REPEATED MULTIPLE-FREQUENCY VLA SURVEYS OF THE ρ OPHIUCHI CLOUD

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1. INTRODUCTION

Our goal was to look for radio non-thermal emission from active PMS stars, as suggested by the presence of numerous, highly variable X-rays sources in the cloud (Montmerle *et al.* 1983), and by optical periodicities probably linked with starspots (Bouvier and Bertout, in prep.). Previous radio surveys have been done by Brown and Zuckermann (1975), and Falgarone and Gilmore (1981). Emission mechanisms are mainly *thermal* (free-free, from H II regions, winds, accretion flows; gyrosynchrotron), and *non-thermal* (gyrosynchrotron from flares; synchrotron in winds, White 1985; corotating interaction regions, Mullan 1984).

2. OBSERVATIONS

Two surveys were made in Feb. 1983 with the VLA(C): a *wide-field* snapshot (exp. 5 min.) 20-cm survey, and a *central region* 20-cm and 6-cm deeper survey (exp. 60-90 min. over 5 hrs). Preliminary results from data reprocessed with AIPS task MX are as follows. (The reality of some sources is still unclear). The first survey uncovered 64 sources (11 have stellar counterparts on PSS prints). The second survey uncovered 55-61 sources (2-90 mJy at 6cm, 2-45 mJy at 20cm). Of these, 8-12 have an *inverted* spectrum, 5-7 are coincident with objects seen at X/IR/optical wavelengths, and belonging to the cloud (*e.g.* Wilking and Lada 1984). 2-4 were unknown in the radio region; 4-8 more may be associated with the cloud (for early results, see Montmerle *et al.* 1985). Very recent developments include VLA(A/B) observations at 2, 6, and 20-cm (Mar. 1985) for variability studies; a systematic optical survey of the X-ray sources, yielding spectral types for 3 radio-emitting stars (Bertout and Bouvier, in prep.).

3. HIGHLIGHTS

(i) Radio variability (timescales $\lesssim$ few months) is widespread. (ii) Spectra can be misinterpreted if no time information and source size are available. (iii) Several sources are enigmatic. The situation can be il-

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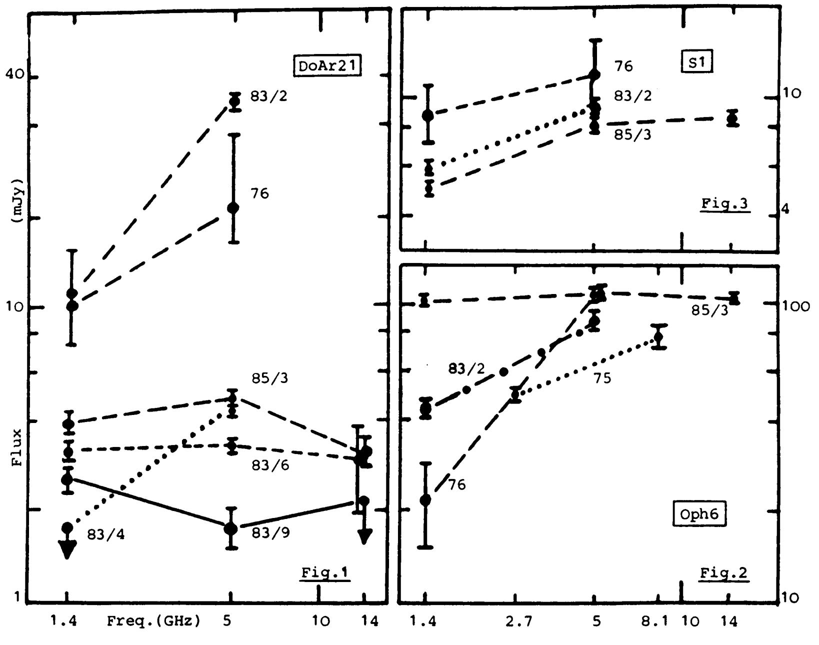
lustrated as follows. A clear-cut case of *flare emission* is DoAr 21 (Fig. 1; Feigelson and Montmerle 1985). (Flares are consistent with the X-ray results). *Inverted spectra* have been widely interpreted as thermal emission from compact H II regions around early B stars, but this is in general not tenable for the ρ Oph sources, even if the spectral fit is good. Indeed, upper limits to source sizes (see below) lead to impossibly low ages (<< $10^3 - 10^4$ yrs) unless the densities are >> 10^8 cm^{-3}, i.e., much higher than given by molecular data (∿ 10^5 cm^{-3}). *Source sizes* must be very small in general. All dense core sources are unresolved at 2 cm in A/B conf. (beam FWHM ∿0\"3). For a strong source like Oph6 (Fig. 2), the visibility function lead to a size < 0\"04, i.e., 10^{14} cm at 160 pc. Such a source may well be extragalactic, in spite of its spectrum (see Kühr *et al.* 1981). Source S1 (Fig. 3) is perhaps resolved at 6 cm in conf. C, yielding a size ≲5". This may be compatible with a standard H II region, but very young (∿ 2.10^4 yrs for 10^8 cm^{-3}). In general (see above), *we do not confirm* the presence of several alleged embedded B stars. This emphasizes the deficiency of massive stars in the cloud, hence a non-standard IMF.



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KUTNER: Could you be seeing hot chromospheres?

MONTMERLE: If you define a "chromosphere" as a thermal region around the star which has a comparatively small scale height, the answer is no. The reason is that, with the fluxes we observe, a small size ($\ell \lesssim R_*$, say) implies a high brightness temperature, hence a non-thermal mechanism. Conversely, a lower brightness temperature ($\sim 10^4$ K, say) leads to an extended emission region (10^{14} - 10^{15} cm, typically).

BALLY: Polarization may in principle distinguish between non-thermal and thermal source models. Detection of polarization implies a non-thermal emission mechanism. Do you have any information on the polarization of the ρ-Oph radio sources?

MONTMERLE: For most of them, not yet; the corresponding data is being processed. Just note that, if it is true that a high level of polarization implies a non-thermal mechanism, the converse is not true. For instance, we are reasonably sure to have seen a flare on DoAr21 (in fact,the first flare ever detected in radio from a pre-main sequence star), whereas the upper limit on polarization (circular as well as linear) is a few percent. In fact, this is to be expected if the emitting region is large enough for the magnetic field along its line-of-sight to have all orientations (case of a loop, etc.).

KAHN: Could it be that these very compact H II regions are really the inner parts of accretion flows?

MONTMERLE: This is quite possible. We just have up to now investigated the more conventional view that we were dealing with standard (but small) H II regions, or with stellar winds. I see that you have a model on accretion flows, so I look forward to some inspiration...

FELLI: Before discarding the thermal interpretation for the radio emission (i.e., that coming from a stellar envelope created by mass loss) I would like to remind you that if the mass loss is close to the critical value: a) small size, b) time variability, and c) change in spectral shape, could be "easily" accounted for.

MONTMERLE: I agree except for the fact that your mechanism requires the flow to be photoionized, whereas in several cases we are dealing with late-type stars, which then must somehow ionize the flow by other mechanism(s),(for instance, DoAr21 is a G star). We plan to look into this in more detail.