# The evolution of planetesimals in a post-main-sequence planetary system with a migrating planet

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## Polluted White Dwarfs

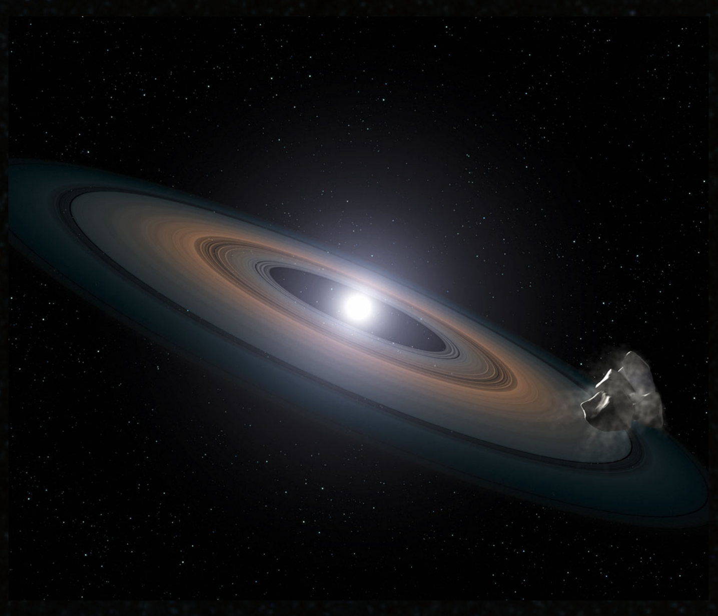

*Figure 1: Artists impression of a debris disc being created around a white dwarf by a tidally disrupting asteroid. Credit: NASA, ESA, STSci, and G.*

- 95% of stars in the Milky Way will become white dwarfs (WDs), extremely small and dense stellar remnants [1].
- Elements heavier than hydrogen or helium should quickly sink out of the WD atmosphere [2], but up to 50% of WDs show evidence for metals inside their photospheres [3].
- This metallic material is thought to be the recently accreted remains of remnant planetesimals, but the processes which lead to delivery of material to the WD remain an active area of research.

## Post-Main-Sequence Planetary Systems

Planetary systems evolve alongside their stars, adapting to the sometimes violent stellar changes which leads to drastically different architectures in the final stages of the stars life.

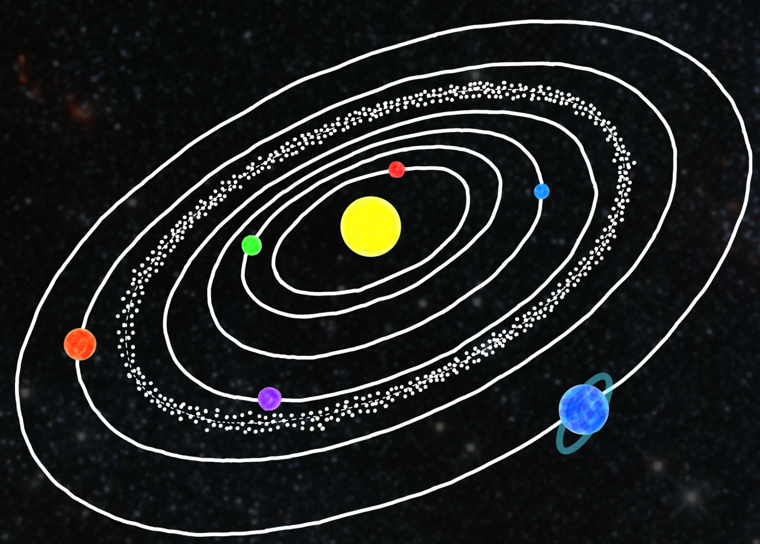

*Figure 2: Cartoon of a main sequence planetary system*

### Main Sequence

- Majority of stars in the Milky Way host at least one planet [4].

### Giant Branches

- Star loses up to 80% of its mass and becomes 1000x larger and brighter.
- Close in planets are engulfed.
- Planetary orbits get 2-3x larger [5].

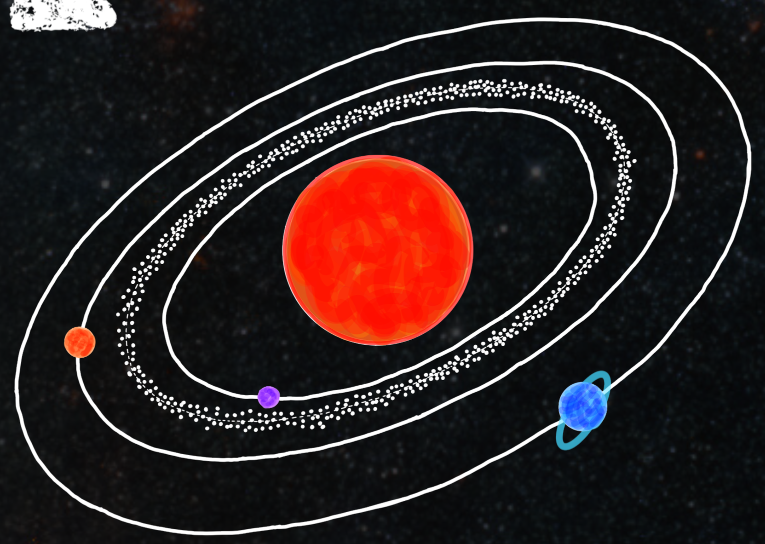

*Figure 3: Cartoon of a giant branch planetary system.*

### White Dwarf

- Unstable remnant planetary systems with planets and planetesimals on much wider orbits at the onset of WD phase.
- Observed transits of close in asteroids breaking up near the Roche radius [6,7].
- Inferred presence of gas/ice giants on short period orbits [8,9].

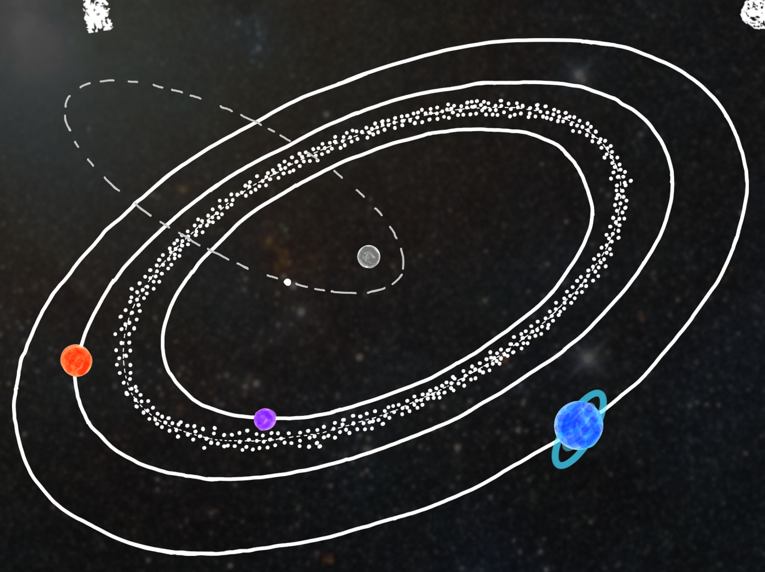

*Figure 4: Cartoon of a white dwarf planetary system.*

*NOT TO SCALE!*

## WD1856+534b

- WD1856+534 is an unpolluted, ~0.5M⊙ WD observed with a large transit signature (~56% transit depth, see Fig. 5) [9].
- Planet candidate properties:
  - $R \sim 0.9 R_J$,
  - $M \leq 11.7 M_J$,
  - a ~ 0.02 au.
- It is unlikely that the planet candidate survived a common envelope evolution and thus must have migrated to this close in distance during the WD phase of stellar evolution, without perturbing any planetesimals onto Roche radius crossing orbits.

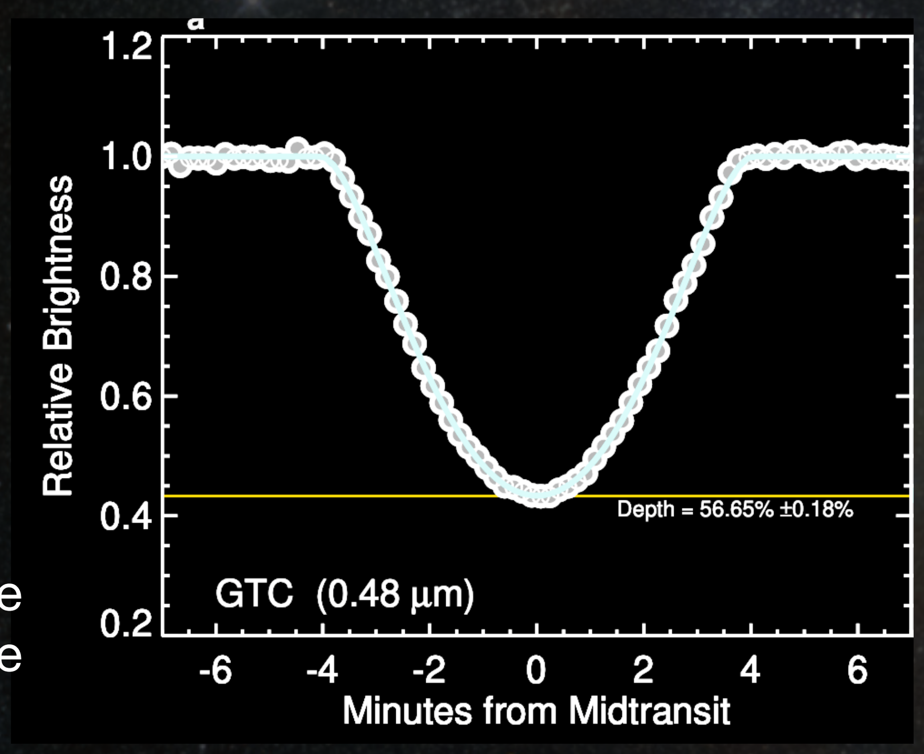


*Figure 5: Optical transit signature of WD1856b taken with the GTC [9].*

- But the response of post-main-sequence planetesimals to a migrating planet remains unstudied.

## Post-Main-Sequence Planetary Migration

WORK IN PROGRESS

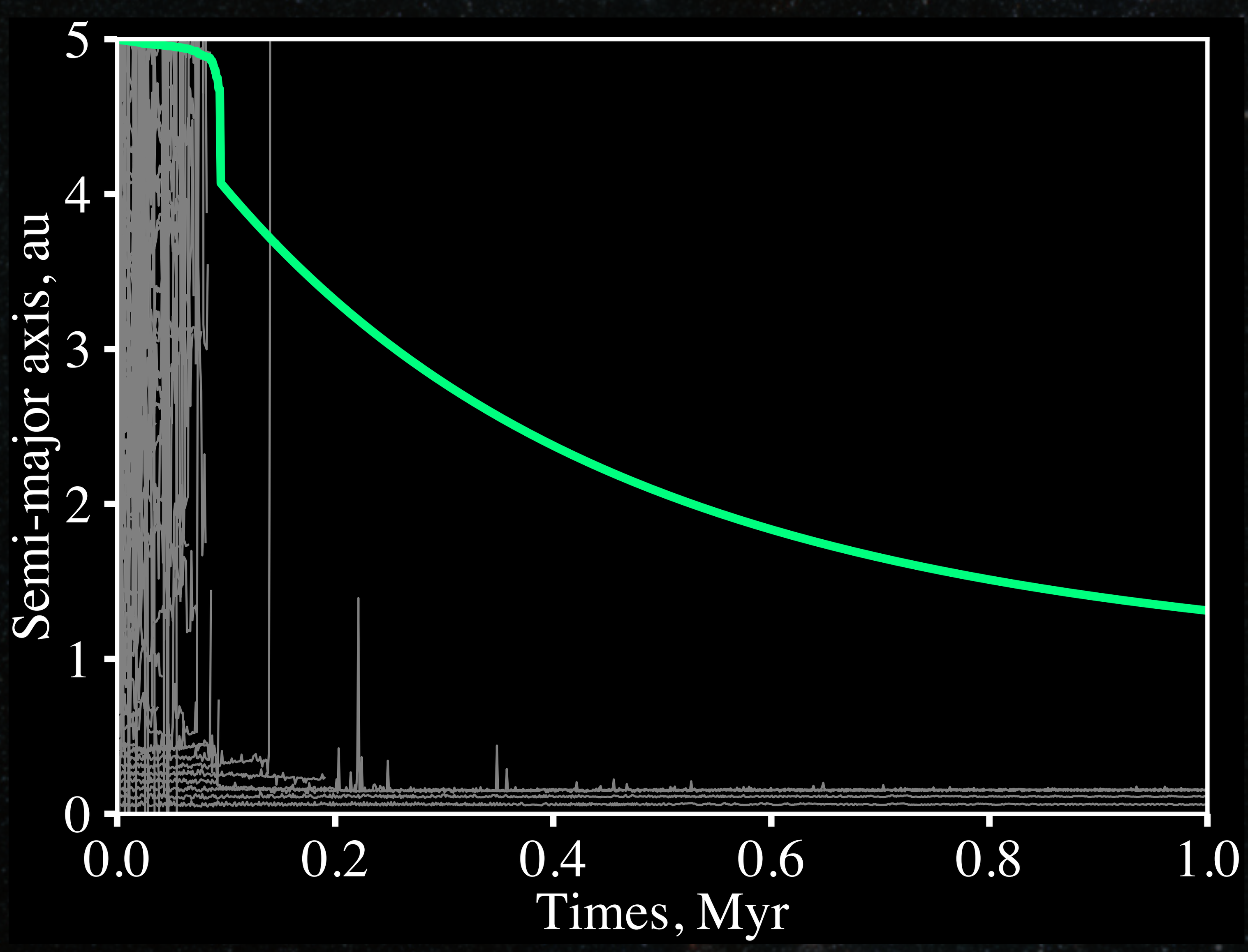


*Figure 6: Semi-major axis evolution of 100 equally spaced planetesimals (thin grey lines) as a Jupiter mass planet (green line) migrates through the system.*

- To find what effect the a planet migrating through a post-main-sequence planetary system will have on a reservoir of remnant planetesimals, we neglect the initial interaction which gives the planet a very high eccentricity and focus on the recircularization process.
- N body simulations using Rebound and Reboundx:
  - $1 M_J$ planet migrating through directly applied exponential semi-major axis decay to approximate tidal recircularisation,
  - 100 test particles equally spaced from the planets a to 0.01 au,
  - $\tau_{\mathrm{migration}} = 1 \times 10^6$ yrs.
- Migration effectively clears out planetesimal reservoirs unless they are very close to the central star, a region where they could not survive giant branch evolution.
- If main sequence hot Jupiters undergo migration after the protoplanetary disc has dissipated, they could effectively clear their systems of planetesimals.

### References

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Background image: NGC 6946 ESA/Hubble & NASA, A. Leroy, K. S. Long