The Fraction of Infrared Bright and Unseen Circumstellar Debris at White Dwarfs

M. Rocchetto[1], J. Farihi[1], B. T. Gänsicke[2], C. Bergfors[1]

[1] Department of Physics & Astronomy, University College London, Gower Street, WC1E 6BT, UK
[2] Department of Physics, University of Warwick, Coventry CV4 7AL, UK

Contact: m.rocchetto@ucl.ac.uk

UCL

1 Introduction

Asteroid polluted white dwarfs commonly exhibit closely orbiting circumstellar material, resulting from the tidal disruption of rocky minor planets (Farihi et al. 2009). These stars offer a unique laboratory to examine the bulk composition of terrestrial exoplanets, via the metal pollutants in their atmospheres, which mirror the composition of the accreted material (Zuckerman et al. 2007).

Here we present the results of an unbiased double-blind *Spitzer* and *HST* survey of a 134 young white dwarfs, to determine the fraction of infrared bright and unseen circumstellar discs at white dwarfs.

2 *Spitzer* & *HST* observations

We selected an unbiased sample of 134 white dwarfs in the age range 20–120 Myr and corresponding effective temperature 17000 K < $T_{\rm eff}$ < 25000 K.

The entire sample was observed with *HST* COS in order to identify metals indicating the presence of circumstellar material, and with *Spitzer* IRAC in order to detect infrared bright discs.

The *HST* results are published in Koester et al. (2014) and the *Spitzer* results in Rocchetto et al. (in prep.)

3 Result: distinct disc frequencies observed with *HST* & *Spitzer*

HST observations of 85 sample stars show that a fraction of at least 27% of white dwarfs have metals indicating the presence of accreting circumstellar material. However, only five infrared excesses were found amongst the 134 degenerates observed with *Spitzer*, translating to a nominal frequency of 3.7% of bright debris discs in this $T_{\rm eff}$ range.

For those stars observed by both *HST* and *Spitzer*, only two infrared excesses were found amongst metal polluted degenerates with circumstellar material, indicating that *91% of debris discs remain undetected in the infrared due to their low fractional luminosity*. The higher frequency of very subtle infrared excesses found amongst metal polluted degenerates corroborates this interpretation (Fig. 1).

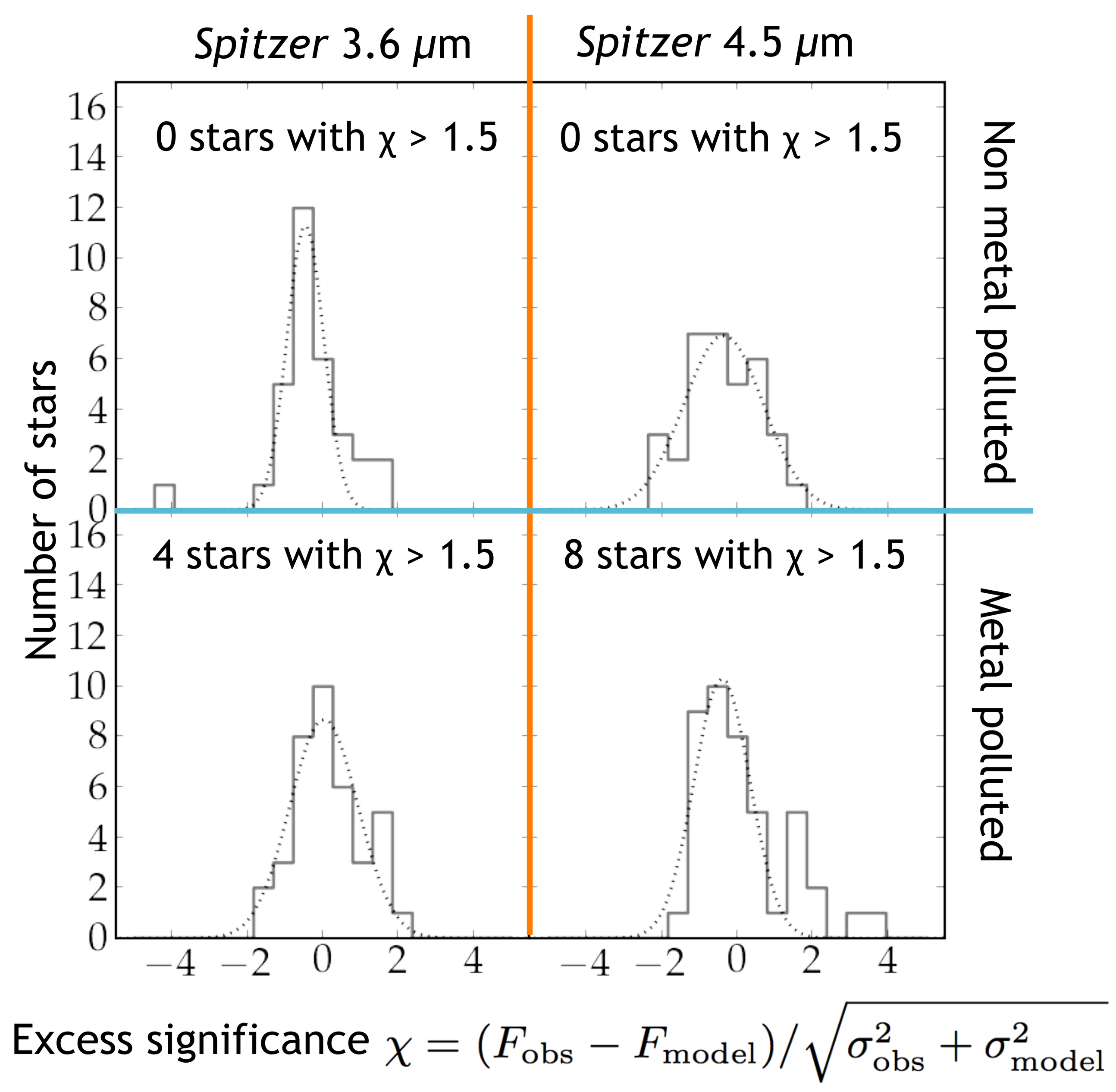

Fig. 1 - Excess significance χ of stars observed with *Spitzer* and *HST*. Excesses with χ > 4 are excluded. In the absence of real excesses the distribution of χ should resemble a Gaussian.

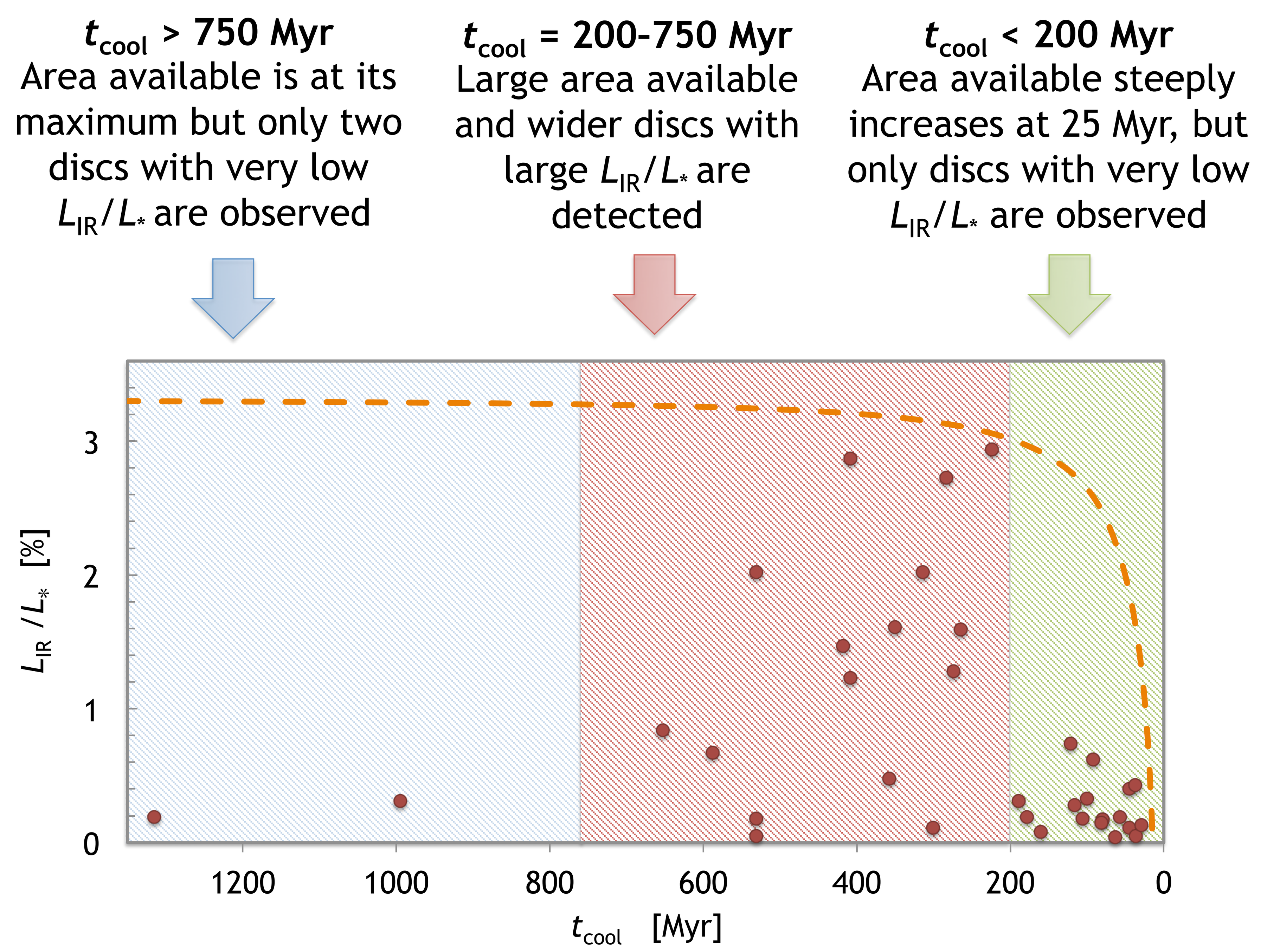

Fig. 2 - Infrared disc fractional luminosity ($L_{\rm IR}/L_*$) for all known dusty white dwarfs as a function of cooling age ($t_{\rm cool}$). The orange line shows the total area available to dust grains between the silicate sublimation radius and the stellar Roche limit (≈ 1.2 $R_\odot$) and scaled to the infrared excess found at GD 56, which has been modeled with a face-on disc and has the highest observed $L_{\rm IR}/L_*$

4 Disc evolution: the emerging picture

The distribution of the infrared fractional luminosity (Fig. 2) can provide insight into the evolution of the discs. At cooling age $t_{\rm cool}$ < 25 Myr dust grains rapidly sublimate and no dust disc can form.

As the white dwarf cools and ages the area available for dust grains steeply increases as shown by the red dashed line in Fig 2. However, this increase is not seen in the observed values of $L_{\rm IR}/L_*$, suggesting that only narrow rings form at white dwarfs with $t_{\rm cool}$ <200 Myr (green region).

For $t_{\rm cool}$ = 200–750 Myr (red region) a wide range of observed $L_{\rm IR}/L_*$ is seen, compatible with a random distribution of disc inclination and radial extent.

A sudden drop in both the fraction of detected discs and the observed fractional luminosity is seen at $t_{\rm cool}$ > 750 Myr (blue region), where only two narrow rings are detected. This suggests a possible decline in the reservoir of large asteroids.