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Warm debris disks candidates in transiting planets systems

Á. Ribas (1), B. Merín (1), D. R. Ardila (2) and H. Bouy (3)
(1) Herschel Science Centre, European Space Astronomy Centre (ESA), Spain (aribas@sciops.esa.int) (2) NASA Herschel Science Center, California Institute of Technology, USA, (3) Centro de Astrobiología, INTA-CSIC, Spain

Abstract

We have bandmerged candidate transiting planetary systems (from the Kepler satellite) and confirmed transiting planetary systems (from the literature) with the recent Wide-field Infrared Survey Explorer (WISE) preliminary release catalog. We have found 13 stars showing infrared excesses at either 12 μm and/or 22 μm. Without longer wavelength observations it is not possible to conclusively determine the nature of the excesses, although we argue that they are likely due to debris disks around the stars. The ratios between the measured fluxes and the stellar photospheres are generally larger than expected for Gyr-old stars, such as these planetary hosts. Assuming temperature limits for the dust and emission from large dust particles, we derive estimates for the disk radii. These values are comparable to the planet's semi-major axis, suggesting that the planets may be stirring the planetesimals in the system.

1. Introduction

Debris disks are the remnant of the planet formation process. The small detected amounts of dust are produced by collisions among, or evaporation of, planetesimals [5]. According to [4], ~16% of main-sequence FGK stars have debris disks, which typically show a peak in their Spectral Energy Distribution (SED) at 70-100 μm, suggesting the presence of relatively cold dust (brightness temperatures $\sim$ 50 K). This reveals they are analogs to the Solar System's Kuiper Belt rather than the asteroid belt.

However, ~4% of solar-type stars have 24 μm excess flux, as seen with the *S*pitzer Space Observatory [4]. Its presence at ages above 100 Myr is problematic since neither terrestrial-planet formation models nor steady state asteroid planetesimal grinding models can reproduce them. Their interpretation requires the warm dust to be very transient in nature. The influence of planets close to an existing asteroid belt can result in planetesimal collisions and thus an increasement in the dust amount, that would appear as a warm infrared excess.

Matching the 1235 first transiting planets candidates from the *Kepler mission* and the confirmed transiting systems with photometric values from the Sloan Digital Sky Survey (SDSS), the 2 Microns All Sky Survey (2MASS) and the Wide-field Infrared Survey Explorer (WISE) Preliminary Release Catalog (PRC), we were able to identify 13 objects which show strong evidences of harboring a warm debris disk [2].

2. The sample

2.1. Observations

We crossmatched the initial sample (Kepler + known transiting planets) with SDSS, 2MASS and WISE photometry, covering from the near-UV up to the mid-IR range. From the initial sample, 546 objects showed counterparts both in 2MASS and WISE.

2.2. Candidates selection

We fitted a Kuruzc model to these 546 objects. Following the procedure at [1], we searched for excesses at the two longest bands of the WISE survey (12 and 22 μm). An "infrared excess" was defined as

$$\chi_\lambda = \frac{F_{observed} - F_{model}}{\sigma_{total}} \quad (1)$$

Those objects with $\chi_{12} > 2$ or $\chi_{22} > 2$ were selected and visually inspected to exlude those sources with possible source confusion or problems with the photometry. 13 objects survived this process.

3. Results

We fitted a blackbody to reproduce the excess found at 12 and/or 22 μm (see fig. 1). Upper limits at 22 μm (when existing) are used to constrain the dust temperature (100-500 K).

This temperature value can be used to estimate the distance of the dust to the host star, leading to values ranging from 1 to 5 AU.

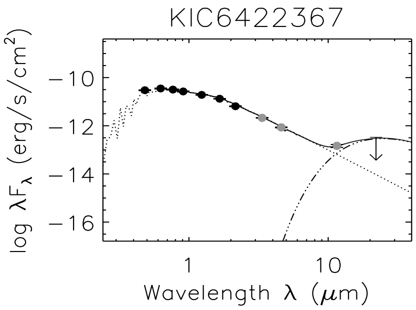

Figure 1: An example of the SED of one of the selected systems. SDSS and 2MASS (black dots) and WISE photometry (grey dots) is shown (an upper limit is found at 22 μm). The fitted photosphere (dashed line) does not reproduced the observed fluxes at 12 and 22 μm. The fitted blackbody is also plotted (dashed-dotted line).

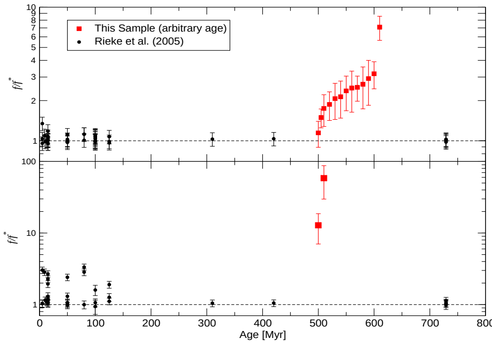

Figure 2: Excess as a function of time (F /F_{model}) for 12 (top) and 22 μm (bottom). The sample in [3](black dots) and this sample (red dots) are shown. Since the ages of the Kepler candidates are generally unknown, we have assumed ages between 500 and 600 Myr for our sample for illustrative purposes.

4. Analysis

Although different explanations can be given to this phenomenon (a background galaxy alignment, a cool companion, interaction between the host star and an interstellar cloud,...), all of them are found to be higly improbable. On the other hand, all of these systems harbor planets with semi-mayor axis >1 AU. This fact could be pointing to a gravitational interaction between the planet and a close asteroid belt. The stirring of the disk would result in dynamical instabilities which would produce collisions among the planetesimals, filling the inner regions of the systems with dust. Other reasonable explanations for this excesses are the existence of a massive cometary reservoir with highly eccentric orbits, or the infall of bodies from an outer debris disk.

The existence of warm IR excess is correlated with age, appearing at a greater frequency for young stars. However, the sample of the *Kepler mission* has been explicitly selected to contain mostly old solar-type FGK stars. Altough there are no age measurements yet for this sample, a prelimiary comparison of these excess with the sample in [3] is shown in fig. 2.

5. Summary and Conclusions

Significant IR excess at 12 and/or 22 μm is found in 13 planetary systems from matching the first 1235 candidates from the *Kepler misison* and a sample of previously known transiting planets hosts with the WISE Preliminary Release Catalog. Different explanations for these excesses are considered.

This study is being extended using the WISE All Sky Catalog, and therefore the presented results and candidates are bound to be modified in the near future.

Acknowledgements

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