Tidal star-planet interaction and its observed impact on stellar activity

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ESO Workshop: The Star-Planet Connection
Motivation

Angular momentum transfer between spin and orbit ($P_{\text{rot}} \neq P_{\text{orb}}$)

Star-planet tidal interaction:

$P_{\text{orb}} > P_{\text{rot}} \rightarrow$ spin-up of the host star

(and decrease of semi-major axis)
Motivation

Expectation: massive close-in planets increase the activity level of the host star
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Concern: Activity bias in planet detection!
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Concern: Activity bias in planet detection!

Solution: estimate host’s excess in activity by comparing it to a ‘negative control’

→ wide stellar binaries (observed in X-rays)
Data Analysis

- 17 wide binary systems observed by XMM-Newton and Chandra
Data Analysis: comparing luminosities

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- log Lx distributions of field stars in solar neighbourhood (Schmitt & Liefke, 2004)
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- $\log L_x$ distributions of field stars in solar neighbourhood (Schmitt & Liefke, 2004)

HD 189733

$15.87\%$  

$84.13\%$
Data Analysis: comparing luminosities

- 17 wide binary systems observed by XMM-Newton and Chandra
- log Lx distributions of field stars in solar neighbourhood (Schmitt & Liefke, 2004)

**HD 189733**

- Companion 44.34%
- Planet host 74.65%

15.87% and 84.13% indicating luminosity distributions.
Data Analysis: comparing luminosities

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- log Lx distributions of field stars in solar neighbourhood (Schmitt & Liefke, 2004)

HD 189733

Difference in percentile values is used as an indicator for the excess in the stellar activity of the planet host
Comparing the activity level difference to star-planet tidal interaction parameters

Credit: L. Calcada / N. Risinger / ESO
Star-Planet Tidal Interaction Models

Gravitational perturbation at the stellar photosphere

(Cuntz et al. 2000)

\[ \frac{\Delta g}{g} = \frac{m_{pl}}{M_{\text{star}}} \frac{2R_{\text{star}}^3}{(a-R_{\text{star}})^3} \]
Result: Gravitational Perturbation

Ilic et al., submitted

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Result: Gravitational Perturbation
Star-Planet Tidal Interaction Models

Angular momentum transfer rate (Penev et al. 2012)

\[
\left( \frac{dL_{\text{conv}}}{dt} \right)_{\text{tidal}} \sim -\text{sign}(\omega_{\text{conv}} - \omega_{\text{orb}}) \frac{m_p^2 R_{\text{star}}^5}{a^6} \frac{1}{Q_{\text{star}}} \quad \text{for } m_p \ll M_{\text{star}}
\]
Result: Angular momentum transfer rate

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Result: Magnetic vs. Tidal SP Interaction

Tidal interaction couples the stellar rotation rate and activity level
Magnetic interaction, if short term, only affects the stellar activity level

Ilic et al., submitted
Summary

- Star-Planet tidal interaction in 17 wide binary systems was investigated

- Activity excess of the planet-hosting star was estimated by comparing the X-ray luminosities of the binary companions

- Planet-hosting stars that have a strong tidal interaction with their planet tend to be more active

Thank you!