The Disk Fraction of WTTS in the c2d Cloud Maps: Preliminary Results

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ABSTRACT

One of the main goals of the *Spitzer* Legacy Project "From Molecular Cores to Planet-forming disks" (c2d) is to determine whether or not most wTTs have circumstellar disks and to study their properties and evolutionary status. Here we present preliminary results on the disk fraction of a sample of 75 spectroscopically identified wTTs in the c2d IRAC (3.6-8.0 μm) and MIPS (24 μm) maps of the Lupus and Ophiuchus molecular clouds. We find that < 10% of the wTTs in the sample (6/75) have any noticeable IR-excess. Assuming an evolutionary sequence of the form: cTTs ⟶ wTTs with disks ⟶ wTTs without disks, the small number of wTTs with disks implies a rapid transition between optically tick disks and very tenuous disks undetectable at 8 or 24 μm.

Introduction

Weak-lined T Tauri stars (wTTs) are low-mass pre-main sequence stars which occupy the same region of the H-R diagrams as classical T Tauri stars (cTTs) but do not show clear evidence of accretion. Most wTTs show little or no near-IR excess. However, their mid- and far-IR properties remain unclear because past IR telescopes, such as IRAS and ISO, lacked the sensitivity needed to detect mid- and far-IR excesses in low-mass stars at the distances of the nearest star-forming regions. Thus, it remains to be established if wTTs have debris disks, disks with inner holes, or no disks at all. One of the main goals of the *Spitzer* Legacy Project "From Molecular Cores to Planet-forming Disks" (c2d; Evans et al. 2003) is to determine whether or not most wTTs have circumstellar disks and to study their properties and evolutionary status. Here we present preliminary results on the disk fraction of a sample of 75 spectroscopically identified wTTs in the c2d IRAC (3.6-8 μm) and MIPS (24 μm) maps of the Lupus and Ophiuchus molecular clouds.

Sample selection and observations

We analyzed a sample of 75 spectroscopically identified wTTs collected from the literature and located in the c2d IRAC and MIPS maps of Lupus Ophichus. The Lupus wTTs come from Krautter et al. (1997), while the Ophiuchus wTTs were taken from Bouvier & Appenzeller (1992), Chen et al. (1995), Greene & Meyer (1995), and Martin et al. (1998). Most stars in the sample have both IRAC and MIPS photometry from the c2d project; however, for some of the objects only IRAC data is currently available because they fall into MIPS GTO embargoed areas. All the near-IR photometry (J, H, and K bands) comes from the 2MASS all sky survey. Figure 1 shows that < 10% of the wTTs in the sample (6/75) have any noticeable IR-excess. The spectral energy distributions (SEDs) of the 6 wTTs showing noticeable IR-excess (see Table 1) are shown in Figure 2. The optical photometry and the spectral types of the cTTs shown in Figure 3 come from Hughes & Hartigan (1992) and Strom et al. (1989)

Age estimation

We estimated the ages of the wTTs (Figure 1 and Figure3) and cTTs (Figure 3) using the evolutionary tracks presented by D'Antona & Mazzitelli (1998) and Yi et al. (2003). To estimate the stellar effective temperatures (T_{eff}), we adopt the spectral type-Teff relations from Kenyon & Hartmann (1995). The stellar luminosities of the wTTs were obtained from the extinction corrected J-band magnitudes and the bolometric corrections, appropriate for the spectral type, from Hartigan et al. (1994). For cTTs, the I_C-band was used to calculate their luminosities. We estimated the extinction of the wTTs from the J-H color excess assuming an extinction law with R_v=3.1. For cTTs, we used the R_C-I_C colors to calculate the extinction. The age error bars in Figure 2 were calculated assuming one sub-type uncertainty in the spectral type and a 10 % uncertainty in the distance to the objects. According to the models, the ages of the wTTs with IR-excess are indistinguishable from those of cTTs (Figure 3).

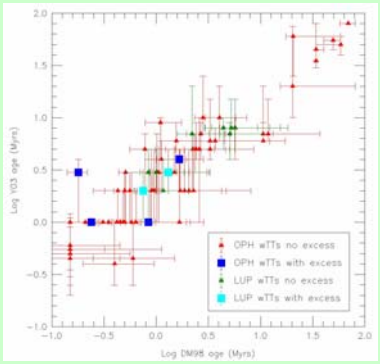

Figure 1. The ages of wTTs with and without IR-excess according to the models by D'Antona & Mazzitelli (1998) and Yi et al. 2003. The age error bars were calculated assuming one sub-type uncertainty in the spectral type and a 10 % uncertainty in the distance to the objects. The figures shows that < 10% of the wTTs in the sample have noticeable IR-excesses at IRAC (3.6-8 μm) and MIPS (24 μm) wavelengths.

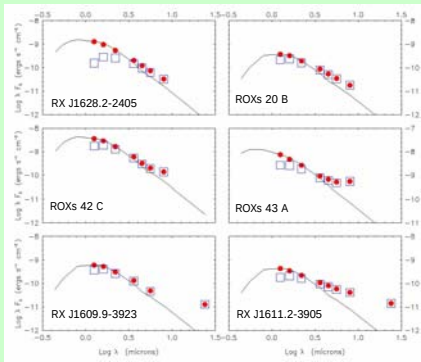

Figure 2. The spectral energy distributions (SEDs) of the 6 wTTs showing noticeable IR-excess. The open squares represent observed fluxes while filled circles denote extinction-corrected fluxes. The solid line represent the expected photosphere normalized to the J-band. Typical uncertainties in photometry are comparable to the size of the symbols shown.

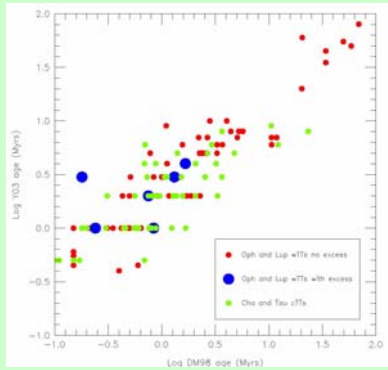

Figure 3. The ages of wTTs and cTTs according to the models by D'Antona & Mazzitelli (1998) and Yi et al. 2003. The large blue circles denote wTTs with IR-excess. According to the models, the ages of wTTs with IR-excess are indistinguishable from those of cTTs.

Table 1: properties of the wTTs with disks

STAR ID	Spectral Type	Lum star ($L_\odot$)	Age D98 (Myrs)	Age Y03 (Myrs)
RX J1628.2-2405	K5	1.04	0.8	1
ROXs 20 B	M2	0.26	1.7	4
ROXs 42 C	K6	2.83	< 0.5	< 1
ROXs 43 A	G8	8.38	<0.5	3
RX J1609.9-3923	M2	0.42	1.3	3
RX J1611.2-3905	M2	0.30	0.8	2

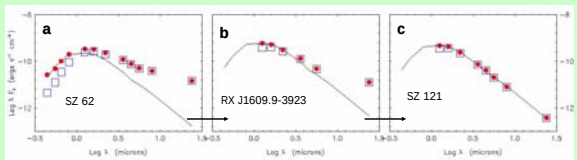

Figure 4. The SED's of a typical cTTs (a), and a typical wTTs (c). Only a small fraction of the PMS show IR-excess in the 3.6-24 μm range AND no near-IR at 2MASS wavelengths as in (b). The open squares represent observed fluxes while filled circles denote extinction-corrected fluxes. The solid line represent the expected photosphere normalized to the I-band (a) and J-band (b) and (c). Typical uncertainties in the photometry are comparable to the size of the symbols shown. Assuming an evolutionary sequence of the form: cTTs ⟶ wTTs with disks ⟶ wTTs without disks, the small number of "transitions objects" such as RX J1609.9-3923 (b), implies a rapid transition between optically tick disks and very tenuous disks undetectable at 8 or 24 μm.

Preliminary results

- Less than 10% of the wTTs in the sample (6/75) have any noticeable IR-excess at IRAC and MIPS (24 μm) wavelengths.
- The ages wTTs with IRAC and MIPS excesses are indistinguishable from those of cTTs.
- Assuming an evolutionary sequence of the form: cTTs ⟶ wTTs with disks ⟶ wTTs without disks, the small number of wTTs with disks implies a rapid transition between optically tick disks and very tenuous disks undetectable at 8 or 24 μm.

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