# The Incidence of Debris Disks Around M Dwarfs Within 25pc

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## Introduction

**DEBRIS disks are made up of planetesimals** that have been ground up by repeated collisions. Our solar system contains two such disks: the Asteroid Belt and the Kuiper Belt. Is this normal?

The incidence of debris disks around sun-like stars has been determined to be ≈16% for cold disks and ≈4% for warm disks (Trilling et al. 2008). However, the incidence of debris disks around the stars that make up around 75% of our stellar neighborhood, M stars, is unknown. This is mainly because debris disks are more difficult to detect around cooler stars. Debris disks absorb the light of their host star then re-emit the light in the infrared. To identify a debris disk, we detect this emitted infrared light. Due to the star's colder temperature, a disk around an M star will radiate at a longer wavelength than the same disk at the same distance around a G star, making it more difficult to detect. Therefore, we will only be able to detect disks that are relatively close to their host stars. In this study, we attempt to answer two questions:

- **What is the incidence of detectable debris disks around M stars within 25pc?**
- **What are the fractional luminosities and inner radii of these disks?**

Ultimately, these results can be compared to models to determine the overall distribution of all debris disks around M stars.

## Methods

**WE examined two samples of stars:** one of 1288 M and K dwarfs within 25pc (sample 1) and another of 172 young M and K dwarf stars within 25pc (sample 2). For each sample we searched for excesses in 12 and 22 microns using data from WISE.

We first plotted each sample on a color-color diagram (Figure 1). Each axis of a color-color diagram represents one color or the difference in brightness between two wavelengths. Stars of a given spectral type should clump together in this diagram. Stars with debris disks will appear unusually red due to the infrared light from the disk. This will push them to the right of the main clump on the color-color diagram.

However, not all extra-red stars have debris disks. We therefore made spectral energy distribution (SED) plots for each outlier. The SED plots show the brightness of each star as a function of wavelength. If a star has a debris disk, its SED will appear brighter in the infrared than would be expected if the star were a perfect blackbody (Figures 2 and 3).

Once we identified the stars with debris disks, we then determined the distance from the star to the inner edge of the debris disk using the method outlined in Trilling et al. (2008). We finally determined the fractional luminosity, which reflects the mass of the disk, using the method outlined in Koerner et al. (2010).

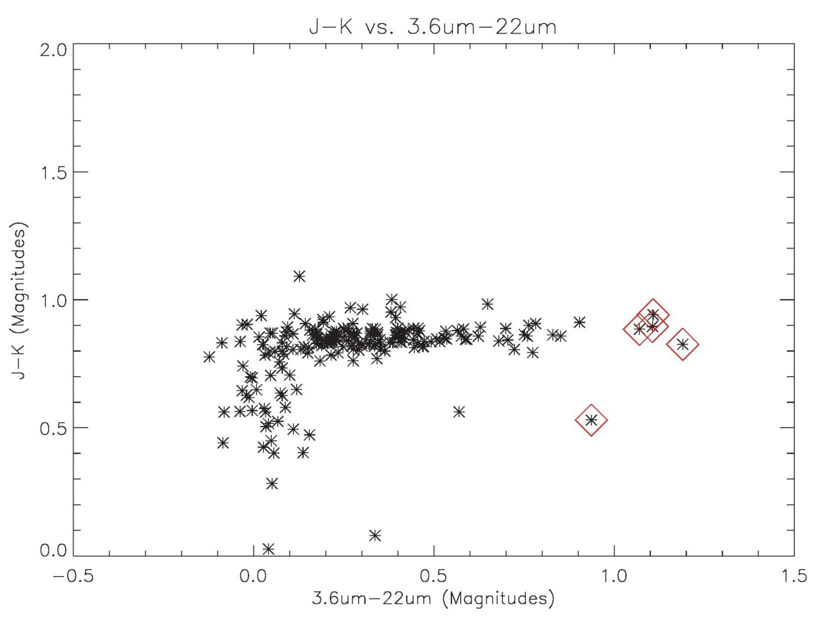


**Figure 1:** A color-color diagram of J-K vs. 3.6µm-12µm for sample 1. Each black asterisk represents a star. Each red diamond represents a star that has an excesses at either 12 or 22µm, indicating the presence of a debris disk.

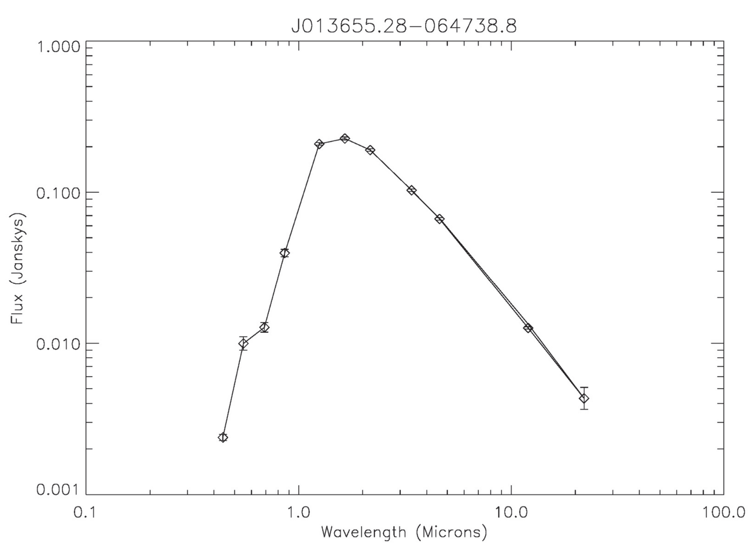


**Figure 2**: The observed SED of this star lines up almost exactly with the Rayleigh-Jeans section of the theoretical blackbody plotted on top of it. This indicates that this star does not have an infrared excess and therefore does not have a debris disk.

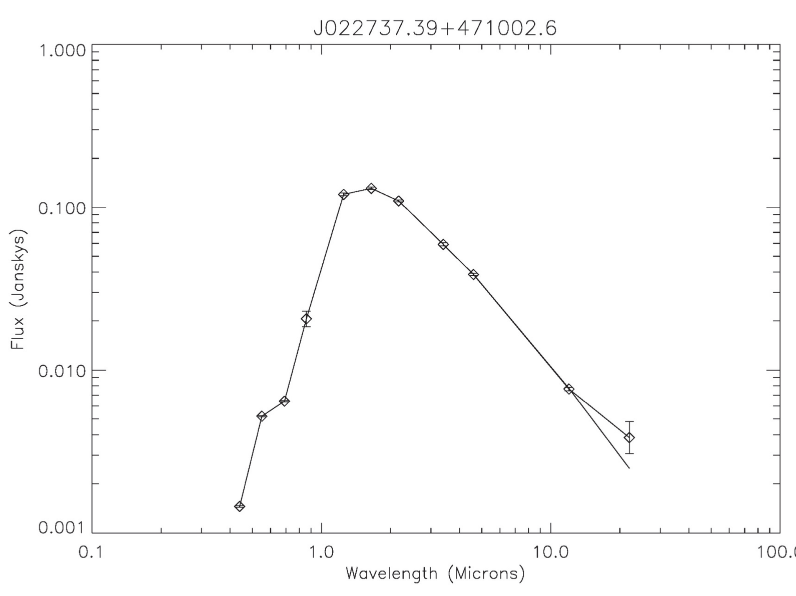


**Figure 3:** The observed SED of this star deviates from the Rayleigh-Jeans section of the theoretical blackbody plotted on top of it at 22µm. This indicates the presence of an infrared excess and, therefore, a debris disk.

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## Results

**WE detected a total of 19 debris disks**, corresponding to an incidence of $1.8^{+2.4}_{-1.3}$. Figures 4 and 5 show the distribution of fractional luminosities and inner radii for the debris disks we detected. The inner radius for our asteroid belt is about 2.0AU (Spratt, 1990) and has a fractional luminosity on the order of $10^{-7}$ (Wyatt, 2008). Thus, all of the disks that we were able to detect were relatively large and close to their host star. This is consistent with the low temperatures of the M stars. Figure 6 shows the properties of debris disks we could detect.

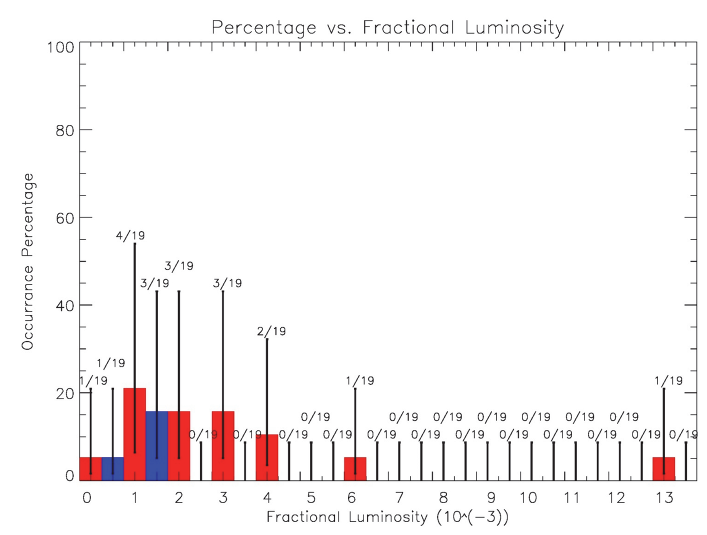


**Figure 4:** A histogram of the number of disk having a range of fractional luminosities.

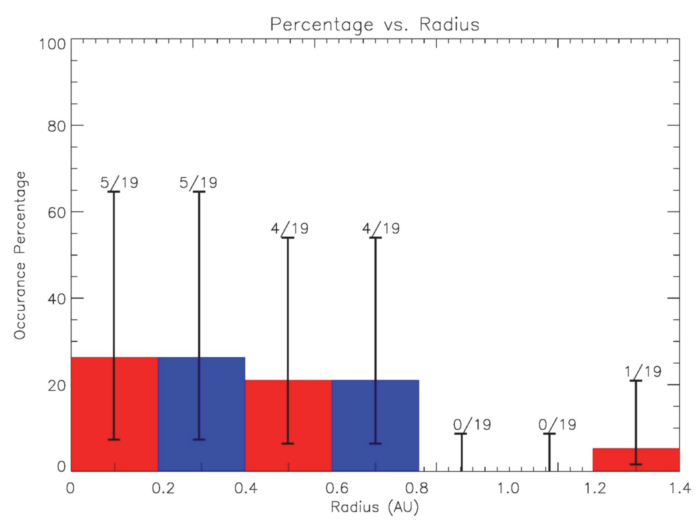


**Figure 5:** A histogram of the number of disk at each radius.

## Future Work

**TO apply these results** to the overall distribution of debris disks around M dwarfs, we must compare the debris disks we detected to the debris disks we could have detected. Figure 6 plots distance from star to disk versus fractional luminosity with each line representing 3σ detections for spectral types K0 through M9. In our study, any disk above a given line would be detected at 3σ if it were around a star of that spectral type. A model of the distribution of debris disks around M stars can be now be applied to test if that distribution yields the same percentage of detected debris disks found in this study.

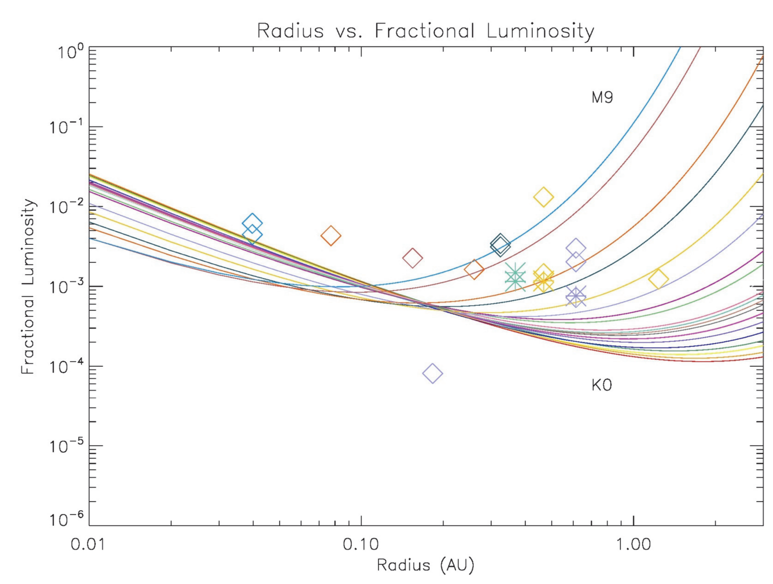


**Figure 6:** Plot of distance from star to disk versus fractional luminosity with each line representing 3σ detections for spectral types K0 through M9 with the line for K0 on the bottom and the line for M9 on the top. The lines in between ascend linearly. The diamonds and asterisks represent the debris disks we detected around old and young stars respectively. The color of the diamonds and asterisks corresponds to the color of the line for that object's spectral type.

## Acknowledgements

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