THE NAKED T TAURI STARS: THE LOW MASS PRE-MAIN SEQUENCE UNVEILED

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ABSTRACT. I discuss a survey of X-ray sources in regions of star formation. The survey has revealed at least 30 low mass PMS, naked T Tauri stars (NTTS) in Tau-Aur, and a comparable number in Oph. I summarize the properties of these stars, and argue that the spectra of the classical T Tauri stars are due to the interaction of an underlying NTTS with a dominant circumstellar environment. I discuss the impact the NTTS are likely to have on our understanding of the PMS evolution of low mass stars.

The classical T Tauri stars (CTTS) are often considered synonymous with the low mass pre-main sequence (LMPMS) stars. Despite their extreme properties, all we know of LMPMS stars is based on obervations and interpretations of the CTTS. However, there do exist LMPMS stars which lack the complications afflicting most of the CTTS, and which may lead to a better understanding of the LMPMS stars and their evolution. Here I summarize the properties and implications of recently discovered LMPMS stars, the naked T Tauri stars (NTTS). See Walter (1986b) for a complete discussion.

A method of finding the less active LMPMS stars is through X-ray surveys. Walter (1986a) and Walter et al (1986) discuss the X-ray discovered LMPMS stars found to date. Expanding on this work, I observed more optical counterparts of X-ray sources in regions of star formation, confirming 30 NTTS in Tau, with another 6 possible. The identification criteria include strong Li 6707 absorption, a radial velocity consistent with that of the Tau T association, and CaII emission. Less complete studies in Oph and CrA have revealed 33 more NTTS.

The properties of the NTTS are unremarkable, as predicted by Herbig (1978). $H\alpha$ profiles are symmetric and are in absorption in stars hotter than about K5. The colors are normal. Many NTTS are low amplitude variables; none are catalogued variable stars. Only one NTTS is coincident with an IRAS source. Overall, the NTTS look like normal, but active, cool stars. They certainly cannot be mistaken for the typical CTTS. The NTTS comprise roughly half the LMPMS stars now known in Tau-Aur, and a larger fraction in Oph. They are distributed throughout regions of star formation, with no tendency to concentrate near the dark clouds like the CTTS. In Tau and Oph, prominent clumpings

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of NTTS lie 10 to 20 pc from the nearest dark clouds. Ages range from about 10^6 yrs (comparable to the CTTS) to about 2×10^7 yrs. The youngest stars lie closest to the clouds, and the oldest stars tend to lie furthest away.

I argue that NTTS and the underlying stars in the CTTS are the same, as established by the identical radial and rotational velocity distributions. These similarities cease once we consider those characteristics which define the CTTS. But these (the IR excesses and the $H\alpha$ and forbidden line emission) are likely not photospheric or chromospheric in origin. The CTTS emission line profiles imply extended atmospheres with significant mass motions, and there is strong evidence for disks around some stars. The properties that make a LMPMS star a CTTS are more likely symptomatic of the circumstellar (CS) environment than of the underlying star. Without the CS material (CSM), one would have an unveiled LMPMS star - a star with no IR or UV excesses, and no line emission beyond that generated by a solar-like atmosphere - i.e., a naked T Tauri star.

The NTTS afford an opportunity to study the PMS evolution of low mass stars and not the of the CSM. They will allow tests of the evolutionary tracks, because the luminosities and the temperatures are known. NTTS counts will improve estimates of the star formation efficiency. The NTTS can probe the relation between activity, rotation and age for $T < 10^7$ years. Now that we can see the underlying stars, perhaps we will be able to understand the CTTS and how a young star interacts with its CS environment. The NTTS are more representative of the true LMPMS stars than are the CTTS because in the latter we observe primarily the interaction of a star with a dominant CS environment. This may explain the lack of correlation of CTTS activity with either age or rotation, since the observed activity has little contribution from a solar-like chromosphere. The extreme CTTS are stars where the circumstellar material dominates the spectrum; in the NTTS the stellar contribution dominates at all wavelengths.

One would expect that the LMPMS stars follow an evolutionary sequence from extreme to less extreme CTTS to NTTS, as the CSM dissipates. This cannot be strictly an age sequence. It is likely that the rate of dissipation of the CSM depends on initial conditions. Stars which form in less dense regions of clouds, or which move out of the dense regions, might dissipate their CSM before those stars which remain in the dense regions. Indeed, the CTTS tend to be associated with dark clouds or nebulosity on the sky, while the NTTS are found in unobscured regions. The age of an LMPMS star is not a good predictor of its evolutionary state.

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