Heliospheric solar wind charge exchange studies with high resolution microcalorimeters

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Introduction

Solar wind charge exchange X-ray (SWCX) emission from the heliosphere has long been considered a hindrance to studies of more distant diffuse astrophysical sources (Fig. 1). The diffuse and slowly varying signal, in contrast to the highly variable geocoronal SWCX emission, is the most difficult component to distinguish and separate from the diffuse X-ray background. The similarity of the SWCX spectrum to thermal emission at CCD resolution (Fig. 2) adds to the complexity of spectral data analysis.

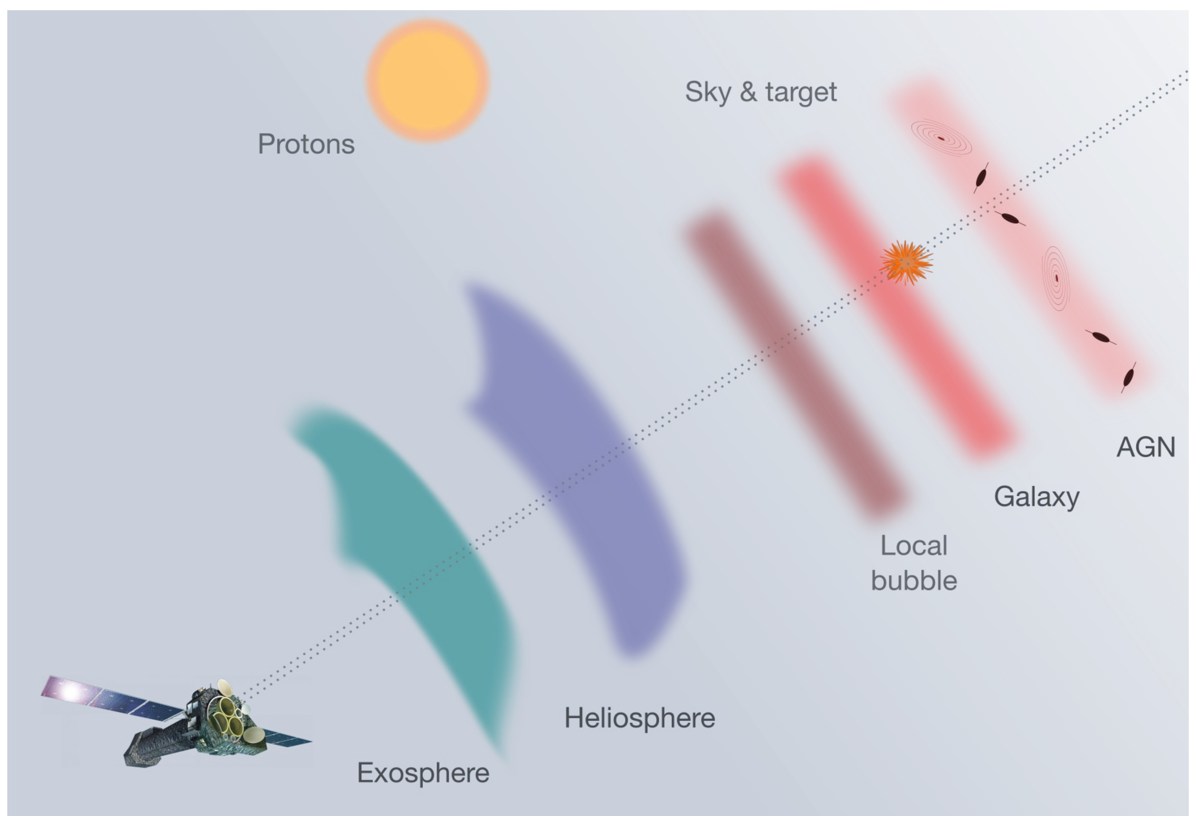

Fig. 1 Components of the X-ray sky. Credit: J. A. Carter, U. of Leicester

From CCDs to microcalorimeters

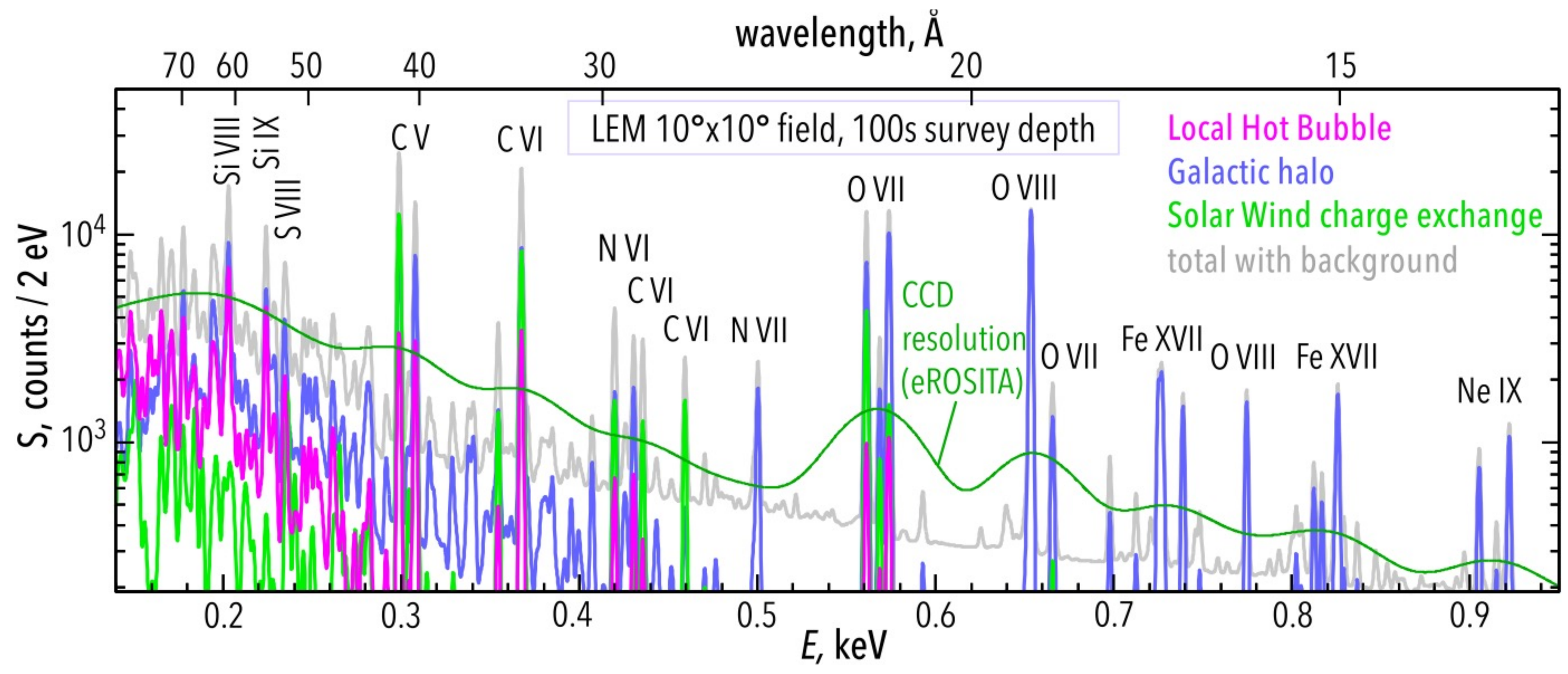

Fig. 2 Simulated spectrum of the soft X-ray background components with LEM. (McCammon et al. 2002, adapted by the LEM All-Sky Survey working group)

The advent of high-resolution microcalorimeter spectroscopy opens new paths to studying the heliospheric SWCX signal, giving access to:

-key spectral diagnostics such as the triplet complexes of He-like ions (e.g. O VII, Ne IX), to clearly separate the SWCX and thermal emission contributions
-the forest of spectral lines that constitute the bulk of the SWCX emission down to 0.1 keV.

Velocimetry studies: Doppler shift measurements

The drastic changes in solar wind plasma parameters in the outer heliosheath may be revealed using Doppler measurements of the SWCX X-ray spectral lines.

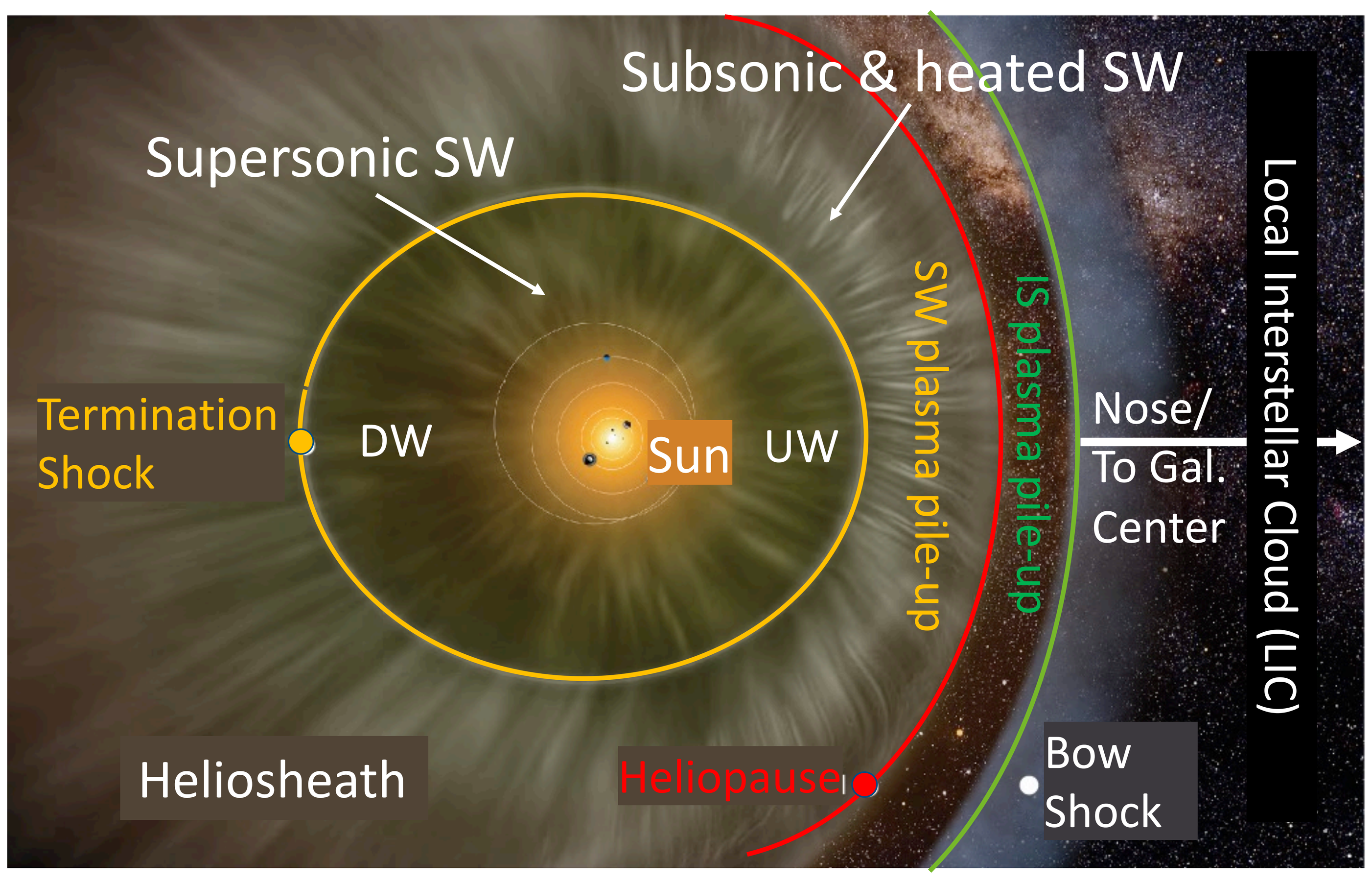

Fig. 3 Sketch of the heliosphere. Credit: NASA/Adler Planetarium

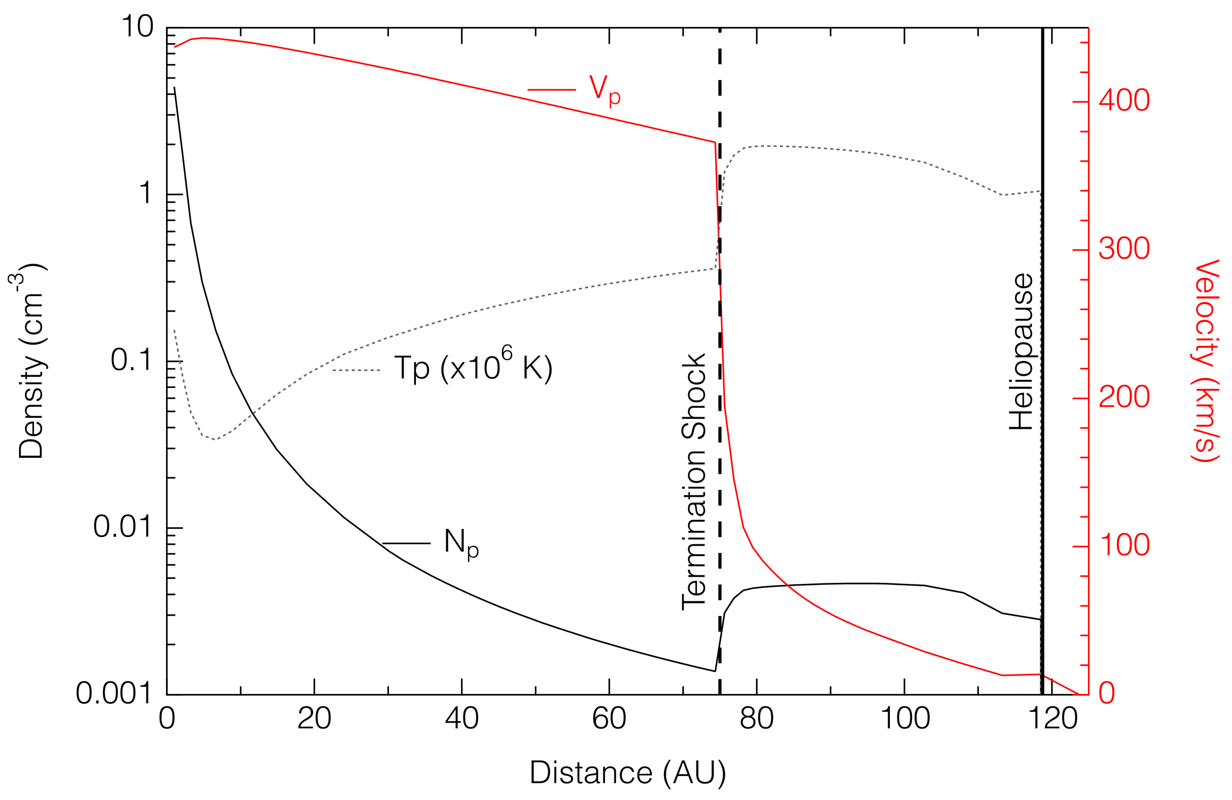

Fig. 4 Solar wind density, temperature and velocity towards the heliospheric nose direction (Izmodenov & Alexashov, 2015)

With a judicious choice of dark sky regions near the nose of the heliosphere (Fig. 5) and spectral lines (e.g. Mg XI @ 1.3 keV, Fig. 6), we will be able to separate the Doppler-shifted signal of the supersonic interplanetary SW from the signal of the heated solar wind in the outer heliosheath.

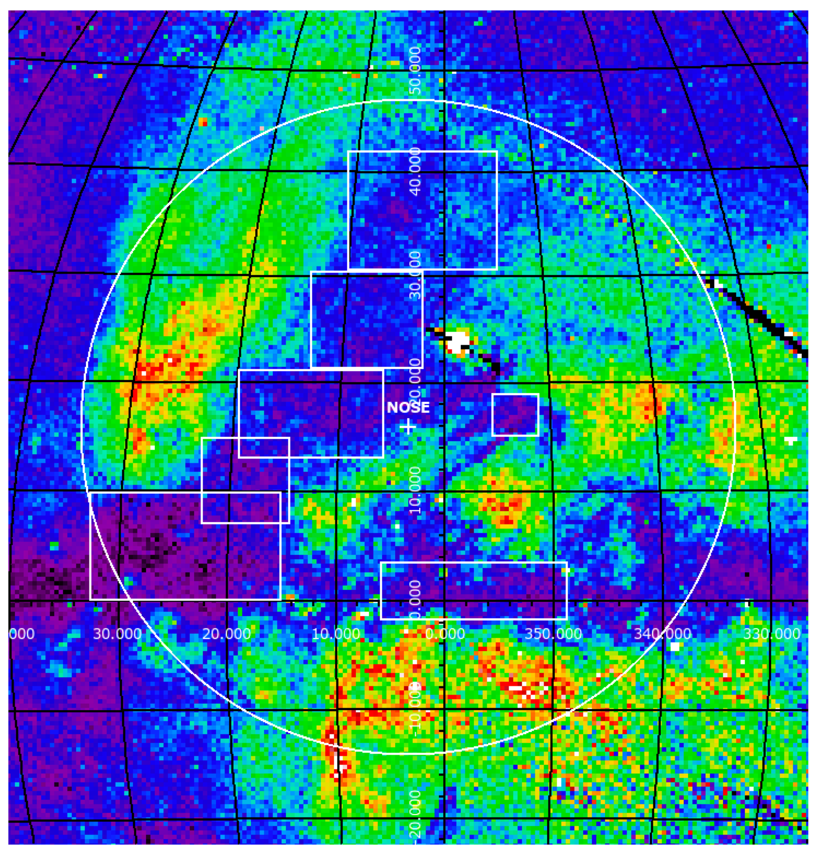

Fig. 5 RASS map in the ¾ keV band of the galactic center with dark target regions (white boxes) near the direction of the nose of the heliosphere.

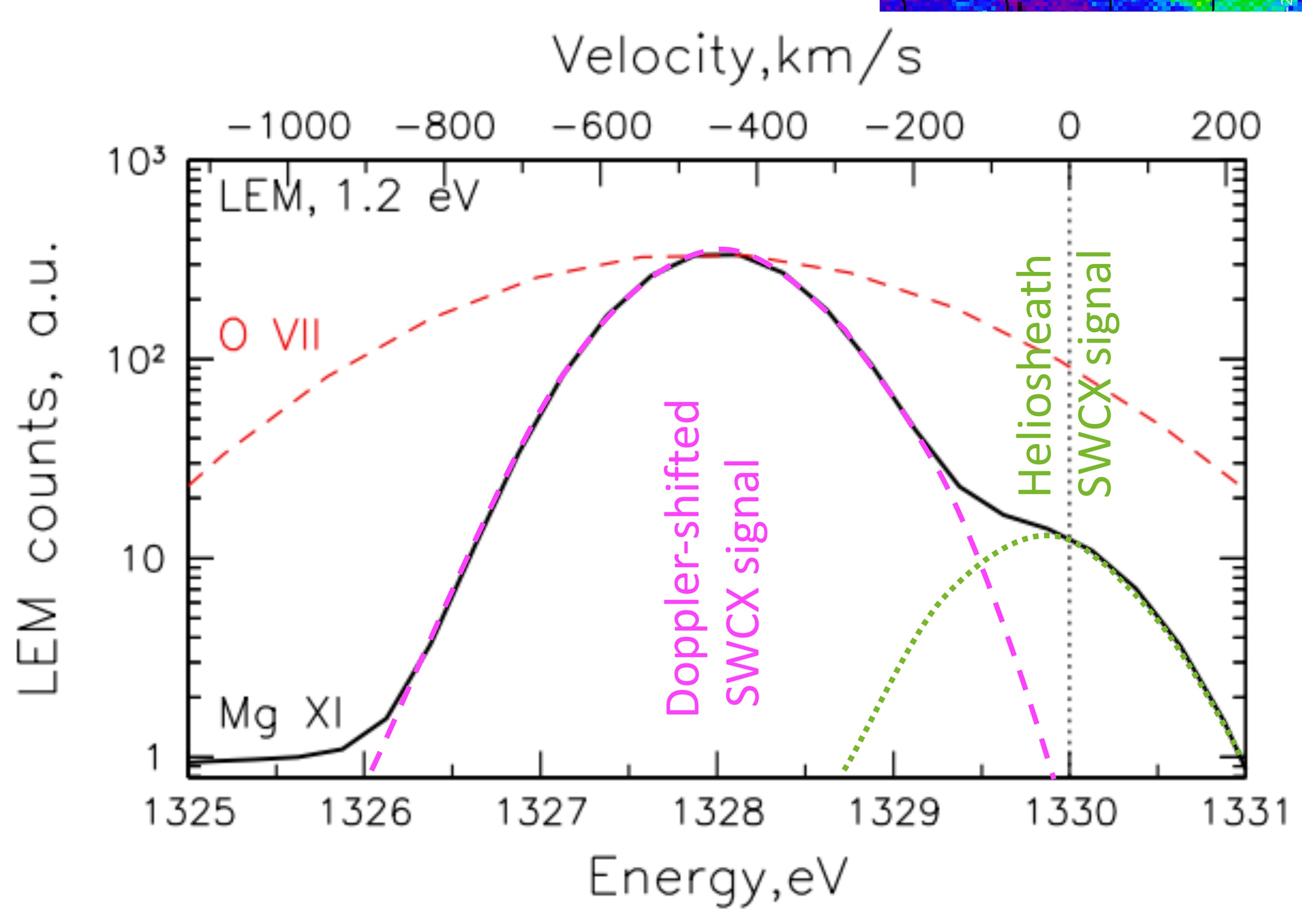

Fig. 6 Convolution of the SWCX Mg XI line velocity profile with LEM response function (FWHM=1.2 eV). For comparison, in red the SWCX O VII line velocity profile.

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