The role of X-rays in exoplanet evolution and habitability

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Research on exoplanetary atmospheres has developed an increasing interest. Astrobiology has put its eyes on the effects that stellar irradiance may have on the atmosphere of planets, and on the early development of life. The high energy (XUV and UV) part of the spectrum is of special interest for this purpose. This radiation is originated in the outer layers of late type (F, G, K, M) stars. Stellar coronae, transition region and chromosphere are present in these stars as a combined effect of convection and stellar rotation. Younger stars heritage a fast rotation from their parental cloud, resulting on an enhanced stellar activity, that implies a copious XUV emission. As the star ages, its rotation decreases. The XUV emission is sensitive to this lower rotation: the Sun has three orders of magnitude lower X-ray luminosity now than it had at its early stages.

There are three main effects of XUV radiation: i) dissipation of protoplanetary disk during planet formation phase, ii) planet inflation and atmospheric evaporation due to energetic irradiance of the atmosphere, iii) effect of the atmosphere chemistry, and eventually, the life forms on the planet surface. Planet formation takes place in the first ~10 Myr of the star, although other processes, such as dust production and absorption, and collisions with minor bodies are frequent during several tens of Myr. Once the planet is formed, the incoming stellar irradiance is the main external ingredient for its evolution. An example of its effects is the observed distribution of planet radii in the biased sample of transiting planets (due to observational reasons, these planets use to be planets close to their stars). The distribution (see Figure 1) shows a large number of Jovian-mass planets with radii quite larger than 1 Jupiter radii. This can be interpreted as planet inflation due to the incoming high-energy radiation. Atmospheric chemistry is also strongly affected by the radiation. Finally, life forms in the planet evolve partly due to the incoming UV photons, some of them produced as secondary photons after absorption of X-rays in the upper atmosphere.

Along the talk the example of the solar evolution will be displayed, with some comments on activity cycles, and how the effects on planets change with the stellar Spectral Type.

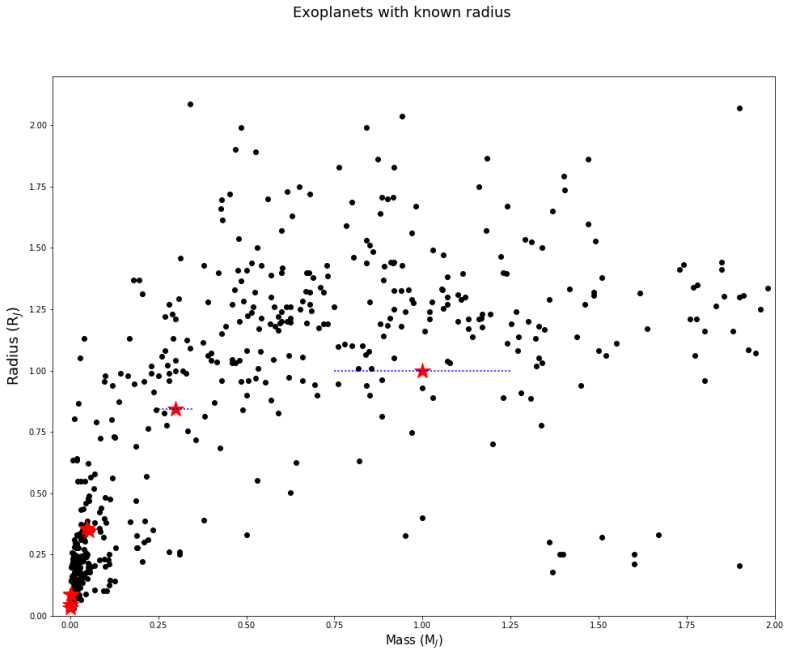

Figure 1: Distribution of planets mass and radius. Solar System planets are indicated with red asterisks.

Short Summary

Stellar coronae and transition region emit high energy (XUV and UV) radiation that has strong influence on exoplanet atmospheres. Early evolution of planet atmospheres, planet inflation and even mass loss due to evaporation are among its effects. The early development and evolution of life can be affected too.