Hints for star-planet interaction in CoRoT-exo2a

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Abstract

CoRoT-Exo-2a is a young G7V star accompanied by a transiting hot-Jupiter, recently discovered by CoRoT (see Alonso et al. 2008). As discussed by Lanza et al. (2009), CoRoT-Exo-2a shows rotationally modulated variability due to photospheric magnetic activity. Here we show that the variance of the stellar light curve is modulated in phase with the planet orbital period. This may suggest a possible star-planet magnetic interaction, a phenomenon already seen in other extrasolar planetary systems hosting hot-Jupiters.

Star Planet interaction - background

Among the 306 extrasolar planets discovered up to date, about 24% are massive planets ($M_p \sin i > 0.2\ M_J$) in tight orbits (< 0.1 AU) around their parent stars. Cuntz et al. (2000) predicted that a giant planet orbiting close-by a star may increase stellar activity by means of tidal and magnetospheric interactions. Observational support to the Stellar-Planet Interaction (SPI) phenomenon has been provided by several authors: e.g., Shkolnik et al. (2003, 2005, 2008), who found chromospheric emission of stars hosting planets to be variable with the planet orbital period; Henry et al. (2002) and Walker et al. (2008) who found hints for photospheric activity in phase with the planet orbital period.

Several other independent studies have highlighted that a short-period planet can induce activity on the photosphere and upper atmosphere of its host star. The nature of SPI appears to be strongly affected by both the stellar and planetary magnetic fields. Shkolnik et al. (2008) suggest that for extrasolar planets around young stars conditions similar to those observed for the Jupiter-Io system are met and consequently similar processes are expected to occur on far larger scales. Lanza (2008) describes the SPI considering the reconnection between the stellar coronal field and the magnetic field of the planet. Reconnection events produce energetic particles that, moving along magnetic field lines, impact onto the stellar chromosphere giving rise to a localized hot spot. Eventually, reconnection events in the corona may influence subphotospheric dynamo action in those stars producing localized photospheric (and chromospheric) activity migrating in phase with their planets.

Specifically, for HD 179749 and upsilon Andromedae a chromospheric hot spot rotating with a period equal to the planet orbital period but leading the planet of 70 and 170 degree has been observed. In order to understand this observed phenomenon, theoretical model of magnetic star-planet interaction in the coronae of stars hosting hot-Jupiters have been developed. In some cases, (tau Bootis, HD 192263) the magnetic interaction could also produce photospheric active regions, characterized by cool spots.

Long baseline and continuous observations provided by CoRoT are optimal to study the photospheric variability of the stars hosting the planets it detects. We present here evidences for SPI at work in **CoRoT-Exo-2ab**, a planetary system made by a hot-Jupiter planet orbiting around a main-sequence G7 star which displays a remarkable photospheric activity (Alonso et al. 2008; Bouchy et al. 2008). A detailed spot modelling analysis of the light curve of CoRoT-Exo-2a has been performed by Lanza et al. (2009). Here we focus our analysis on the aspects suggesting the presence of star planet magnetic interaction.

Observations

CoRoT-Exo-2a was observed from May 16 to October 5, 2007. We extracted from the data archive the N2 chromatic light curves having a sampling of 512 s during the first week and 32 s thereinafter. The white colour light curve shown in Fig. 1 is obtained by the combination of red, green and blue fluxes. **Transits and rotational modulation due to stellar activity are clearly visible.**

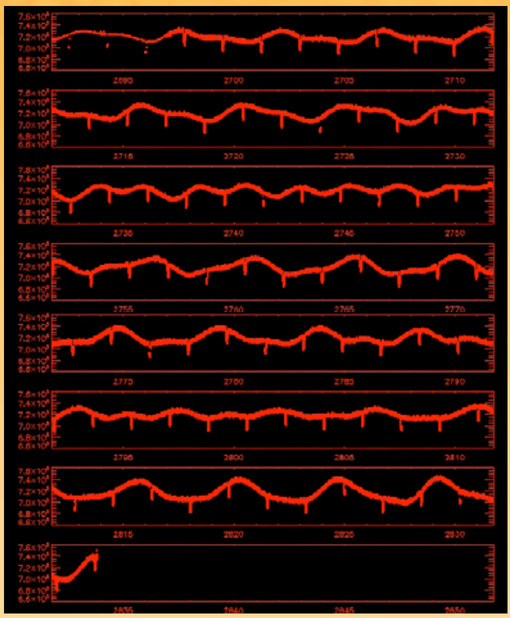

Fig. 1: CoRoT-exo2ab white light time series. Integrated counts ($e^- s^{-1}$) in y-axis, HJD since 2,450,000 in x-axis.

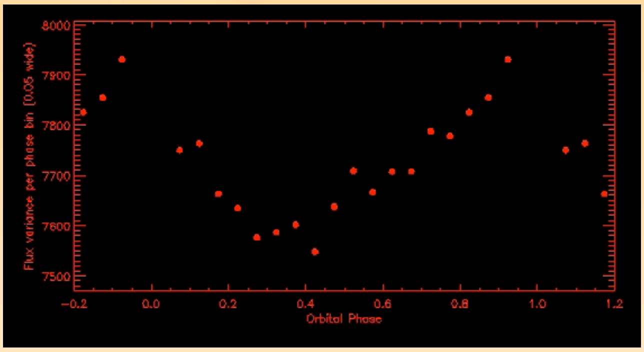

Fig. 2: Flux variance computed in orbital phase bins wide 0.05. Phase are reckoned by means of the planet ephemeris P=1.7429964 days, HJD0=2454237.5356 as in Alonso et al. 2008.

Method

In order to assess if the system flux variability is related to the planet orbit, we have computed the average **flux and its variance** in phase bins of size 0.04, 0.05 and 0.1. Phases are reckoned by means of the planet ephemeris - P_p=1.7429964 days, HJD0=2454237.5356 given by Alonso et al. (2008). In order to have the best statistic possible in each phase bin, we have used the full time resolved light curve. However, we have used the data obtained in the first 75 days of observations only, because this subset is clearly less affected by noise, due to not well corrected jitter, that can alter the flux variance.

Results

A clear wave-like behavior is apparent in the **flux variance vs. orbital phases** as shown in Fig. 2, obtained with phase bin=0.05. **The maximum system variability is reached when the planet is in front of the star - slightly before the planet transit - and the minimum when it is behind.**

The behavior does not change with phase bins of 0.04 or 0.1. We have also checked that the result is robust for shifts in the position of used phase bins.

That the planetary system optical variability, mainly do to magnetic activity, is so clearly phased with hot-Jupiter orbit is inferred also from the behaviour of the **total spotted area vs. time** derived by Lanza et al. (2009).

The suggested SPI can be explained by the model proposed by Lanza (2008). Specifically, if some sub-photospheric dynamo action takes place in the star, the amplified field emerges once the radial gradient of its intensity reaches some threshold value. The emergence of the flux might be triggered by a small localized perturbation of the dynamo effect associated with the planet when it passes by the most active longitude. An integer number of synodic periods are necessary for the planet to trigger again field emergence in a given active longitude because the planetary perturbation can play a role only when the field is already close to the threshold thanks to the steady amplification provided by the stellar dynamo.

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***Acknowledgements**: (*)* The present study is based on observations obtained with CoRoT, a space project operated by the French Space Agency, CNES, with participation of the Science Program of ESA, ESTEC/RSSD, Austria, Belgium, Brazil, Germany and Spain. AFL, IP, GI and SM have been partially supported by the Italian Space Agency (ASI) under contract ASI/INAF I/015/07/0, WPP3170.

1st CoRoT International Symposium Paris, 2-5 February 2009

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