Towards a complete picture of the evolution of planetary systems around evolved stars

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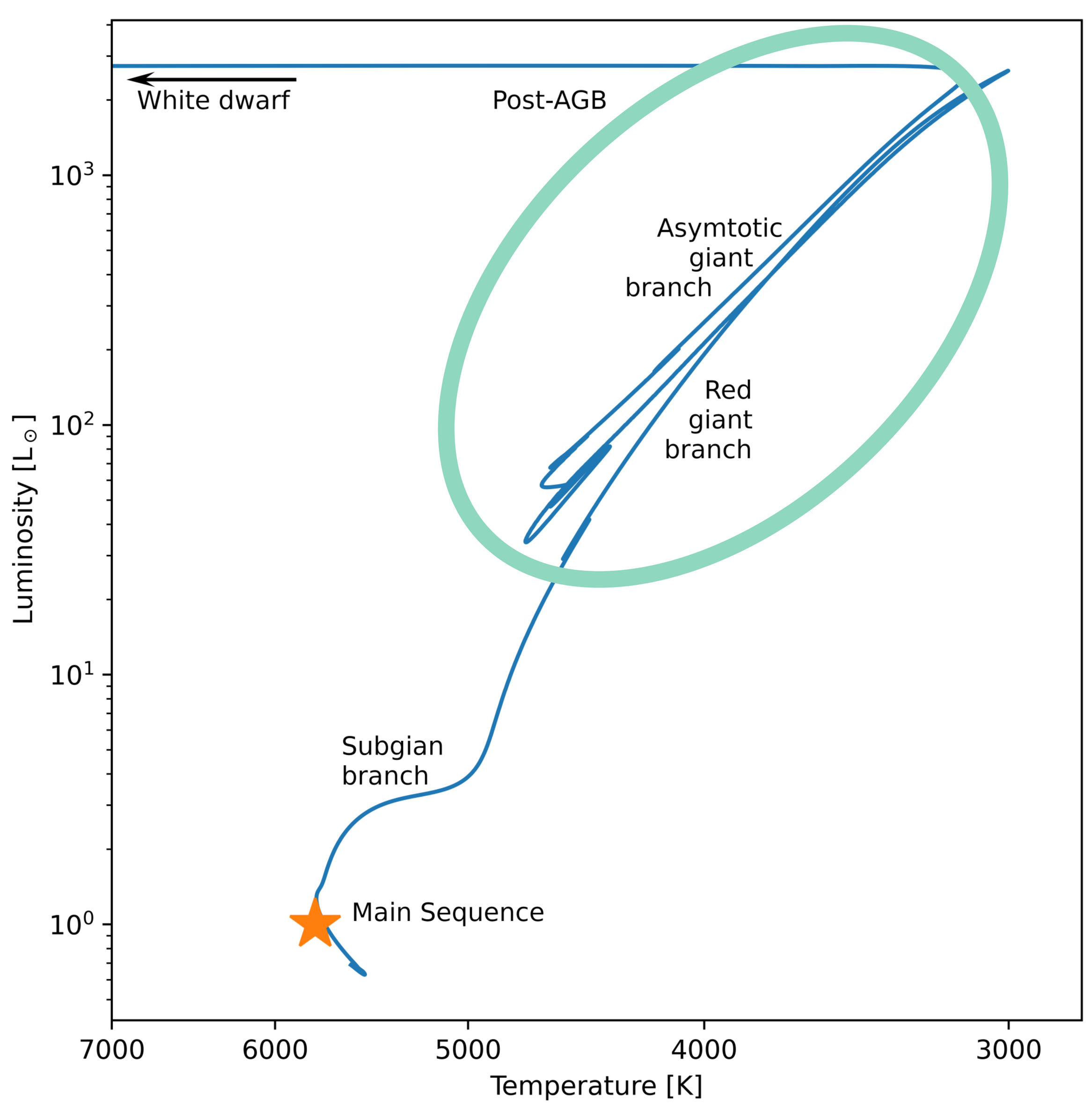


During their evolution, solar-like stars evolve through the Asymptotic Giant Branch (AGB) phase. This phase is characterized by increased radii, high luminosities, intense pulsations, and significant mass loss. In order to comprehend the survival of planetary or stellar companions during this phase and explain the presence of planets orbiting white dwarfs, it is essential to examine the orbital evolution of these systems. Several factors come into play for AGB stars, such as the stellar mass-loss rate, the mass accretion onto the companion, and the tidal interactions between the star and its companion.

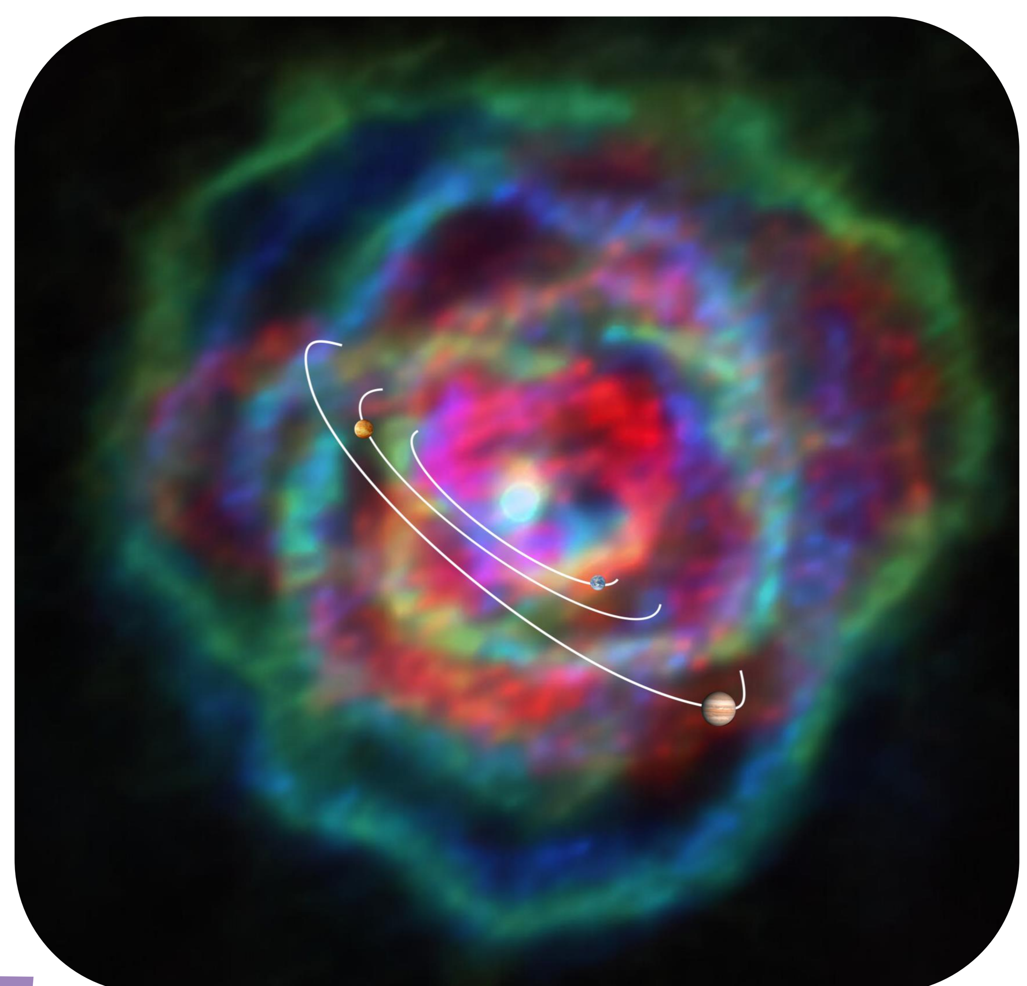
AGB Stars

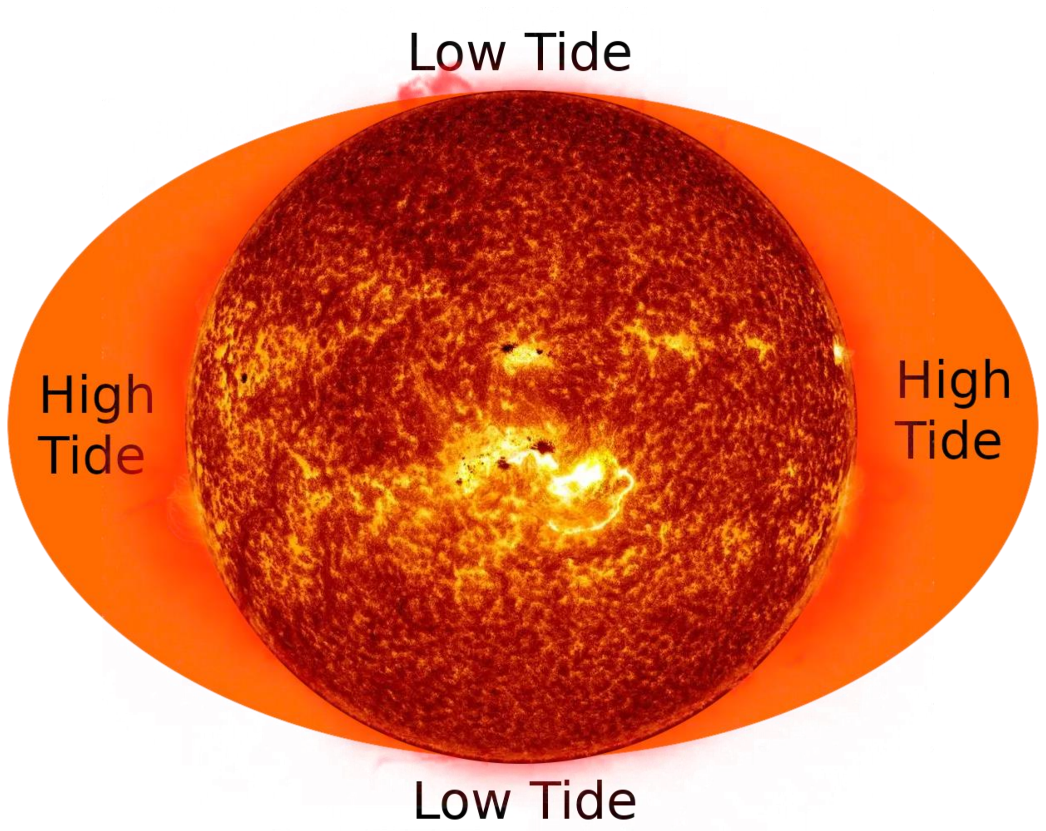
Typical stellar parameters for AGB stars

$R \approx 1.3$ AU

$L \approx 10^2 - 10^5\ L_\odot$

$\dot{M} \approx 10^{-8} - 10^{-5} M_\odot/yr$





Mass Loss

AGB stars lose mass through a dust-driven wind, caused by pulsations and radiation pressure acting on newly formed dust grains. The outflows from these stars exhibit intricate shapes, often influenced by an unseen companion. To understand this phenomenon, complex 3D hydro-chemical simulations are necessary. These simulations allow to investigate the impact of the companion on the star's mass loss rate and the efficiency of accretion onto the companion. However, the existing simulations are computationally demanding, and ongoing efforts are concentrated on enhancing the computational speed.

Coupling

AGB winds are driven by pulsations, and tides may induce pulsations. Hence tides can result in an increased mass-loss rate

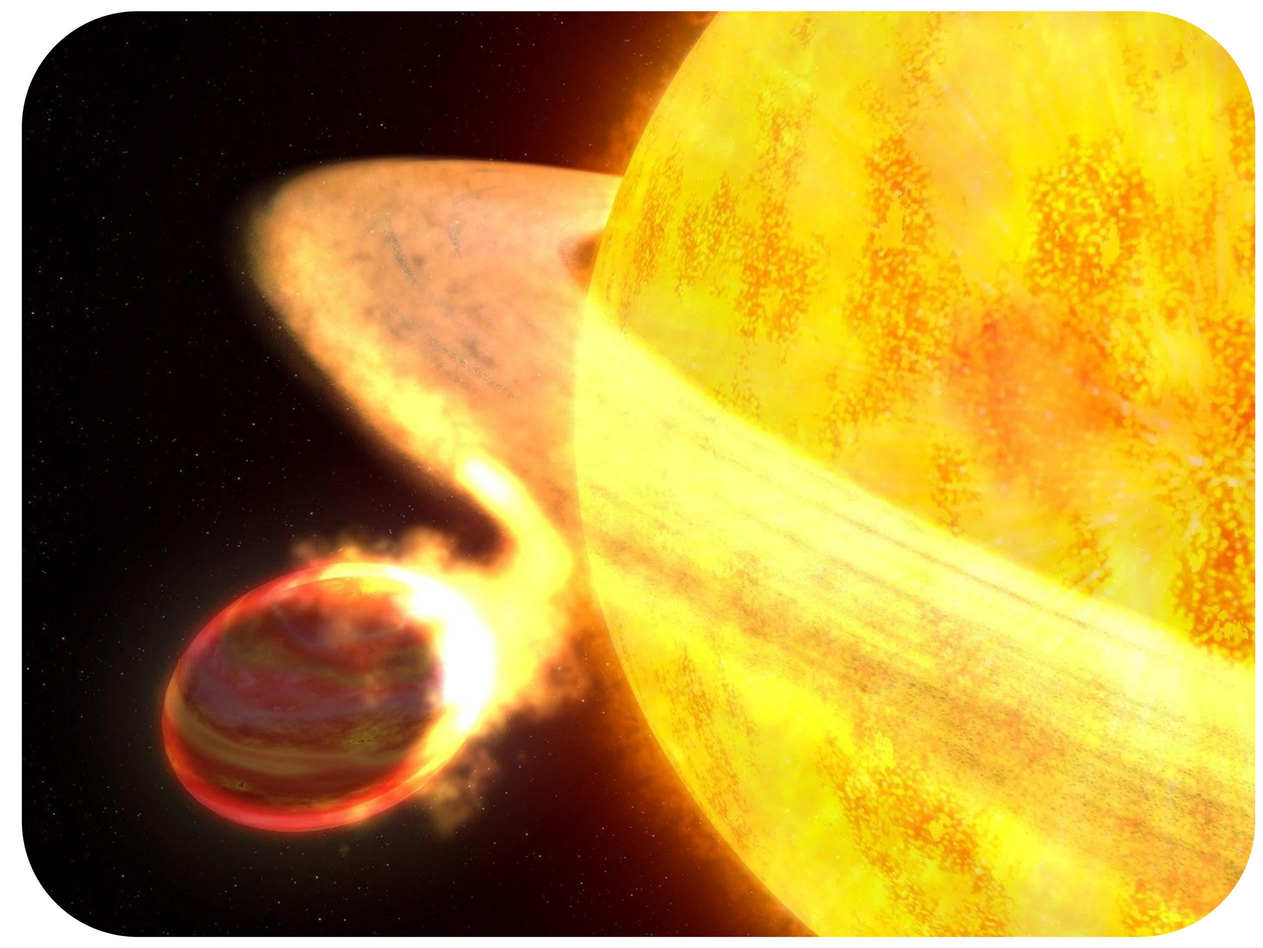
Mass loss modifies the tidal dissipation boundary conditions. Hence, mass-loss may induce additional dissipation

Tidal Dissipation

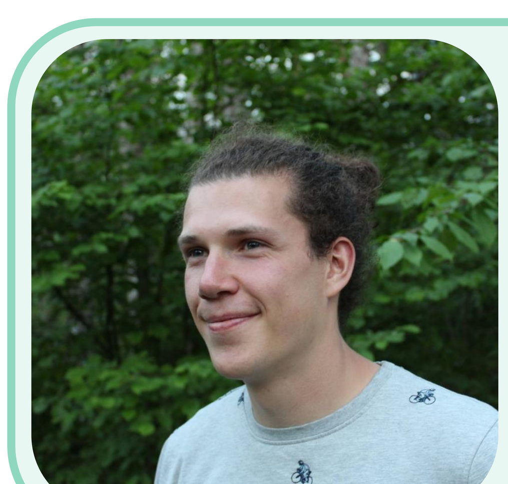
Tidal dissipation encompasses two components: equilibrium and dynamical tides. The former occurs due to the gravitational pull of the companion, causing a deformation of the star. Viscosity creates a tidal lag which facilitates transfer of angular momentum. The latter involves secondary effects, such as pulsations, which are influenced by the star's internal structure. AGB stars possess a convective envelope exciting inertial modes and a radiative core exciting gravity waves in response to tides. The dissipation of these waves varies depending on the boundary conditions. While for main-sequence stars static boundary conditions are adequate, the substantial mass loss of AGB stars necessitates the exploration of more suitable boundary conditions.

Orbital Evolution

$$\left(\frac{\dot{a}}{a}\right) = -\frac{\dot{M}_* + \dot{M}_p}{M_* + M_p} + \left(\frac{\dot{a}}{a}\right)_{tide}$$



In order to investigate the orbital evolution of companions around AGB stars, both mass loss and tidal dissipation play crucial roles. Complex simulations are essential for understanding how companions impact a star's mass loss rate, and the efficiency of accretion onto the companion. Tidal dissipation, which relies on internal structure and boundary conditions, requires further exploration regarding mass loss. The interplay between winds, pulsations, and tides signifies a mutual influence between mass loss and tidal dissipation, presenting a complex problem that demands further investigation.



Get in Touch!

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