetic field (ISMF) and recent modeling, suggest a “bubble-shape” heliosphere, i.e with little substantial tail-like feature. These observations are essential in determining the context for the measurements anticipated by the forthcoming IMAP mission.