A New View of the LHB and $\frac{1}{4}$ keV X-ray Halo

S.L. Snowden

NASA Goddard Space Flight Center, Code 662, Greenbelt, MD 20771, USA

Abstract. The X-ray sky at $\frac{1}{4}$ keV is completely dominated by diffuse emission. It has become clear that it originates as at least three separate components: local emission within the nearest $\sim 100$ pc from the Sun, halo emission from beyond most of the neutral material of the Galactic disk, and the superposition of unresolved extragalactic sources. The only way to determine the temperatures and relative emission measures of the hot plasma responsible for the Galactic components is to use the X-ray intensity variations due to column density variations in the intervening H I to separate the components. "Shadowing" studies have been pursued for individual objects using ROSAT data from both pointed observations and the all-sky survey with considerable success.

This paper presents the results of an all-sky analysis of the $\frac{1}{4}$ keV background from the ROSAT survey. A Local Hot Bubble is found consistent with, although somewhat smaller than, previous models. It has a temperature of $10^6$ K and an emission measure which varies by a factor of $\sim 3.3$ over large angles. The halo emission has a temperature near $10^6$ K with an emission measure which varies from near zero to more than five times that of the local emission.

1 Introduction

The source of the $\frac{1}{4}$ keV soft X-ray diffuse background (SXRB) has proved elusive since its discovery in the late 1960s (e.g., Bowyer, Field, & Mack 1968). The general negative correlation between the SXRB and the column density of Galactic neutral hydrogen (dominated by a Galactic plane-to-pole variation) was strongly suggestive of an "absorption" model, where the angular structure of the SXRB is produced by the absorption of a flux of distant origin (e.g., Marshall & Clark 1984). The absence of the expected detailed negative correlation (some specific H I features showed little indication of shadowing, e.g., Burrows et al. 1984), the shallowness of the apparent absorption, and the weakness of the energy dependence of the apparent absorption encouraged the investigation of other possibilities.

By the end of the 1980s, the displacement model (e.g., Sanders et al. 1977; Snowden et al. 1990, hereafter SCMS) proved to be the most consistent with the available data. The displacement model suggests that the irregularly shaped cavity which surrounds the Sun (known independently from interstellar absorption line studies: e.g., Frisch & York 1983, and $N_H$ studies: e.g., Knapp 1975) contains an X-ray-emitting plasma, and that the cavity is extended more toward the Galactic poles than within the Galactic
plane. The greater the extent of the plasma-filled cavity in a given direction, the greater the emission measure of the plasma and the lower the measured column density of H I (at constant Galactic latitudes), which produces the general negative correlation between the two. The displacement model provided a natural explanation for the weakness and energy independence of the apparent absorption and allowed for H I features which had no apparent effect on the X-ray flux.

With the launch of the Röntgensatellit (ROSAT, Trümper 1983), the situation became more complicated. One of the first unique discoveries of ROSAT was the observation of deep shadows in the general SXRB cast by the Draco Nebula (l, b ~ 90°, 40°, Burrows & Mendenhall 1991; Snowden et al. 1991). These observations unequivocally proved that there is significant 1/4 keV X-ray emission in at least the lower Galactic halo: roughly 50% of the observed flux in that direction originates ≥ 300 pc from the Sun, ≥ 200 pc above the Galactic plane. Additional studies using both pointed observations and all-sky survey data demonstrated that the shadows were not unique to Draco but common features of the 1/4 keV SXRB.

2 Data and Analysis

X-ray Data: This analysis uses the R1 and R2 band data (PSPC PI channels 8 – 19 and 20 – 41, respectively; Snowden et al. 1994) from the ROSAT all-sky survey (Snowden & Schmitt 1990) as presented in Snowden et al. (1997). The 1/4 keV band is appropriate for the study of the LHB, as the LHB has a temperature near 10^6 K. Thermal equilibrium spectra near 10^6 K produce only ~ 2% as many counts in the 3/4 keV band as in 1/4 keV band. The results of this analysis show that the temperature of much of the halo emission is near 10^6 K as well.

Measure of Galactic Absorption: Corrected IRAS 100 μm maps (Schlegel, Finkbeiner, & Davis 1997 and Finkbeiner, this volume) are used for Galactic absorption. The low spatial frequencies in the IRAS 100 μm data have been replaced by those from the well-calibrated DIRBE data. The DIRBE 100 μm, 140 μm, and 240 μm data have been used to determine temperature variations and to correct the 100 μm map to a constant reference temperature. In addition, the Leiden-Dwingeloo 21-cm survey data (Hartmann & Burton, 1997) in the velocity range from -74 km s^{-1} to 24 km s^{-1} in relatively low column density directions were used to determine a global normalization. Finally, the data were scaled to a column density of hydrogen.

In order to determine the foreground and distant (relative to the Galactic absorbing gas) contributions to the observed 1/4 keV SXRB, the negative correlation (shadowing) between the 1/4 keV background and the column density of absorbing material along the line of sight is examined. The sky is divided into 4°×4° regions with 24'×24' pixels, and the negative correlation between X-ray intensity and H I column density as measured by the corrected