RADIO EMISSION FROM YOUNG STELLAR OBJECTS IN THE RHO OPHIUCHI CLOUD

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1. Observations. Following an Einstein X-ray survey of the rho Oph molecular cloud, uncovering several dozen young stellar objects (YSO) (Montmerle et al. 1983), an extensive radio continuum VLA(C) survey was conducted in 1983 to look for counterparts to these sources at 1.4 and 5 GHz (André et al. 1986) To shed light on emission mechanisms, we performed follow-up VLA(A/B) observations of identified radio stars in March 1985 at 1.4, 5 and 15 GHz.

2. Comparison with known populations of YSO in the cloud. The X-ray sources make up a population of late-type PMS stars (Bouvier and Appenzeller in prep.) undergoing solar-type flares. In the VLA(C) survey, out of 93 detected radio sources, we found 8 to be definitely stellar. Only 3 of them were previously known. Few X-ray sources (< 10%) are detected, but most (> 60%) stellar radio sources have X-ray counterparts. This can be understood by analogy with the radio vs X-ray properties of RS CVn systems (well-studied flaring stars) since few of them would be seen at the distance of the cloud (160 pc). However, our stellar radio sources are probably not all flaring objects (see 3). They are distinct from optical T Tauri stars (TTS) since we detected none of 10 bona fide TTS in our entire 1983 radio survey. This emphasizes the finding by Bieging et al. (1984) that TTS are not the strongest radio emitters among YSO. Also, among the infrared sources listed by Lada and Wilking (1984), we detect selectively 'class III' (~reddened blackbodies, see Lada 1987) sources: none of the 5 protostars ('class I') and none of the 21 embedded TTS ('class II') are detected, while 4 out of 6 'class III' objects show radio emission. Along with their spatial distribution (loosely clustered around the dense molecular core of the cloud), this suggests that our stellar radio sources make up a new population of relatively evolved YSO.

3. Nature of emitting objects. The variety of radio spectra observed in 1983 and 1985 (see fig.) suggests that a single emission mechanism cannot account for them all. A previous interpretation (Falgarone and Gilmore 1981) for all sources in terms of thermal emission from compact HII regions around main-sequence B stars is ruled out (see Montmerle et

I. Appenzeller and C. Jordan (eds.), Circumstellar Matter, 61–62.
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https://doi.org/10.1017/S0074180900155913 Published online by Cambridge University Press

al. 1987). Spherical ionized stellar winds are dismissed too, for they lead to spectra (e.g. Wright and Barlow 1975) steeper than observed (see fig.). Collimated winds (see Reynolds 1986) are more likely, leading to flatter power-law spectra. We best interpret the steady radio emission from a source like VSSG 14 as arising from an ionized envelope such that Ne(r)~r(-3/2) (accretion or ballistic expansion, see Bertout 1986). Non-thermal emission from flares (which produces rather steep and bent spectra, see Klein and Trottet 1984) is certainly the explanation for two highly variable sources like ROX 8 (Feigelson and Montmerle 1985) and ROX 31. But clearly, more information is needed to distinguish non-thermal from thermal models in the case of a source like WL 5 (see fig.), and additional observations are planned.

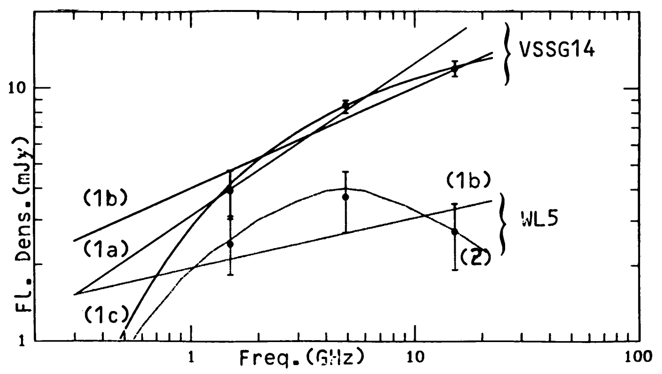

Figure: Possible interpretations of the spectra of VSSG 14 and WL 5. (1) Parameters of thermal emission models: gas temperature, 10(4) K. Wind models: term. velocity: ~ 200 km/s; mass-loss rates : (a) ~ 10(-7) M⊙/yr (spherical wind), (b) ~ 10(-8) M⊙/yr (collimated winds); widths of the collimated winds proportional to (r/r0)(&) with & = 3/4 and 2/3 for VSSG 14 and WL 5 respectively. (c) Accretion model: M* ~ 1 M⊙, Ṁ ~ 10(-8) M⊙/yr; size of the ionized flow: rmax ~ 10(15) cm. (2) Parameters of the non-thermal flare model for WL 5: energetic electron spectrum ~ E(-1.5) between 0.5 and 50 MeV in B = 100 G; density of energetic electrons: 10 cm-3; free-free absorption in the flare plasma of density 10(8) cm-3 and temperature 10(6) K; flare size ~ 10(12) cm.

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https://doi.org/10.1017/S0074180900155913 Published online by Cambridge University Press