Stellar and Galactic Physics

Planetary Dynamics and Stellar Evolution (PlaDySe)

Summary of the METEOR
In this METEOR the student will use star evolution codes (MESA) and dynamics code (REBOUND) to study the planetary orbits and small bodies motion during the the different phase of stellar evolution. Several non gravitational forces will have to be considered as a function of the physical characteristics of the central star and of he various conditions of the circumstellar environment resulting of the loss of mass of the star

Theory

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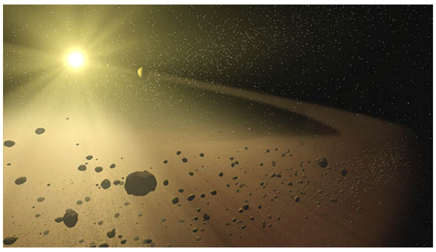
Stellar evolution for star with mass between 1 an 8 solar masses is, at the end of the Principal Sequence, a period of drastic transformations both for the star itself but also for the circumstellar environment. The travel from Red Giant (RG) phase to the White Dwarf (WD) ultimate one (through AGB, post AGB and planetary nebulae (PN) stages) is a fast and violent transformation during which more than 1 solar mass of the star can be expelled in 10 000 years and the star luminosity can increase of several order of magnitude. The circumstellar environment is hence deeply modified during these phases. The dynamics of planets and small bodies around the central star will be deeply modified by these events and many non gravitational perturbations have to be considered in the dynamical equations. Preliminary studies have been conducted (Mustill and Villager 2013) for the RGB and AGB phases for the becoming of the planets but small bodies dynamics has not been studied by these authors. Yet many observational facts, specially in the WD phase revealed a collisional fate for the small bodies. Indeed "Polluted" WD as well as WD with an infra red (IR) excess in their spectral energy distribution (SED) (Koester et al. 2012, Girven et al. 2012, Farihi 2012 Jura and Xu 2013, Bear and Socker 2013) are atypic WD exhibiting for the first one spectral lines of heavy elements (Ca, Mg, SiÉ) and for the second ones the íR excess in the SED tracks the presence of a disk of dust. It is now commonly admitted that these two observational facts are originated from the collision or the disruption of small bodies such as asteroids. A collisional rate is even proposed by Bear and Soker 2012 to justify the life time of the disks of dust around WD. We can hence imagine that even in this ultimate phase of stellar evolution planets and small bodies have survived to the whole process of the central star transformation.

Applications

The subject of this METEOR is to introduce the student to this field mixing planetary dynamics and star evolution. She/he will have to use existing softwares on stellar evolution (MESA) and dynamics (RE- BOUND). The dynamics of small bodies are strongly influenced by their interaction with the circumstellar environment through non gravitational mechanisms : frictional forces, gravitational drag force (interaction of the body with its own wake), radiation pressure, tidal forces, etc ... All this process are characterized in one way or an another by stellar parameters and a proper description of stellar evolution is consequently crucial. All these physical ingredients will be included in the dynamics of the objects in order to track down collisions process (with the star and/or a planet). Part of the work is to find a plausible "scenario" to reproduce the collision rate as inferred from observations. An exhaustive and statistical study of the behavior of both planets and small body reservoirs (such as the main belt of asteroid or the Kuiper Belt or the Oort Cloud in our solar system) can lead to a new niche of exoplanet search around evolved star.



See also

MESA
REBOUND

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