Characterisation of exo-planetesimals using white dwarfs

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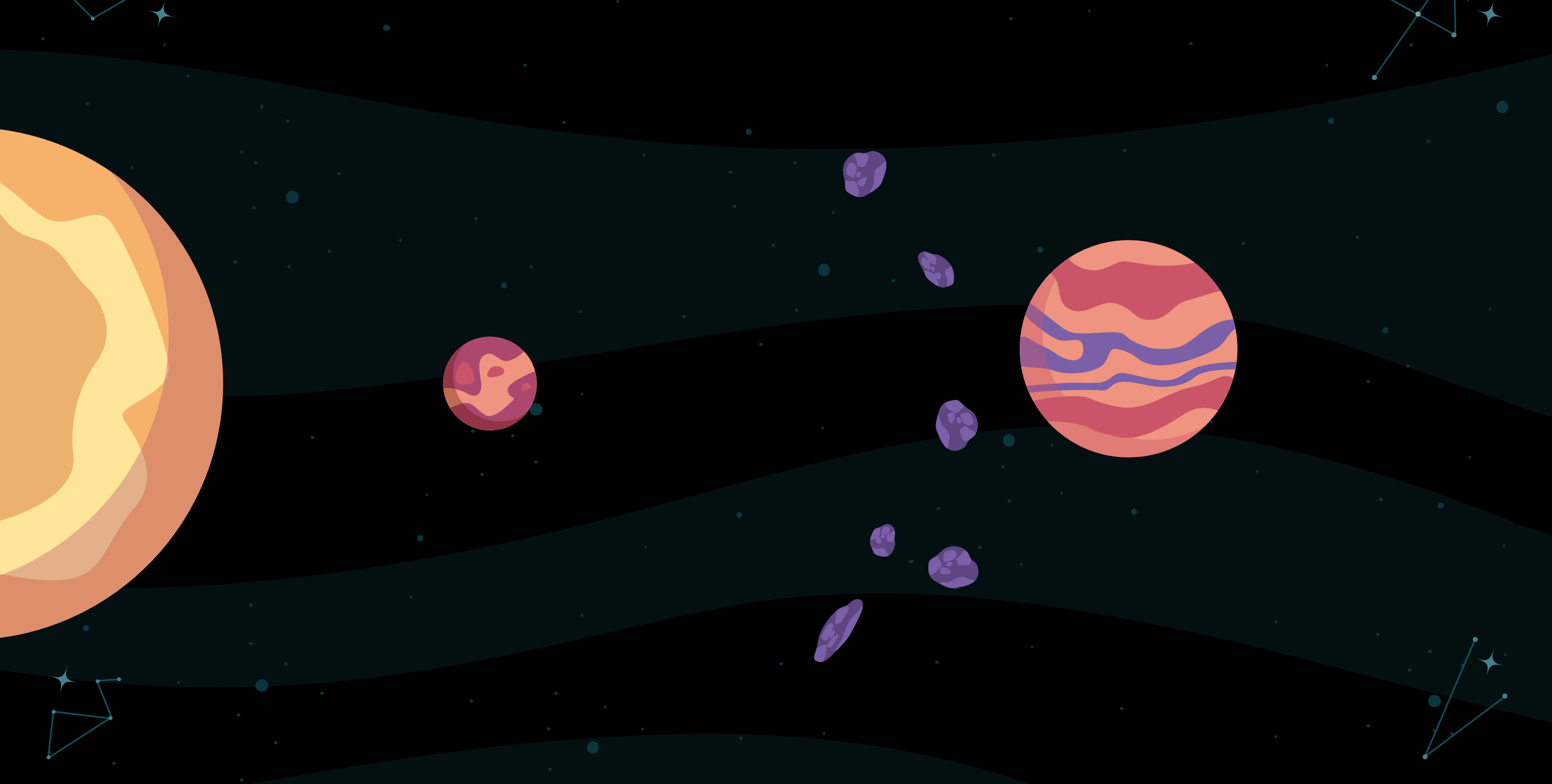
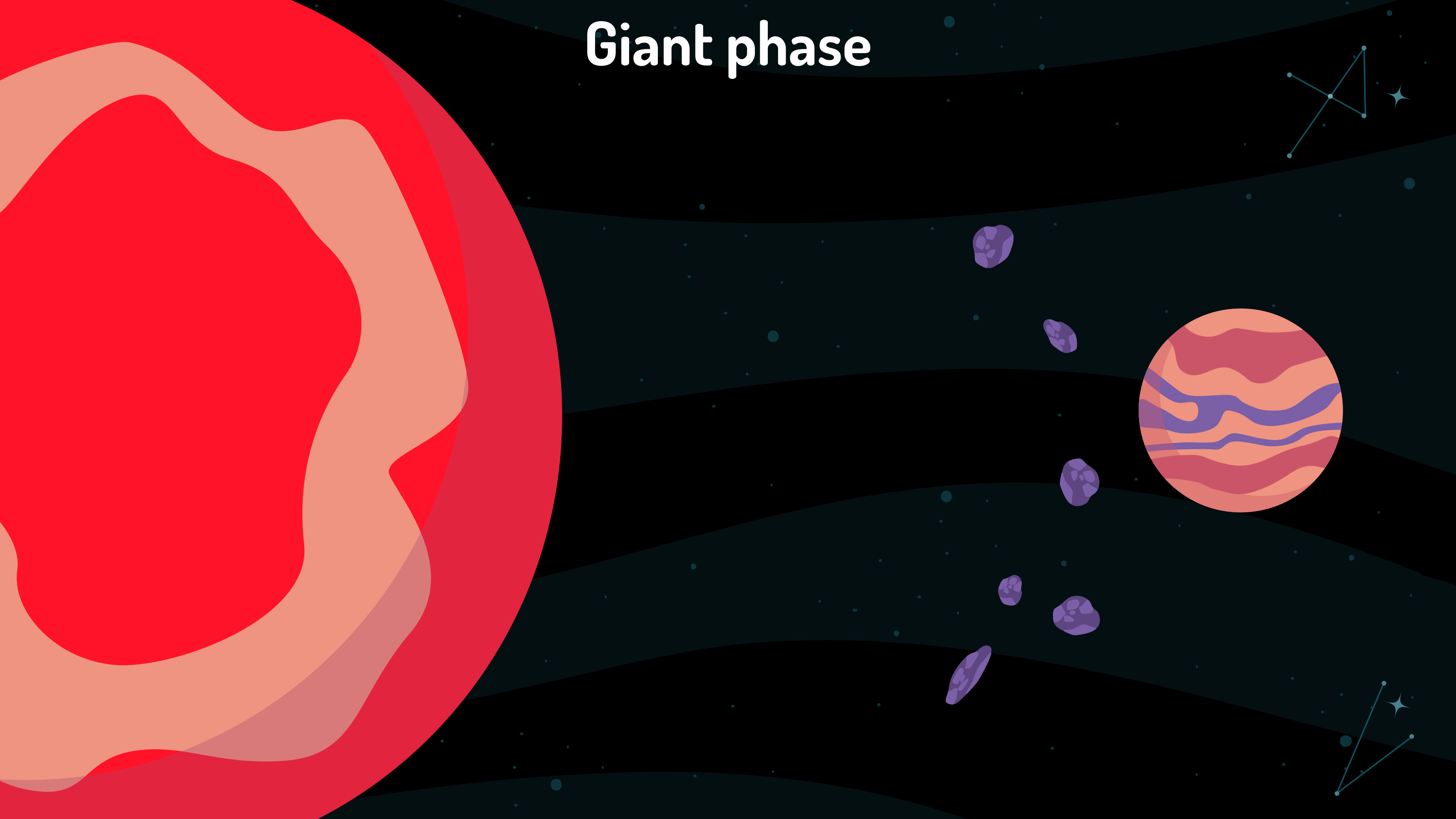
Boris T. Gänsicke, Snehalata Sahu, David J. Wilson, Detlev Koester, Andrew M. Buchan, Odette Toloza, Yuqi Li, and Jay Farihi

White dwarfs allow us to explore the **composition of small bodies in exoplanetary systems**

Simple exoplanetary system

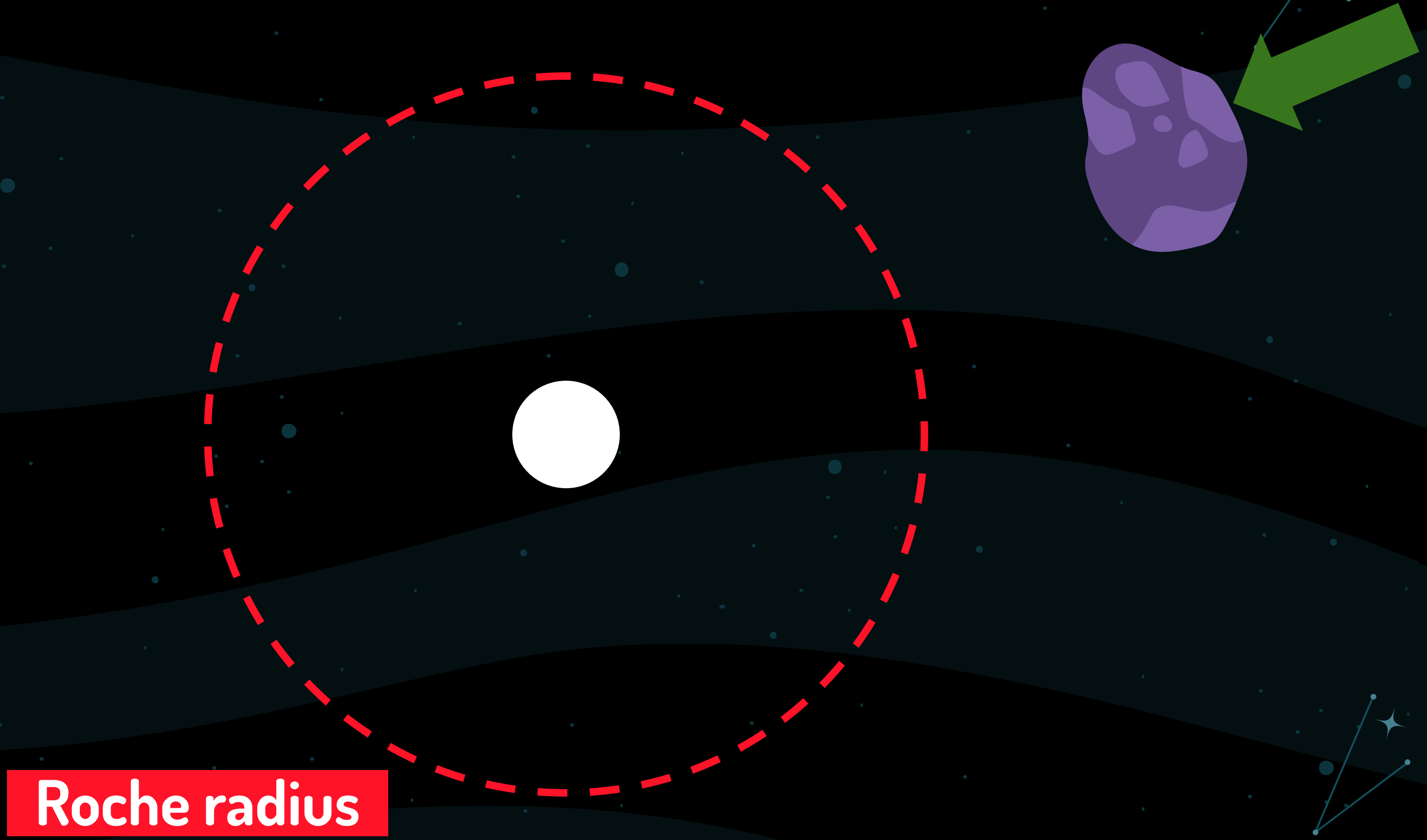


Giant phase

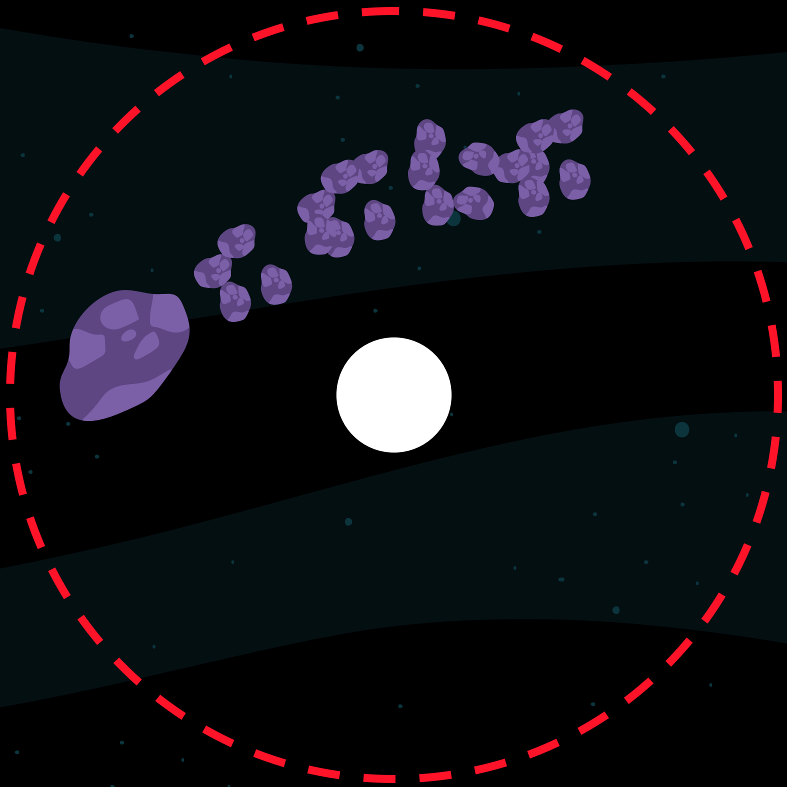


White dwarf phase

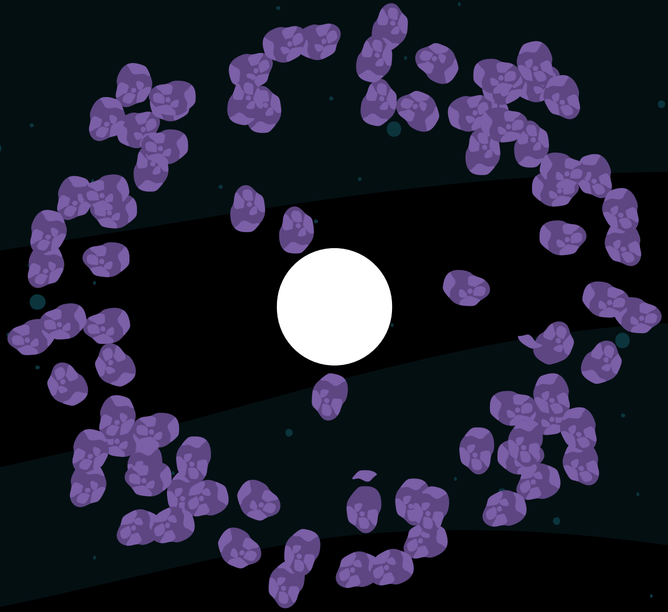
White dwarf accretion



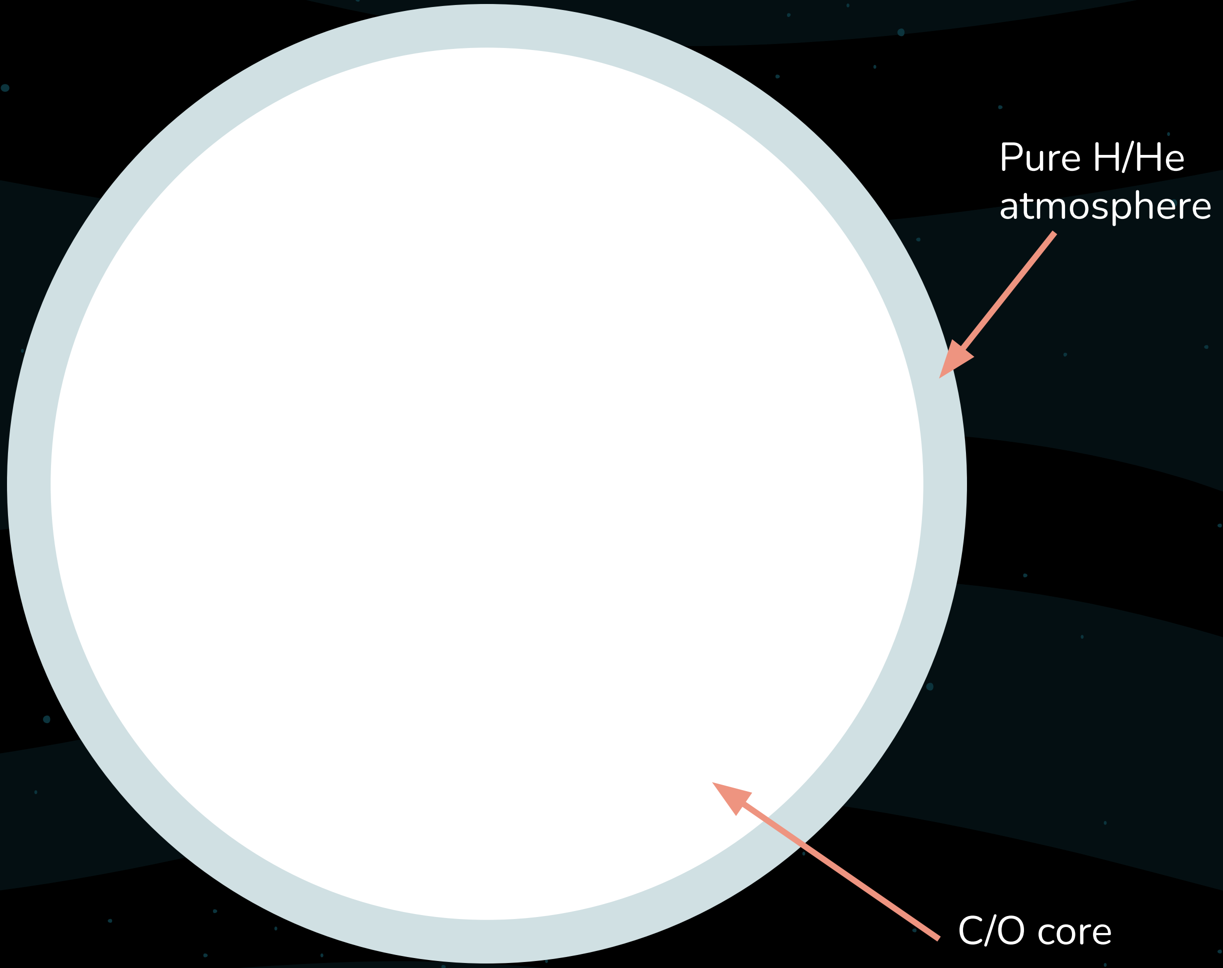
White dwarf accretion



White dwarf accretion



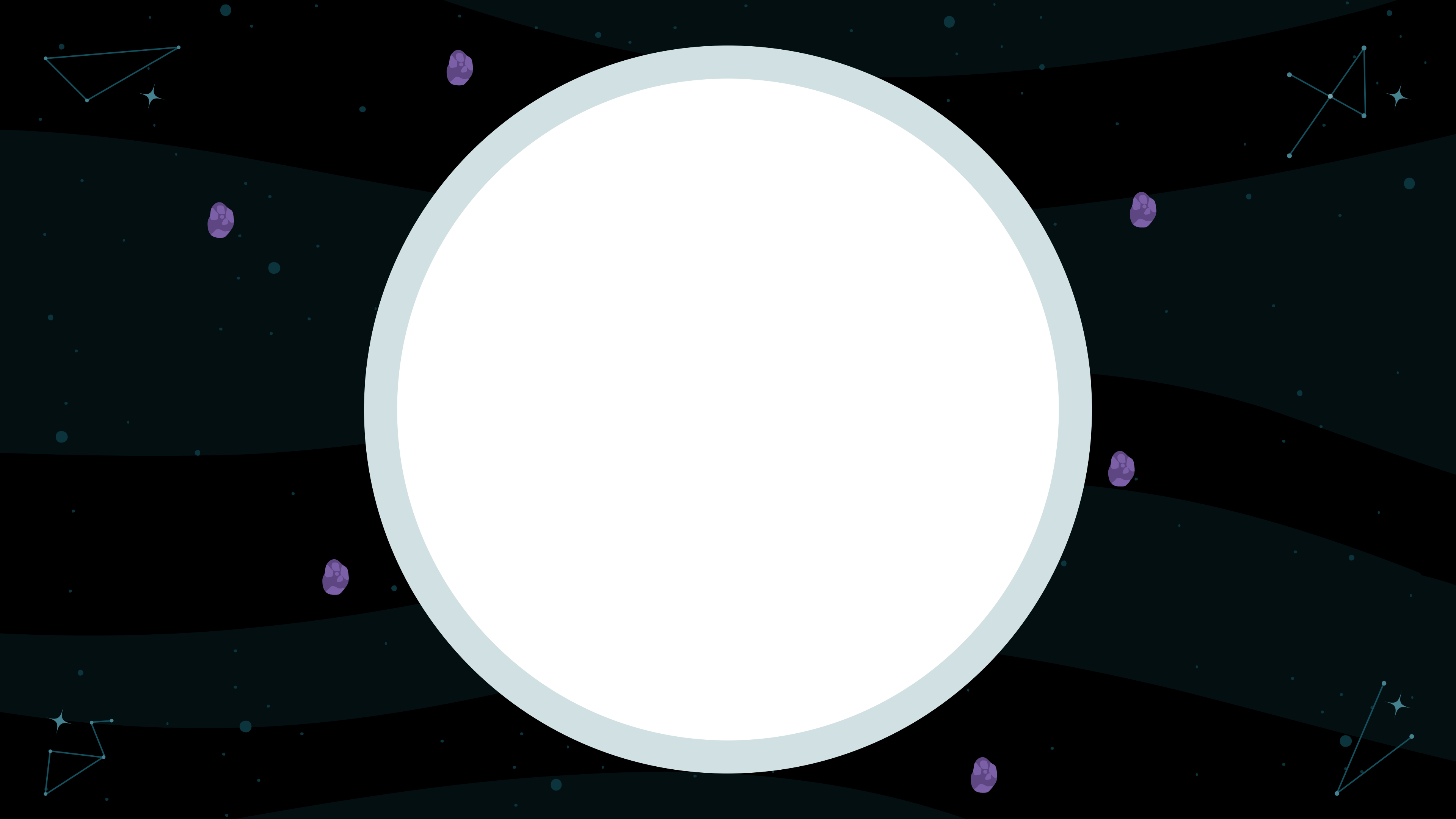
What is a white dwarf?

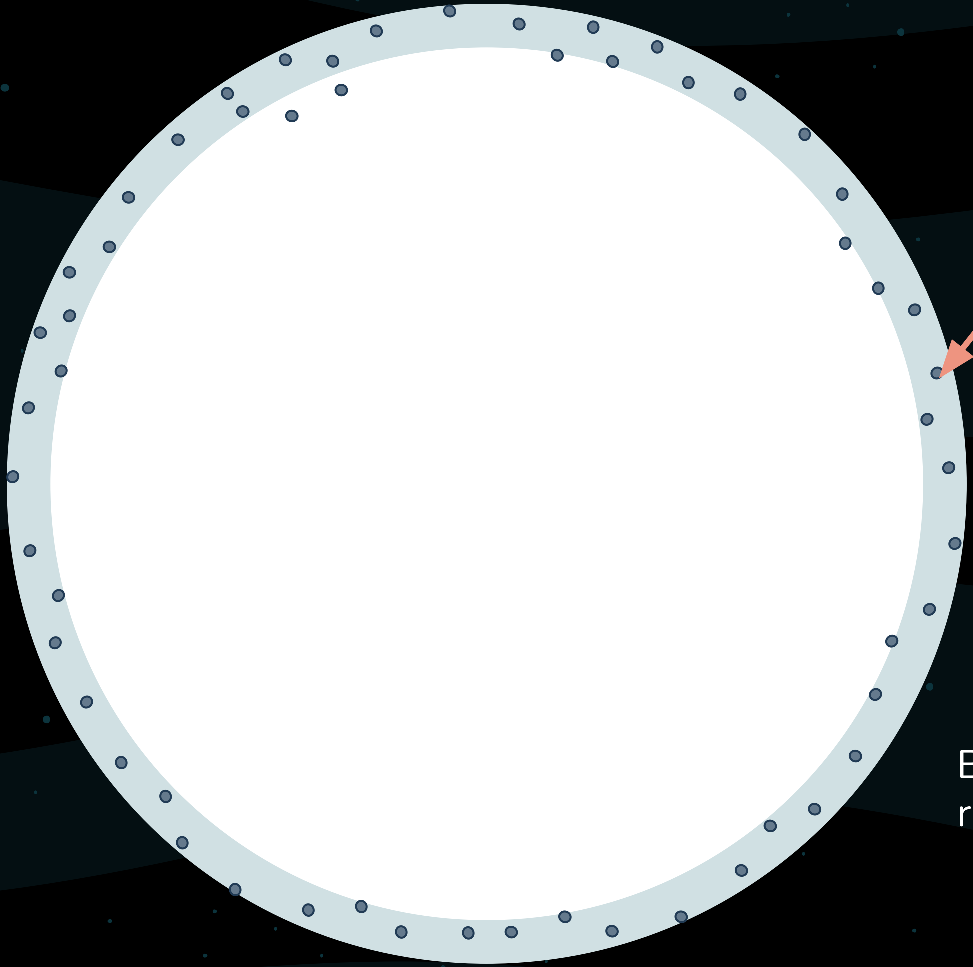


M~0.6 solar masses

R~1 Earth radius

High surface gravity





Atmosphere
“enriched” by metals

But metals sink
rapidly!

The origin of metals in white dwarf atmospheres **must** be recent accretion of planetary material

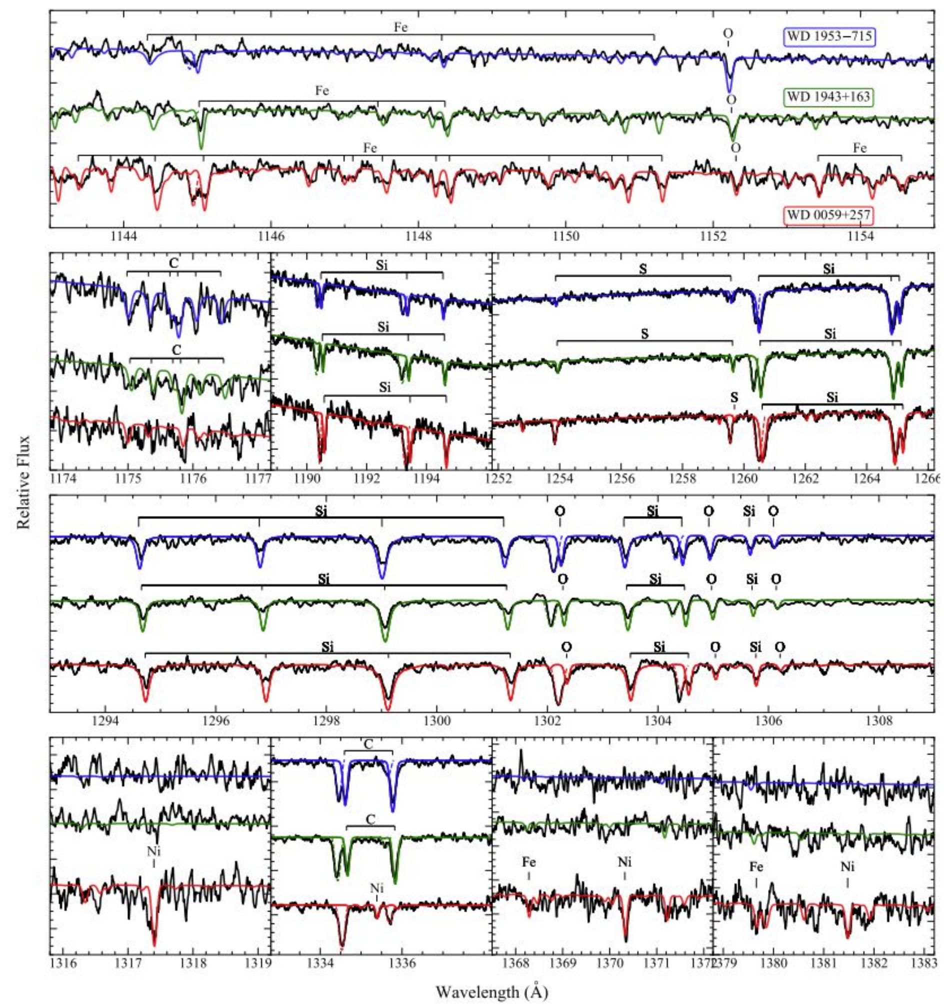
The majority of accreted material is likely **asteroids** or **planetesimals**

Measuring planetary abundances

We take spectra of planetary enriched white dwarfs

Measure the metal abundances by fitting synthetic spectra to observed lines

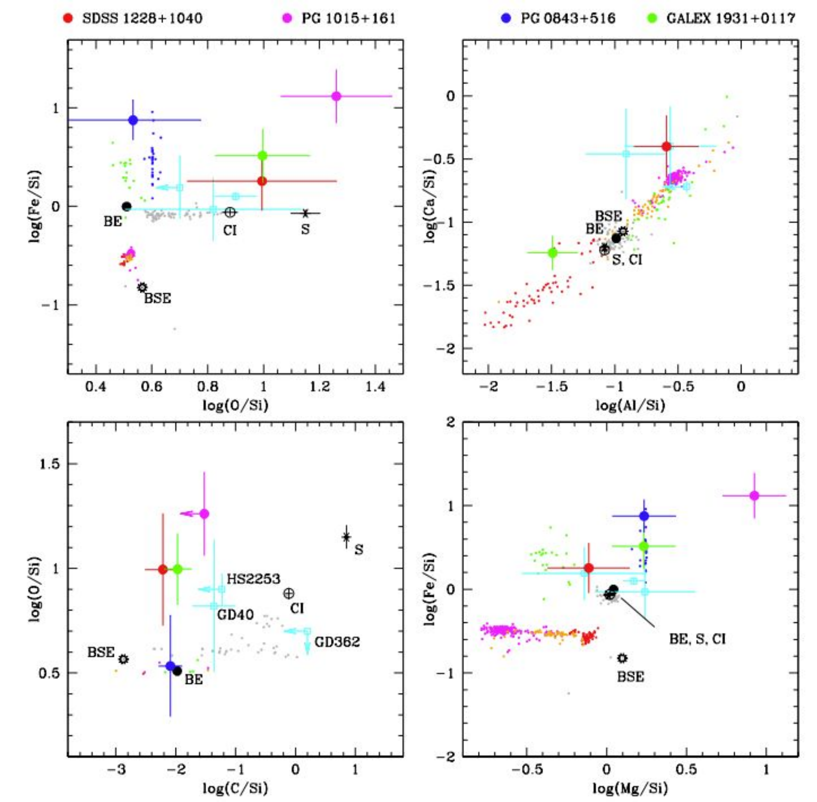
By modelling the white dwarf atmosphere, we can convert the photospheric abundances to planetary abundances



How do we interpret accreted material?

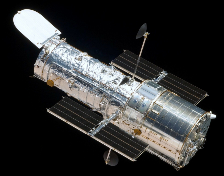
We can measure metal mass fractions and number abundances of the planetary material

We then compare to similar Solar System bodies to identify the potential formation and evolution



Gänsicke et al. (2012)

Example: *HST*/COS snapshot survey



Observed over 400 white dwarfs with 12 000 < T_{eff} < 33 000 K

Approximately 40% show evidence of recent accretion

~20-30 show lines from multiple metals

Focus on three of the most enriched which also have optical spectra from VLT/UVES

WD 0059+257

WD 1943+163

WD 1953-715

HST programs 12169, 12474, 13652, 14077, 15073, 16011, 16642 and 17698.

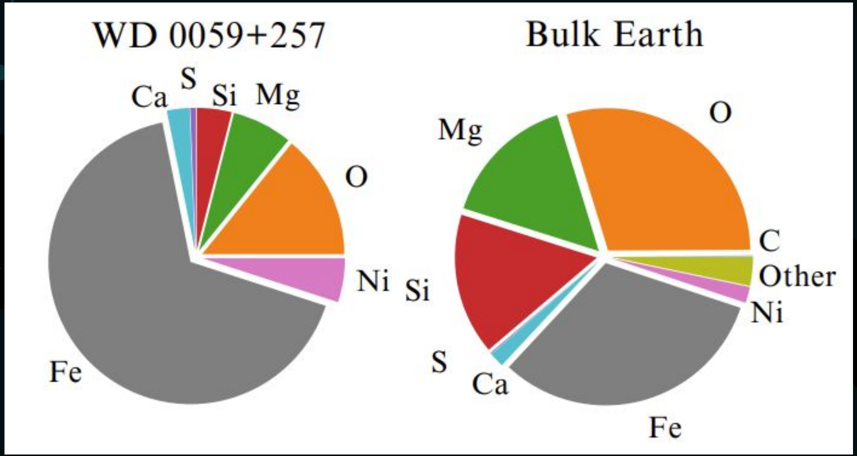
WD 0059+257

Core mass fraction of 69%

Analogous to Mercury or Psyche

Consistent with a differentiated object with its mantle stripped

Enhanced in sulfur: possible light element in the core?



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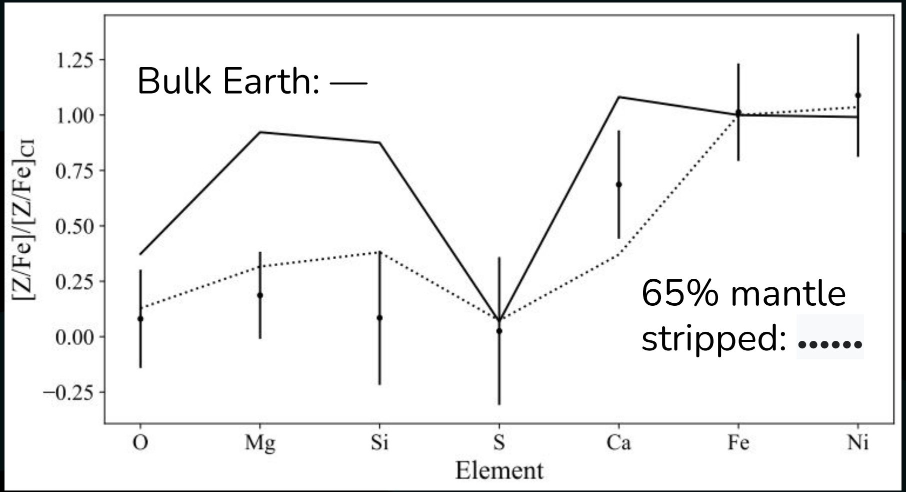
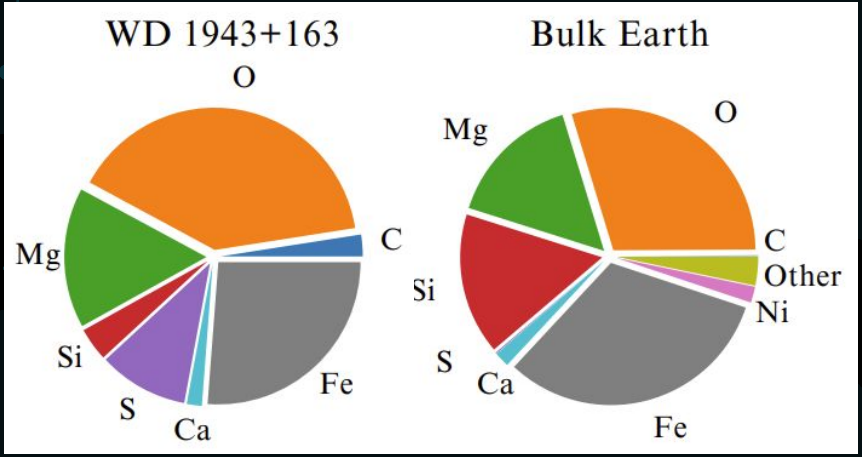


WD 1943+163

Similar composition to carbonaceous chondrites

Volatile abundances suggest it formed far from its host star

Significant silicon depletion unlike any other Solar System object



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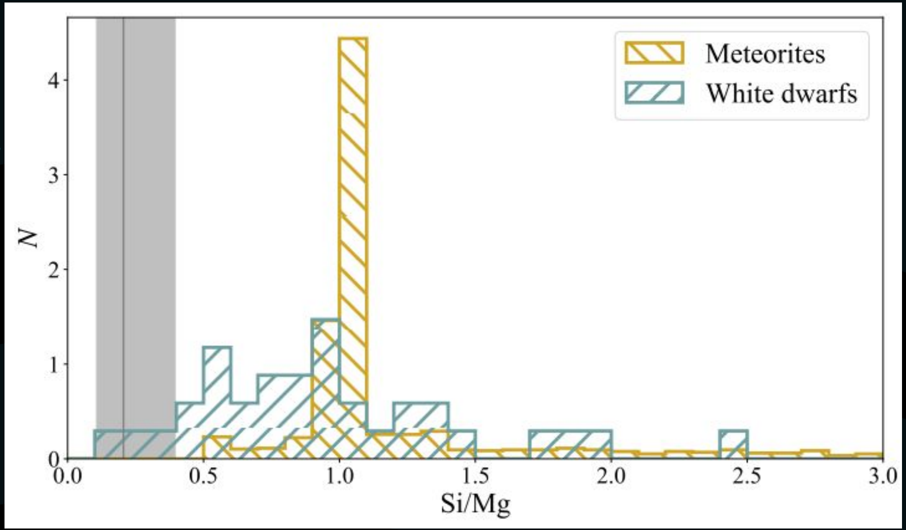
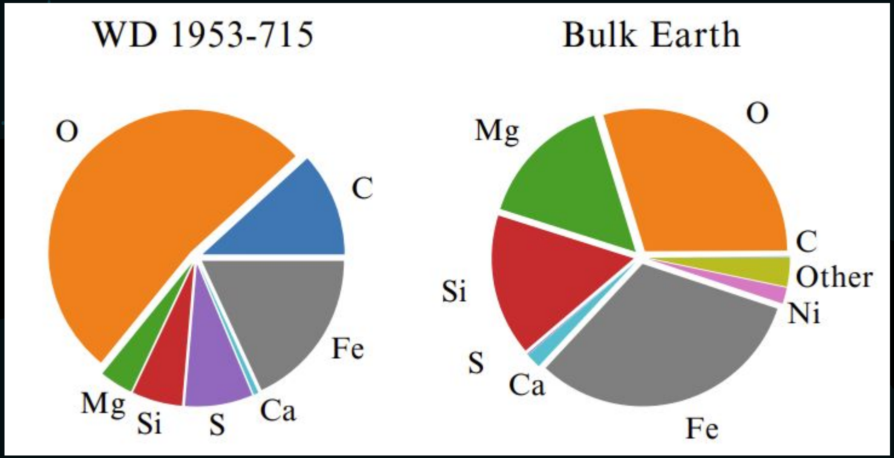


WD 1953-715

Very volatile rich, especially in carbon

Likely contained large mass fraction of water

To survive post-main sequence evolution, needed to be located in a region similar to the Kuiper Belt



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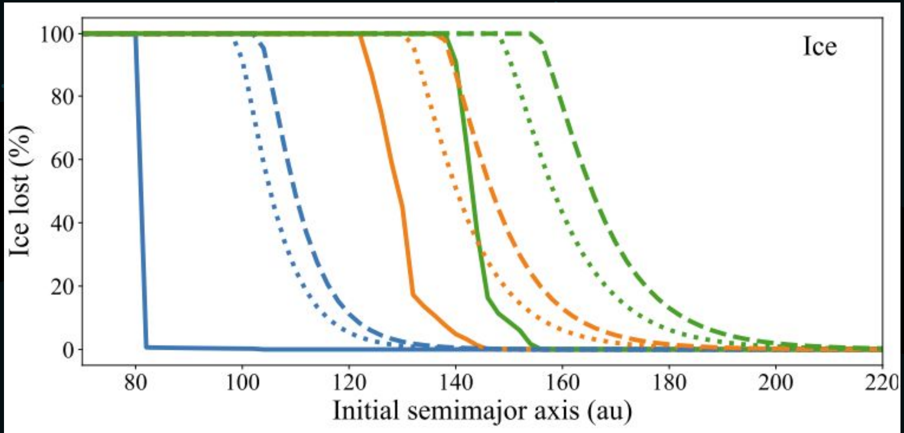

How can planetary scientists help the white dwarf field?

- Accurate meteorite abundances
- Predicted formation mechanisms
- Diversity of Solar System objects

How can white dwarf scientists help the planetary field?

- Increase the sample size of detailed abundances of planetary systems from 1 to 100s
- Offer insight into the interiors of bodies inaccessible by any other means
- Help solve the mystery of Earth’s underdense core
- Understand the eventual fate of the Solar System

Conclusions

White dwarfs can be used to measure the compositions of small bodies in exoplanetary systems

They are accreting a diverse mix of objects.

WD 0059+257: a very core-rich object

WD 1943+163: a carbonaceous chondrite

WD 1953-715: a Kuiper Belt object analogue

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