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The Context for IMAP: Voyager and INCA Observations of the Heliosheath at E > 5 keV

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The basic premise of the proposed Interstellar Mapping and Acceleration Probe (IMAP) is detailed scientific understanding of the Heliosheath (HS) and beyond, a region of space explored in situ by Voyager 1 (V1) since 2004, Voyager 2 (V2) since 2007, and remotely via energetic neutral atoms (ENA) by the Cassini/INCA (Ion and Neutral CAmera) since 2003 and IBEX since 2009. The IMAP instrumentation proposed for this purpose combines and extends the IBEX and INCA ENA energy ranges (0.3- 20 keV and 3-200 keV, for low and high energy, respectively). All three missions-Voyagers, Cassini/INCA, and IBEX- have made discovery-class measurements in the HS, the Voyagers providing in situ ion intensities at $E > 30$ keV, while INCA images ENA in the range $5 < E < 55$ keV, and IBEX $0.3 < E < 6$ keV. The partial overlap in energy coverage between Voyager ions and INCA ENA allows for the possibility of observing the intensity and time evolution of ions in the HS, thought to give rise to the ENAs via charge-exchange, and the resultant ENA images in the inner heliosphere and their spatial and/or temporal variability. Unfortunately, no such "ground truth" ion measurements are possible at Voyager in the ENA energy range imaged by IBEX. Some of the key findings from the Voyager and Cassini/INCA measurements are as follows: (1) The HS contains a hot plasma population that carries a substantial part (30-50 %) of the total pressure at $E > 5$ keV, the rest residing below that range, resulting in a beta (particle/magnetic pressure) always > 1, typically >10. (2) The width of the HS in the direction of V1 is $\sim$ 30 AU, but is thought to be larger (40-70 AU) in the southern ecliptic where V2 currently travels.. (3) The ENA intensities at $E > 5$ keV exhibit a correlation with the solar cycle (SC) over the period 2003 to 2015, with minimum intensities in the anti-nose direction observed $\sim$ 1.5 yrs after solar minimum followed by a recovery thereafter. (4) The in situ ion measurements at V2 within the HS also show a similar SC dependence. The totality of the observations, together with the near-contemporaneous variability in intensities of ions in situ in the HS and ENAs in the inner heliosphere suggests that the source of such ENA emissions at $E > 5$ keV must reside in the HS. Thus IMAP observations must have sufficient sensitivity and pointing accuracy to resolve potential differences in location between the lowest energy ($\sim$ 1 keV) features from those at > 5 keV.