On the formation, evolution, and destruction of minor planetary bodies.

Thomas Wilson
Jonathan Rawling, Jay Farihi, Bruce Swinyard (UCL)
Ovidiu Vaduvescu (ING)

Outline

Formation

- Modelling the Origin of O_2 in Comet 67P

Evolution

- **Herschel Observations of Non-Typical Cometary Water Ortho-to-Para Ratios**

Destruction

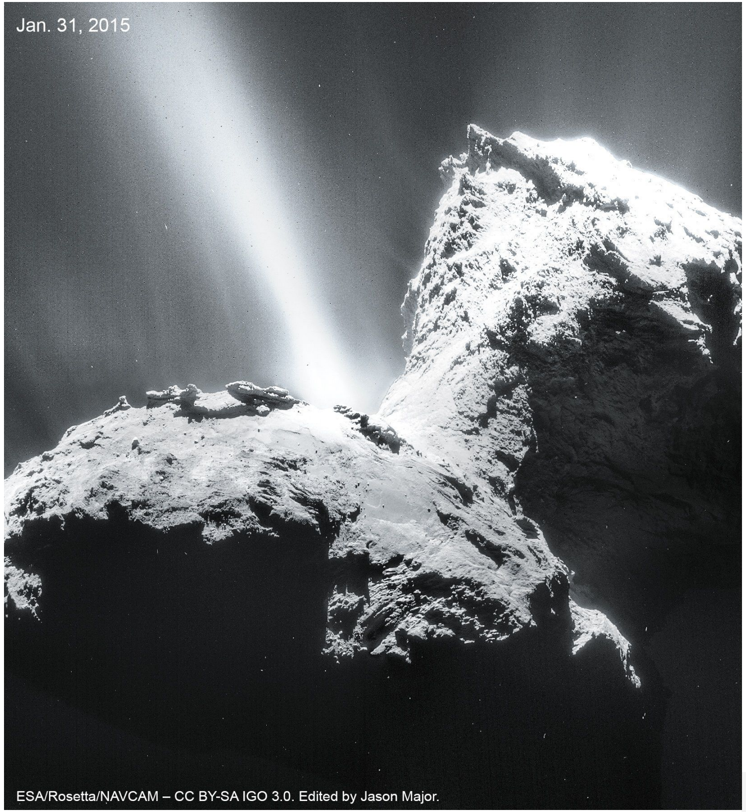
- **White Dwarf Planetary Debris Disks Frequencies**
- Planetesimal Debris Disk Variation

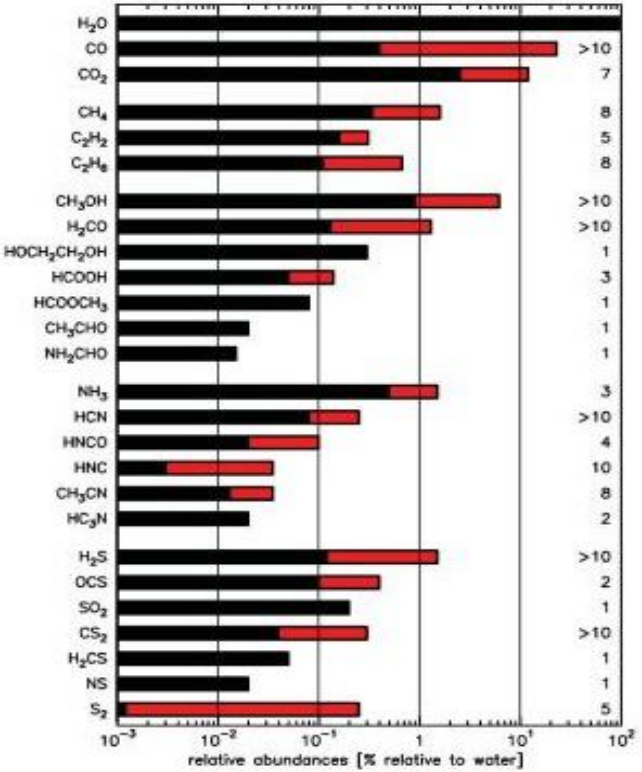
Other projects I have worked on:
Near-Earth Asteroids, Carbon-dominant white dwarfs, dwarf-Carbon stars.

Herschel Observations of Non-Typical Cometary Water Ortho-to-Para Ratios

Why study comets???

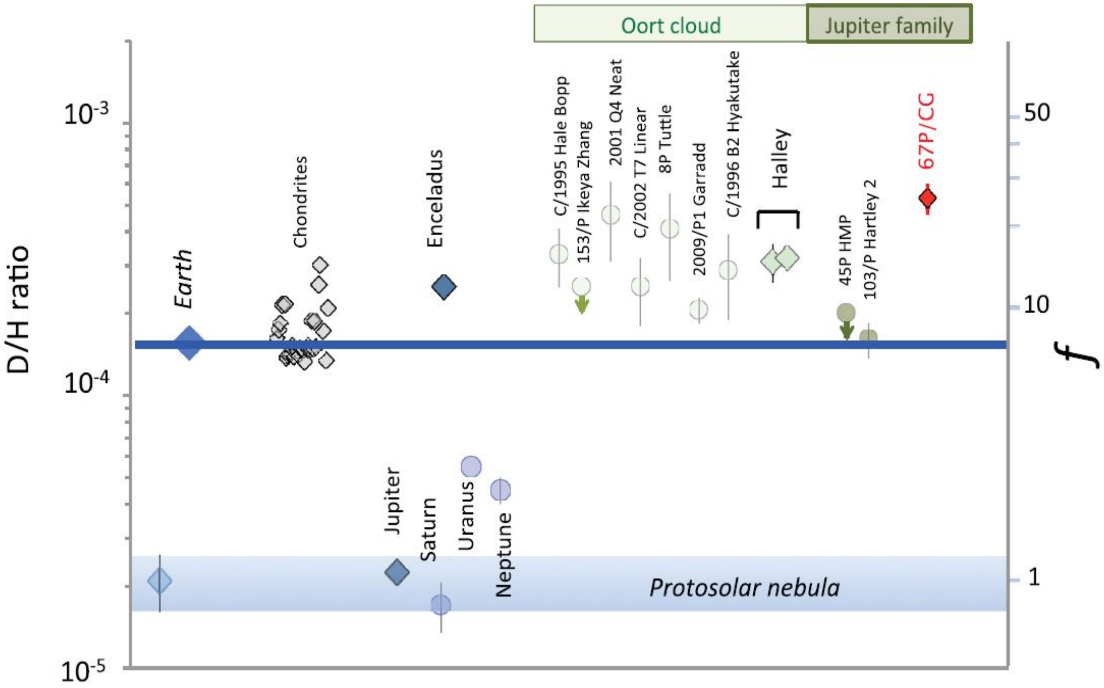
Water, water everywhere





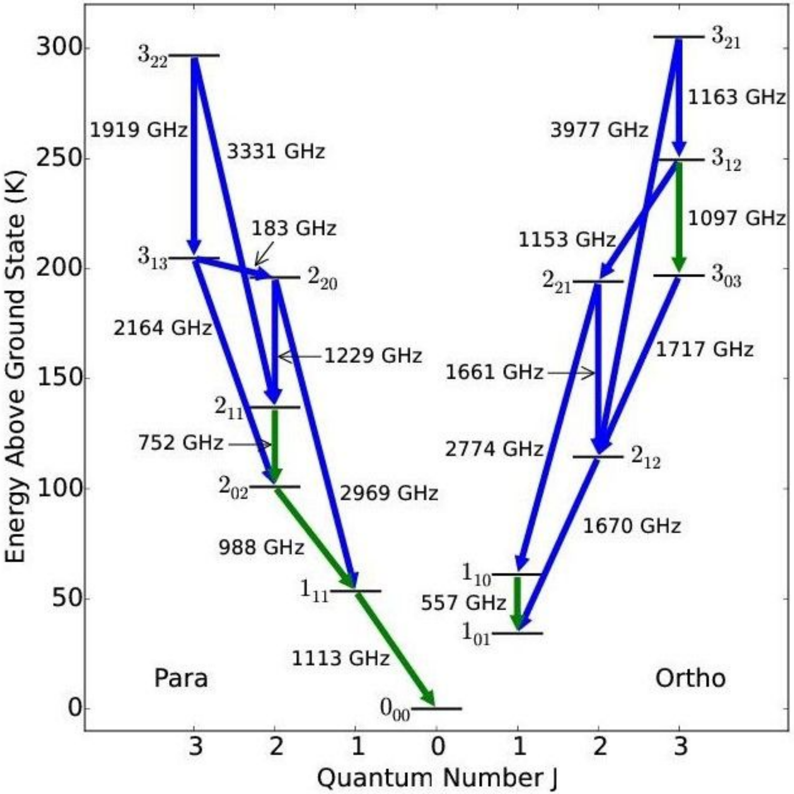
Bockelée-Morvan et al. 2004

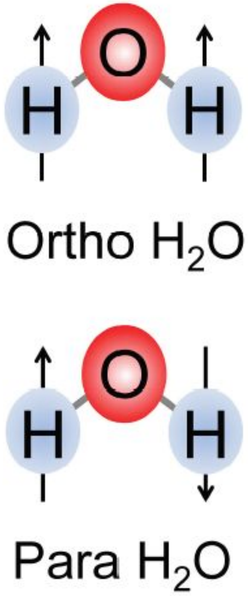
Using isotopic ratios as a proxy for formation location



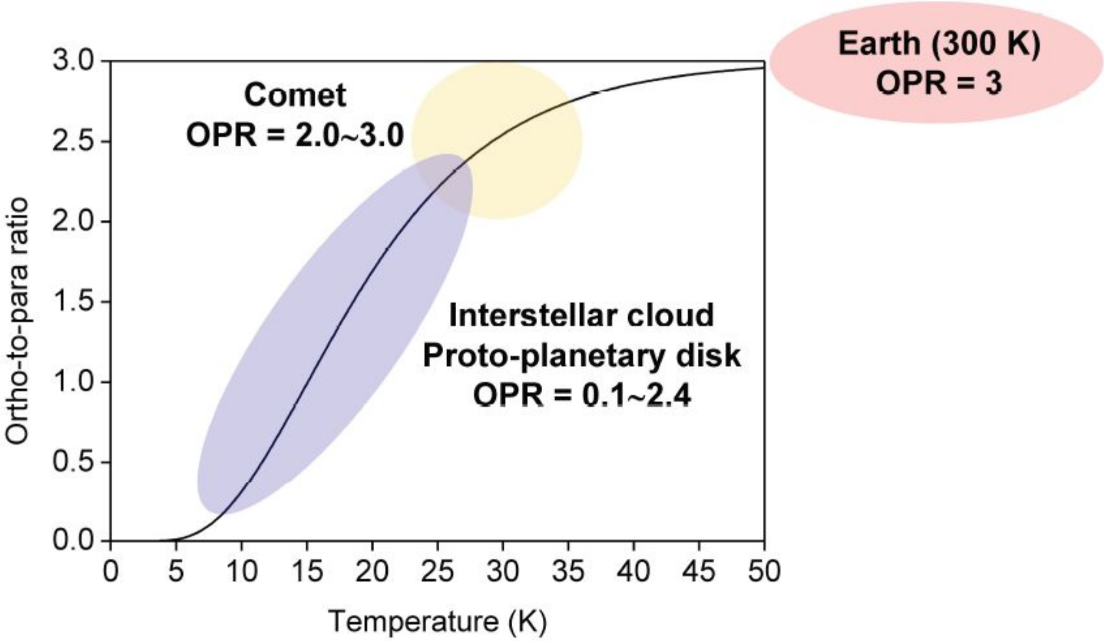
Altwegg et al. 2015

Observing water in the sub-millimetre

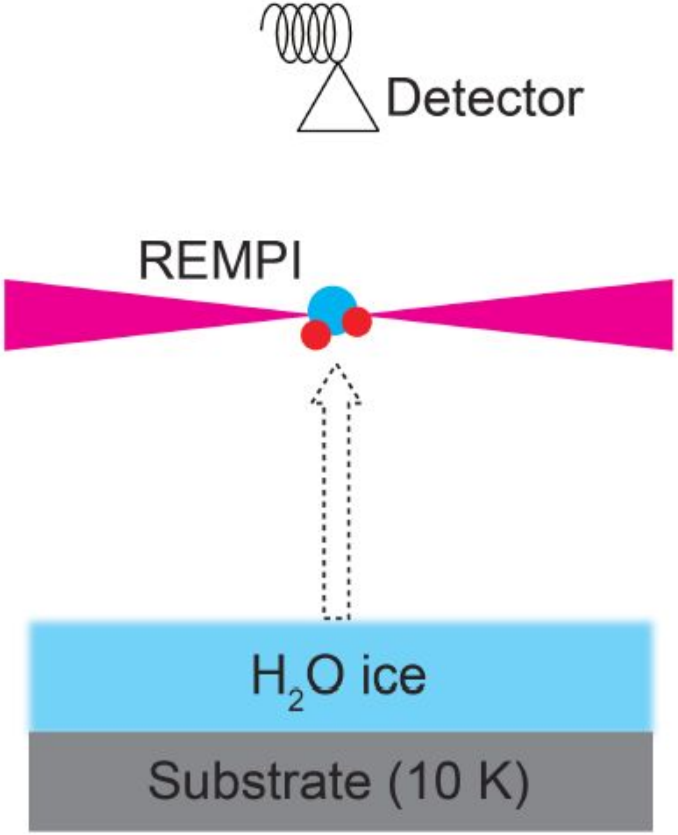




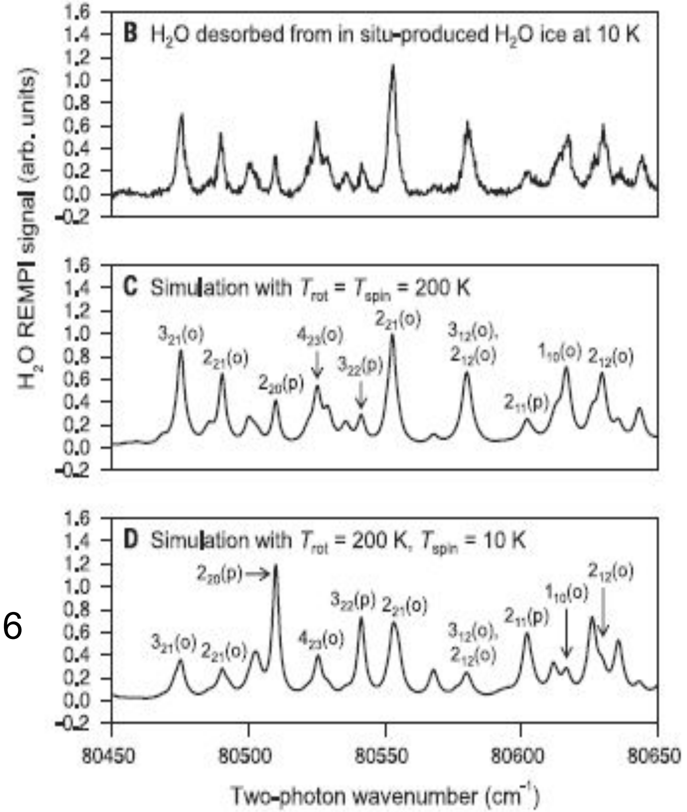
Ortho-to-Para Ratio (OPR) as a function of temperature



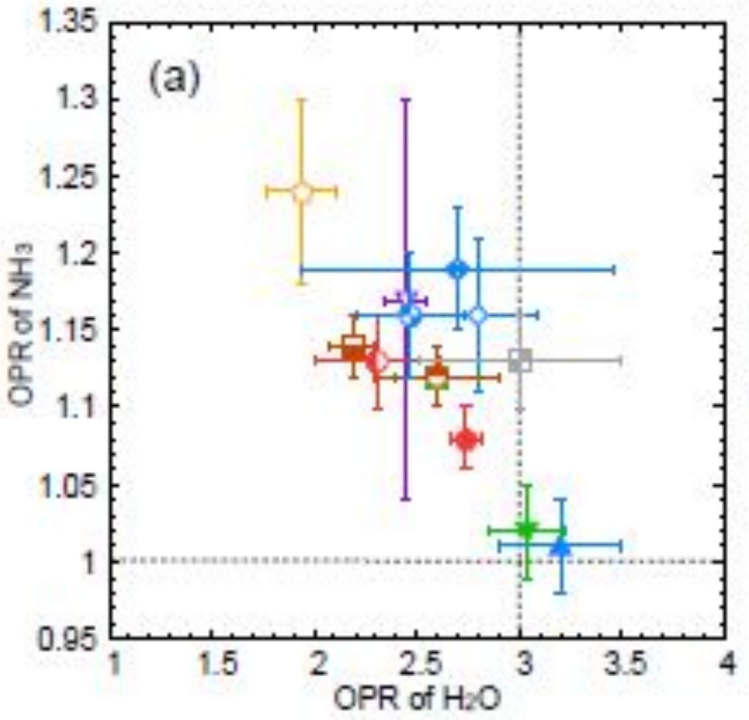
Ortho-to-Para Ratio should always be 3...



Hama et al. 2016



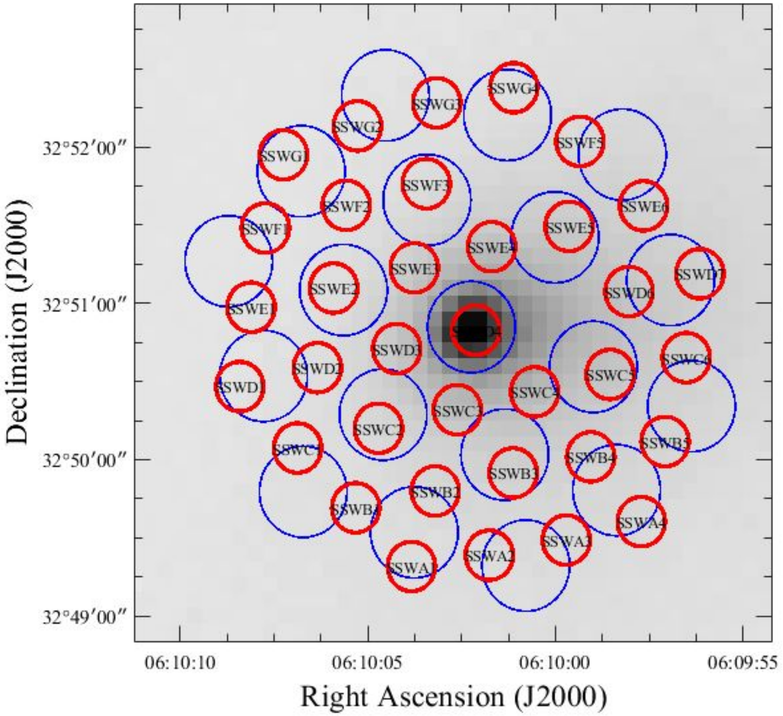
H2O and NH3 Ortho-to-Para ratios



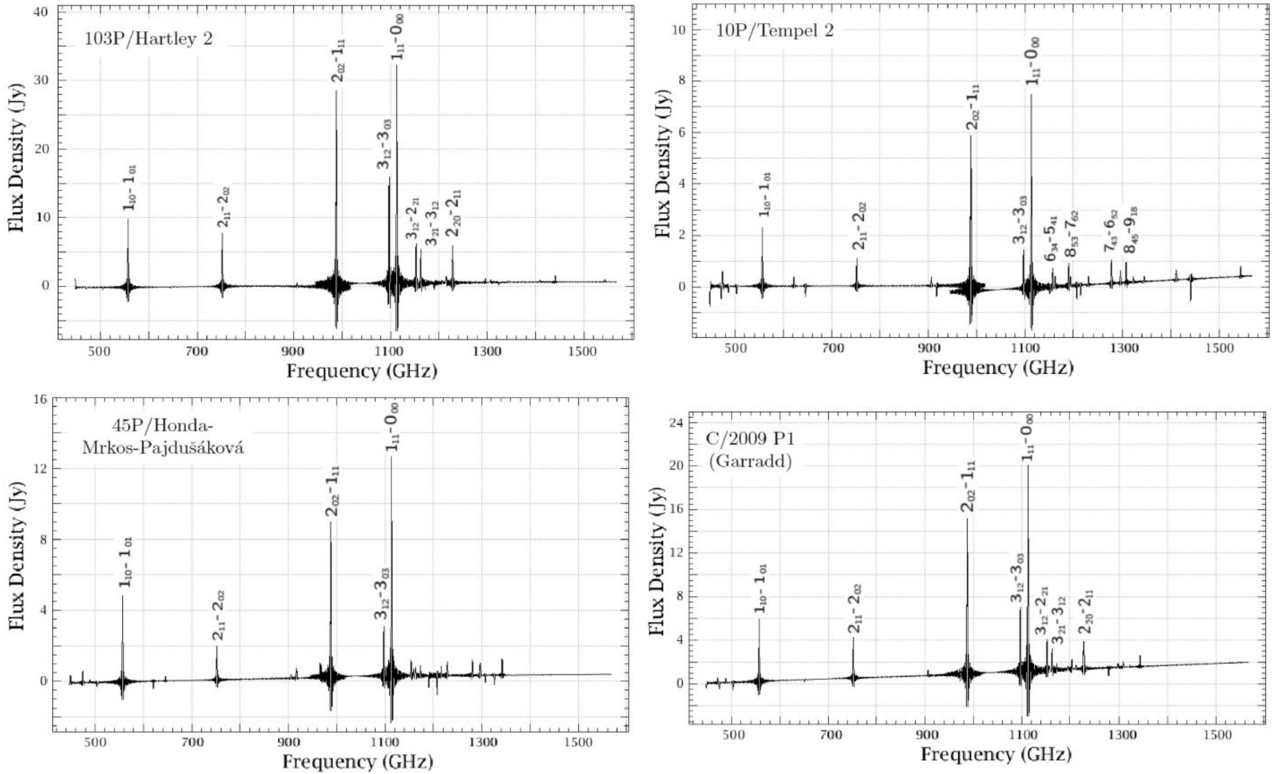
Shinnaka et al. 2016

Herschel/SPIRE Observations

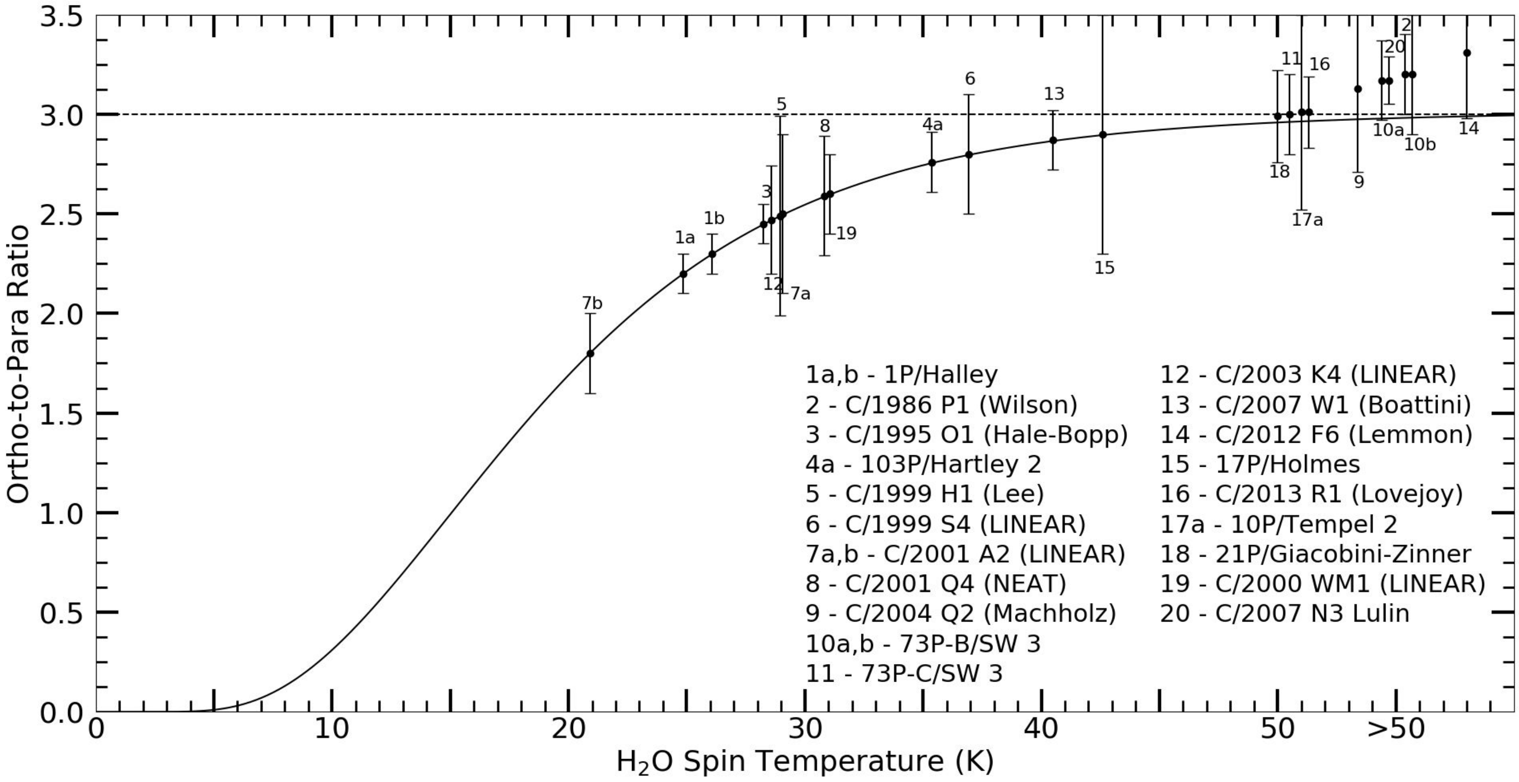
Comet	Period (yr)	Radius (km)	Observed Heliocentric Distance, r_h, (AU)
103P/Hartley 2	6.47	0.7	1.07
10P/Tempel 2	5.36	5.3	1.42
45P/Honda-Mrkos-Pajdušáková	5.26	0.8	1.00
C/2009 P1 (Garradd)	127,000	<5.6	1.81



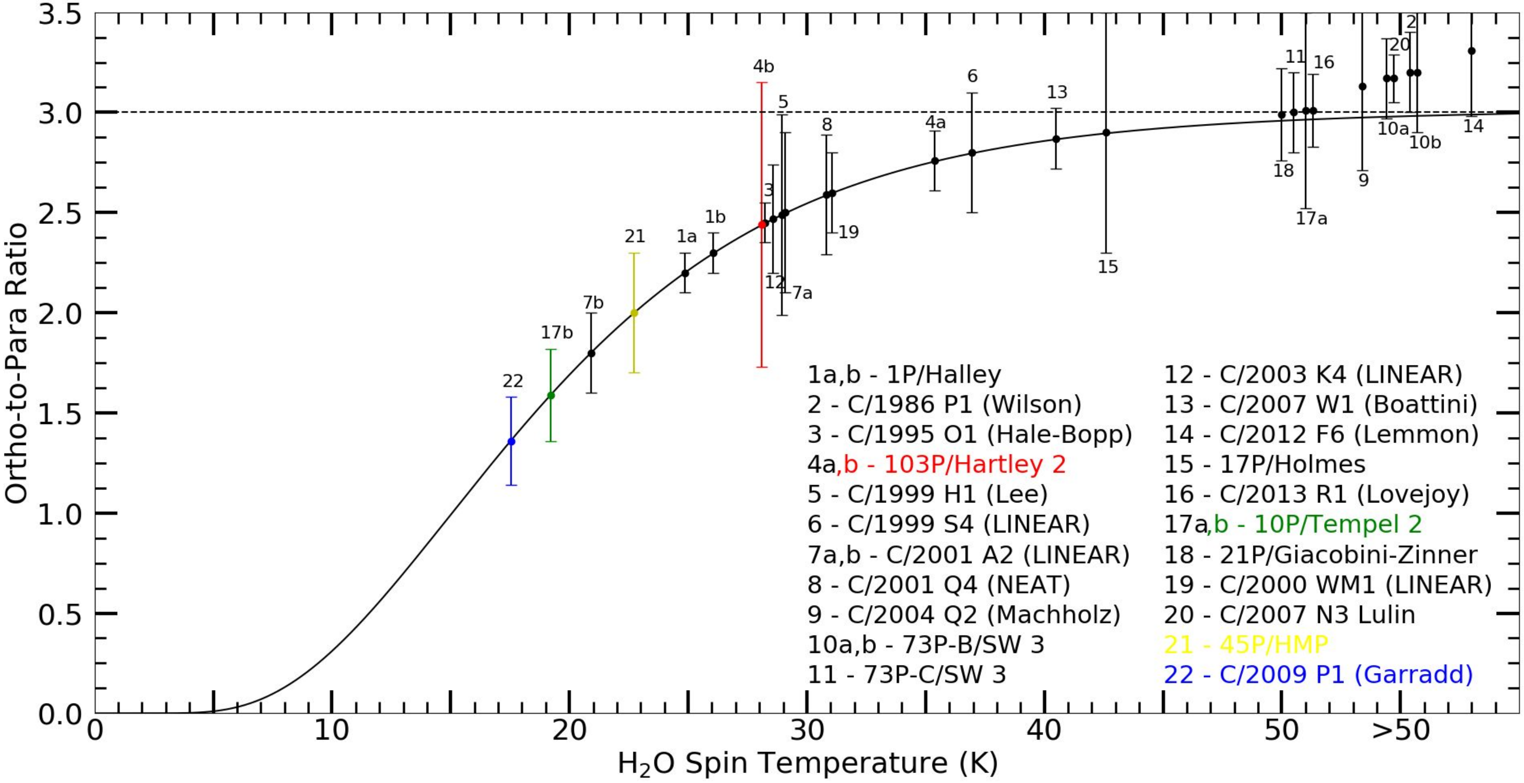
Observations show multiple rotational lines



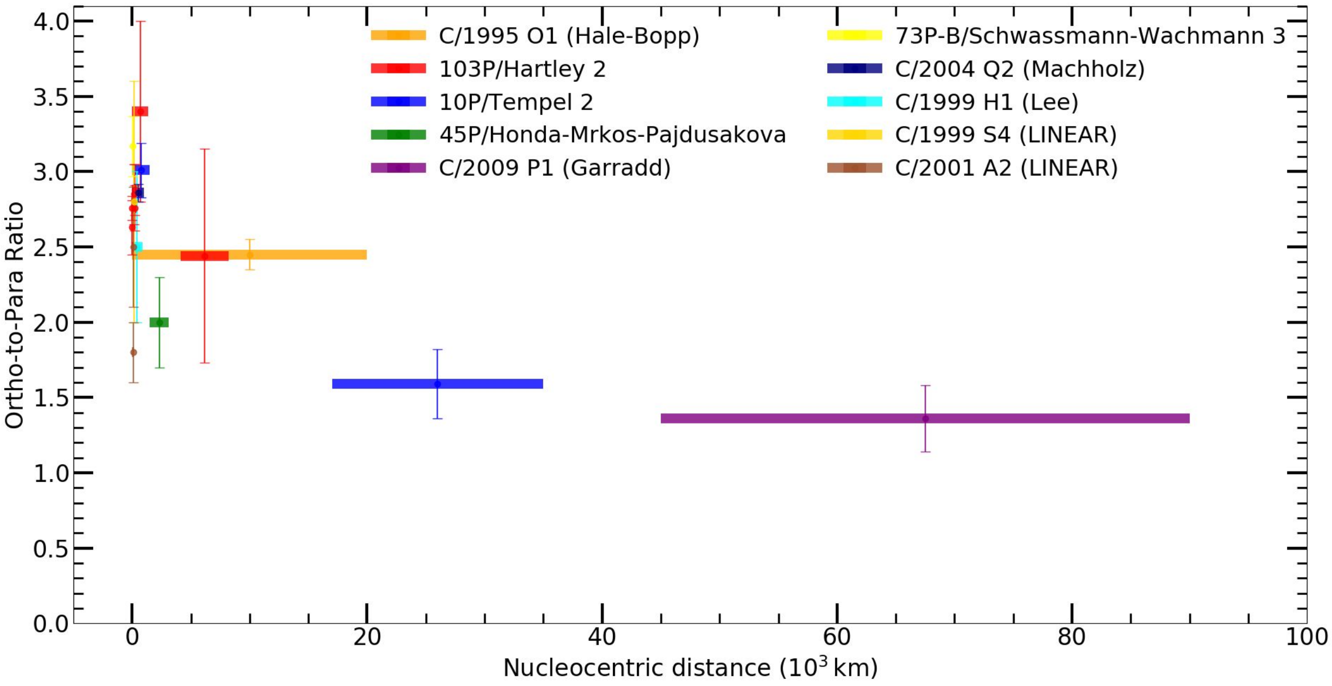
Observations show an OPR less than 3…



Observations show an OPR less than 3…



… and OPR seems to vary with nucleocentric distance



Conclusions

- Using spectroscopic observations taken by *Herschel*/SPIRE we determined values for the OPR of three JFCs and one OCC.

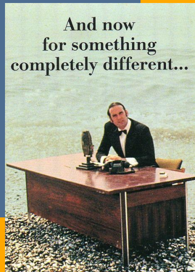
- While there is no substantial difference in the OPRs for comets from different families, implying a similar spin temperature, three of the comets have a non-typical OPR.

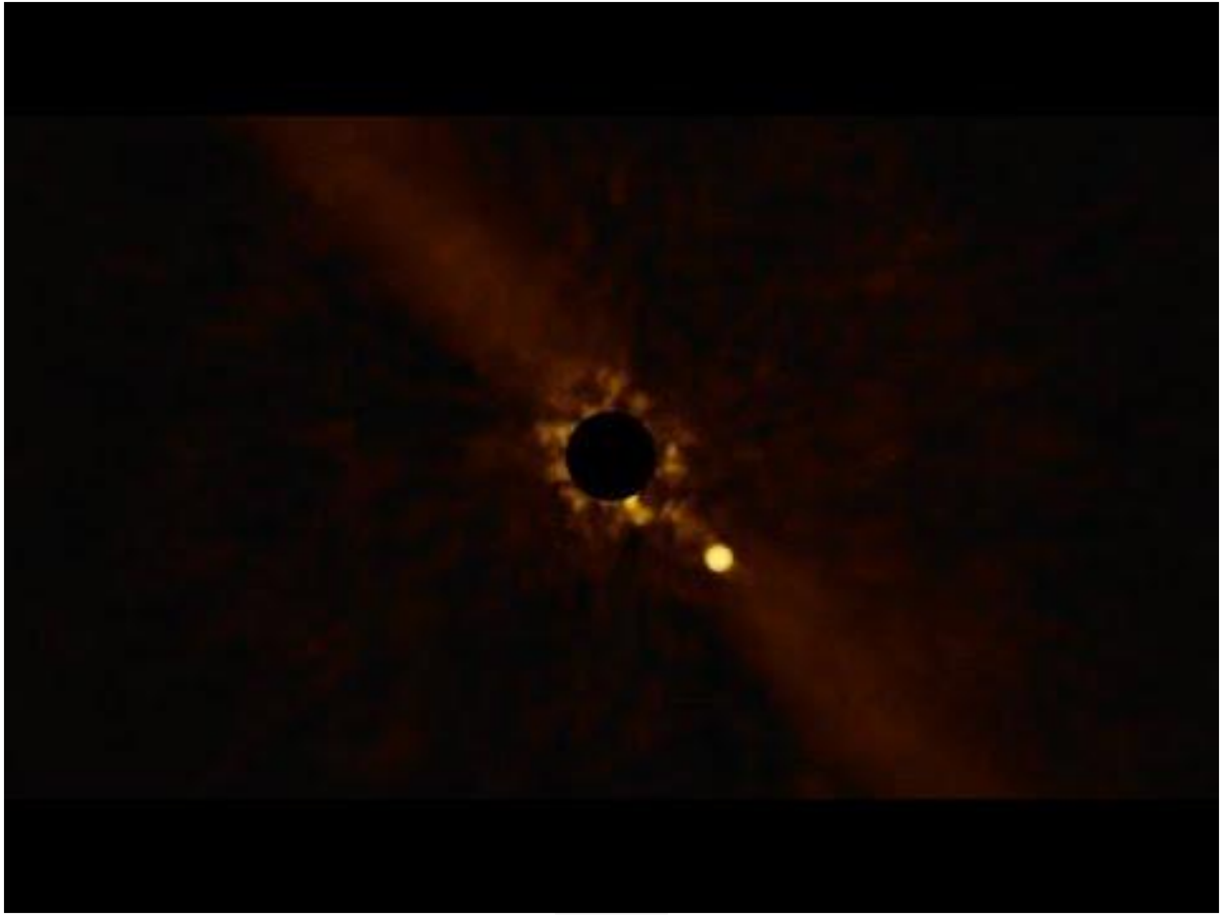
- This could be explained coma based nuclear spin conversion, however further theoretical, observational, and laboratory work is needed.

Wilson, T. G., et al. 2017. MNRAS; 466: 1954-1962

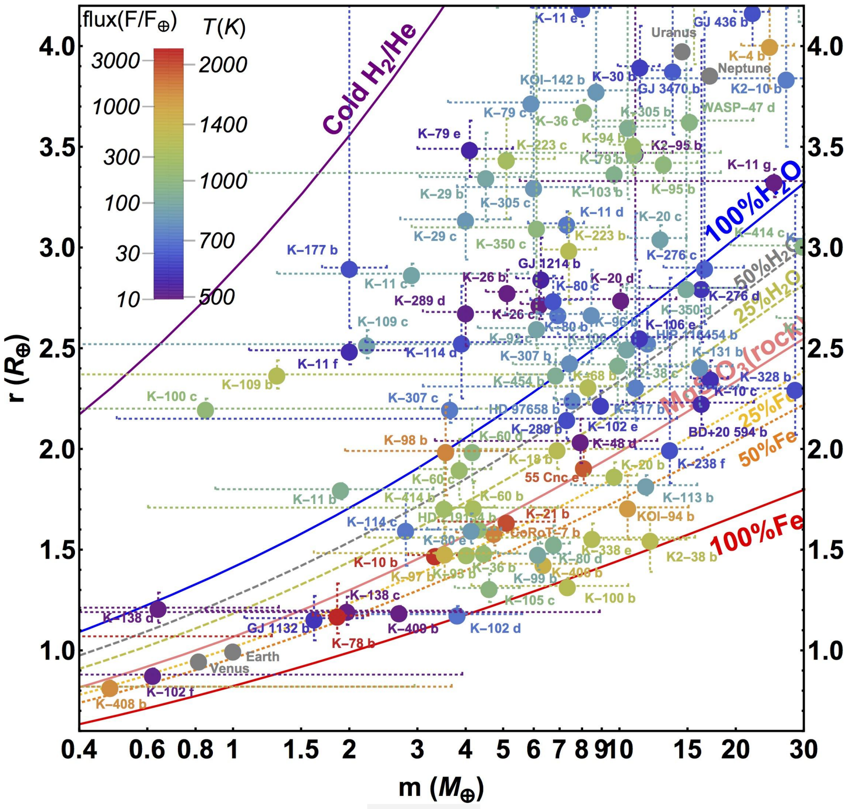
https://doi.org/10.1093/mnras/stw3152

White Dwarf Planetary Debris Disks Frequencies



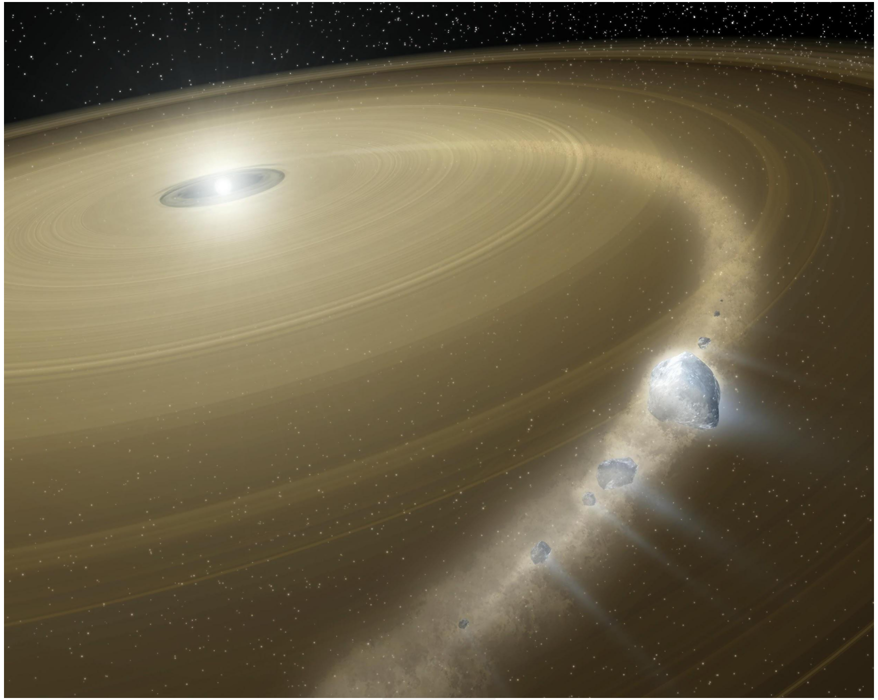


Exoplanet Zoo

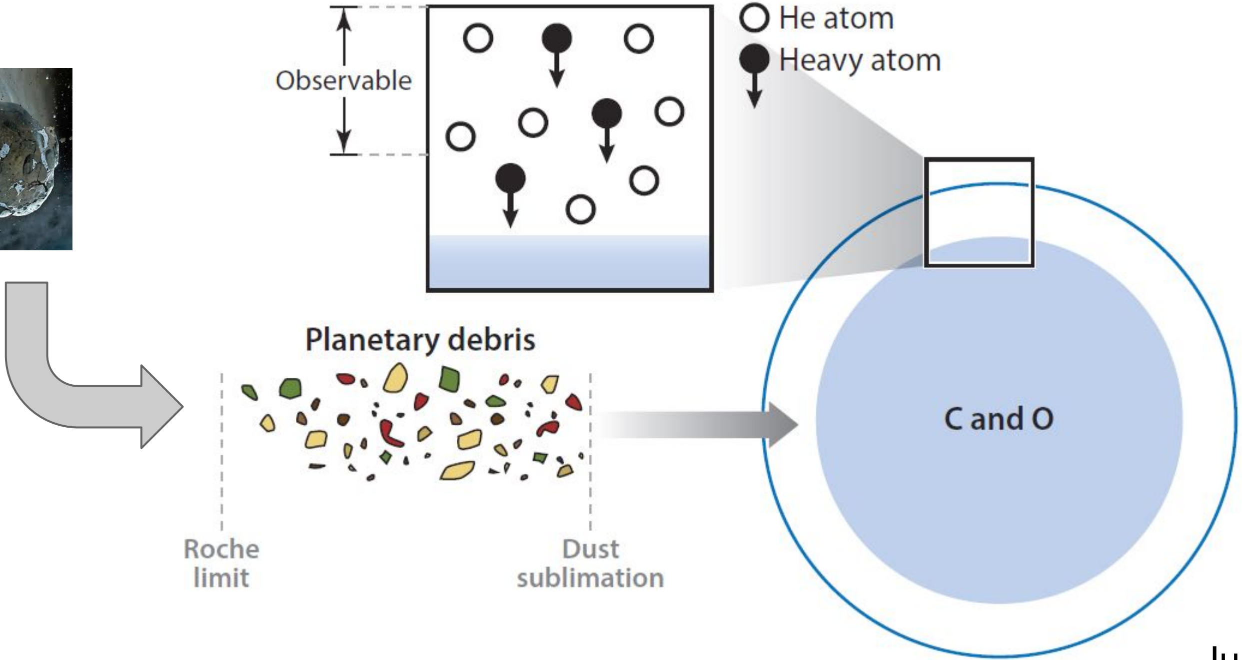


Kaltenegger 2017

Planetesimal debris disks around white dwarfs!

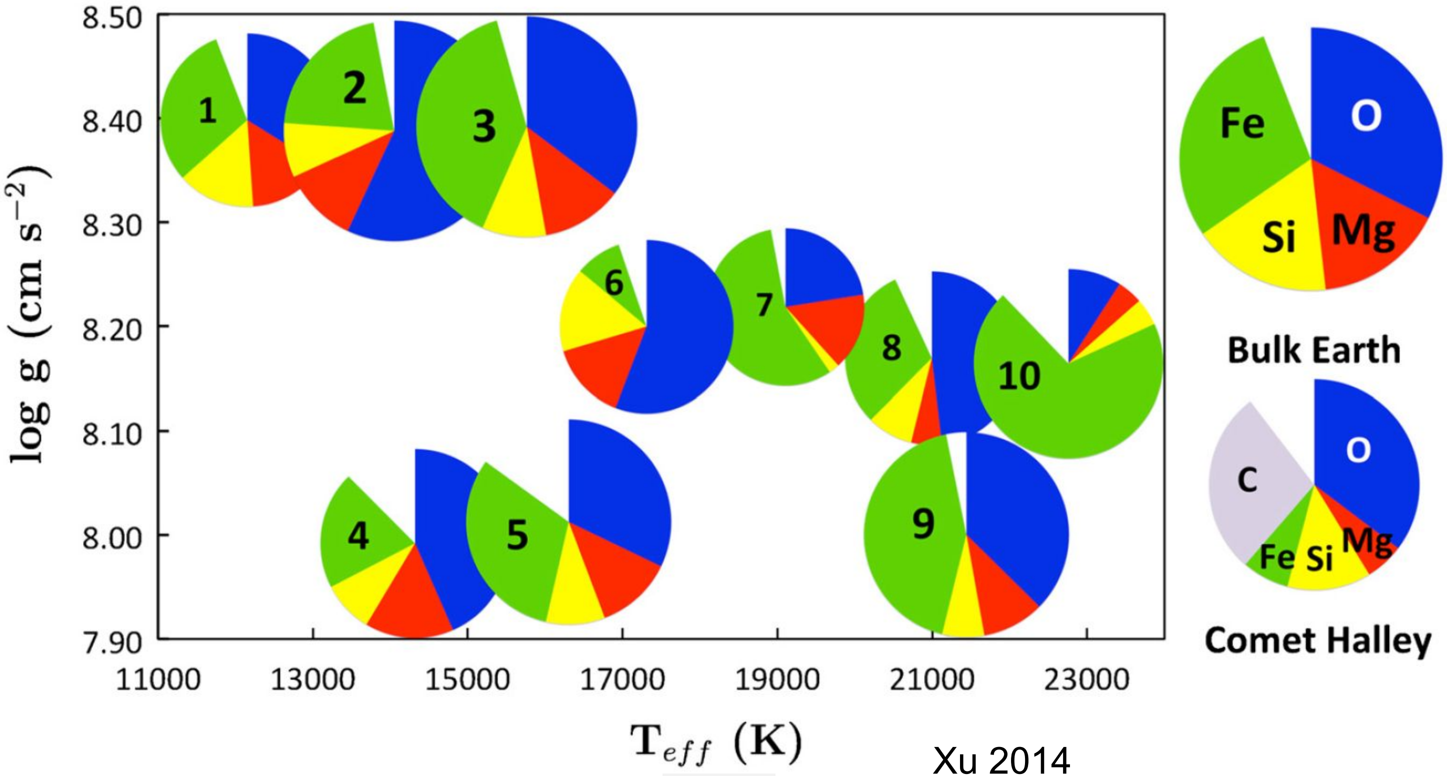


Disrupted planets form disks which accretes onto the star



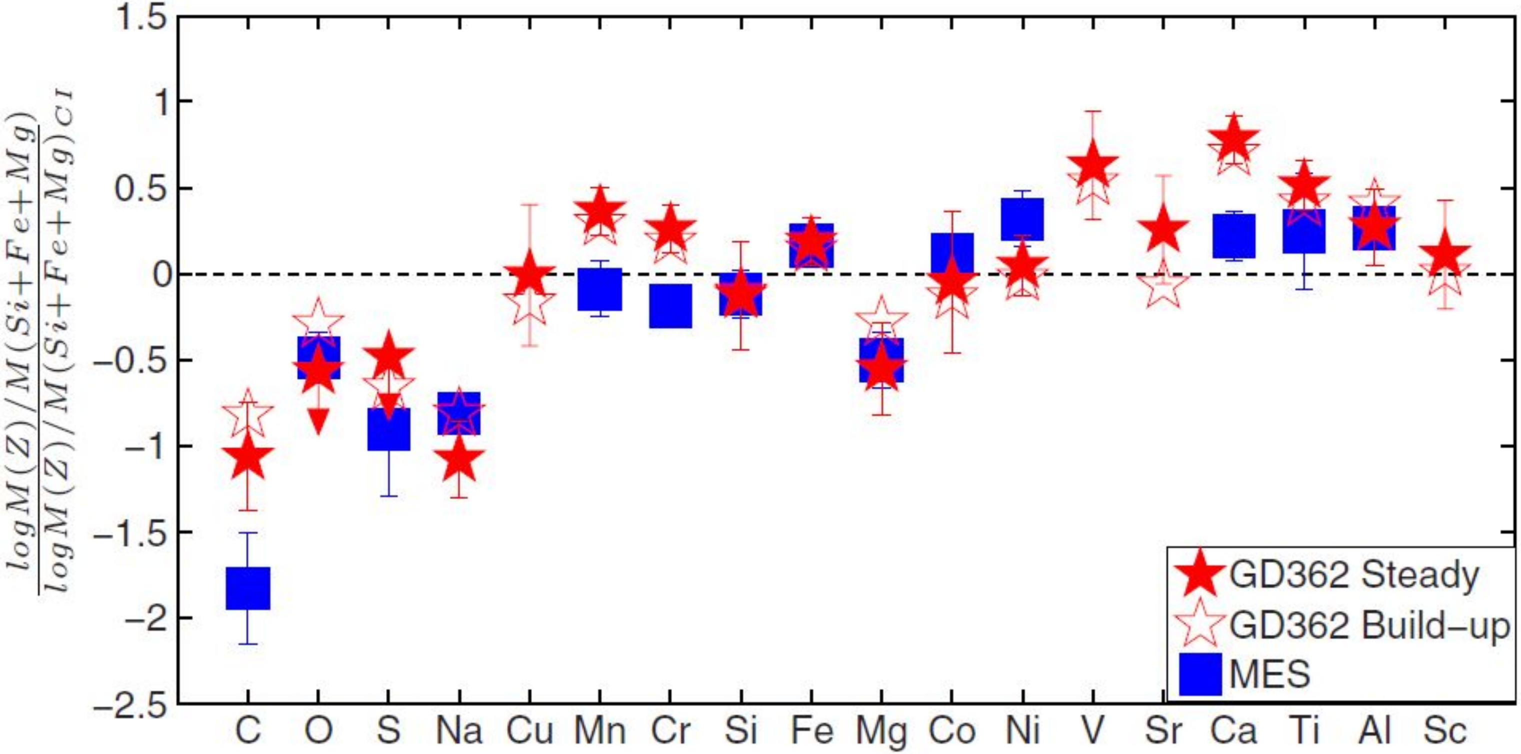
Jura & Young 2014

(Exo)planetary compositions



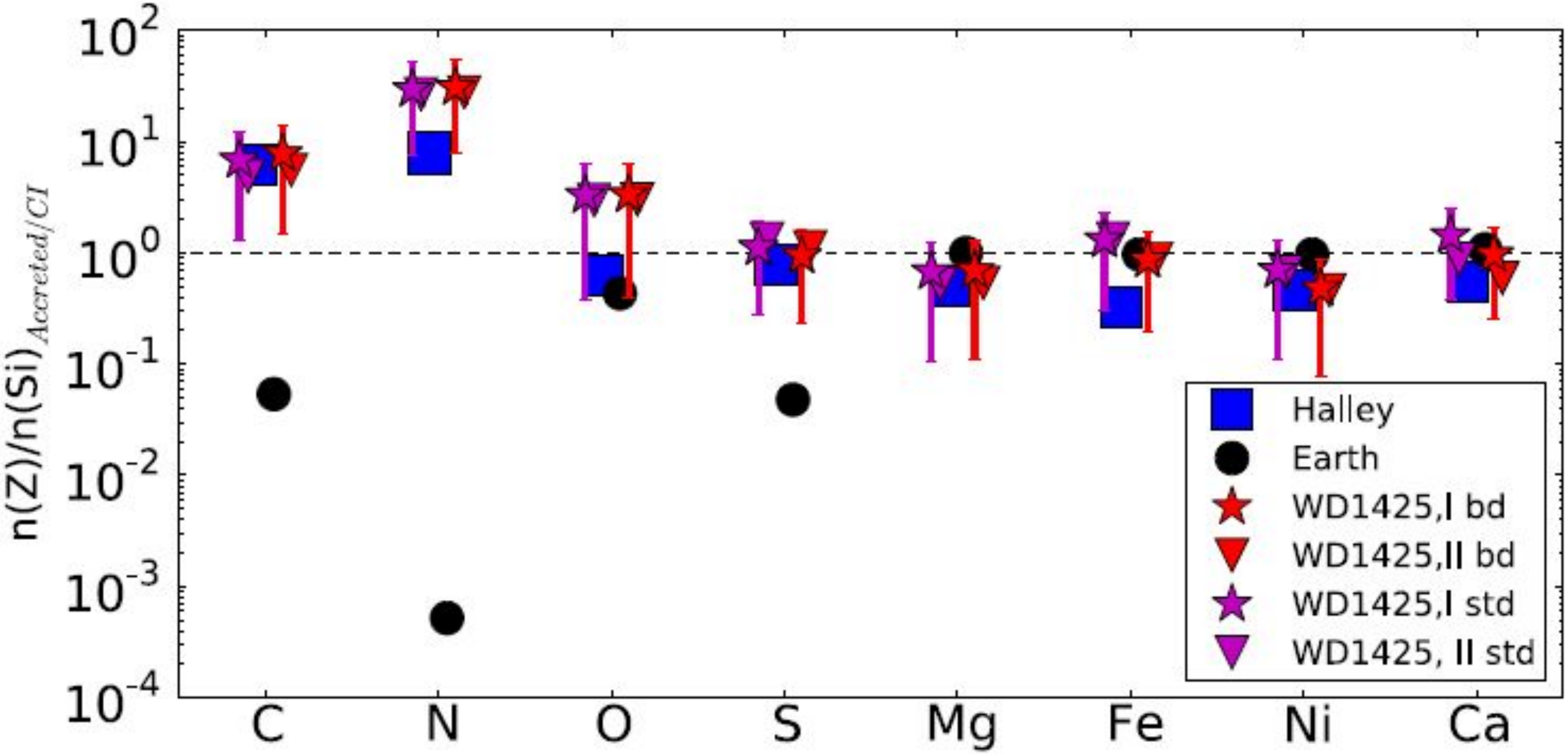
Xu 2014

GD 362



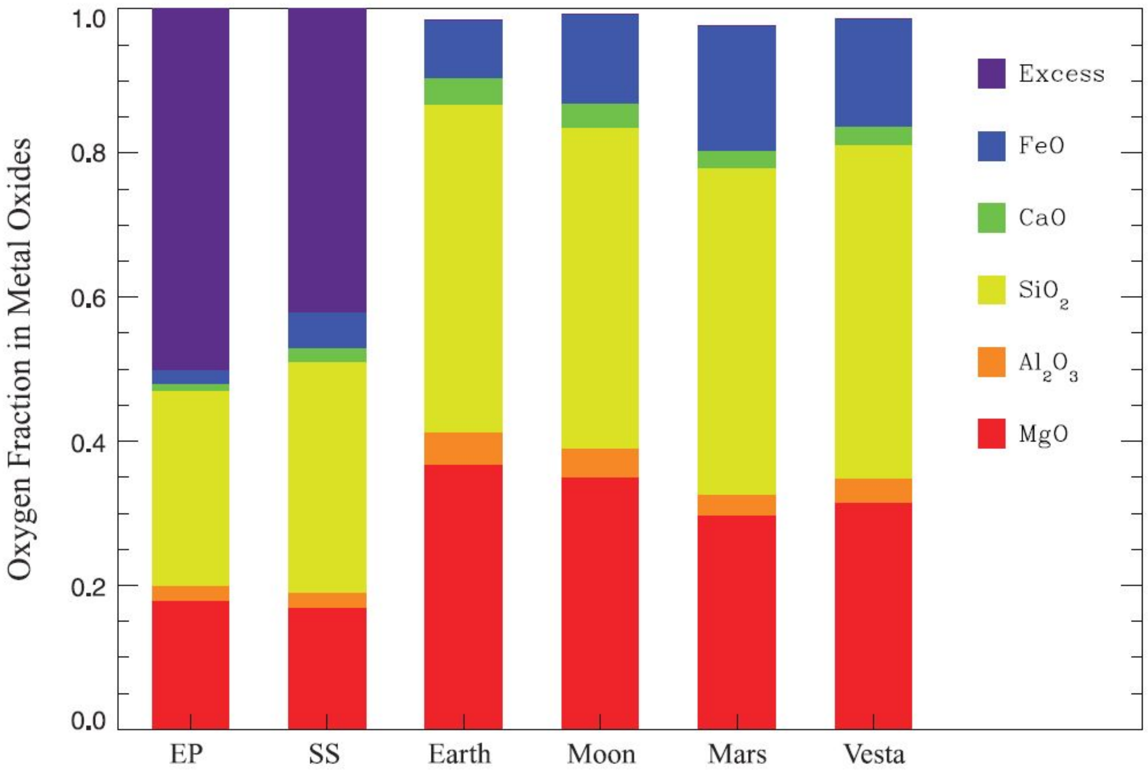
Xu 2014

WD 1425+540



Xu et al. 2017

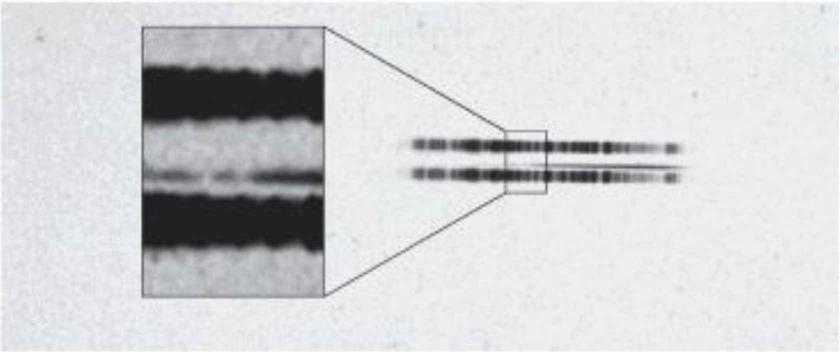
Water, water everywhere? in GD 61



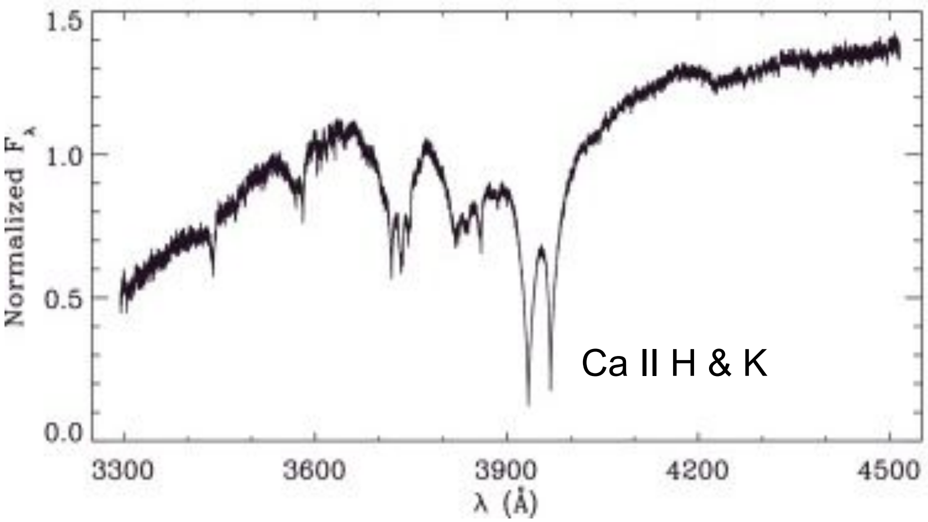
Farihi et al. 2013

How do we find debris disks? - Atmospheric metals

v Ma 2

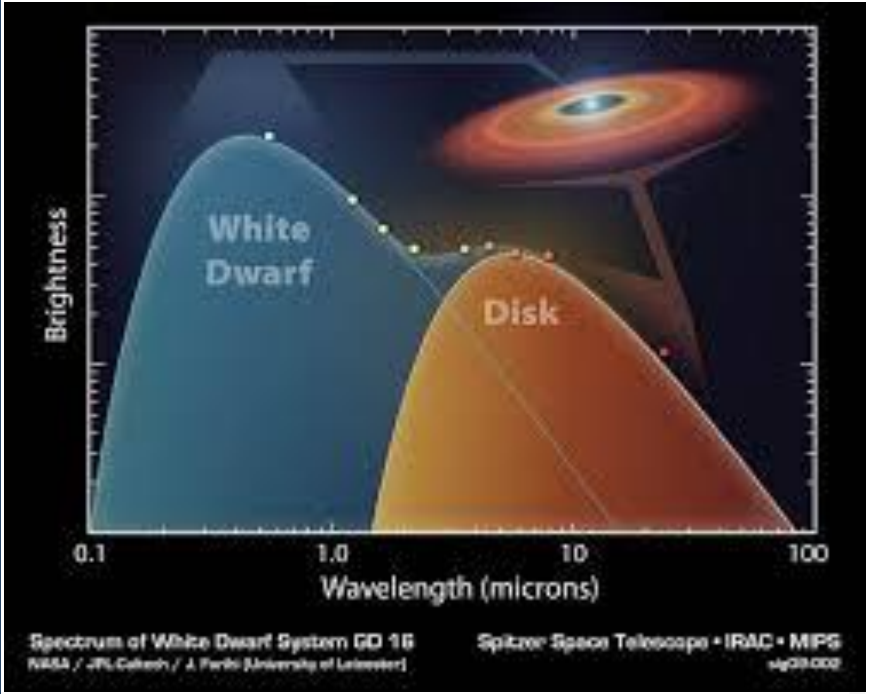


van Maanen, 1917

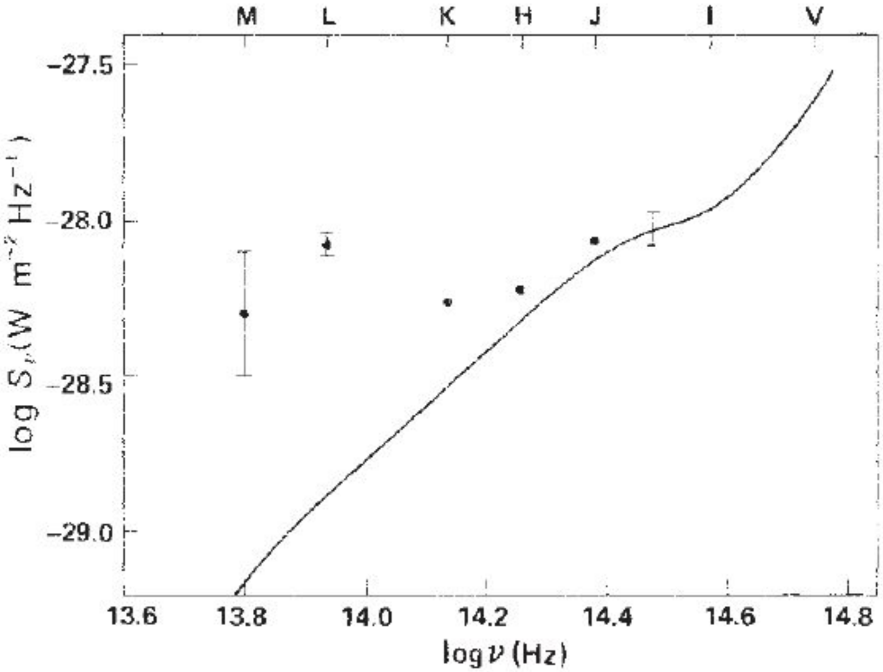


Farihi 2016

How do we find debris disks? - Infrared excess



G29-38

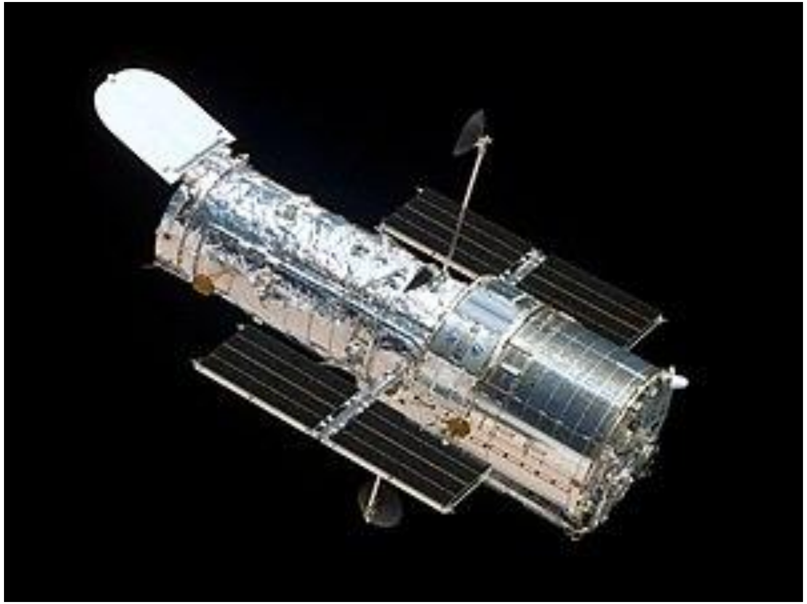


Zuckerman & Becklin 1987

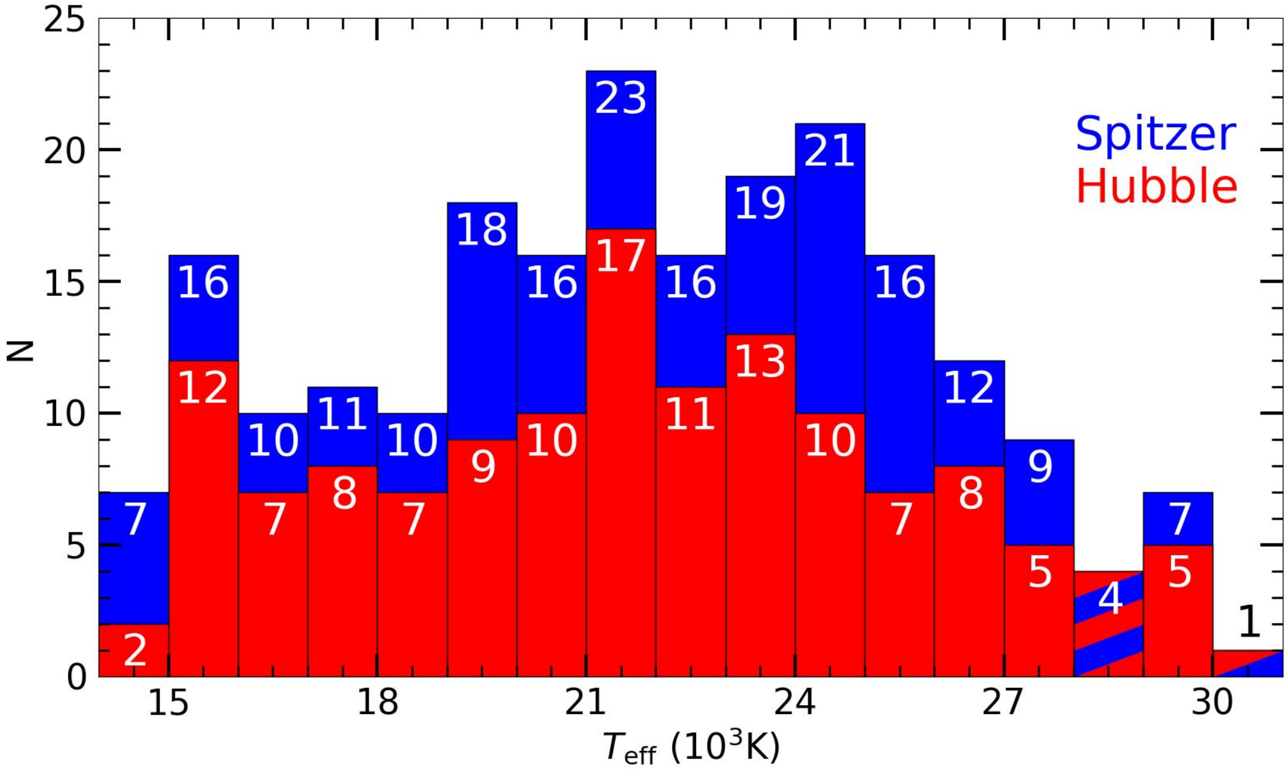
Our unbiased samples

Infrared excess sample

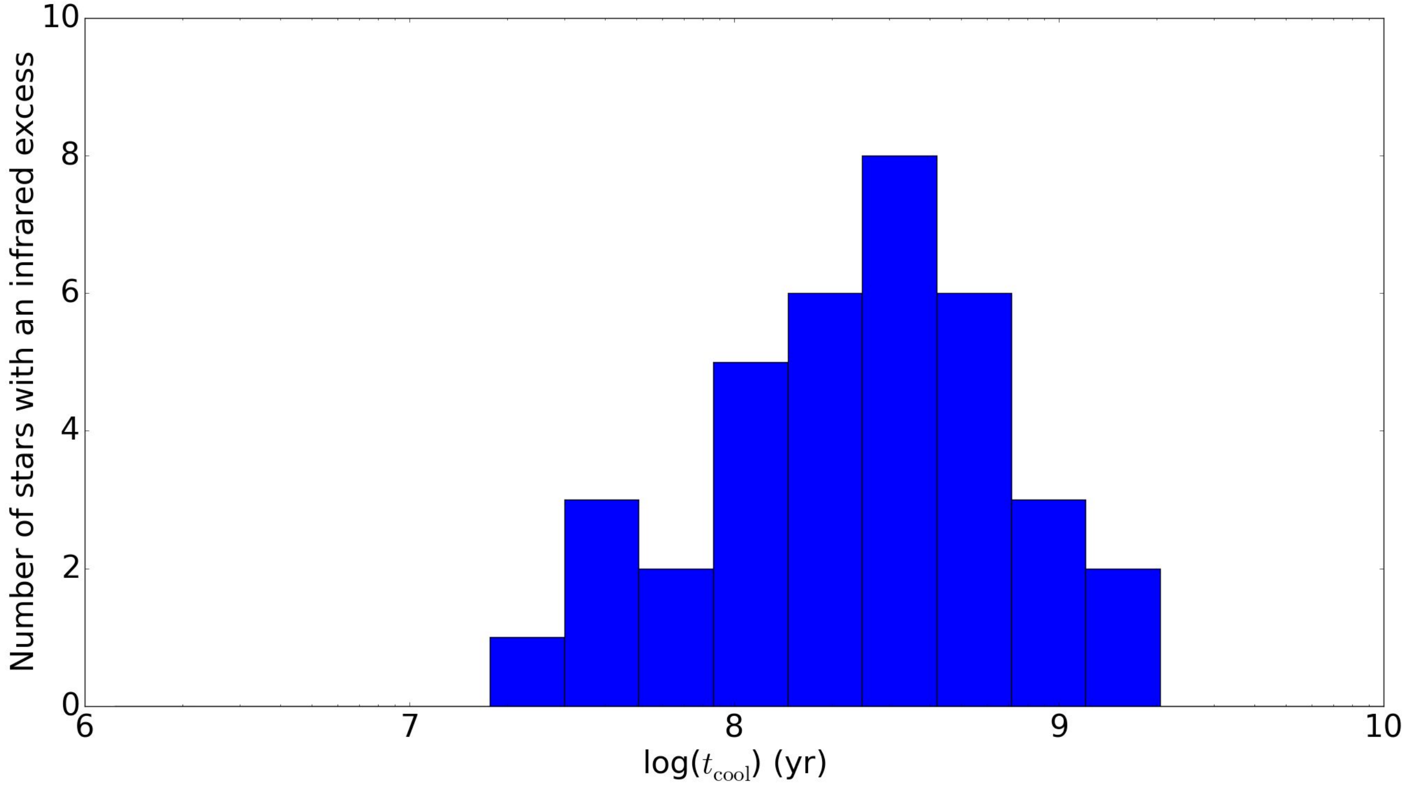
Atmospheric metals sample



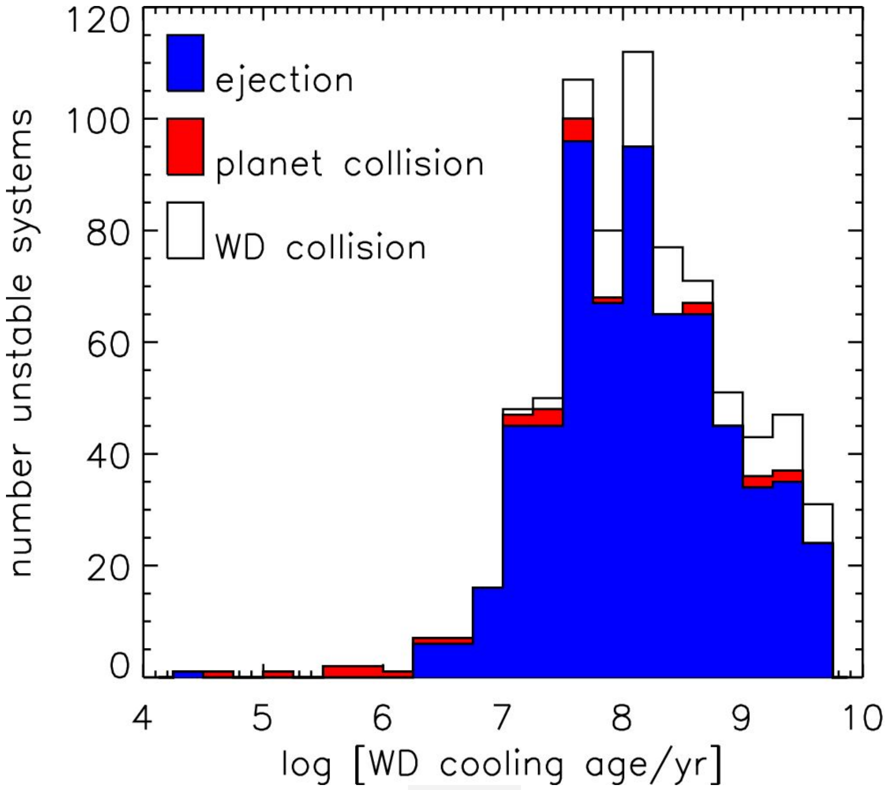
The complete sample



What do we know so far?

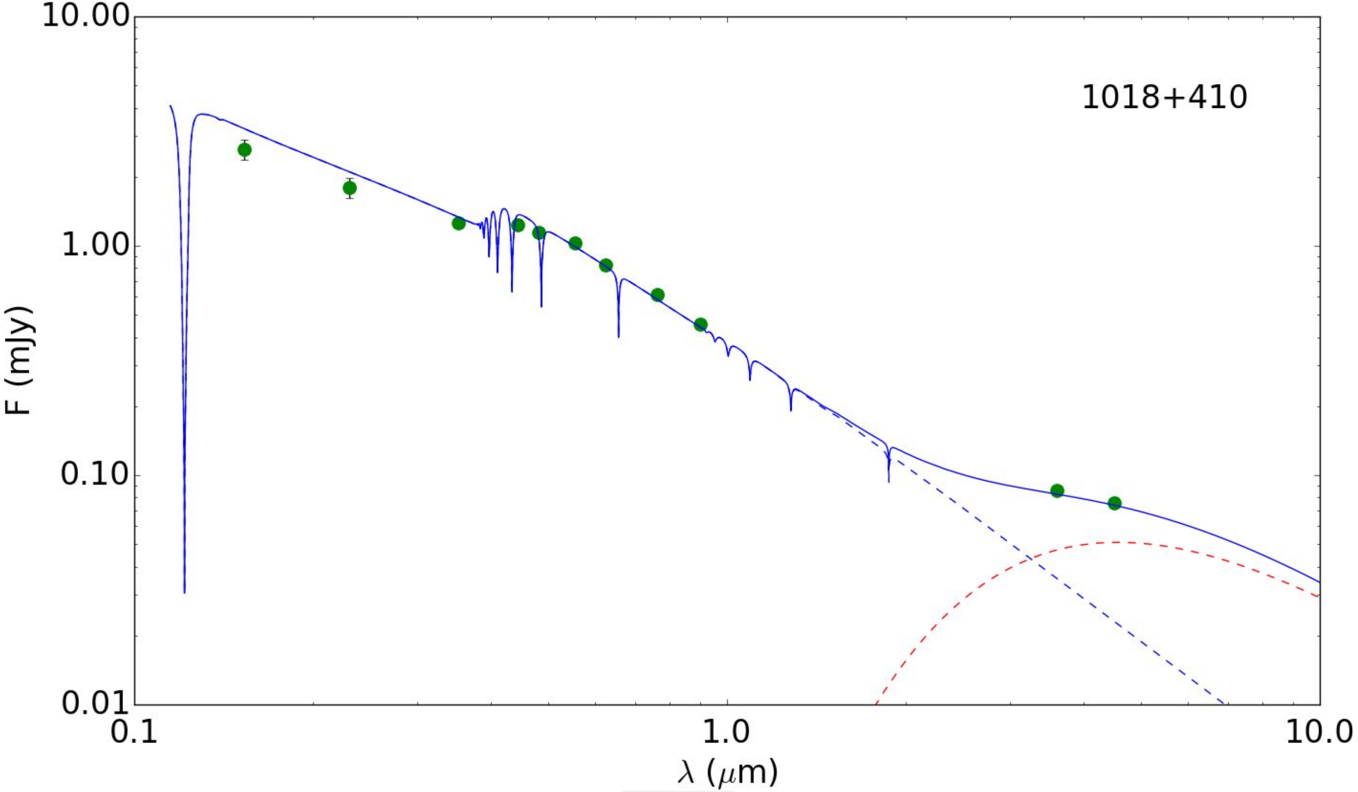


Why do we see this? - Modeling



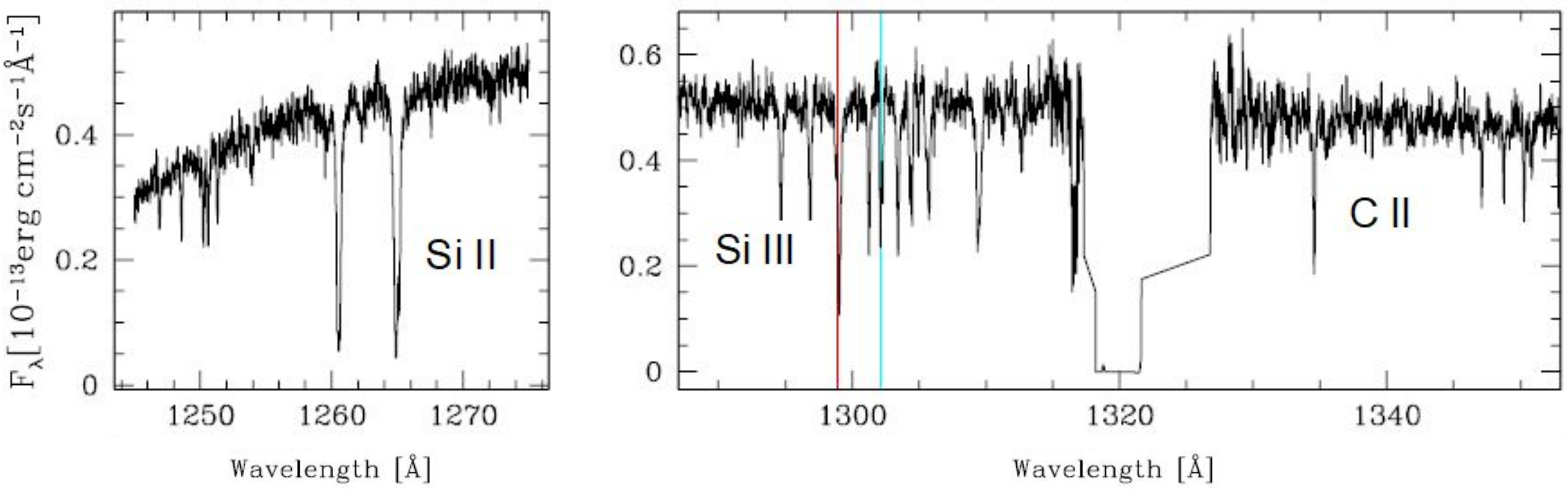
Mustill et al. 2014

A white dwarf with an infrared excess...

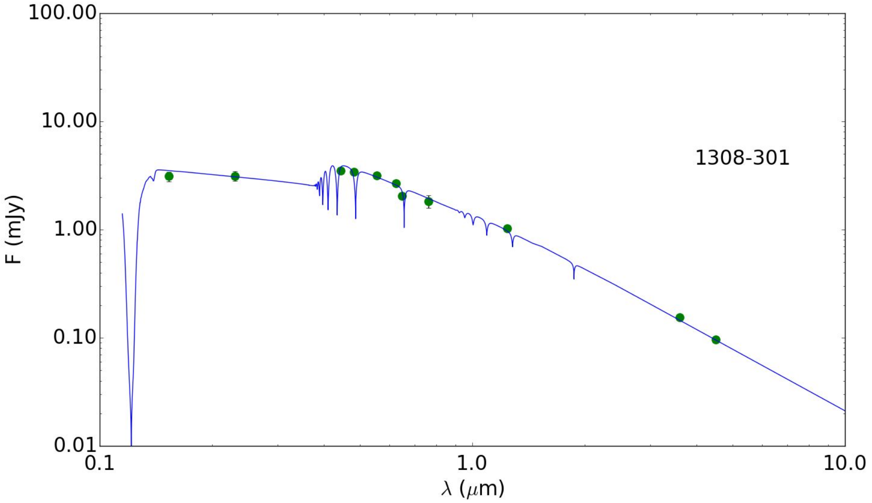


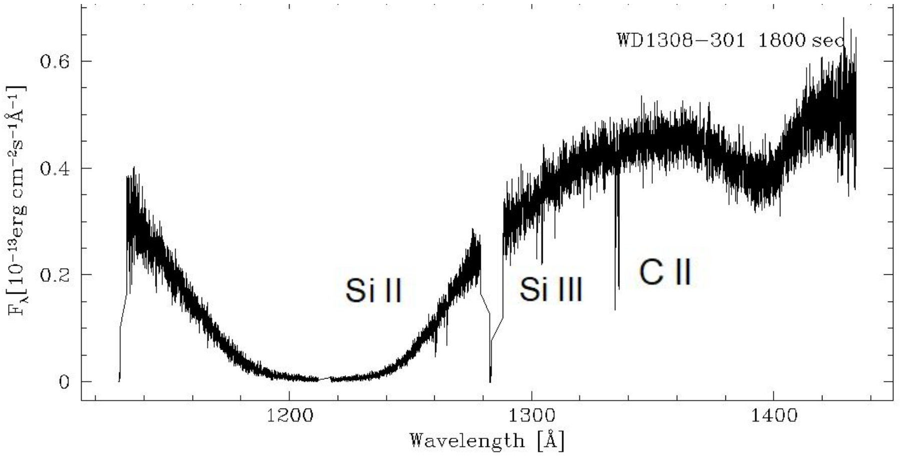
… and atmospheric metals

WD 1018+410

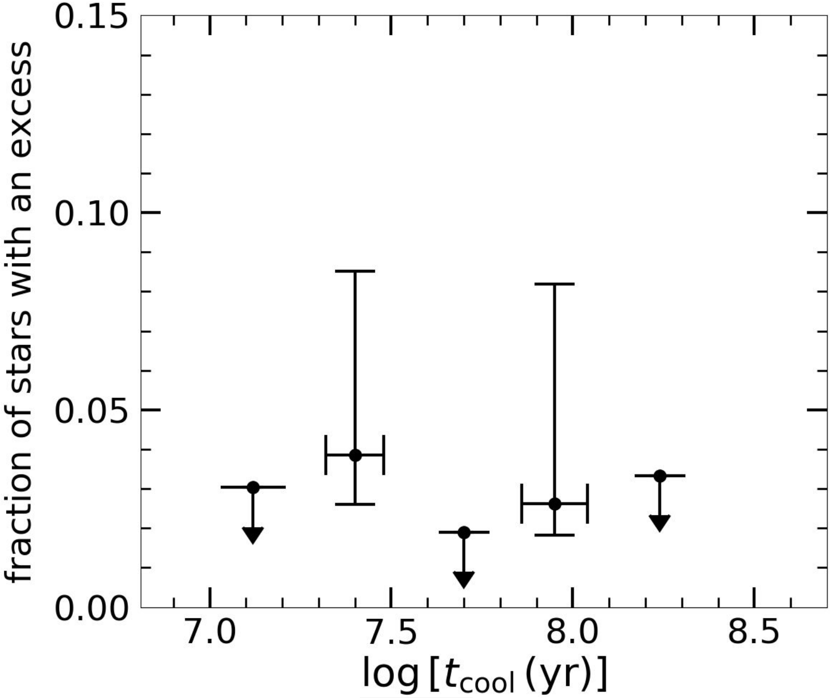


Some white dwarfs show metals, but no infrared excess

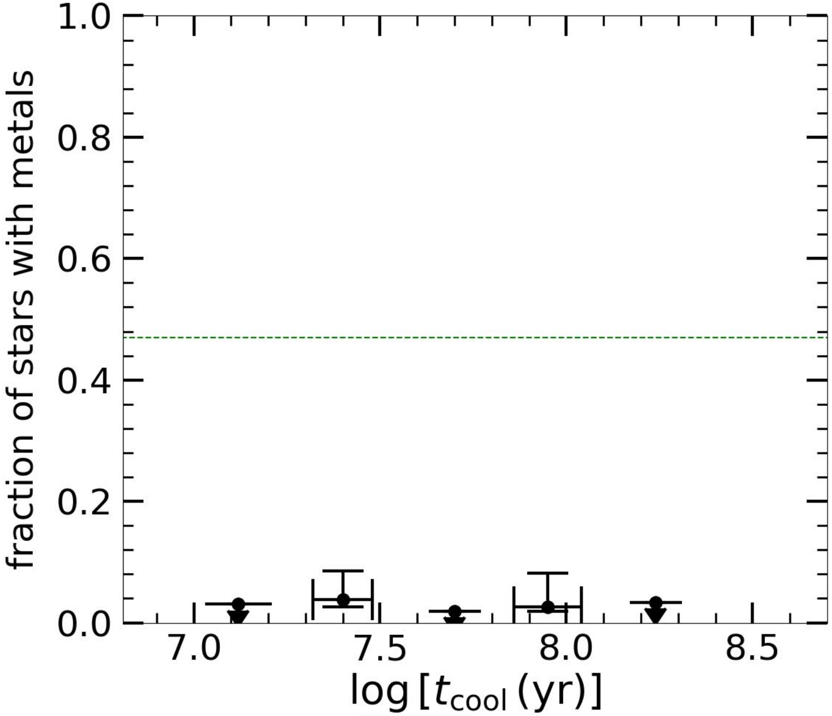




Infrared excess frequencies are a few percent...



… but, the nominal atmospheric metals frequency is 47%!



Conclusions

- The only unbiased Spitzer and Hubble single hydrogen dominated white dwarf sample over a large temperature/age range.
- 3 out of 206 stars have an infrared excess, yielding a frequency of 1.5%, whereas 61 out of 130 stars have atmospheric metals, roughly 47%.
- A significant percentage of debris disks still remain unobserved via infrared excesses.

The end

Thanks for listening.

Any questions?

Formation

- Modelling the Origin of O_2 in Comet 67P

Evolution

- **Herschel Observations of Non-Typical Cometary Water Ortho-to-Para Ratios**

Destruction

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- Planetesimal Debris Disk Variation

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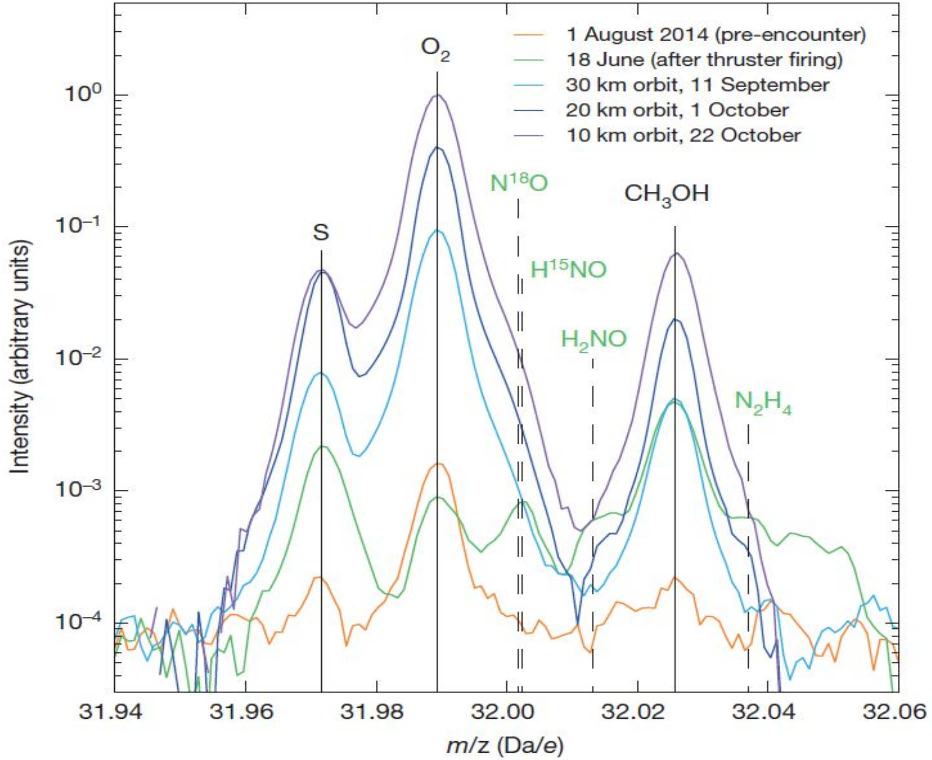
Extra slides

Modelling the Origin of O_2 in Comet 67P

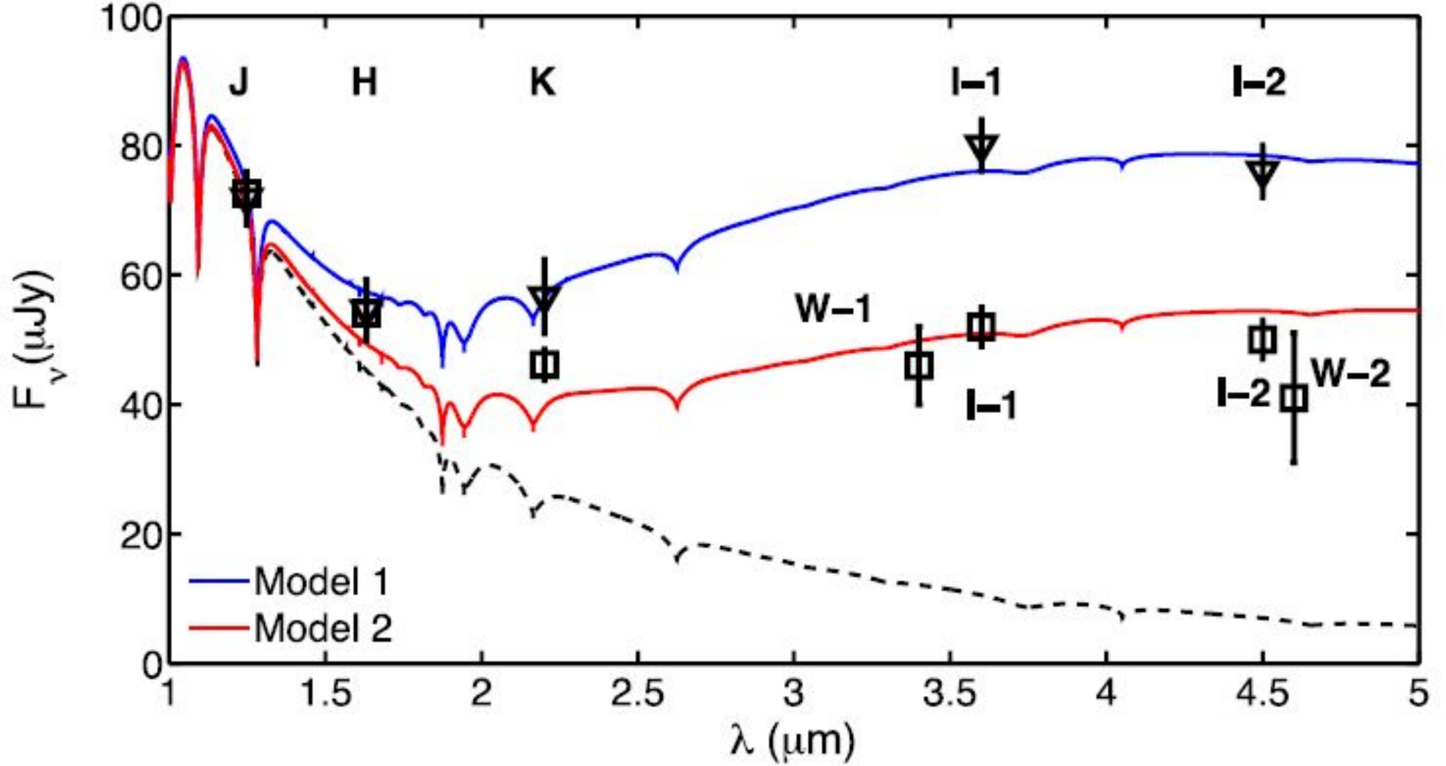
Detection of O_2 in Comet 67P



Bieler et al. 2015

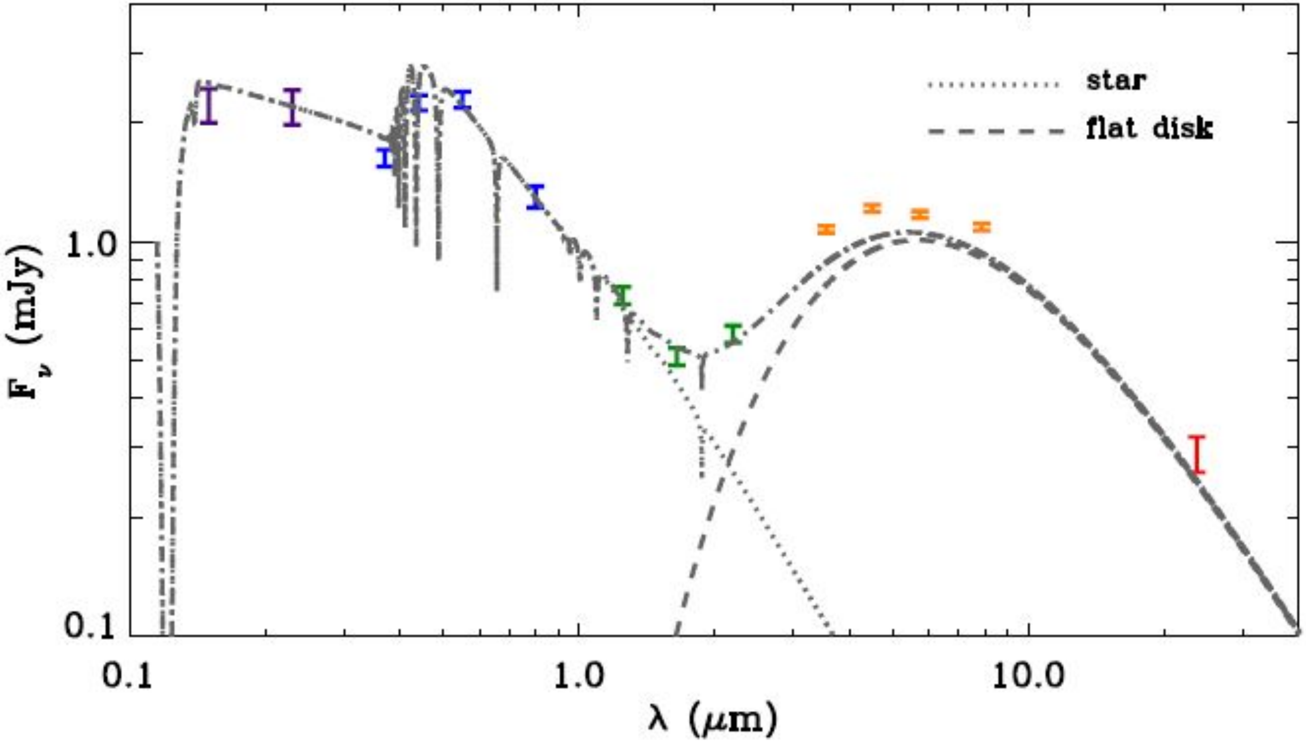
Planetesimal Debris Disk Variation

WD 0959-0200 - The first variable disk



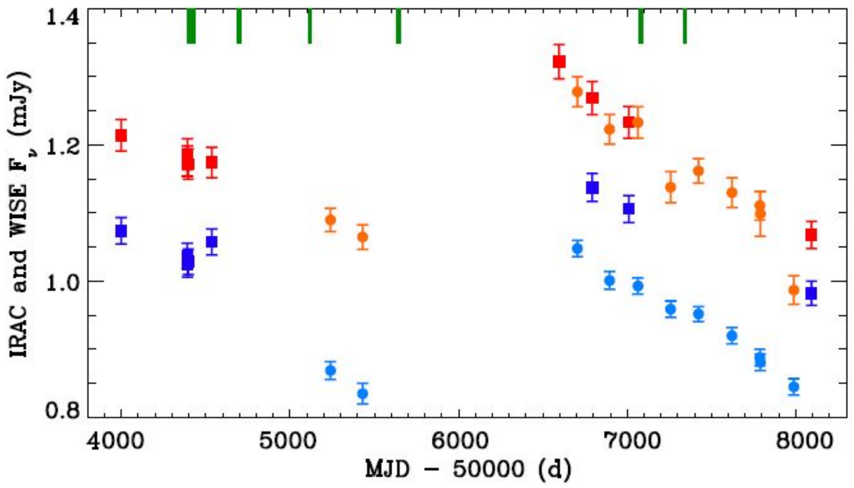
Xu & Jura 2014

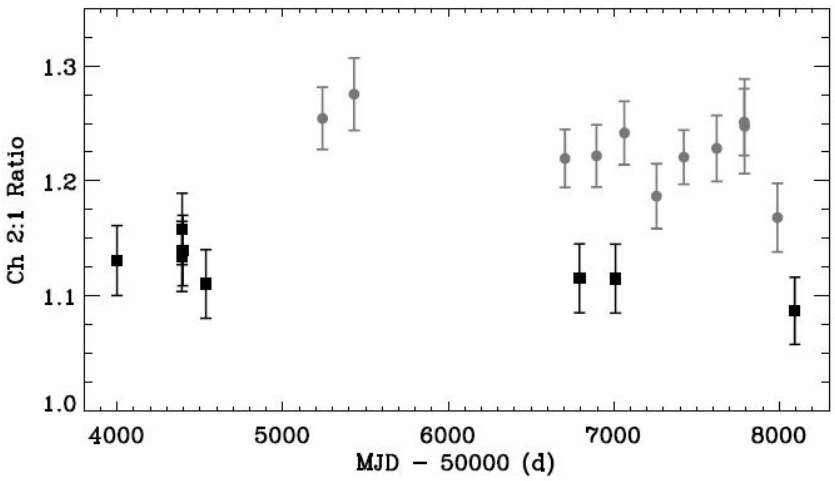
GD 56 - A highly variable disk



Farihi et al. 2018

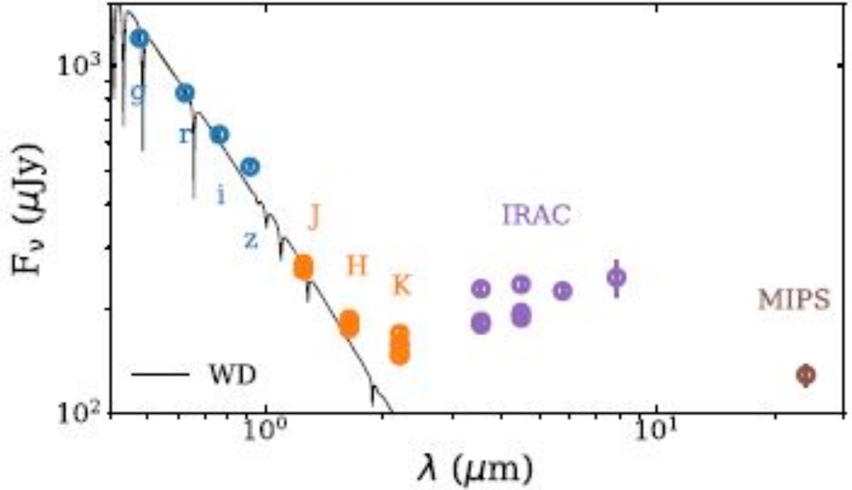
GD 56 - A highly variable disk

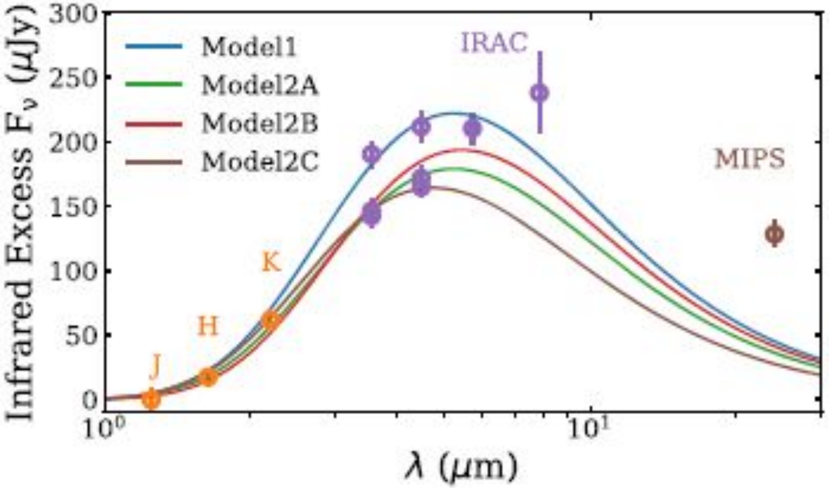




Farihi et al. 2018

SDSS 1228





Xu et al. 2018