Astrophysical Sciences & Technology
Ph.D. Dissertation Defense

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Young, Low-Mass Stars: X-rays and Circumstellar Environments

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Abstract:

Nearby, young stars are the ideal targets for investigations of stellar and protoplanetary disk evolution, so as to understand the processes involved in planet formation and evolution, as well as the origins of our Solar System. High energy radiation (X-ray and FUV) from the central star significantly alters the structure, chemistry, and ionization of planet-forming circumstellar disks. In this dissertation, I present observations of young stars and star-disk systems to better understand the connection between stellar high energy radiation and the evolution of circumstellar environments, methods to exploit the signatures of youth, as well as methods to identify nearby, young stars.

Our unbiased radio spectroscopic survey with the Institute de Radioastronomie Millimetrique (IRAM) 30 m telescope reveals the chemical richness of the cirumstellar disk orbiting the ~2-5 Myr-old, actively accreting solar analog LkCa 15. We find that that high-energy (FUV and/or X-ray) radiation from the central star, a known X-ray luminous source, may be enhancing the abundances of CN and C_2H within the disk. To ascertain the evolutionary status of the erratically variable star RZ Piscium (RZ Psc), we obtained observations of RZ Psc with the European Space Agency's X-ray Multi-Mirror Mission (XMM-Newton), as well as high-resolution optical spectroscopy with the Hamilton Echelle on the Lick Shane 3 m telescope and with HIRES on the Keck I 10 m telescope. These data provide strong support for the young-star status of RZ Psc, as well as evidence for the presence of a significant mass of circumstellar gas, suggesting the recent destruction of one or more young exoplanets within 1 au of the star. It is evident from our Chandra X-ray Observatory survey of very cool members of the ~8 Myr-old TW Hydra Association (TWA) that X-ray luminosity relative to bolometric luminosity (L_X/L_{bol}) decreases with decreasing effective temperature (T_{eff}). The fraction of TWA stars that display evidence for residual primordial disk material sharply increases in this same (mid-M) spectral type regime, suggesting that disk survival times may be longer for ultra-low-mass stars and brown dwarfs than for higher-mass M stars. Finally, we use parallax data available in Gaia Data Release 1 (DR1) to estimate the distances and ages of a sample of candidate young stars identified by the Galex Nearby Young Star Survey (GALNYSS). The youth of these stars is confirmed by their relative positions, compared to main sequence stars and giant stars, in Gaia-based color-magnitude and color-color diagrams produced for all Galex and WISE-detected stars with parallax measurements available in Gaia DR1.