FAR INFRARED EMISSION FROM POST-T-TAURI STARS

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ABSTRACT. We have investigated a large sample of faint Post-T-Tauri stars located far from dark cloud complexes, for far-infrared emission and infrared excess, using the IRAS data-base. ~12% of the stars studied here were detected by IRAS at 12 μm. Their 12 μm luminosities L_{12} are in the range of $4x10^{30}$- $6x10^{33}$ erg/sec and correlate well with the stars' bolometric luminosities (L_{bol}).

IRAS has detected emission from the photospheres of the stars studied here and for a few of them it may have observed far-IR excess.

1. INTRODUCTION

Post-T-Tauri stars are young stars, <150 million years of age, in the pre-main sequence phase of their evolution; they are more evolved than T-Tauri stars. Many P-T-Tauri stars show CaII and Hα emission lines as well as Li absorption lines, in their spectra; these features appear weaker here than in T-Tauri stars.

A very extensive and detailed study of eighty such stars was done by Lindroos (1986), in the optical wavelength region. Here we investigate the far infrared emission and possible IR excess of these 80 stars, using the IRAS data-base.

T-Tauri stars are strong sources of infrared emission and show IR excess, which is attributed to cold dust surrounding the star. P-T-Tauri stars, on the other hand, do not exhibit appreciable IR excess, as the scanty observations at 1 μm, show. The stars studied here are mainly F, G and K spectral type and are physical companions to B and A primaries, with which they form wide pairs. About thirty such systems were detected by IRAS; here we consider only the detections (eleven of them) for which the infrared fluxes can be attributed to the late-type secondary, i.e. to the P-T-Tauri star.

2. OBSERVATIONS

The Infrared Astronomical Satellite (IRAS) scanned the entire sky (98%)

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between 8 and 120 μm, with peaks at 12, 25, 60 and 100 μm. The IRAS survey of the IR sky was extremely reliable and very sensitive. Point sources detected during the survey mode are given in the Point Source Catalogue (PSC 2; 1987). In addition to the sky survey, the infrared satellite performed a series of pointed observations over selected areas of the sky, which were three to five times more sensitive than the survey mode and resulted in extending the IRAS detection threshold for point sources. Sources detected during pointed observations appear in the Serendipitous Survey Catalogue (SSC; 1986).

We searched the PSC 2 and the SSC at the positions of the eighty P-T-Tauri stars, for positional coincidences with the IRAS-detected sources. For stars with positive detections (in the PSC 2) we proceeded with coadding the multiple survey scans in order to enhance flux sensitivity. The fluxes given here are 10% better than those in the PSC 2; The flux errors are 0.03 - 0.05 Jy.

3. RESULTS AND DISCUSSION

IRAS has detected eleven P-T-Tauri stars at 12 μm and a few at 25 μm. For these stars it was possible to obtain 12 μm fluxes (f_{12}) and in turn estimate their 12 μm magnitutes (m_{12}) through the expression, $m_{12} = 4.03 - 2.5 \log f_{12}$ (IRAS Explanatory Supplement, 1985). Table I gives the IRAS-detected sources (columns 1 and 2), together with their far IR fluxes (columns 3 and 4), magnitudes (column 5) and luminosities (column 6). In column 7 the ratio of 12 μm luminosity (L_{12}) to the star's total luminosity (L_{bol}) is shown. In column 8 a measure of the IR excess is estimated.

The L_{12} of the detected stars is in the range of 4×10^{30} - 6×10^{33} erg/sec and comprise only 0.01-1% of the star's bolometric luminosity. A good correlation is found to exist between L_{12} and L_{bol}, as seen in Fig. 1. The two stars, SAO 196352 and 218788, deviate considerably from the mean relationship; they are not included in the least squares fit, which is indicated by the line drawn through the data points. The correlation coefficient of this relationship is 0.96.

In order to investigate whether the detected far IR emission of the P-T-Tauri stars is solely due to the stellar photosphere, we compare it to that of normal stars (stars with no IR excess), of the same spectral type. A large number of normal stars has been studied extensively by Waters et al. (1987), at the far infrared. They found a very tight color-color relationship to exist between B-V and V-12 of all main-sequence stars (from O to K spectral type) with no IR excess or other peculiarities. In terms of an equation this relationship is best described by:

$$V-12 = 0.05 + 3.13\,(B-V) - 1.26\,(B-V)^2 + 0.29\,(B-V)^3 + 0.16\,(B-V)^4$$

Making use of the above expression the predicted V-12 and m_{12} were obtained for the detected P-T-Tauri stars. The predicted values were in turn compared with the corresponding observed quantities. The last column in Table I gives the deviation of the observed 12 μm magnitude from that expected of a normal photosphere. As it can be seen, there are several stars for which the $m_{12}(obs) - m_{12}(pred)$ is considerably larger than the errors associated with the estimated quantities;such large deviations

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would tend to indicate the presence of excess emission. The stars that deviate the most from the normal stellar situation are SAO 196352, 218788 and 207208 with $\Delta m(12\mu m)>2.0$ mag. The first two stars were also seen (on Fig.1) to emit more radiation at 12 μm than their bolometric luminosity would tend to indicate.

It is concluded that for the P-T-Tauri stars studied here, the far IR emission observed by IRAS is photospheric in origin with the exception of a few stars for which there is an apparent excess emission. This IR excess tends to indicate the presence of an additional emitting component which could be material surrounding the star.

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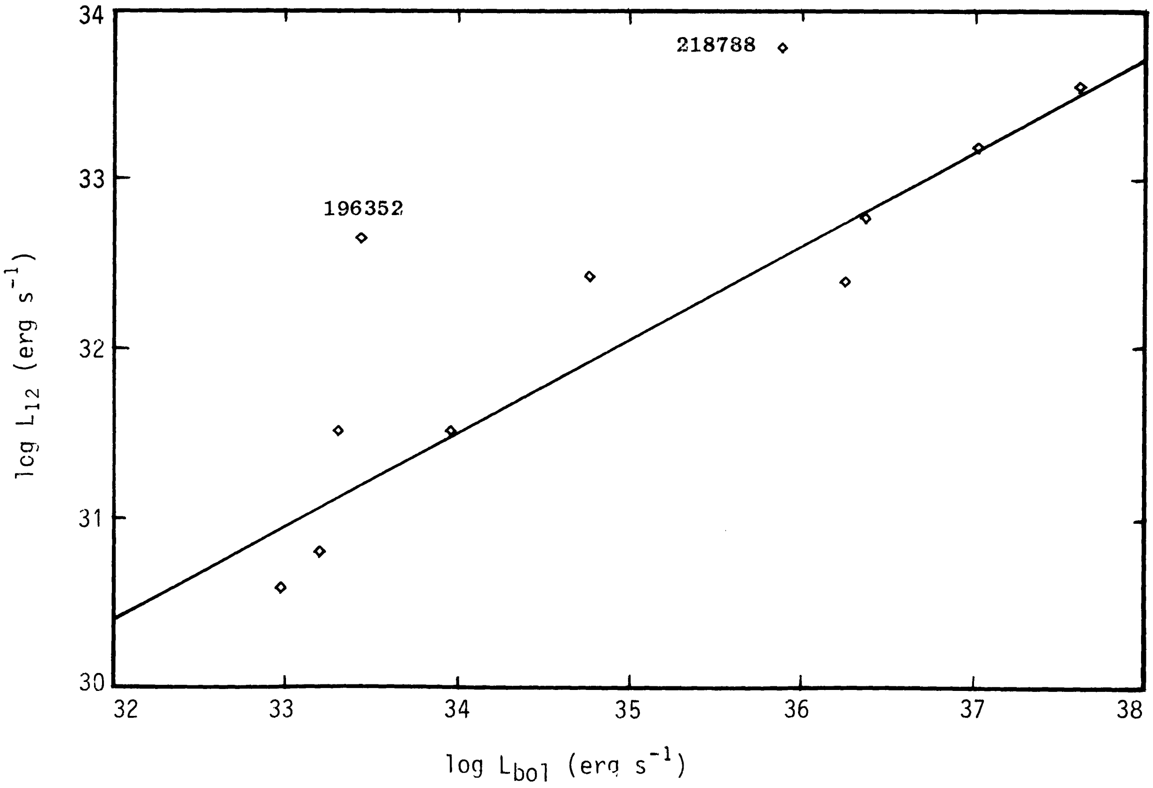

Fig. 1: Plot of 12 μm luminosity L_{12} vs bolometric luminosity L_{bol} for IRAS-detected Post-T-Tauri stars. The straight line shows the best least squares fit, not including SAO 196352 and 218788.

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TABLE I

Far-infrared properties of IRAS-detected P-T-Tauri stars

IRAS source name	SAO name	f_{12} Jy	f_{25} Jy	m_{12} mag	$\log L_{12}$ [erg s^{-1}]	L_{12}/L_{bol} $\times 10^{-2}$	Δm (12 μm) $m_{obs}-m_{pred}$
00075+1052	91750	0.17	-	5.95	31.52	1.6	-1.62
04195+2530	76573	0.18	-	5.89	31.52	0.36	-0.15
05325-0602	132301	0.44	-	4.92	33.56	0.01	-1.02
05557-3517	196352	0.17	-	5.95	32.66	17.0	-4.74
07314-4905	218788	0.31	-	5.30	33.78	0.77	-2.74
07367-2641	174199	0.52	0.36	4.74	32.40	0.01	0.23
10056+1212	98967	0.28	-	5.53	30.81	0.41	0.13
12272-1614	157323	0.25	-	5.54	30.59	0.42	-1.00
S12516-5653	240367	1.00	0.64	4.03	32.78	0.02	-0.40
15568-3815	207208	0.37	-	5.10	32.43	0.47	-2.10
16025-1940	159682	1.75	0.39	3.42	33.20	0.02	-1.24

Notes: Columns 1 and 2 give the IRAS-source name and the name of the associated star as it appears in the SAO catalogue. Columns 3 and 4 give the 12 and 25 μm fluxes in Jy. Columns 5 and 6 show the estimated (using the fluxes in column 3) 12 μm magnitudes and luminosities. Column 7 gives the ratio of the 12 μm luminosity to the star's total luminosity. Column 8 shows the difference between the IRAS (observed) 12 μm magnitude and that of a stellar photosphere (predicted).

MIRZOYAN: How can a B star be a post-T Tauri star?

TSIKOUDI: The stars are above the main sequence. The early type stars could be called post-Herbig Ae,Be stars.

MIRZOYAN: How is the age determined?

TSIKOUDI: From Stromgren photometry of the primary main sequence component and calibration over standard main sequence models.

GAHM: In the survey the separation between the components were not very large. Are the IRAS sources separated?