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An Analysis of the Relationship Between X-ray Luminosity Functions and Star Formation Rates in Different Types of Galaxies

This study aims to investigate the characteristics of X-ray sources in elliptical (E), lenticular (S0), spiral (S), and active/interacting galaxies, and analyze their relationship with star formation activity. We use X-ray data from the Chandra X-ray Observatory, combined with infrared observations from Spitzer and Herschel, to estimate the star formation rate (SFR) using the X-ray luminosity function (XLF) and infrared luminosity (IR luminosity).

Through XLF analysis, we classify X-ray sources into high-mass X-ray binaries (HMXB) and low-mass X-ray binaries (LMXB), while excluding the influence of active galactic nuclei (AGN). Using linear fitting and Bayesian MCMC methods to estimate the slope (α) of the XLF, the results show that the XLF slope α ranges from -1.5 to -0.96, with a certain similarity in the X-ray source luminosity distribution across different galaxies. The Bayesian MCMC method is more stable than the linear fitting method, with the resulting α values concentrated between -1 and -1.1, indicating that the XLF follows a general exponential decay trend.

The XLF of elliptical galaxies (e.g., NGC 4486) is steeper (α ≈ -1.48), reflecting a larger contribution from LMXBs, which is consistent with a low SFR environment. The XLF of spiral galaxies (e.g., NGC 4569, NGC 4192) is flatter (α ≈ -0.96 to -0.97), likely dominated by HMXBs and associated with higher SFR. Furthermore, comparing the XLF with SFR estimates derived from infrared luminosity, we find that the XLF of HMXB-dominated galaxies is flatter and associated with higher SFR, while the XLF of LMXB-dominated galaxies is steeper and associated with lower SFR. These results further support the feasibility of using XLF as an indicator for estimating SFR. Overall, the characteristics of the XLF in different galaxy types are closely related to their star formation history, providing important insights for estimating SFR using X-ray observations.

Section

High Energy

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