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Circumstellar environment around young stars in nearby OB associations

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Abstract. We study the circumstellar environment around intermediate mass young stars in nearby OB associations of different ages. We find that a significant fraction of stars in these associations have cool circumstellar dust around them. Very few of these stars show any emission line activity. These are young Vega-like systems with tenuous dusty disks made of material left over from a more active pre-main sequence phase.

1. Introduction

Young stellar objects (Pre-main sequence stars) are invariably associated with circumstellar material, often distributed in a disk or an envelope, around them. The observable signatures of this circumstellar environment are presence of emission lines in the spectra, near and far infrared excess emission and appreciable polarization of starlight. To wards the end of their pre-main sequence evolution the emission lines and near infrared excesses in these stars weaken and gradually disappear signifying the end of accretion and the consequent disruption of the inner disk; but far infrared excess and polarization can be expected from a gas depleted, tenuous dusty disk which can remain around these stars well into their main sequence phase. However, the disk dispersal timescales and mechanisms are only poorly understood.

Recent discovery of old ($\sim 100 Myr$) main sequence circumstellar dust systems (Vega-like stars) which have been found to occur in at least 15% of nearby field stars (Lagrange et al., 2000) has provided new insights into the disk dispersal processes. These gas depleted, dusty disks are believed to be replenished by the collisional destruction of asteroidal and cometary bodies. A secondary grain generation mechanism had to be invoked because of the old ages of Vega-like systems and the relatively short dust survival timescales

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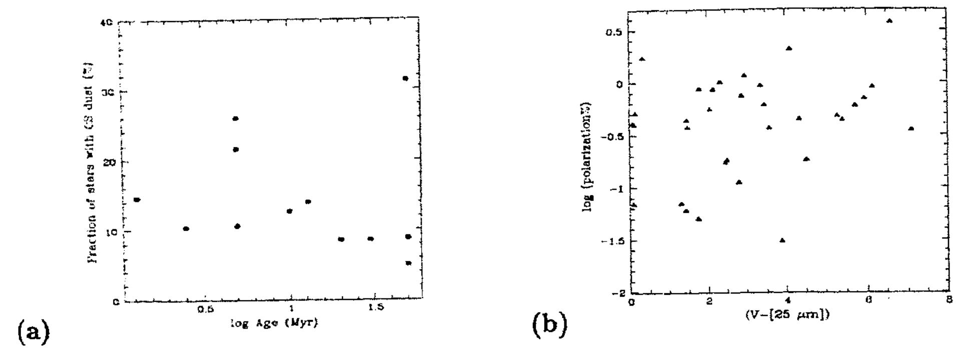

Figure 1. (a) Fraction of stars with IRAS excesses plotted against the ages of the OB associations to which they are kinematically connected (b) Log of polarization for stars in the OB associations plotted against their excess at $25\mu m$. The correlation seen is indicative of the presence of circumstellar dust around the stars

($\sim 10^5$yr) in a gas depleted disk. However, there have been suggestions in the literature, lately, about the existence of young Vega-like systems which are either at the end of their pre-main sequence phase or have just reached the main sequence (Lagrange et al, 2000;. Zuckerman 2001).

A systematic study of the temporal evolution of the circumstellar environment around young stars is not easy because the age determination of individual field stars is a difficult task. But, such a study can be attempted for stars which are members of young clusters and OB associations. The kinematic connection with a cluster or an OB association of known age constrains the stellar ages. Here we study the circumstellar environment around young stars which are members of nearby OB associations of known ages.

Table 1. OB associations studied for signatures of CS environment around member stars

OB Association	Age (Myr)	Mean Distance (pc)	Number of Hipparcos members	Number of stars with CS dust
Perseus OB2	1.3	320	41	6
Lacerta OB1	2.5	370	96	10
Cepheus OB2	5	620	71	19
Collinder121	5	600	103	11
Upper Scorpius	5	145	120	26
Vela OB2	20	410	93	8
Lower Centaurus Crux	10	120	180	23
Upper Centaurus Lupus	13	140	221	31
Trumpler10	30	370	23	2
Cassiopeia-Taurus	50	200	83	26
Perseus OB3	50	200	79	7
Cepheus OB6	50	270	20	1

2. Analysis

We have looked for signatures of circumstellar material around intermediate mass (spectral type B, A or F) stars which are Hipparcos selected members of nearby young OB associations (de Zeeuw et al., 1999). We study 12 OB associations whose ages are in the range of 2 to 50 Myr and which are at mean distances of 120 to 650 pc (see Table 1.). For all the stars in these associations we searched the IRAS Point Source Catalog (PSC) for any possible detection. An excess at any of the IRAS wave bands which has certain detection was taken as an evidence for the presence of circumstellar dust. The frequency of occurrence of emission line stars in these associations was also studied. Available polarization measurements for the association member stars were compiled from literature (Heiles 2000) and analysed for any anomalous polarization indicative of circumstellar material.

3. Results

The fraction of stars showing emission line activity is less than 3% in these associations. It would appear that most of the stars in these associations have ceased to actively accrete circumstellar matter. Even in very young associations with ages $2 - 5Myr$ the number of stars with emision line activity are glaringly small. This suggests that the pre-main sequence phase with active accretion in the intermediate mass young stars last only for a few Myr in these associations.

We find that a significant fraction of stars in the OB associations have circumstellar dust around them. In Figure 1(a). we plot the fraction of stars with circumstellar dust against the ages of associations. On the average $\sim$ 15% of stars in these associations have circumstellar dust around them. A significant number of stars in these associations show appreciable polarization (Figure 1(b).) which cannot be attributed to interstellar component alone. They have intrinsic polarization caused by the scattering of the starlight by the dust in their circumstellar disks as is evident from the correlation between the polarization and the infrared excess. This supports the existence of circumstellar dust in highly flattened disks around the stars.

In Figure 2. we present representative spectral energy distributions for 2 stars in Cas-Tau, and Upper Scorpius OB associations. The excesses at IRAS wavelengths are clearly seen. Estimated dust temperatures from 12 & 25μ flux densities for stars with circumstellar material are found to range from 250 K to 600 K. Dust masses estimated for these stars are in the range of 10^{-3} to $1M_{\oplus}$ which are very similar to that of Vega-like systems.The fact that in Cas-Tau association, which is of 50 Myr old, 31% of the stars show evidence for circumstellar dust argues in favour of a longer timescale for disk dispersal.

The cold dust that we detect is more likely to be the matter left over from the

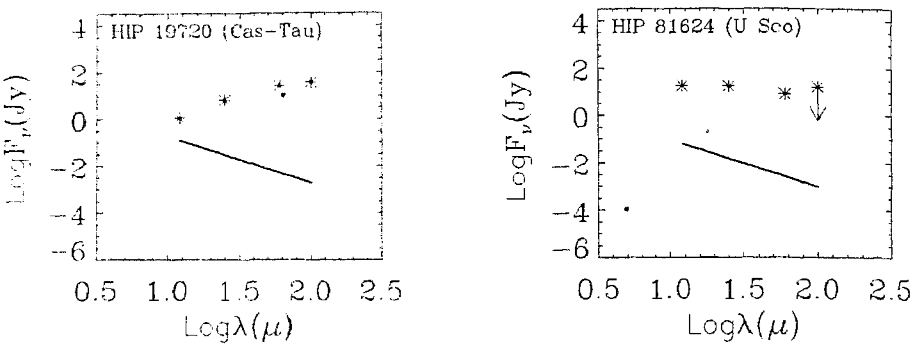

Figure 2. Representative far infrared spectral energy distributions of stars in two different OB associations. The solid line represents the photospheric flux density expected from the star at IRAS wavelengths. Asterisks are IRAS flux densities measured for the stars. Arrows pointing downwards indicates that flux density given is an upper limit

accretion phase distributed in a tenuous and translucent disk around the stars. These stars are very similar to Vega-like stars but much younger.

4. Conclusions

- The active pre-main sequence phase with emission line activity lasts only for a few Myr in the intermediate mass young stars.
- We detect several young Vega-like systems with dusty disks among the members of nearby OB associations.
- The dust we detect around these stars is more likely to be the material left over from their massive pre-main sequence disks rather than the debris product of collisional cascading as in the 'true' Vega-like systems.

References

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