Probing Bow Shocks Around Exoplanets During Transits
University of St Andrews, UK; Open University, UK
Aline.Vidotto@st-andrews.ac.uk

The Earth hosts a bow shock that is formed around its magnetosphere as a result of its interaction with the solar wind. Analogously, from the interaction of an exoplanet with the coronal material of its host star, similar shock structures are expected to develop. Recently, near-UV transit observations of the gas giant planet WASP-12b detected the presence of an extended material ahead of the planetary orbit. We propose that this material is indeed the bow shock surrounding WASP-12b. We investigate the conditions that might lead to the formation of such a bow shock and conclude that observable shocks should be a common feature in other transiting systems as well. We also show that shock detection through transit observations can constrain the planetary magnetic field \( B_p \). In the case of WASP-12b, the material revealed by near-UV observations extends out to 4.2 planetary radii, implying an upper limit of \( B_p \leq 24 \) G.

Observations
Near-UV transit starts prior to optical transit: such early ingress suggests the presence of material around WASP-12b (Fossati et al. 2010a)

Results: Measuring Planetary Magnetic Fields
• Near-UV light curve suggests the planetary material extends out to 4.2 planetary radii, taken to be the size of the magnetosphere \( r_M \).

\[
p_m = \frac{B_p (R_{ch})^2}{8\pi} + p = \frac{B_p (r_M)^2}{8\pi} + p_p
\]

dominant terms

• i.e., the coronal magnetic field \( B_c \) is balanced by the planetary magnetic field \( B_p \) at \( r_M \):

\[
B_c (R_{ch}) \approx B_p (r_M)
\]

• Assuming dipolar magnetic field configurations for the star and the planet and from observational upper limit in the stellar magnetic field (<10G, Fossati et al. 2010b)

\[
B_p < 24 \text{ G}
\]

More details:
- Llama et al. (2011) MNRAS Letters, in press

System Parameters
WASP-12b (Hebb et al. 2009)
• Mass: 1.41 M\( _J \)
• Radius 1.79 R\( _J \) (Optical)
• Orbital distance: 0.023 AU (3.15 R\( _J \)) \( \Rightarrow \) \( P_{orb} = 1 \) day

WASP-12 – Host star:
• Late E/Early G \( \Rightarrow \) corona (Temperature: a few MK)
• Density @ the planet: 1.5x10\(^6\) cm\(^3\) (Lai et al. 2010)
• Slow rotator: \( v \sin(i) \leq 4.6 \text{ km/s} \) (Fossati et al. 2010b)

Summary:
• Shock occurs for a large range of coronal parameters: compression of the planetary atmosphere should be a common effect in close-in planetary systems.
• Ahead-shock model: new technique to probe for the presence of a planetary magnetic field.
• In the case of WASP-12b: \( B_p \leq 24 \) G.
• Other equally interesting planets, where the model can be successfully applied once UV data is provided: WASP-19b, WASP-4b, WASP-18b, CoRoT-7b, HAT-P-7b, CoRoT-1b, TrES-3 and WASP-5b (Vidotto, Jardine & Helling, 2011).