

TITLE: Search for Planetary Companions in Stars with mid-IR Excess

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Scientific Motivation

The vast majority of the circumstellar stellar disks identified around mature stars ever since the discovery of a far-infrared excess over the photospheric flux in VEGA correspond to cold ($T_{\text{dust}} < 120$ K) dust. Since the dust removal time-scales by the Poynting-Robertson drag or radiation pressure are much less than the stellar ages, this material is necessarily replenished by processes such as collisions of planetesimals. This dust, akin to that in the Edgeworth-Kuiper Belt (EKB) of our solar system, is usually located at large stellocentric distances and has its principal observational imprint at (sub-)millimeter wavelengths, with little to no effects at shorter wavelengths. In contrast, a second class of debris disks with warm ($T_{\text{dust}} > 120$ K) component is easily identified at mid-IR wavelengths.

Warm debris disks around Sun-like stars are unusual and have been confirmed for a few stars (see, e. g., Kennedy and Wyatt 2012), however, this picture is gradually changing with results from the pointed observations of Spitzer MIPS and the all sky survey carried out by AKARI (Fujiwara et al. 2013) and WISE (Cruz-Saenz de Miera et al. 2014; Patel et al. 2014). These new mid-IR detections await confirmation through observations at far-IR and (sub-)mm wavelengths. Even though warm debris disks are still rare, their study is strongly motivated by two principal aspects: (i) warm material is expected to be close to the host star, within a few astronomical units, and therefore, they represent valuable laboratories to study the potential correlation between the detected material and the presence of larger bodies (planets) in orbits similar to that of the Earth, and (ii) warm disks have posed interesting theoretical challenges to explain their presence and relatively large masses. Their fractional luminosities, well above the estimated fractional luminosity of the solar system zodiacal dust cloud (Dermott et al. 2002), escape explanations through the models of terrestrial planet formation (Kenyon & Bromley 2005) or the steady state planetesimal grinding, and have to be formed through other mechanisms such as transient events (Wyatt et al. 2007). The origin of the warm dust has been explained under two possible scenarios. The first, (a) includes small-scale collisions among a large population of solid bodies, something analogous to the so-called Late Heavy Bombardment (LHB) in the Solar System (Cohen et al. 2000). In fact, such an explanation has been proposed by (Lisse et al. 2012) to account for the debris disk around η Corvi. The second (b) scenario involves the cataclysmic collision of two rocky, planetary-scale bodies, which could explain the debris disk around BD+20 307 (Weinberger et al. 2011).

In the case of evolved pre-AGB stars, two additional scenarios may explain the presence of mid-IR excess: (c) it could be caused by a PAH-rich disk, such as in HD 233517 (Jura et al. 2006), due to the engulfment of a low-mass star in a short-lived binary system; or (d) the increased luminosity of the post-MS star increases the sublimation radius of the system releasing a significant amount of mass encased in cometary bodies or EKB objects (e.g., Jones 2008). Giant stars with planets and WISE W4 excess have already been observed, as in Morales et al. (2012). In general, evolved stars of luminosity classes II, III, and IV represent a significant fraction of the host stars of the so far 1786 identified exoplanets. From the first detection of an exoplanet around the giant star HD137759 (K2III), reported by Frink et al. (2002), to the latest finding around the M67 member Sand634 (Brucalassi et al. 2014), a total of 156 evolved stars, with ascribed spectral classification, have planetary companions.

The Sample

We propose to observe a small sample of stars that have been identified to possibly possess warm circumstellar dust. To construct the sample we have searched the WISE database for objects that appear to be detected (at 5σ) at both W3 ($12\mu\text{m}$) and W4 ($22\mu\text{m}$) bands and that have an ($>3\sigma$) excess over the photospheric value at $22\mu\text{m}$ (see Cruz-Saenz de Miera et al. 2014 for details on the procedure). In Field 2, we obtain 282 targets (with k2fov flag=1 and 2), while, in Field 3, they are a total of 36.

In scenarios (a) and (b), bandished to explain the origin of warm dust, planetary companions are the source, hence there are great chances of discovery of new exoplanets, in particular Earth-sized planets in the terrestrial planet zone. Overall, the proposed observations, together with ancillary data at other wavelengths, will contribute to address fundamental questions as: What is the origin of this warm dust component?, How often is it associated with a cold component, as for instance the case of η Corvi?, How does it correlate with stellar properties such as age?. The answer to these questions are of fundamental importance to understand the dynamical evolution and the presence of substellar companions around stars that display IR excesses, and ultimately, to better understand the formation of terrestrial planets within the history of our Solar system.

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