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

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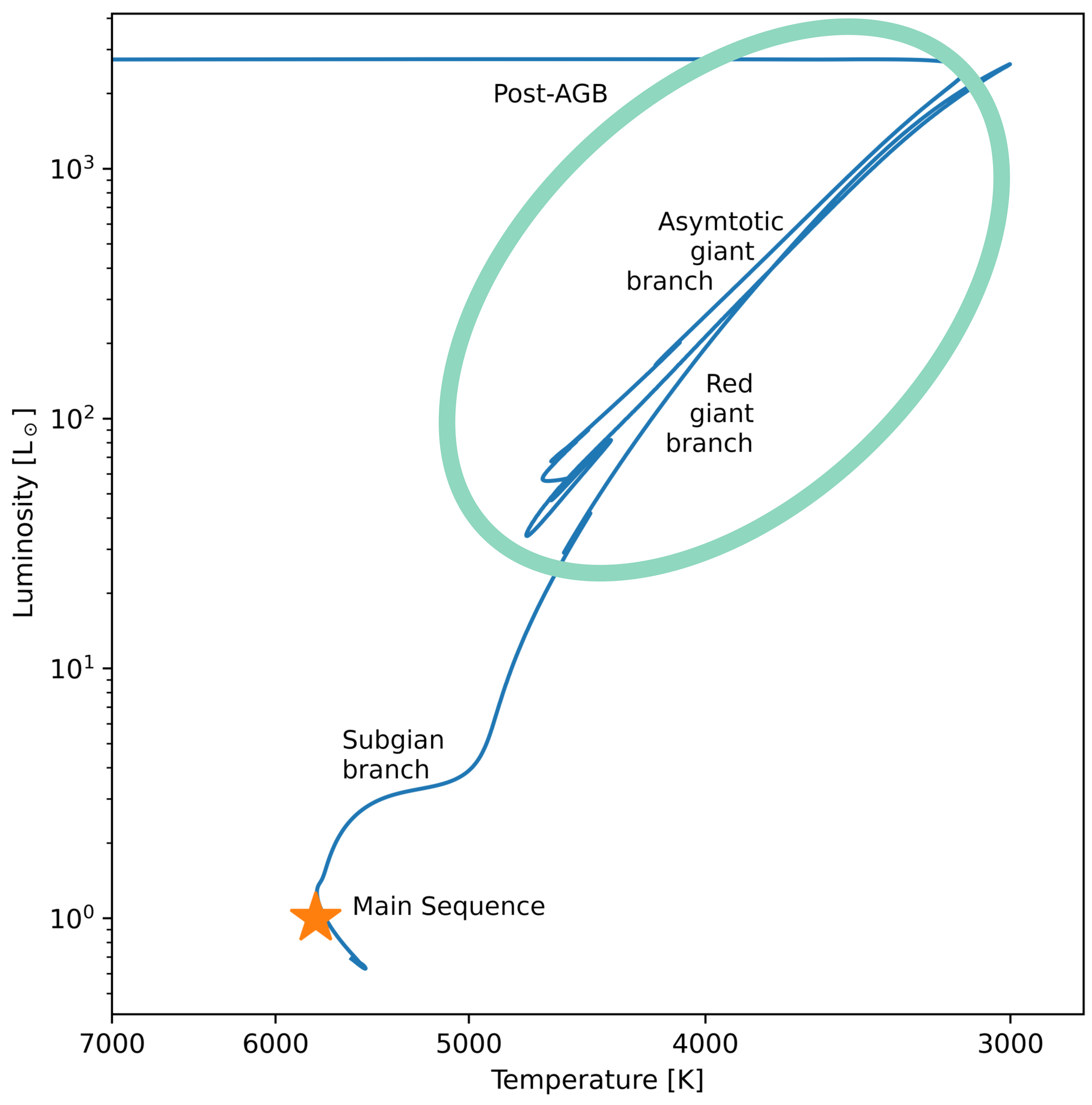
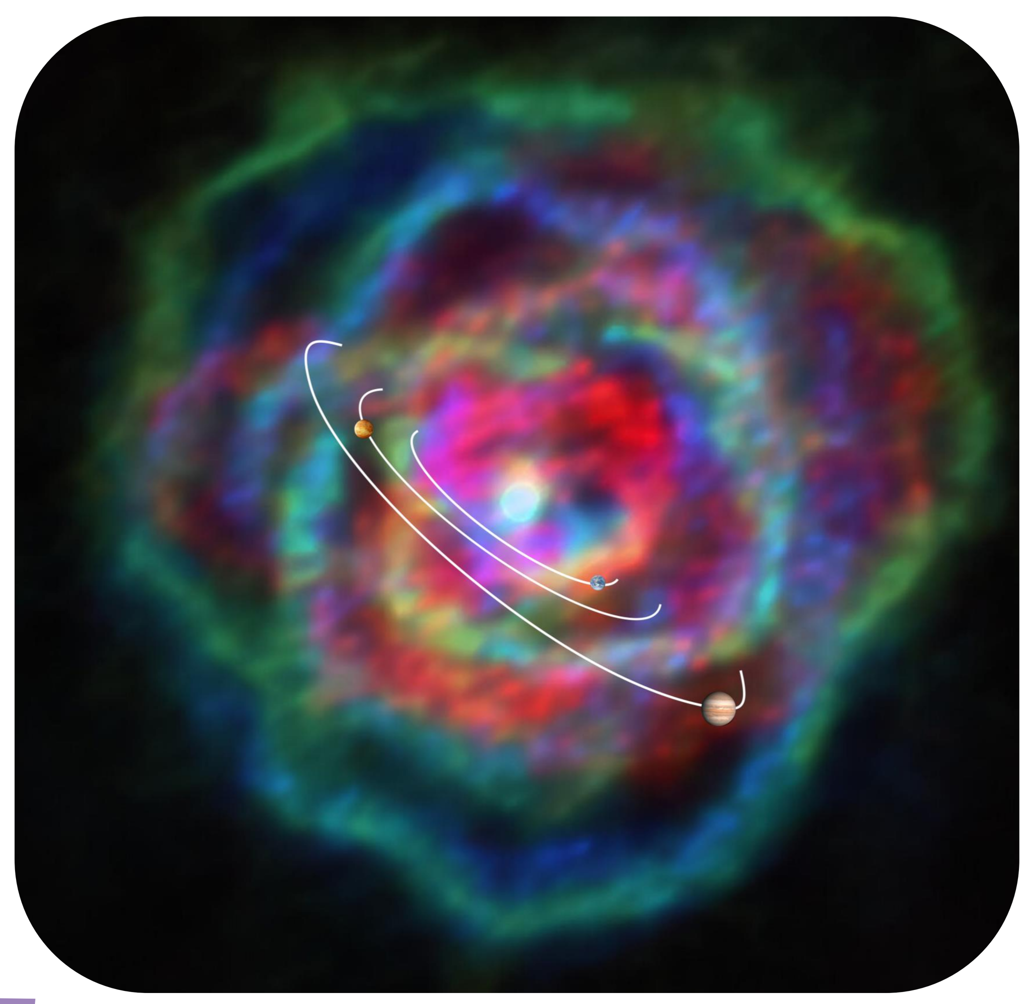


During the evolution of stars like our sun, they undergo the Asymptotic Giant Branch (AGB) phase before becoming white dwarfs. This phase is marked by increased radii, high luminosities, intense pulsations, and substantial mass loss. To understand the survival of planetary or stellar companions during this phase and explain the presence of planets orbiting white dwarfs, the orbital evolution of these systems needs to be examined. Several factors come into play for AGB stars, including the stellar mass loss rate, the efficiency of mass accretion onto the companion, and tidal interactions between the star and its companion.

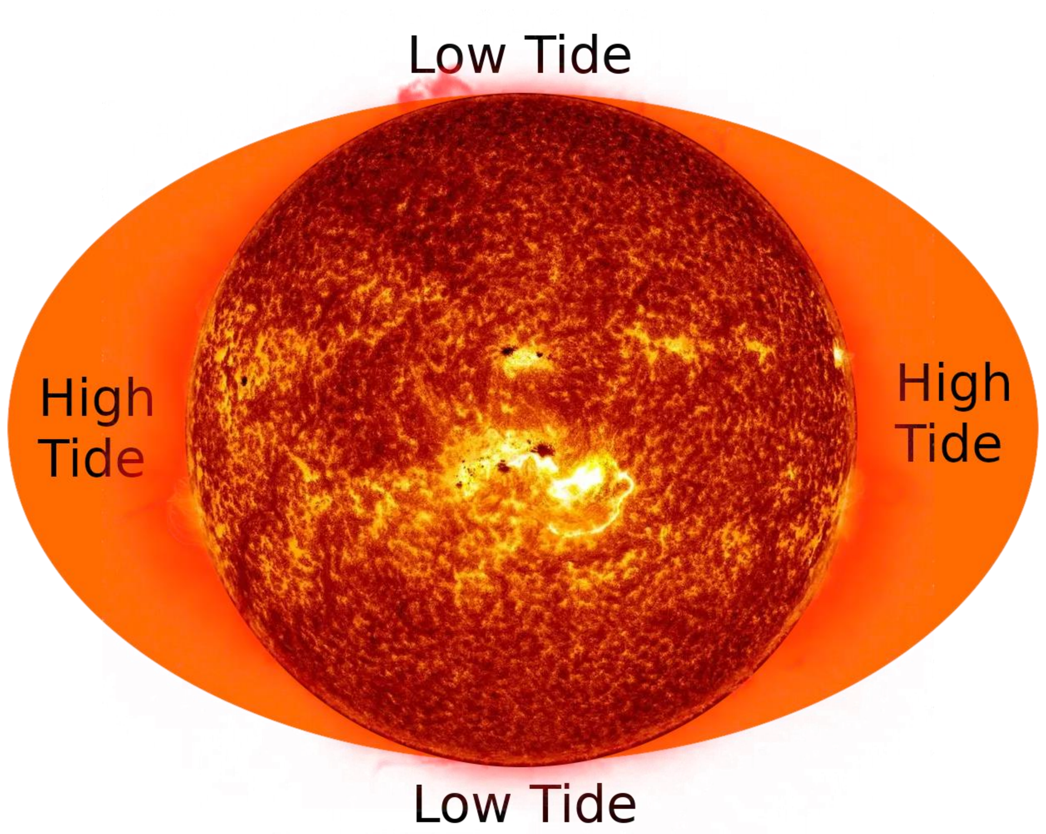
AGB Stars

$R \approx 1.3$ AU
$L \approx 10^2 - 10^5\ \mathrm{L}_\odot$
$\dot{M} \approx 10^{-8} - 10^{-5} \mathrm{M}_\odot/yr$



Mass Loss

AGB stars experience mass loss via a dust-driven wind caused by strong pulsations and radiation pressure on newly formed dust grains. Their outflows display complex shapes, caused to a hidden companion. To understand this phenomenon, we require complex 3D hydro-chemical simulations. These simulations enable us to explore how the companion affects the star's mass loss rate and the accretion efficiency onto the companion. However, the current simulations are computationally intensive, so ongoing efforts are focused on accelerating the speed of these simulations.



Coupling

AGB winds are driven by pulsations, and tides create pulsations, thus tides can induce additional mass loss

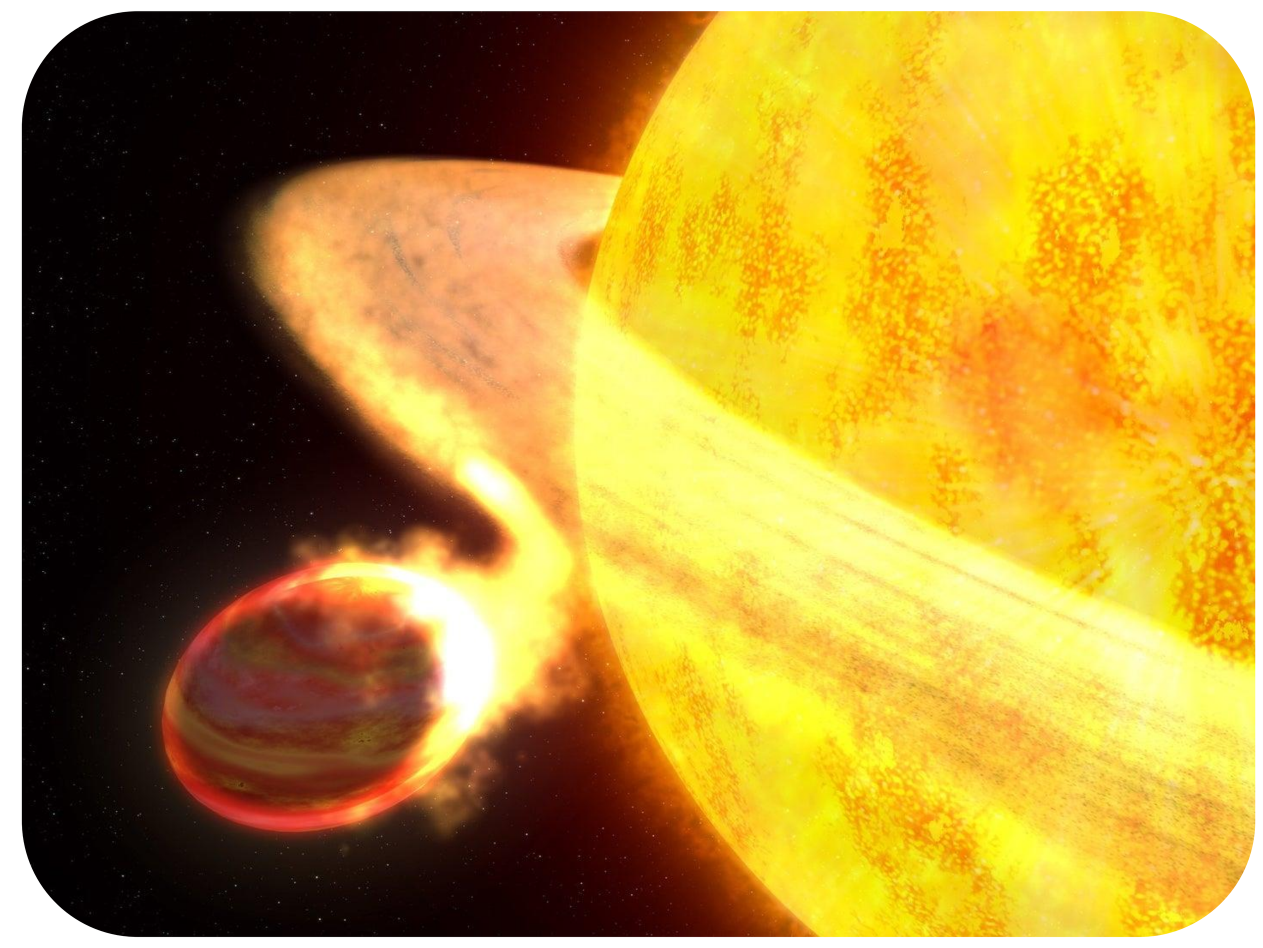
Mass loss modify tidal dissipation boundary conditions, thus mass loss can induce additional dissipation.

Tidal Dissipation

Tidal dissipation consists of equilibrium tide and dynamical tide. The former results from hydrodynamic deformation of the star due to the companion's gravity, with friction and viscosity causing a tidal lag and angular momentum transfer. The latter involves secondary effects like pulsations, dependent on the star's internal structure. AGB stars possess a convective envelope, exciting inertial modes, and a radiative core, exciting gravity waves due to tides. Dissipation and amplitudes of these modes vary based on boundary conditions. While main sequence stars typically use static boundary conditions, the substantial mass loss in AGB stars requires exploring more suitable boundary conditions.

Orbital Evolution

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



To study the orbital evolution of companions around AGB stars, both mass loss and tidal dissipation are important. Complex simulations are necessary to understand how companions effect the star's mass loss rate and the companion's accretion efficiency. Tidal dissipation, involving equilibrium and dynamical tides, are necessary, where dissipation dependent on boundary conditions which need further investigation in the context of substantial mass loss. The interplay between AGB winds, pulsations, and tides indicates mutual induction of mass loss and tidal dissipation, presenting a complex problem that requires further investigation.

Get in Touch!

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