Probing Interstellar Matter with Multi-Wavelength Observations

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Abstract

This work explores the interstellar medium (ISM) by integrating multiple observational methods to better understand dust distribution and its relationship with the Galactic magnetic fields. Adopting a multifrequency approach, this research leverages data across the electromagnetic spectrum to construct a more comprehensive picture of the ISM. Specifically, it investigates whether the dust clouds responsible for X-ray scattering of emission associated with gamma-ray bursts (GRBs) can be independently identified through other ISM measurements.
Studies of six GRBs have revealed a strong correlation between the measured distances of X-ray rings and differential extinction maps, motivating further analysis along additional GRB lines of sight. X-ray rings around GRBs, produced by dust scattering in the Milky Way, provide a unique method for measuring distances to interstellar dust clouds. These measurements are compared with 3D dust distributions derived from stellar extinction (Lallement et al. 2019), validating the use of X-ray rings as a tool for ISM mapping.
To expand the analysis, data from the LOFAR radio telescope and the Planck satellite are incorporated. LOFAR's Faraday tomography reveals the distribution of magnetized, ionized matter through synchrotron radiation. This is compared with infrared dust emission from Planck, which exhibits alignment between depolarized synchrotron channels and magnetic field structures. Additionally, the spectroscopic emission of atomic hydrogen at 21 cm (HI) is visually correlated with LOFAR-polarized intensity (Kalberla & Kerp 2016) and depolarization canals (Jelić et al. 2018) using the Effelsberg-Bonn HI Survey (EBHIS).
By integrating these independent datasets, GRB X-ray rings, 3D extinction maps, LOFAR observations, Planck data, and EBHIS, this study provides a more comprehensive view of the ISM. This approach enhances the prediction and identification of new X-ray rings while refining our understanding of interstellar dust and magnetic fields.

Keywords: interstellar dust, magnetic field, gamma-ray bursts, radio frequencies, infrared emission, neutral hydrogen