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Warm Dust Around Main-Sequence Stars Discovered With 2MASS

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Abstract. We report results of ground-based 10 μm photometry of main-sequence stars with warm ($T_{dust} \sim 300$ K) circumstellar dust. We originally discovered these dust systems through IRAS 12 μm excess emission relative to 2MASS J, H, and K_s photospheric emission. We possibly confirmed circumstellar 10 μm excess emission from four sources.

1. Introduction

The first star known to be associated with terrestrial temperature dust, possibly the analog of zodiacal material in the inner solar system, was β Pictoris (Gillett 1986). Since then, there have been detections of comparably warm ("exozodiacal") dust around a few other stars, such as 51 Oph, B9.5 Ve (Waters, Coté, & Geballe 1988) and ζ Lep, A2 Vann (Aumann & Probst 1991), among others.

More recently, Fajardo-Acosta, Beichman, & Cutri (2000, hereafter FBC) reported the discovery of IRAS 12 μm excess emission, with respect to Two-Micron All-Sky Survey (2MASS) near-infrared photospheric extrapolations, in eight main sequence stars. Determining that these excesses originate from circumstellar dust necessitates small-aperture photometry. In this manner we can discriminate neighboring contaminating background sources in the large (45" × 270") IRAS 12 μm beam.

Here we report on a continuation of the original FBC search for 12 μm excesses using IRAS and 2MASS. We also measured sources via ground-based 10 μm photometry, to check for the reality of circumstellar excesses.

2. Observational Data From IRAS, 2MASS, and Palomar/MIRLIN

In the FBC original survey, 12 μm excesses were searched for from 296 main-sequence stars at $|b| > 20°$. For each star, FBC obtained 2MASS Second Incre-

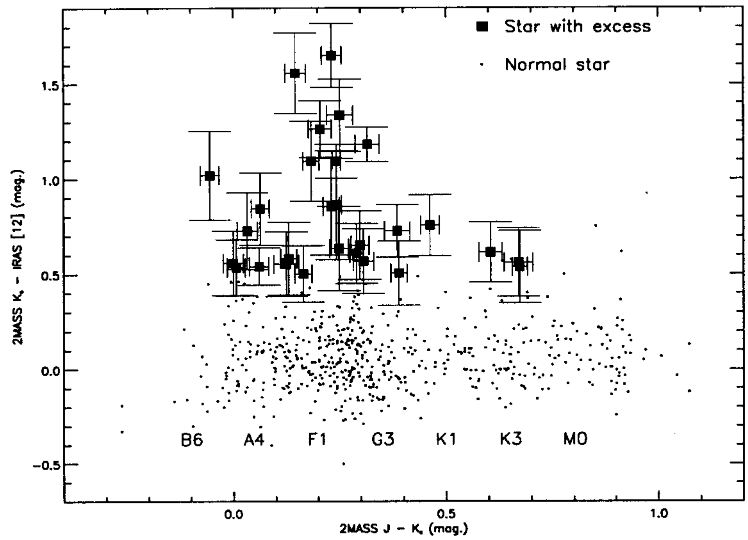

Figure 1. Color-color diagram of 627 main-sequence stars: $K_s-[12]$ vs. $J-K_s$. The 29 stars with 12 μm excesses appear above the mean $K_s-[12]$ of normal stars.

mental Data Release J, H, and K_s photometry, and IRAS Faint Source Catalog (FSC, Moshir et al. 1992) 12 μm photometry. The IRAS 12 μm photometry was required to be of moderate to high quality, with each star having at most one 100 μm-only (cirrus) neighboring source. Excess emission at 12 μm was searched for by comparing the 2MASS K_s – IRAS [12] color of the star, with the same mean color for normal stars of the appropriate spectral type. FBC found eight stars in their sample with $K_s-[12]$ excesses greater than 2σ (including uncertainties in individual star photometry and in the mean $K_s-[12]$ colors of normal stars).

We augmented the survey by FBC, wherein 47% of the sky was covered, by using the 2MASS full-sky database of point sources. We also used, in addition to the FSC, the IRAS Serendipitous Survey Catalog (SSC, Kleinmann et al. 1986). We identified 627 main-sequence stars in our sample. In Figure 1 we show the color-color diagram ($K_s-[12]$ vs. $J-K_s$) that we used to identify 29 stars with 12 μm excesses, among our main-sequence sample. In order to rule out IRAS 12 μm spurious excesses from neighboring background sources, we obtained photometry of 12 stars using the MIRLIN camera at the Palomar Observatory 200-inch telescope. We measured the stars through the broadband N (10.8 μm) and the 7.9–12.5 μm narrowband "silicate" filters.

3. Discussion

We confirmed the IRAS 12 μm excesses, through our MIRLIN photometry, of HIP 21377 (A1m V), HD 67150 (F8 V), HD 59509 (F8 V), and SAO 42588 (G5 V). Figure 2 shows the 2MASS, IRAS, and MIRLIN photometry of SAO 42588. The IRAS data for this, and the majority of our stars with 12 μm excesses, are upper limits at, and longwards of, 25 μm. Therefore, it is not known if our stars with excesses have cold dust ($T_{dust} \approx 100$ K), which would emit at $\gtrsim 20$ μm.

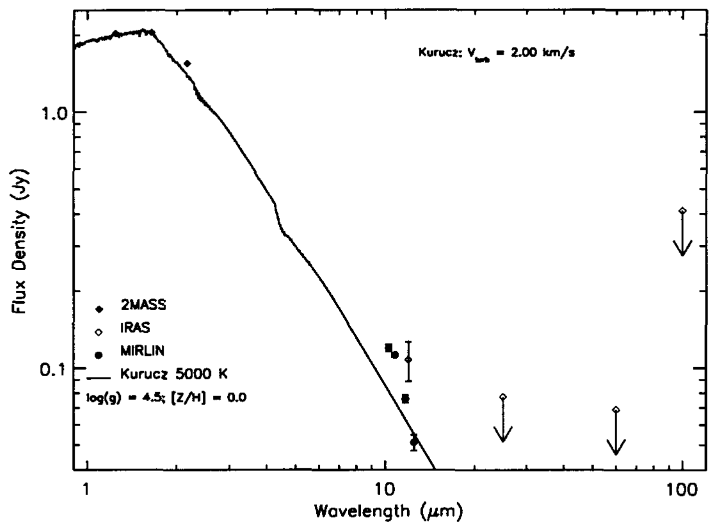

Figure 2. 2MASS, IRAS, and Palomar/MIRLIN photometry of SAO 42588 (G5 V), and Kurucz photospheric model.

Instead, the stars with confirmed 12 μm excesses could have warm dust ($T_{dust} \approx$ 300 K). FBC showed that such warm dust would be located at $\sim$ 10 AU from the stars. The photometry of SAO 42588 (Figure 1) shows a 10 μm emission feature that disappears at 12.5 μm. It is possible that hot silicates ($T_{dust} > 300$ K) emitting at, and shortwards of, 10 μm could explain the excess of this source.

The lack of cold ($\sim$ 100 K) dust emission from these sources could be due to the lack of prominent "Kuiper Belt-type" dust structures around them. Observations at 20 μm and longer wavelengths, with more sensitive instrumentation than IRAS, such as with the MIPS camera on-board SIRTF, will let us see if indeed colder dust is absent from these systems.

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