DXL: a sounding rocket mission for the study of solar wind charge exchange and local hot bubble X-ray emission

M. Galeazzi, M. Chiao, M. R. Collier, T. Cravens, D. Koutroumpa, K. D. Kuntz, S. Lepri, D. McCammon, F. S. Porter, K. Prasai, I. Robertson, S. Snowden, Y. Uprety

Abstract The Diffuse X-rays from the Local galaxy (*DXL*) mission is an approved sounding rocket project with a first launch scheduled around December 2012. Its goal is to identify and separate the X-ray emission generated by solar wind charge exchange from that of the local hot bubble to improve our understanding of both. With 1,000 cm^2 proportional counters and grasp of about 10 cm^2 sr both in the ¼ and ¾ keV bands, DXL will achieve in a 5-minute flight what cannot be achieved by current and future X-ray satellites.

M. Galeazzi (✉), K. Prasai, Y. Uprety
University of Miami, Coral Gables, FL, USA
galeazzi@physics.miami.edu, tel: +1-305-284-2326, fax: +1-305-284-4222

M. Chiao, M. R. Collier, D. Koutroumpa, F. S. Porter, S. Snowden
NASA/Goddard Space Flight Center, Greenbelt, MD, USA

T. Cravens, I. Robertson
University of Kansas, Lawrence, KS, USA

K. D. Kuntz
Johns Hopkins University, Baltimore, MD, USA

S. Lepri
University of Michigan, Ann Arbor, MI, USA

D. McCammon
University of Wisconsin, Madison, WI, USA

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1. Introduction

The first detection of extrasolar X-rays came in 1962 (Giacconi et al. 1962), showing the presence of a diffuse X-ray flux. Observation of diffuse emission was extended to energies below 1 keV identified by a series of three papers in 1968-69 (Boyer et al. 1968, Henry et al., 1968, Bunner et al. 1969), resulting in the discovery of Galactic emission. Subsequent investigations extensively studied the nature of the diffuse emission and its correlation with the neutral material in the Milky Way (McCammon & Sanders 1990, and references therein). X-rays observed in the ¼ keV band in the direction of the Galactic plane must originate locally as they are easily absorbed by the neutral material of the Galactic disk. It is currently believed that a significant fraction of the ¼ keV emission originates in an irregularly shaped cavity in the neutral hydrogen of the Galactic disk which contains the Sun, dubbed the Local Hot Bubble (LHB). Despite the "local" origin of the emission, there is still a significant uncertainty in its nature and characteristics. The reason for this uncertainty lies primarily in the nature of the emission, which is weak and diffuse, and its superimposition on emission from other sources of the Diffuse X-ray Background (DXB). In particular, it has been essentially impossible to isolate the LHB contribution from the emission from Solar Wind Charge eXchange (SWCX) recombination. SWCX emission is generated when the highly ionized solar wind interacts with neutral or near-neutral gas in the Earth's exo-atmosphere and in the interplanetary medium. An electron is captured from a neutral atom (H or He) into an outer orbital of the highly ionized solar wind species in a quasi-resonant process and cascades to the ground state of the ion, often emitting soft X-rays in the process. The SWCX spectrum is therefore dominated by characteristic line emission that is very difficult to separate from the presumably thermal emission of the LHB.

It is, however, possible to separate the foreground SWCX emission from the extra-solar sources, such as the LHB, by looking at its spatial and temporal signatures. The slowest time-varying, and thus most troublesome, component of the SWCX emission originates in the interplanetary medium and should show a significant geometric variation due to the focusing of interplanetary helium. Interstellar neutrals flow through the solar system due to the motion of the heliosphere through the local interstellar cloud. Gravity significantly affects helium trajectories which execute Keplarian orbits and form a "focusing cone" downstream of the Sun centered at $\sim 6^{\circ}$ below the ecliptic plane. This results in a localized downstream enhancement of helium which has the direct effect of increasing the SWCX X-ray emission.

By scanning the sky through the focusing cone, the spatial signature of the SWCX can be identified, allowing a separation and subsequent investigation of LHB and SWCX emission, such as the distribution of the hot plasma within the LHB. Combining this information with the geometry of the local cavity derived from other wavelengths it is then possible to derive the physical parameters of the plasma (its pressure and density). Knowing the physical conditions of the plasma will lead to more accurate pictures of the solar neighborhood and the evolution of bubbles of hot gas produced by supernovae or stellar wind when they near the end of their existence. Identifying and characterizing the SWCX signature will also permit an estimate of the contribution of heliospheric SWCX to the University of Wisconsin (McCammon et al. 1983) and *ROSAT* all-sky maps (Snowden et al. 1997) of the soft x-ray background, and to every current and future investigation of extended sources.