A 5 GHZ SURVEY OF WEAK-LINED T TAUERI STARS

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ABSTRACT  We report the results of a search for radio-continuum emission from weak-lined T Tauri stars selected on the basis of a range of criteria. A correlation is found with strong x-ray emission and with youth. All the stars in the survey older than about 20 million years were not detected as radio sources.

Keywords: stars: activity; stars: coronae; stars: pre-main sequence; radio continuum: stars

THE SURVEY

Weak-lined T Tauri stars are low-mass pre-main sequence stars which do not have the strong Hα emission line of classical T Tauri stars. They are known to be strong x-ray sources, and display solar-like activity thought to be characteristic of PMS stars. PMS stars probably spend a significant fraction of their contraction time in this state.

In this survey we look for continuum radio emission among samples of these stars chosen on the basis of a number of criteria. Many of these stars are already known to be radio sources (Bieging et al. 1984; Kutner et al. 1986; André et al. 1987; Stine et al. 1988; O’Neal et al. 1990). Rather than trying to completely sample the population of PMS stars in a young star-forming region, as most previous surveys have done, our survey was intended to try to identify a number of new sources suitable for further study of the nature of radio emission from these stars. We therefore chose most of the targets on the basis of known high activity levels, and particularly of strong x-ray fluxes. For comparison we included a number of stars known to be radio sources from the observations described above. However, we also included 8 targets chosen because they are late-type stars occurring in visual binaries with an early-type primary, and are therefore likely to be young stars. Such PMS stars, which are away from star forming regions, have not previously been studied in radio observations, and we felt it would be of interest to compare their radio properties with those of other PMS stars in the survey. The observations were carried out at 5 GHz with the Very Large Array in “A”-configuration, on 1990 Feb. 18 and 19. The typical 3σ detection threshold was 0.12 mJy.
Visual binaries with a young early-type primary

We observed 9 stars in this class: 8 chosen from Lindroos (1986), plus HD 28867 from Walter et al. (1988). Nearly all the targets from Lindroos (1986) consist of a late-type B dwarf and an F, G or K dwarf; all are in wide binaries, ensuring that the two components have evolved independently and are not Algol systems. From the large list in Lindroos (1986) we choose a small sample to include some of the closest of the Lindroos (1986) stars, with distances ranging from 23 to 157 pc. We also selected on the basis of other indicators of youth and/or activity. The primaries in all these systems should not have strong winds and are unlikely to be radio sources, and indeed none were detected.

None of the eight young-dwarf companions from Lindroos (1986) were detected. The only detection in this category is HD 28867, which was chosen on the basis of its x-ray flux (Walter et al. 1988). Both known components of HD 28867 are probably B stars. Normal main-sequence single B dwarf stars are not generally detected as radio sources. We believe that either HD 28867 is a Herbig Be star, or that there is an undiscovered pre-main sequence component in the system which produces the radio emission.

Post T Tauri candidates from the original list by Herbig (1978).

Three were observed, and two (V410 Tau and HD 283447, both in Taurus–Auriga) were detected. Both are short-period spotted stars (1.9 days for V410 Tau, 3.4 days for HD 283447) and had been previously detected as radio sources, and both are known to be variable. The distant K binary FK Ser was not detected, although it is otherwise known as a very active star.

Naked T Tauri candidates in Taurus–Auriga

We observed 12 sources identified as x-ray sources by Walter et al. (1988), ranging in spectral type from G5 to M0, with most being K stars. Their x-ray luminosities range from $10^{29.6}$ to $10^{31.3}$ ergs s$^{-1}$. We detected 5 of the 12 targets: the rapidly-rotating G star HDE 283572 (period 1.5 days), the spectroscopic K binary V826 Tau (period 3.9 days); and three stars previously undetected as radio sources, the M2 star 040234+2143, the K5 star 045226+3013 and the K7 star 045251+3016.

Post T Tauri candidates in Ophiuchus

We observed Oph 1 – 4, identified in an x-ray survey of Ophiuchus by Walter (1986), and detected all four stars at fluxes of 0.2 – 0.6 mJy. Oph 1 – 3 are early K-type stars with strong Lithium absorption, and with a Strontium line indicating subgiant luminosity class. Given the results of the rest of the survey, it is remarkable that all four of these stars should prove to be radio sources, when they seem otherwise undistinguished.

Known radio-emitting weak-lined T Tauri’s in ρ Ophiuchi

We observed the well-known radio star DoAr 21, as well as three x-ray-selected targets known to be radio sources: ROX 31, ROX 39 and a source near ROX 43.
(Stine et al. 1988). We detected sources near the center of all four fields, but find that the ROX 43 source (which is about 40" away from the original stellar candidate for the optical counterpart to the x-ray source; the star was not detected) is an extended jet source, and therefore confirm the speculation by Stine et al. (1988) that it is probably extragalactic.

DISCUSSION

Our survey is not complete in any sense, since it was biased in favour of stars already known to be active optically, in x-rays, or in radio. However, we can do some simple comparisons between the stars detected in our survey and those which were not. The mean log of the x-ray flux (ergs s\(^{-1}\)) of the detected stars was 30.5 ± 0.5 (sample of 13), compared with 30.2 ± 0.4 for the undetected stars. We have used the Student t statistic for populations of unequal variance to test the significance of the difference between the two means, and find that there is only a 5% chance that the radio-detected and radio-undetected stars actually have the same distribution of x-ray fluxes.

Ages are given for the subsample of survey stars in the Taurus–Aurigae region by both Walter et al. (1988) and Skrutskie et al. (1990). Using the Walter et al. ages, we find that the mean log of the age of the detected stars was 6.0 ± 0.3, while that of the undetected stars was 6.5 ± 0.6. There is an 11% probability that these two means could arise in samples from a single distribution of ages. However, if we use the Skrutskie et al. values we find that the mean log of the age of the detected stars was 6.2 ± 0.3, while that of the undetected stars was 6.8 ± 0.4; the probability that these two means come from samples from a single distribution of ages is only 0.5%. The Lindroos (1986) stars are nearly all much older than 20 million years, and our failure to detect any of them may be further evidence of an age effect.

A flare was seen on one of the targets, and weak circular polarization was detected on two of the targets: these are discussed by White et al. (1990).

REFERENCES


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