False signs of debris disks

Stellar-ISM interactions

András Gáspár, Kate Y. L. Su, George H. Rieke, Zoltán Balog, Eric Mamajek, Inga Kamp, Juan R. Martínez-Galarza, Karl Stapelfeldt

Steward Observatory, University of Arizona, Tucson, AZ

E-mail: agaspar@as.arizona.edu

Introduction

Planetary debris disks appear to account for the large majority of the mid- and far-infrared excesses around main-sequence stars, however they are not the only plausible explanation.

Hot gas around stars can emit free-free emission, yielding mid-IR excess. Chance alignments of background galaxies can also mimic debris disk-like mid- and far-IR excesses at stars. Also, excesses can arise through the heating of dust grains in the interstellar medium around stars. These ISM structures are usually much too large in extent to be gravitationally bound to the stars, such as the Pleiades reflection nebulosities.

Dynamical, high speed interactions of early-type stars with the ISM can produce mid-IR bow shock structures within a few hundred AUs of the stars, which emit with a spectral energy distribution (SED) that closely resembles that of a planetary debris disk (Martínez-Galarza et al. 2008). We modeled δ Velorum to be such a system in Gáspár et al. (2008). We show the images and fitted SED of δ Velorum in Figures 1 and 2, respectively.

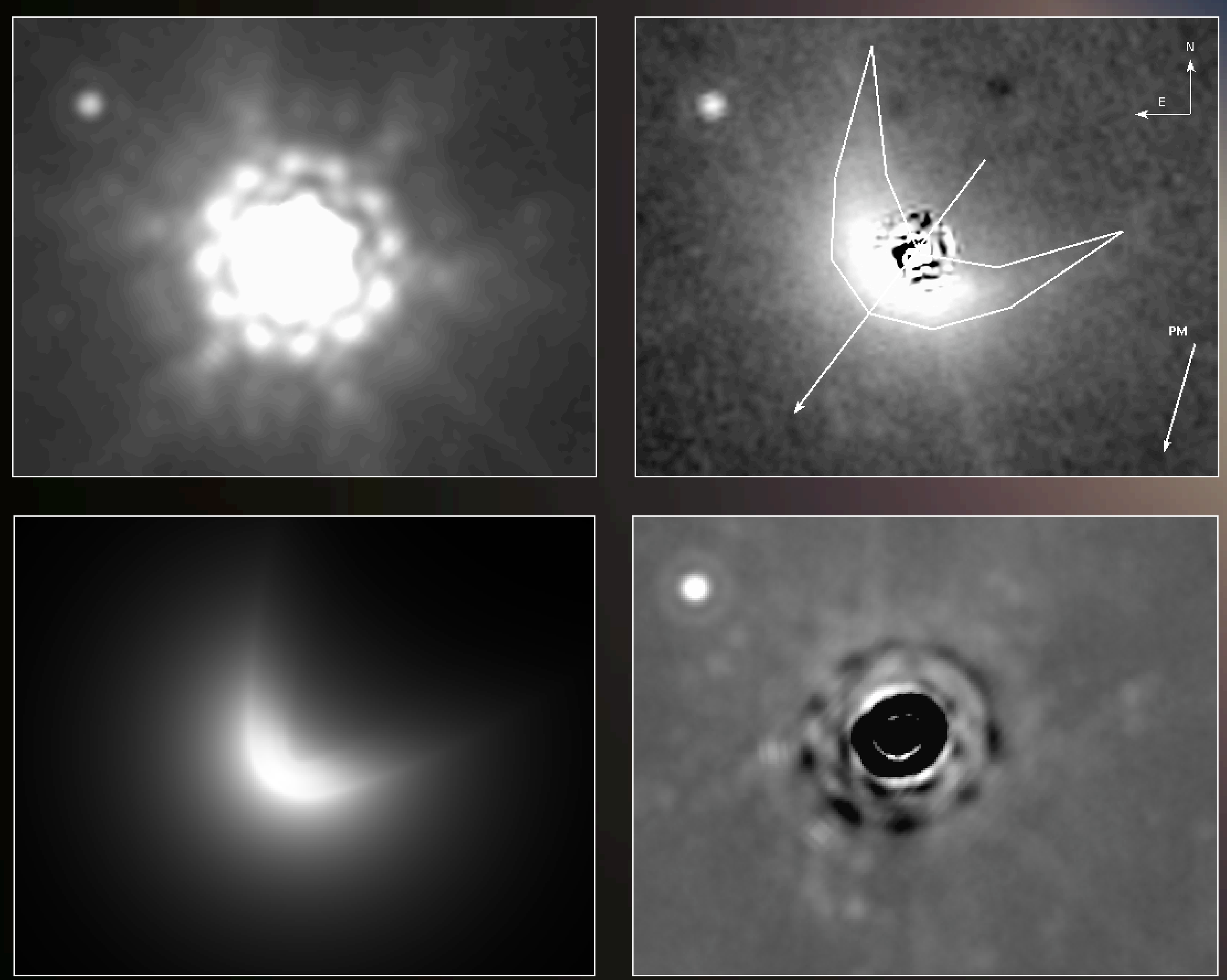

Figure 1. — The panels show images (calculated and observed) of the δ Velorum system. The field of view is ~ 2.74′ x 2.34′ (3900 x 3300 AU). *Top left panel:* Original observed MIPS 24 μm image. *Top right panel:* PSF subtracted image, showing the bow shock structure. The orientation of the images and the star's proper motion is plotted on this image. *Bottom left panel:* The calculated bow shock thermal intensity distribution of the ISM. *Bottom right panel:* The model bow shock and PSF subtracted image, showing only small residual flux.

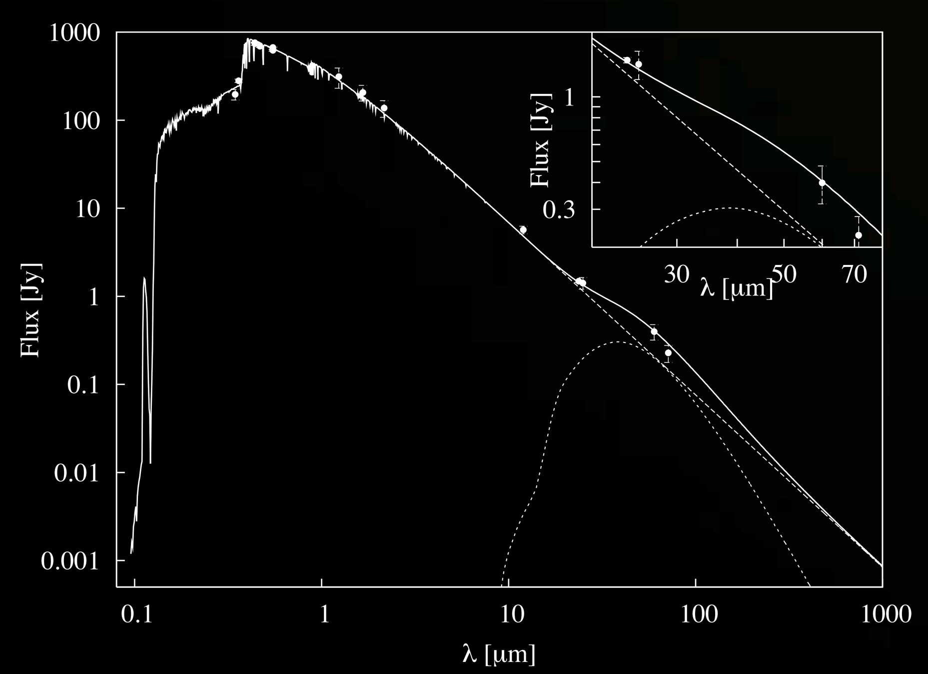

Figure 2. — The calculated SED and the observed photometric points of δ Velorum. The window in the upper right corner is a magnified part of the SED between 20 and 80 μm. The plotted points in the magnified window are MIPS 24 & 70 and IRAS 25 & 60 μm fluxes. The dashed curve of the ISM dust SED shows the 9.7 μm silicate feature. The total amount of mass needed to yield our observed mid-IR fluxes is 0.023 M_{Moon} (within a 1366 AU radius).

Frequency of Bow Shocks

The formation of bow shock structures requires the high velocity (> 25 km s^{-1}) interaction of an early spectral type star (< A9) with its surrounding ISM. The resulting bow shocks will be in the vicinity of the star (~ few hundred AUs), thus challenging to resolve.

We searched the SSC database archive for observations of B and A spectral type stars within 45 pc of the Sun (totaling 182 stars). We found Spitzer 24 μm observations for 105 stars.

We subtracted an empirical Spitzer MIPS 24 μm point-spread function (PSF) from the images of the 105 available stars. We have found 2 definite bow shock stars from the sample of 105 stars, including δ Velorum. Of the 105 stars, 22 show a debris disk like mid-IR excess. This means that roughly 10% of the infrared excesses around early-type stars within the Local Bubble could be the result of stellar-ISM interactions. We also introduce our new Bow Shock star in Figure 3. The star's full modeling has not been completed, our results on it are preliminary.

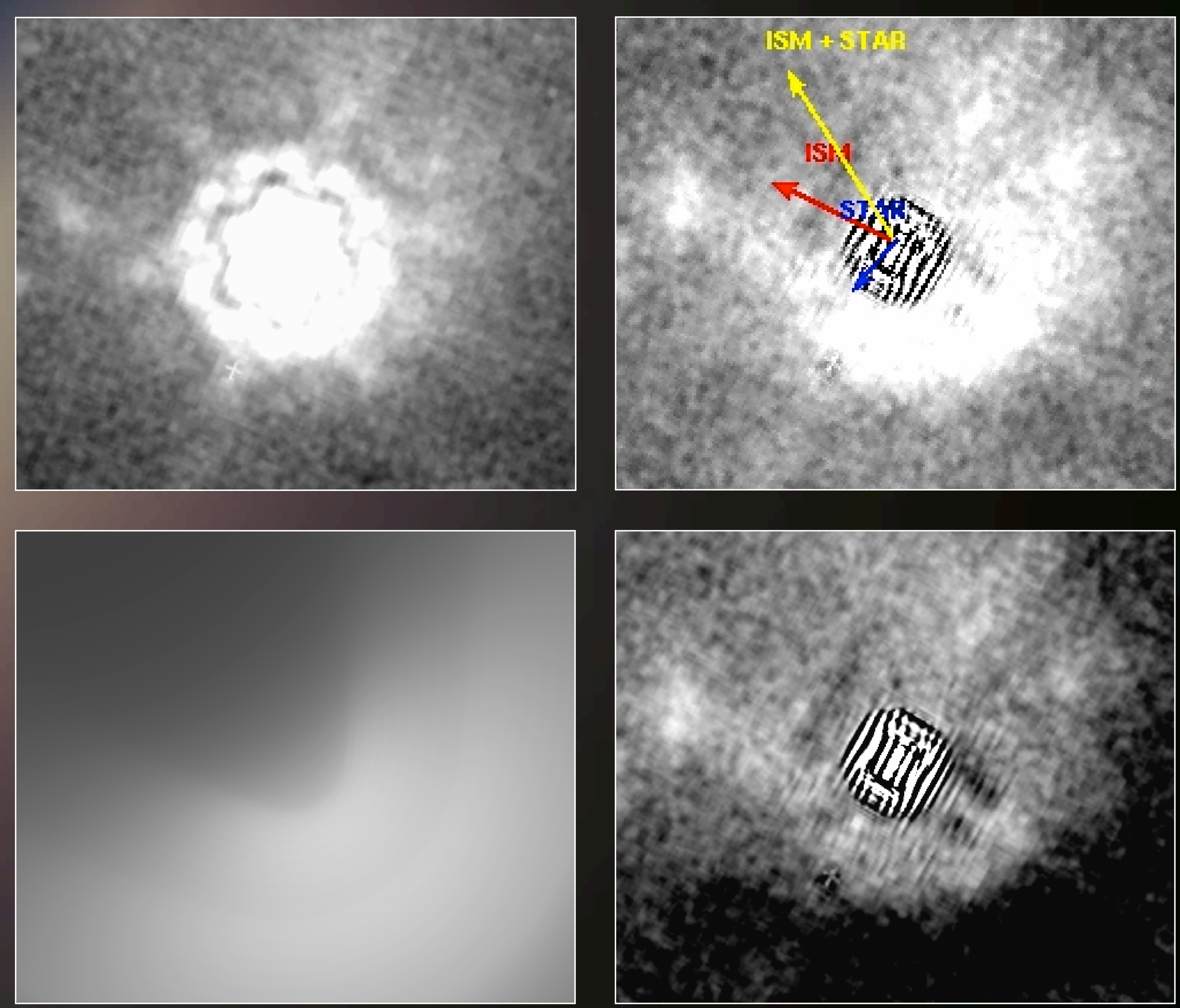

Figure 3. — The panels show images (calculated and observed) of the new candidate system. The field of view is ~ 2.62′ x 2.22′ (4800 x 4100 AU), with N up and E to the left. *Top left panel:* Original observed MIPS 24 μm image. *Top right panel:* PSF subtracted image, showing the bow shock structure. The direction of the star's proper motion and the bulk ISM motion of the Doradus cloud are plotted on this image. *Bottom left panel:* The calculated bow shock thermal intensity distribution of the ISM. *Bottom right panel:* The model bow shock and PSF subtracted image, showing rather large residual flux.

The model used to calculate the surface brightnesses, detailed in Gáspár et al. (2008), is a stationary solution, with the dust removed once it reaches the bow shock surface. The new system shows the problems with this model, as it does not account for the snowplow pile-up of the ISM dust at the shock surface at high relative velocity (~ 52 km s^{-1}) encounters. We are developing a new code that will model the dynamical interaction within such systems.

References

Gáspár, A., et al. 2008, ApJ, 672, 974

Martínez-Galarza et al. 2008, ApJ, submitted