DUST-GAS-PLANETESIMAL INTERACTIONS IN WHITE DWARFS DEBRIS DISCS

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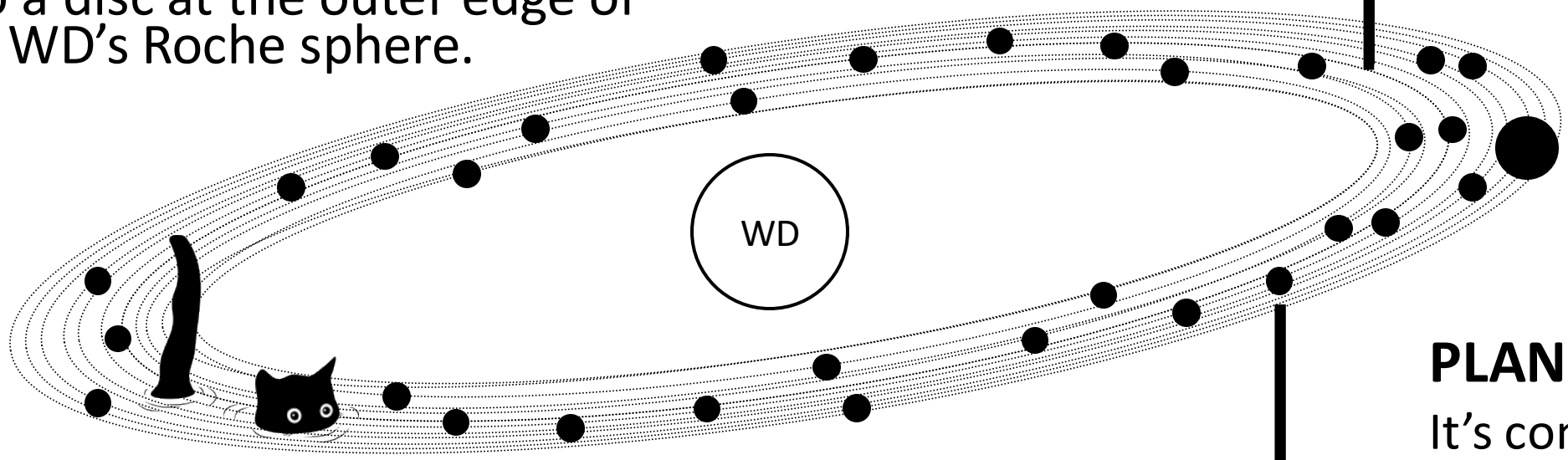
CONTEXT

Planetary material which approaches a white dwarf breaks up and accumulates into a disc at the outer edge of the WD's Roche sphere.



GAS

Ca II triplet

A few

PLANETS

It's complicated

A handful

DUST

IR excess

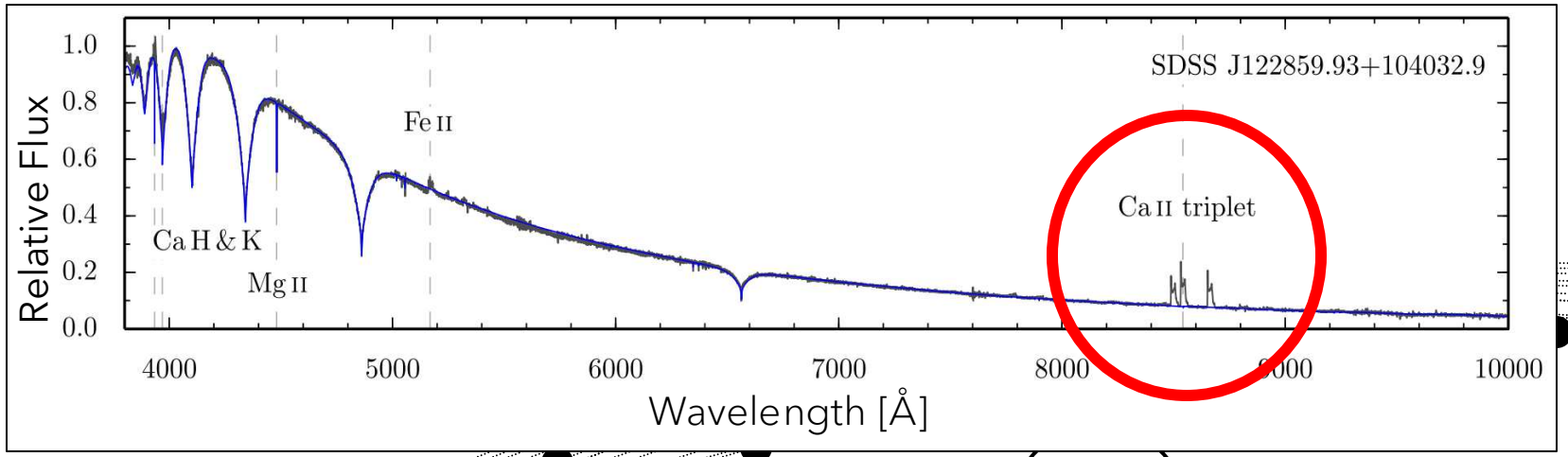
Most of them

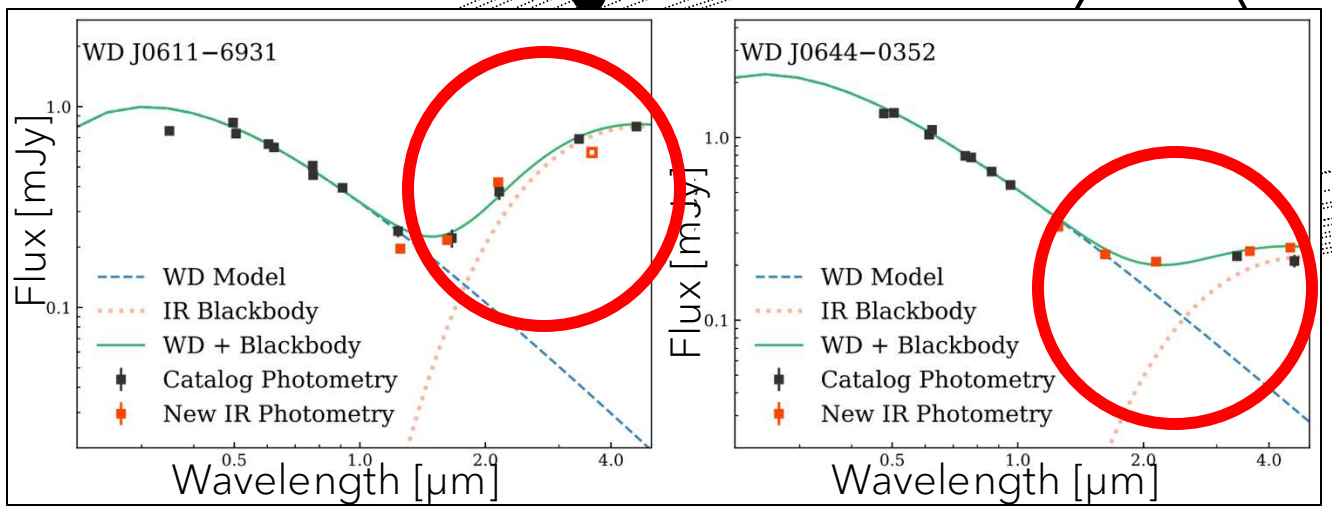
*not to scale

CONTEXT

GAS

Ca II triplet





PLANETS

It's complicated

A handful

DUST

IR excess

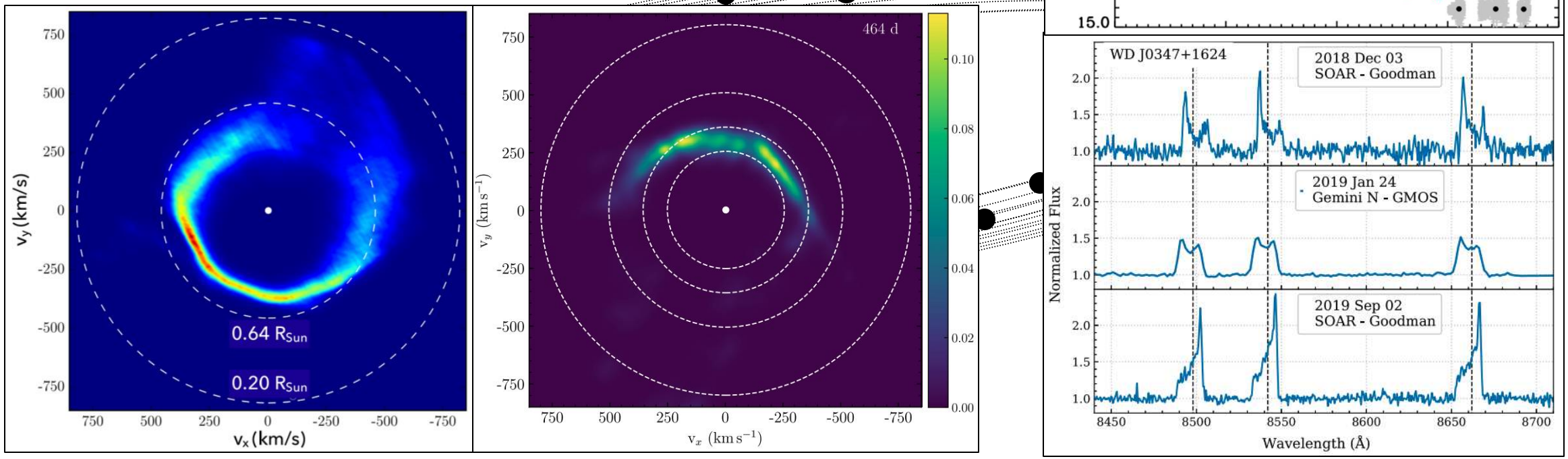
Most of them

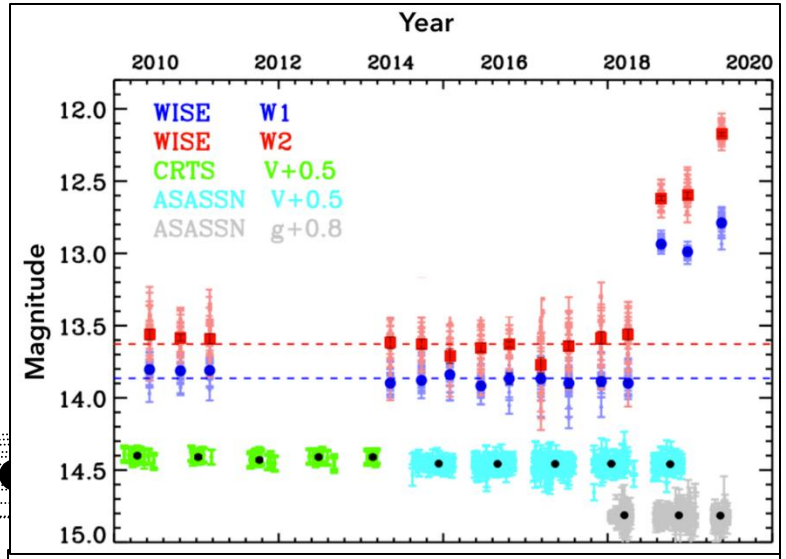
Manser et al. 2016, Dennihy et al. 2020

*not to scale

CONTEXT

More and More observations that show unexplained behaviour like **Flux variations** and **non-axisymmetric geometrical structure**

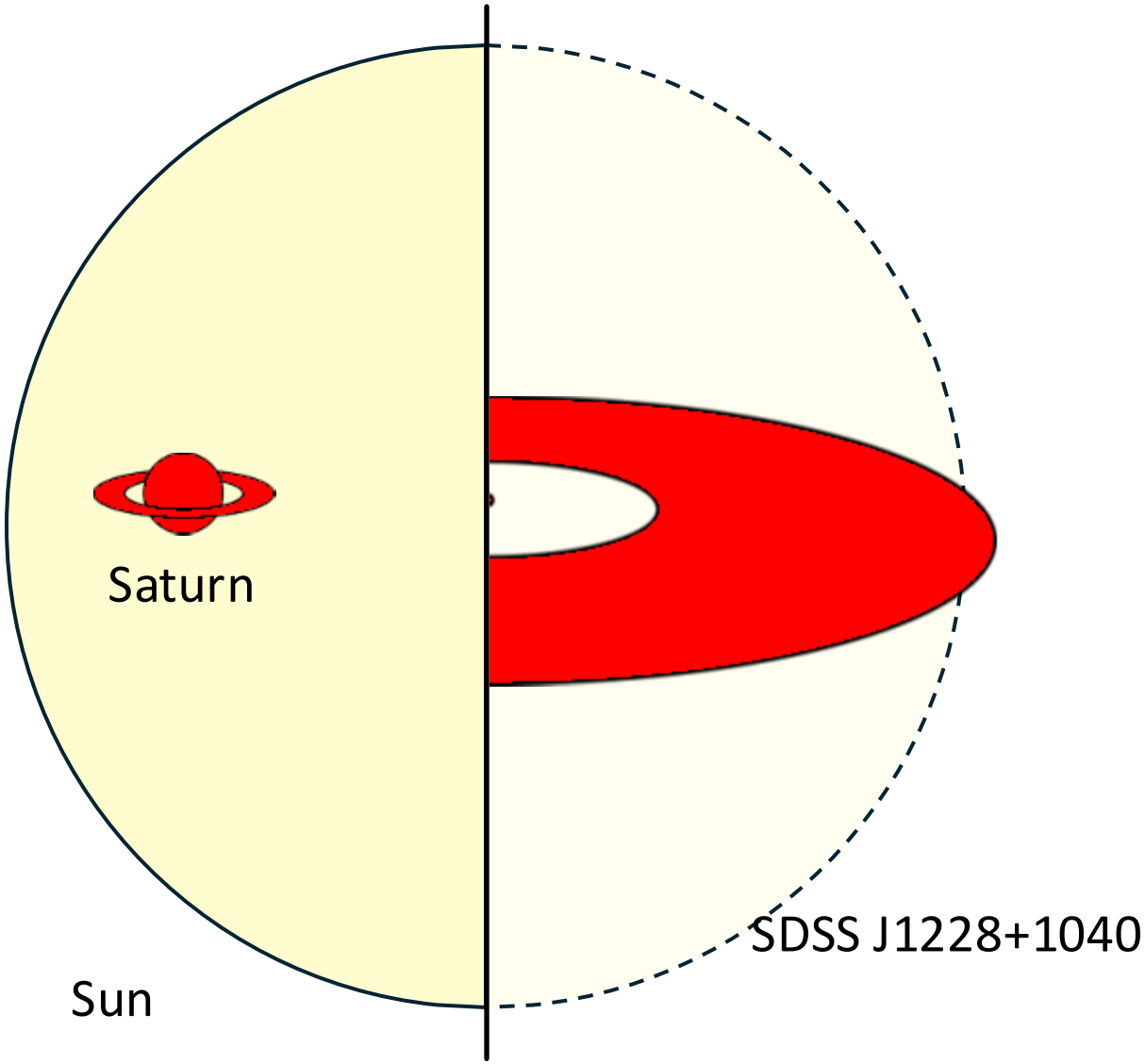


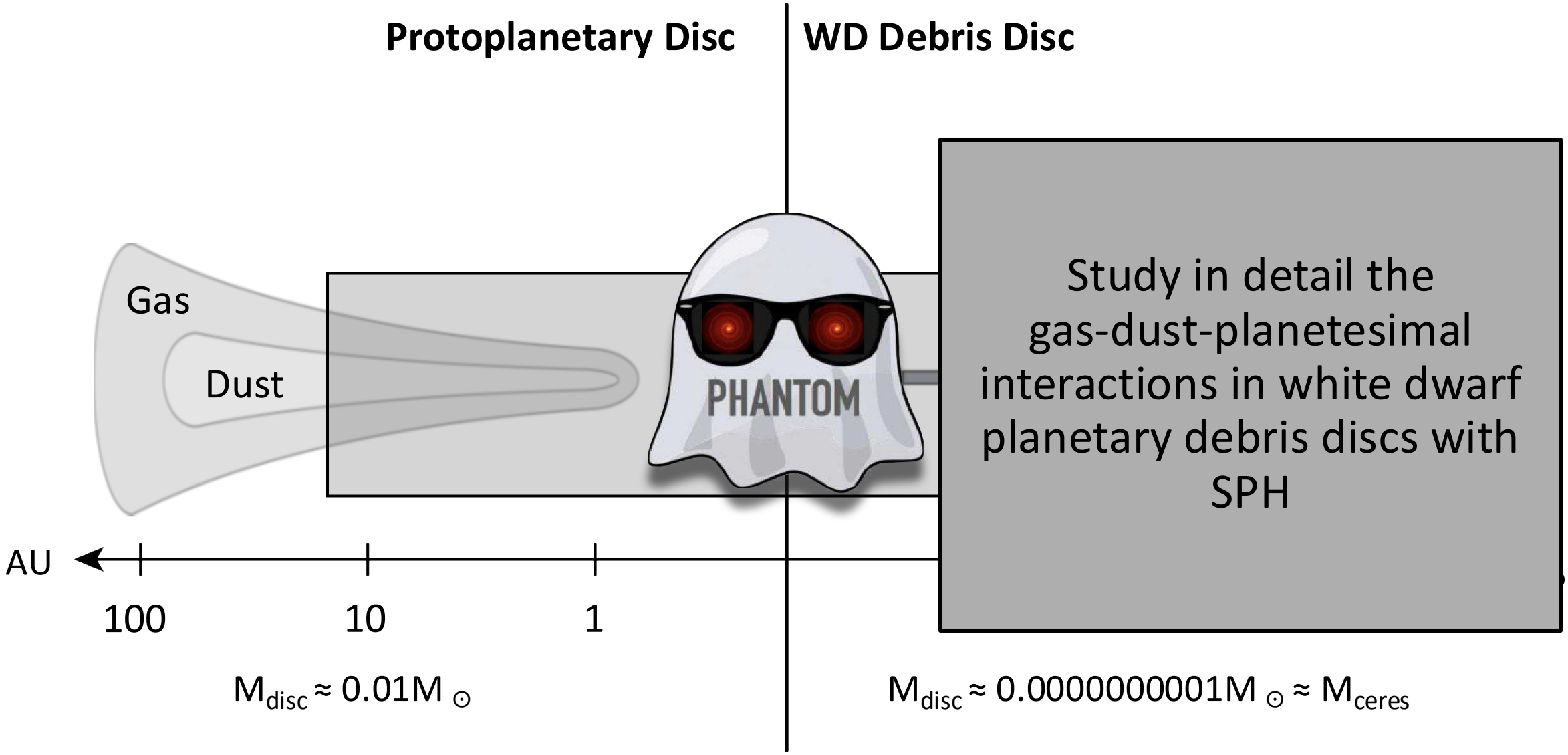


Manser et al. 2016, Manser et al. 2021, Wang et al. 2019, Swan et al. 2020

*not to scale

CONTEXT





Price et al. 2018

HOW TO HAVE GAS/DUST-DOM DISCS

With Individual time stepping:

Special recipes for calculating the stopping time:

$$t_s = \frac{\rho_g \rho_d}{K(\rho_g + \rho_d)}$$

$$t_s = \frac{\rho_g \rho_d}{K \rho_g}$$ Gas-Dominated

$$t_s = \frac{\rho_g \rho_d}{K \rho_d}$$ Dust-Dominated

The approximations allow calculations to proceed efficiently in the case of numerical dust trapping

With Global time stepping:

gas/dust drag implicit scheme (special option in .in file)

SPH SIMULATIONS

GENERAL DISC SETUP

Axisymmetric
Flared
Power law surface density profile
Two fluid simulations:
Gas + Dust (one size)

PARAMETER SPACE

Star parameters:
mass = 0.6 $M_\odot$

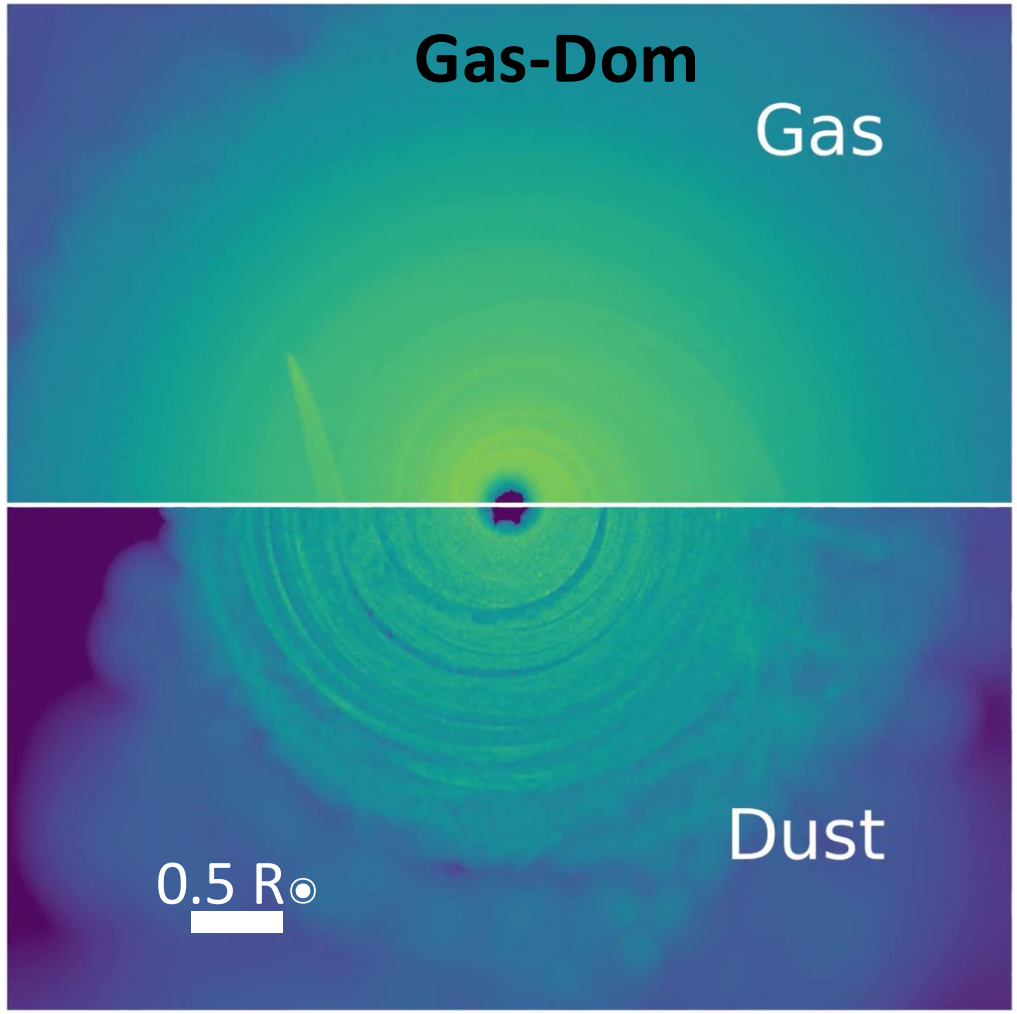
Disc parameters:
mass = 10^{-12} $M_\odot$ = 1 M_{ceres}
inner radius = 0.2 $R_\odot$
outer radius = 1.5 $R_\odot$
eccentricity = 0 – 0.5
dust/gas ratio = 0.001 – 1000

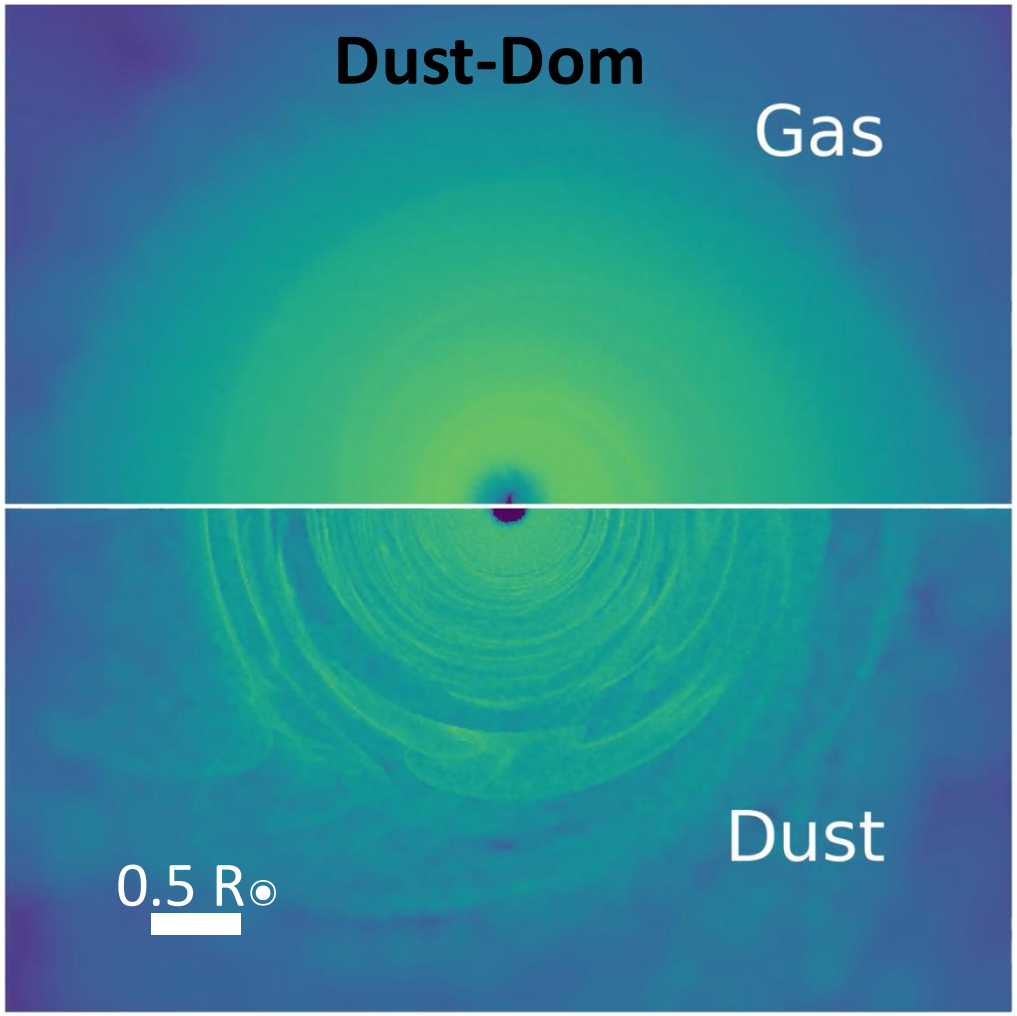
Dust Grain Parameters:
size = 0.1 - 1000 mm

Planet Parameters:
mass = 1 M_{ceres} - 1 M_J
distance = 0.5 $R_\odot$
eccentricity = 0 – 0.5

SPH SIMULATIONS RESULTS

Circular Discs & Eccentric Massive Planet

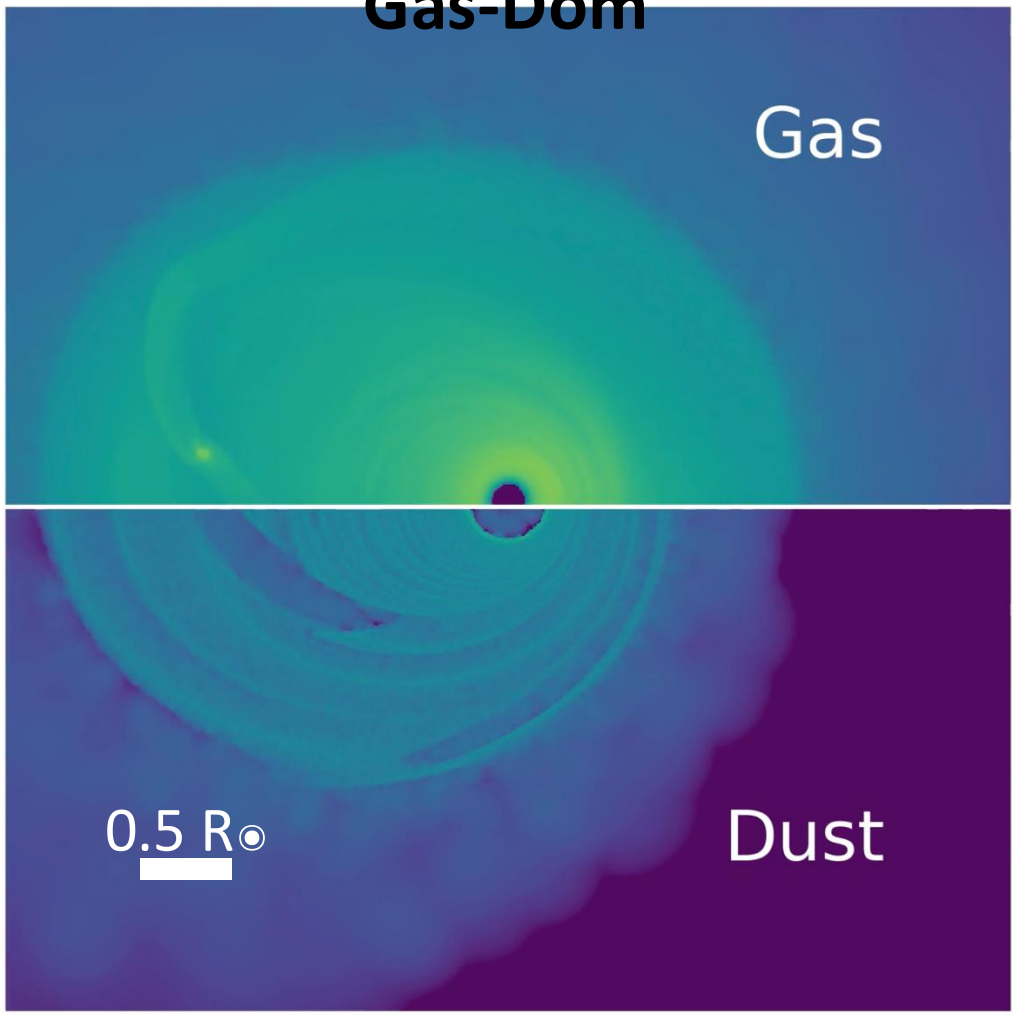




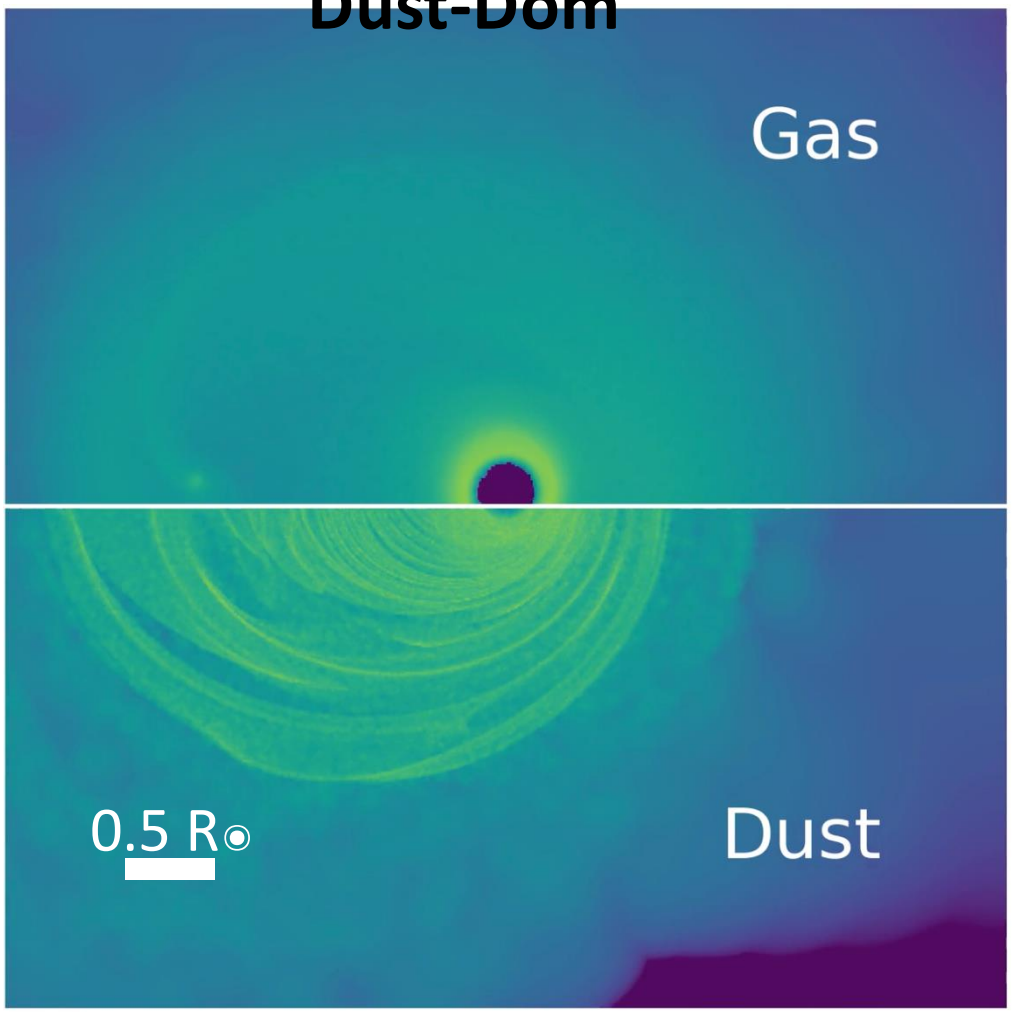
SPH SIMULATIONS RESULTS

Eccentric Discs & Eccentric Massive Planet

Gas-Dom

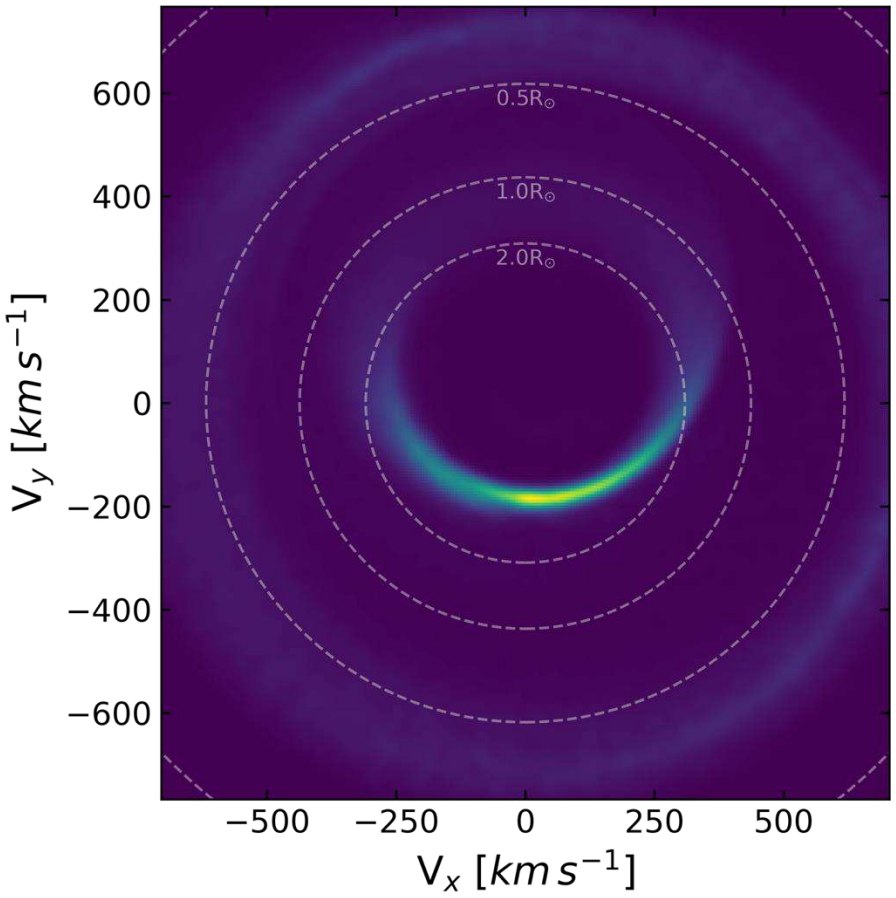


Dust-Dom

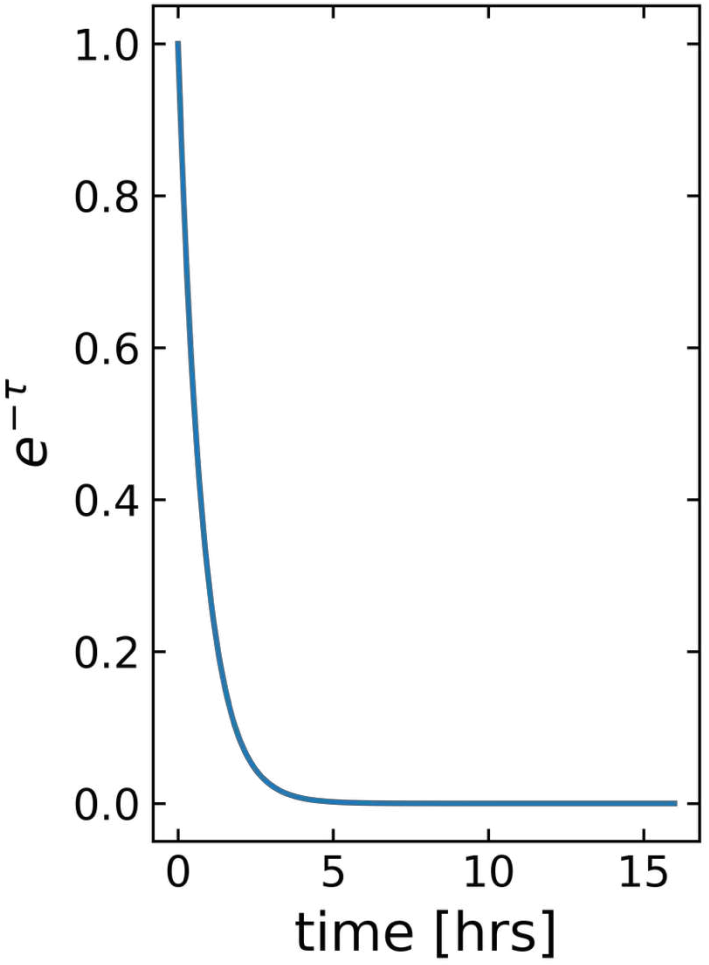


SPH SIMULATIONS OBSERVABLES

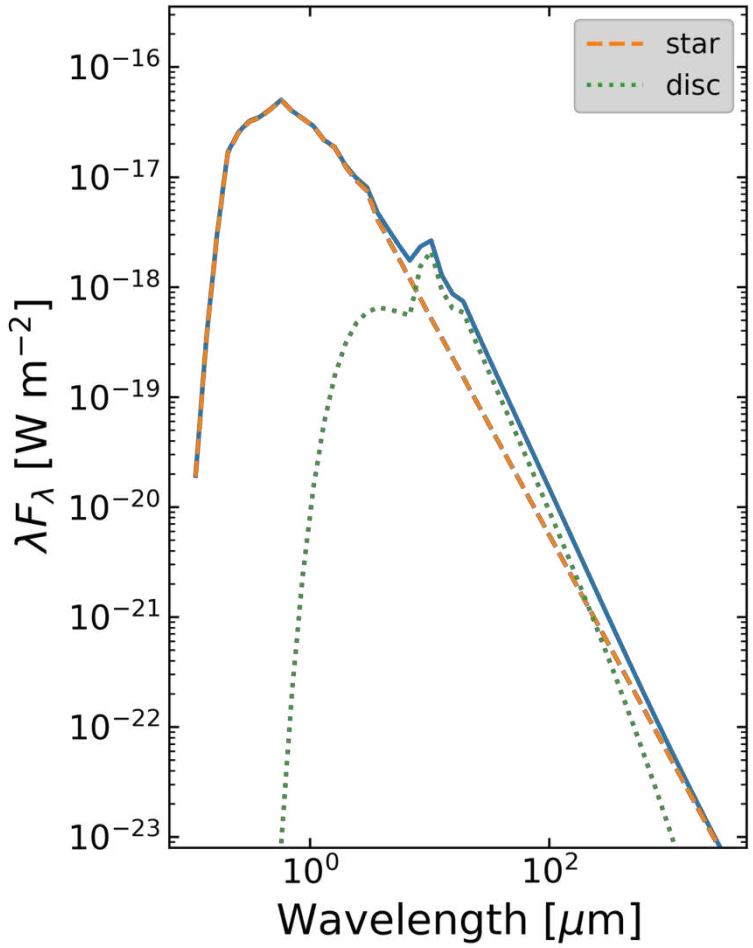
Doppler Tomograph



Light curve(?)

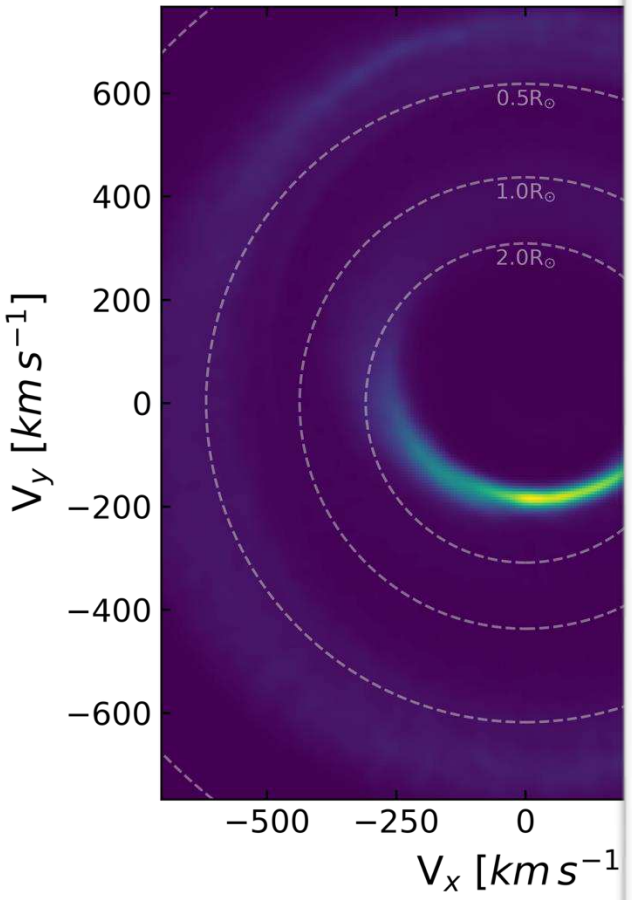


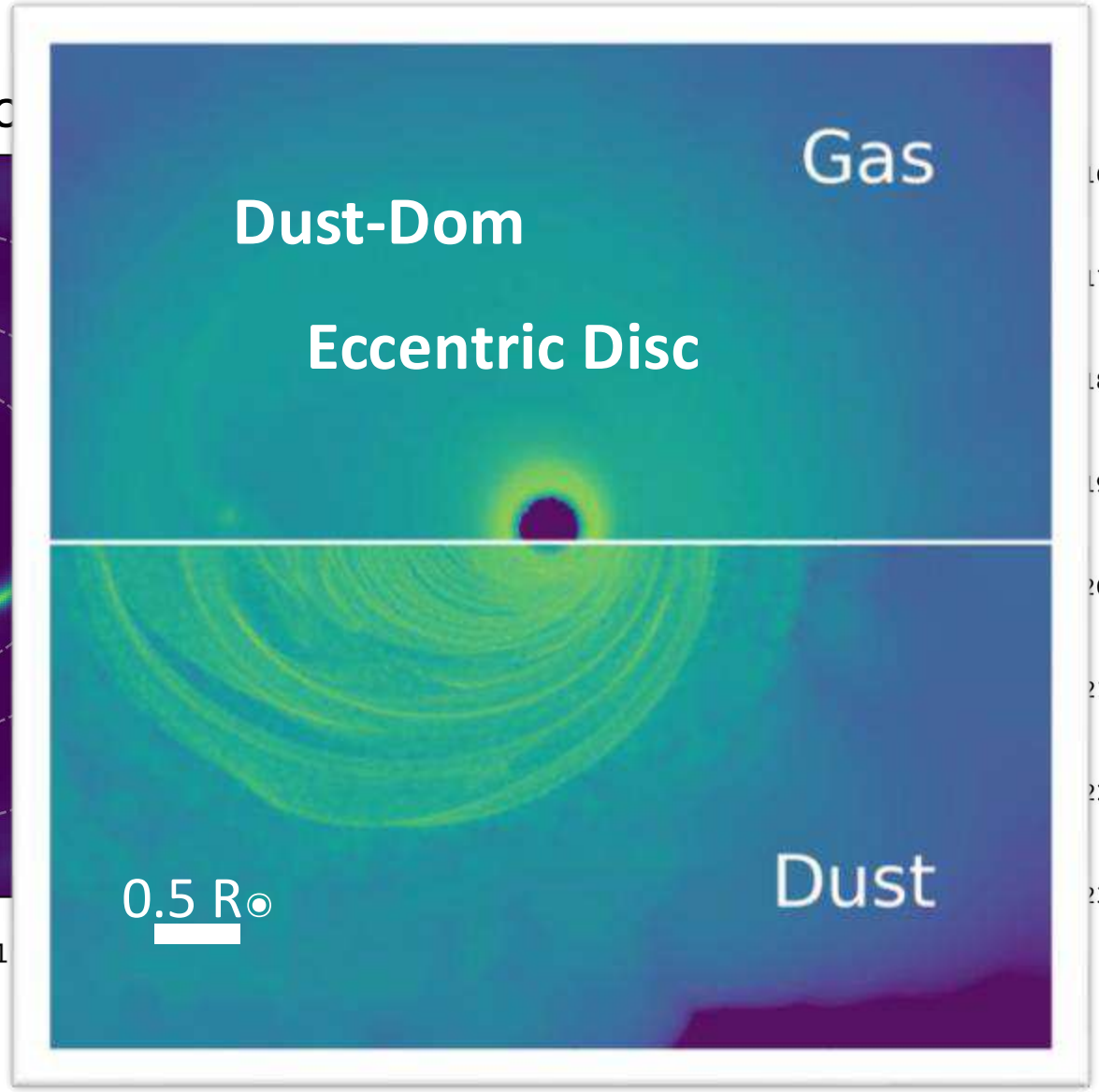
SED



SPH SIMULATIONS OBSERVABLES

Doppler Tomo





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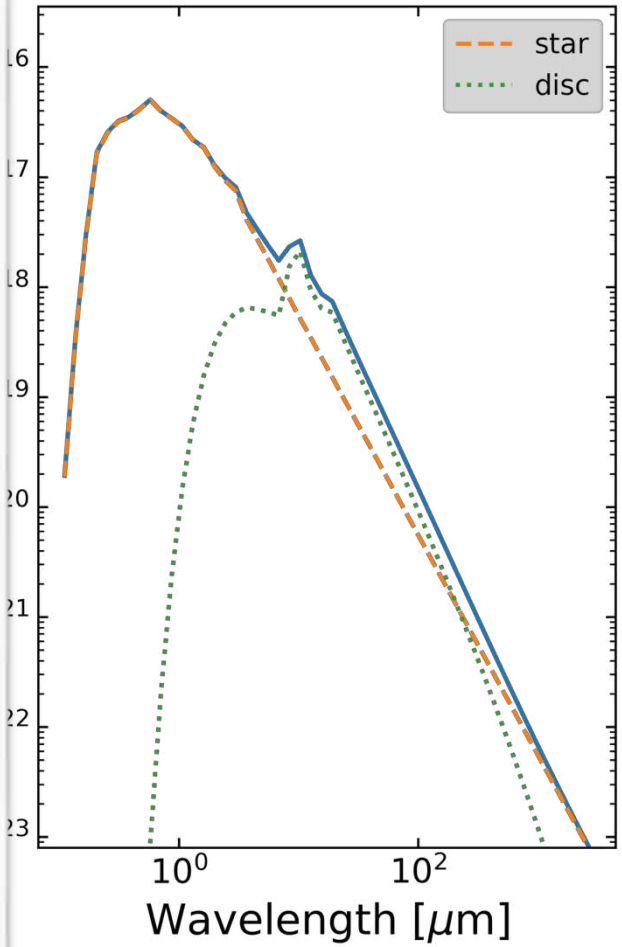

SUMMARY

Conducting a detailed study of gas-dust-planetesimal interactions in white dwarf planetary debris discs.

No actual results yet, but…

Open questions for inspiration:

- Can we explain any aspects of the flux variations?
- Do planets leave any observational signatures?
- Can we accurately measure disc eccentricity from observations?
- Can we make predictions regarding known systems?

FUTURE WORK

- Run a full parameter sweep on Dust-to-Gas ratios and dust-grain sizes
- Go crazy and run many other simulations too
- Write write & write, right?

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