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Energetic neutral helium atoms as a tool to study the heliosphere and the local interstellar medium

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The aim of our study is to determine the utility of helium energetic neutral atoms (ENA) in the studies of the outer heliosphere, its boundary region, and the nearby interstellar medium, and to assess the requirements for future instruments to enable them to observe He ENA fluxes. Presently, studying these regions is rendered possible mostly by combining the in-situ measurements by the plasma and cosmic-ray instruments on Voyagers and the remote-sensing observations of H ENA from IBEX. Helium as the second most abundant species in the universe could potentially enable further extension of our knowledge about nearest surroundings of the Sun. We assessed the expected emission of the heliospheric He ENA and of He ENA from the nearby interstellar medium.

To estimate the heliospheric emission of He ENA we used a simple model of the heliosphere and performed numerical simulations to determine the distribution of various populations of helium ions in the inner heliosphere. Based on this model, we calculated fluxes of He ENA created by charge exchange between helium ions and neutral atoms over a wide energy range from 0.5 keV/nuc up to 1 MeV/nuc. We included binary interactions between various combinations of hydrogen and helium ions and atoms. We also included the signal from the vicinity of the heliosphere produced via the secondary ENA mechanism, which is most likely the source for the observed IBEX Ribbon.

The mean free path against ionization of He ENA in the local interstellar medium reaches about 8000 AU for atoms with an energy of a few keV. This is about 10 times more than the mean free path against ionization for hydrogen atoms at the same energy. Thus emission of helium ENA from hypothetic extraheliospheric sources could be detectable from larger distances than the hydrogen atoms. This could provide a novel method of sounding the sources of suprathermal ions that might operate in the surrounding of the heliosphere. The He ENA produced by charge-exchange could then be detectable by an instrument on the Earth's orbit.

We found that expected fluxes of He ENA from the heliosheath are smaller by about 2-3 orders of magnitudes than the fluxes of H ENA. Thus, to observe the heliospheric He ENA emission, the future instrument with a mass spectrometer should have sensitivity at least an order of magnitude higher than IBEX. On the other hand, the "darkness" and transparency of the heliosheath in He ENA could provide opportunity to discover hypothetic extraheliospheric sources of He ENA on distances comparable with the distance to the edge of the Local Interstellar Cloud. Such sources could be even brighter than the heliospheric emission of He ENA.