A SEARCH FOR RADIO EMISSION IN THE α PERSEI CLUSTER

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ABSTRACT We report on a search for radio emission in the important young open cluster α Persei, which is intermediate in age between the well-known star-forming clusters in Taurus and Ophiuchus, and the well-studied stars in the Pleiades. It contains rapidly-rotating F and G stars which the Pleiades lacks, and thus strong radio activity might be expected in these stars by analogy with the similar star AB Doradus.

THE OPEN CLUSTER α PERSEI

Despite its now–recognized importance, until recently α Per had not been as widely studied as the Pleiades and Hyades clusters because its low galactic latitude makes it difficult to identify faint cluster members on the basis of proper motions or photometry alone. Until 1984, no cluster members later than G5 were known. Recently extensive astrometric, photometric and spectroscopic surveys of α Per, including rotational velocity measurements, have been carried out (Stauffer *et al.* 1985, Stauffer, Hartmann & Jones 1989, Prosser 1992). They have shown that α Per contains many rapidly–rotating F, G, K and M dwarfs ($v \sin i > 100$ km s^{-1}), with the implication being that the cluster is too young for these stars to have spun down. By comparison, the Pleiades and Hyades clusters do not contain rapidly–rotating stars of types earlier than K and M, respectively (Stauffer 1987, Stauffer 1991). From comparative study of the properties of open clusters, it is believed that the rotation and activity of stars change rapidly between ages of 10 and 100 million years. This is assumed to be because magnetized stellar winds carry away angular momentum and this "magnetic braking" spins the stars down, thus turning off the dynamo action reponsible for magnetic activity. α Per lies in this age range, and provides an obvious testbed for theories of the evolution of activity with age. Here we investigate one diagnostic of activity, stellar radio emission.

We selected candidates for radio observations from the ongoing ROSAT survey of the α Per stars. We included a range of spectral types from F to M, in order to have a representative sample, and also included one candidate flare star

("FS1", Semkov *et al.* 1993). We carried out the survey with the Very Large Array at its most sensitive frequency, 8 GHz, which is also close to the spectral peak of most stellar radio emission. We were allocated time with the VLA during its move from its most compact configuration to its widest configuration (D to A). The range of spatial scales sampled by the two configurations is so disparate that we cannot combine them; we have been forced to use just the wide-configuration antennas in the analysis. In addition, a VLBI program was using 5 of the antennas. Thus our sensitivity was only about half of what would be expected for a full array.

The list of observed stars is shown in the accompanying table. Integration times were of the order of 50 minutes for each of 25 stars (upper portion of table), spread over two observing runs several days apart, and we also made 6–minute snapshot maps of 8 other interesting stars (lower portion of table). Typical rms in the final maps was around 25 μJy, and we will quote a detection limit of 100 μJy. None of the targets were detected. We discuss the implications in the following section.

TABLE I Observed sources in α Persei

Name	Type	$v\sin i$	Name	Type	$v\sin i$	Name	Type	$v\sin i$
AP 19	G-K	61	AP 25	G-K	12	AP 28	K	12
AP 32	G0	71	AP 37	K	29	AP 63	K	161
AP 112	K7	13	AP 117	K	83	AP 118	G-K	160
AP 132	M4		AP 145	M3		AP 149	K	117
AP 167	K5	96	AP 197	K4	12	AP 199	K4	23
AP 203	M		HE 93	G4	12	HE 94	G1	
HE 421	F2	90	HE 520	G3	87	HE 699	G3	90
HE 709	G0	59	HE 876	F5	151	HE 935	F8	78
HE 968	F8	38						
AP 51	F8	70	AP 93	G	75	AP 200	K6	SB2
HE 373	G3	140	HE 581	B9	200	HE 917	F4	40
HE 1101	G4	35	FS1	M0				

DISCUSSION

The example of the active southern star AB Doradus makes us somewhat surprised not to have detected any of the candidates in α Per. α Per is believed to be at a distance of about 160 pc, i.e., 6 times further away than AB Dor (25 pc). AB Dor is a K0 star with $v \sin i \sim 80$ km s^{-1}, and thus there are many stars in our survey of α Per which have properties similar to AB Dor (see table). AB Dor is a strong radio source with luminosity reaching up to $5{\times}10^{16}$ ergs cm^{-2} Hz^{-1}, and is rarely seen at less than $3{\times}10^{15}$ ergs cm^{-2} Hz^{-1} (Lim *et al.* 1992, Lim *et al.* 1993). Our detection limit of 0.1 mJy (which is conservative and will probably improve with further processing) at the distance of α Per corresponds to a luminosity of $3{\times}10^{15}$ ergs cm^{-2} Hz^{-1}, i.e., a typical level for AB

Dor at low activity and well below high activity levels. AB Dor is thought to be about 50 million years old, i.e., the same age as α Per. Weak-lined T Tauri stars, which typically are 1 – 10 million years old, easily reach luminosities of 10^{16} ergs cm^{-2} Hz^{-1} (e.g., White, Pallavicini & Kundu 1992). The Pleiades is only slightly older than α Per, but it lacks the rapidly-rotating F and G stars which α Per still displays. The only extensive survey of the Pleiades reached a detection luminosity of 4×10^{15} ergs cm^{-2} Hz^{-1} (Bastian, Dulk & Slee 1988), but at a frequency of 1.5 GHz which is closer to the spectral peak of M dwarfs rather than the G/K dwarfs which interest us most here. A similar survey of the Hyades detected only two evolved close binaries and no single stars with a detection level of 7×10^{14} ergs cm^{-2} Hz^{-1} at 1.5 GHz (White, Jackson & Kundu 1993).

To a large extent we have allowed for the varying flux levels of radio stars by observing a large number of candidates: it would only require that 1 of the 18 G/K stars receiving longer observations in our survey be in a state equivalent to medium radio activity from AB Dor in order for it to have been detected. We thus believe that the G/K stars in α Per, although rotating as rapidly as AB Dor, are less active as radio emitters than AB Dor. **If AB Doradus is so active because it is young and rapidly rotating, then why didn't we detect any of the AB Dor's in α Per?**

ACKNOWLEDGMENTS

Research in stellar radiophysics at the University of Maryland is supported by NSF grant AST 92–17891.

REFERENCES

Bastian, T. S., Dulk, G. A., & Slee, O. B. 1988, *AJ*, **95**, 794.
Lim, J., Nelson, G., Castro, C., Kilkenny, D., & van Wyk, F. 1992, *ApJL*, **388**, 27.
Lim, J., White, S. M., Nelson, G. J., & Benz, A. O. 1993, *ApJL*, submitted.
Prosser, C. F. 1992, *AJ*, **103**, 488.
Semkov, E. H., Tsvetkova, K. P., Tsvetkov, M. K., & Prosser, C. F. 1993, *Int. Bull. Var. Stars*, **3917**.
Stauffer, J. R. 1987, in *Cool Stars, Stellar Systems and the Sun (Lecture Notes in Physics **291**)*, ed. J. L. Linsky & R. E. Stencel (Berlin: Springer), p. 182.
Stauffer, J. R. 1991, in *Angular Momentum Evolution of Young Stars*, ed. S. Catalano & J. R. Stauffer (Dordrecht: Kluwer Academic Publishers), p. 117.
Stauffer, J. R., Hartmann, L. W., Burnham, J. N., & Jones, B. F. 1985, *ApJ*, **289**, 247.
Stauffer, J. R., Hartmann, L. W., & Jones, B. F. 1989, *ApJ*, **346**, 160.
White, S. M., Jackson, P. D., & Kundu, M. R. 1993, *AJ*, **105**, 563.
White, S. M., Pallavicini, R., & Kundu, M. R. 1992, *A&A*, **257**, 557.