The Frequency of Debris Disks at White Dwarfs

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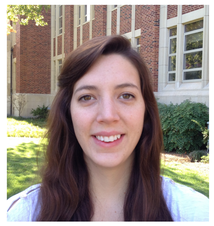

Background

- Circumstellar debris detected as flux excess in IR
  - Giant planets may perturb orbits of minor bodies in post-MS
  - Minor bodies are tidally disrupted when brought near WD
  - Debris eventually embodies disk geometry
- Disks serve as tracers for giant planets at WDs
  - Disk frequency gives lower limit on frequency of planets at WDs
- We present a near- and mid-IR survey of a metallicity-unbiased WD sample to constrain the true frequency of disks at WDs

Observations

- Near- and mid-IR photometry and spectroscopy from PAIRITEL, IRTF, and *Spitzer*
- Unbiased (in terms of metallicity) sample of 117 DA WDs with $T_{\rm eff} = 9,500 - 22,500\,K$ from the PG survey
  - Previous surveys for disks at WDs focused on metal-rich WDs

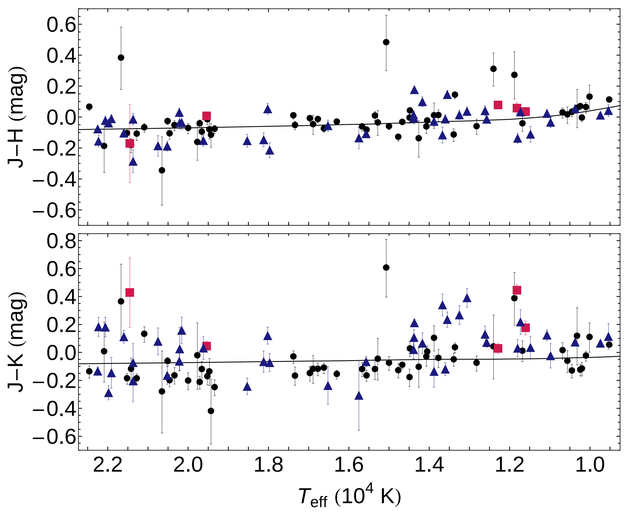

Figure 1: Near-IR photometry of 82 WDs from PAIRITEL

- WDs with positive $J-K$ colors followed-up with *Spitzer* IRAC & IRTF SpeX

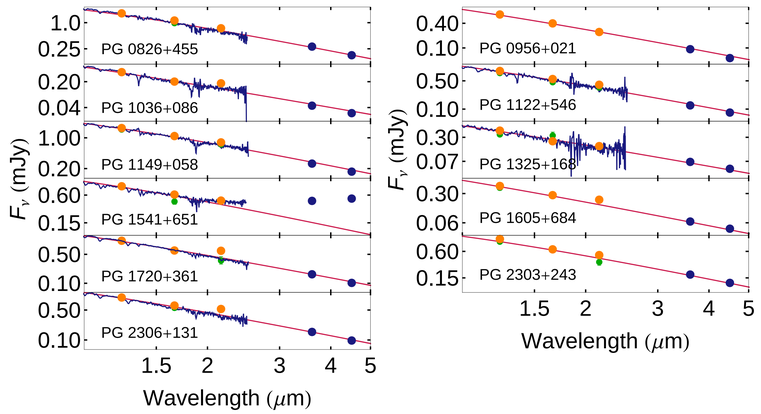

Figure 2: *Spitzer* IRAC photometry of 11 WDs observed in Cycle 7

Results

- Out of 117 DA WDs, 5 show significant IR excess
  - Novel disk discovery around PG 1541+651 (Kilic et al., 2012)
  - Confirmation of four known disks

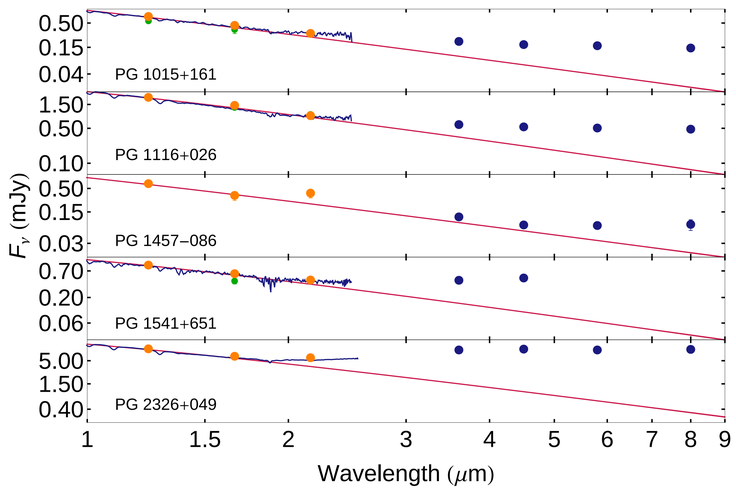

Figure 3: SEDs of the five dusty WDs in our sample

- WISE data reveal no new dusty WDs in our sample

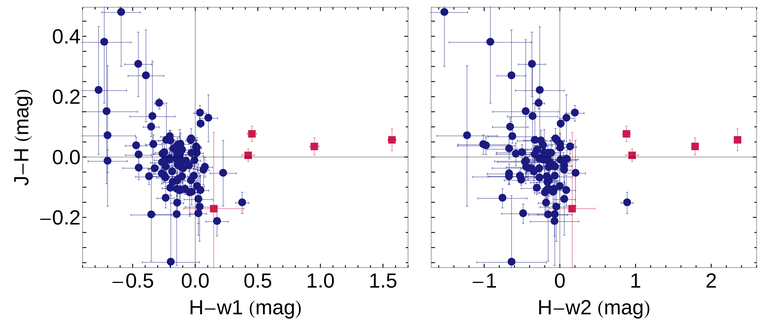

Figure 4: Mid-IR photometry from WISE

Frequency of debris disks is $4.3^{+2.7}_{-1.2}\%$

Discussion

- Using the initial-final mass relation derived by Kalirai et al. (2008) and Williams et al. (2009), we find that a $1-7M_\odot$ MS star has at least a $4.3^{+2.7}_{-1.2}\%$ chance of hosting planets
  - This extends the search for exoplanets beyond the range available to conventional detection methods
- We also find that debris surrounding WDs is supplied through disruption of objects as massive as Solar System asteroids, moons, and dwarf planets
  - Perhaps all WDs host disks, but they survive for only $4.3^{+2.7}_{-1.2}\%$ of the WD cooling age
  - Assuming observed accretion rates of $10^8-10^{11}\,g\,s^{-1}$, typical WDs may accrete up to $10^{24}\,g$ of metal over $10\,Myr$, the total time they host circumstellar disks
  - This amounts to the mass of the dwarf planet Ceres or Pluto's moon Charon

References

Kalirai, J. S., Hansen, B. M. S., Kelson, D. D., et al. 2008, *ApJ*, 676, 594
Kilic, M., Patterson, A. J., Barber, S., Leggett, S. K., & Dufour, P. 2012, *MNRAS*, 419, L59
Williams, K. A., Bolte, M., & Koester, D. 2009, *ApJ*, 693, 355