X-ray Universe

Star-Planet-Interactions in X-rays - mimicked by selection effects?

Katja Poppenhaeger

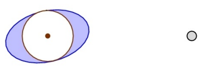
Hamburg Observatory, Hamburg University, Germany, email: katja.poppenhaeger@hs.uni-hamburg.de

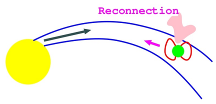
Context: Late-type stars (spectral type F-M) possess X-ray emitting coronae as their outermost atmospheric layers, which are magnetically heated to temperatures of several million degrees. In close binary stars, the coronal X-ray emission is significantly stronger than in single stars of the same spectral class; this is partly due to tidal locking and therefore fast rotation of the two stars, and partly to magnetic interactions between the components of the binary. Theoretically, such X-ray enhancements could also be caused by interactions of a star with its close-in *planetary* companion.

If these Star-Planet-Interactions (SPI) are observed reliably, they can yield valuable information on the magnetic fields of exoplanets, the irradiation of exoplanetary atmospheres by the host star (which in turn affects planetary evaporation), as well as orbital synchronization and planetary migration time scales. However, strong selection effects can be present in samples of planet-hosting stars and interfere with signals one expects from SPI.

Possible SPI mechanisms

The magnetic activity of a planet-hosting star can be influenced by the close-in planetary companion through two basic scenarios of interaction.





Tidal interaction between planet and star can induce tidal bulges in the stellar photosphere; the additional turbulence in the photosphere can lead to faster entanglement of the footpoints of coronal loops and more frequent flaring.

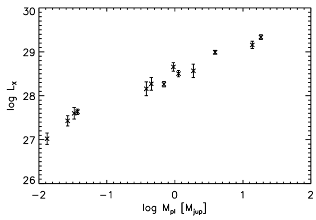
Magnetic interaction may lead to reconnection of planetary and magnetic field lines, or the planetary magnetic field may trigger flares of entangled coronal loops on the star, for example in the vicinity of the subplanetary point.

A trend in X-ray luminosity?

Samples of planet-hosting stars can be a powerful tool to identify SPI-related trends in coronal activity.

When using X-ray data from the ROSAT All-Sky Survey (RASS), there is a very prominent trend in stars with close-in (<0.15 AU) planets of stellar X-ray luminosity with the planetary mass.

However, the RASS is only complete with regard to stellar X-ray detections out to 5-10 pc, depending on the spectral type, so there is a distance-related selection effect in this set of data.



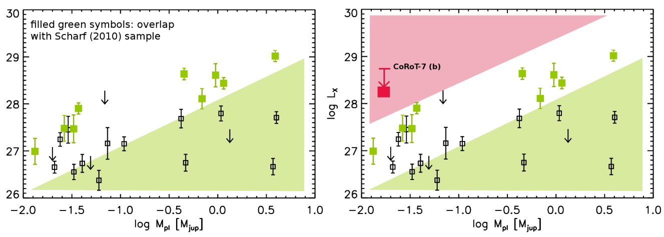
Scharf (2010), ApJ 722:1547

Identifying selection effects

We composed a sample of all known planet-hosting stars within a distance of 30 pc from the Sun. Combining new and archival X-ray observations, our sample is practically complete with regard to X-ray detections (52 of 72 stars detected).

In the solar neighborhood, planets are mostly detected by radial velocity (RV) shifts. Stellar activity makes the detection of RV shifts more difficult, so that for active stars only strong RV signals can be detected, requiring a heavy planet, low-mass host star, or both.

The main difference to the RASS sample is that there ar many stars with low L_X whicl harbour massive planets, filling up the lower right corner of the diagram. The previous lack in such systems obviously stems from the X-ray flux limit of the RASS data. This means that there i no dependence of some minimal L_X on the planetary mass.



Poppenhaeger & Schmitt (2011), ApJ 735, 1, id.59

This means that **small planets are only detected around low-activity stars by the RV method.** In contrast, the transit-detected planet CoRoT-7b, marked in red, orbits a quite active star (L_X estimated from chromospheric activity), which clearly differs from the trend in RV-detected planets.

However, there are no stars with high L_X and small planets in the sample (upper left corner). Again, this is not an SPI signature, but an effect of the non-completeness with regard to planet detections:

→ **Selection effects from planet detection methods can produce trends which look like the signals one expects from SPI.**

→ Clean samples are needed! For example: planet detectability given to some constant semimajor axis for all systems in the sample.

Hamburger Sternwarte

References: Poppenhaeger, Robrade & Schmitt. 2010, A&A 515, id.A98

Poppenhaeger & Schmitt, 2011, ApJ 735, 1, id.59