EPSC Abstracts
Vol. 13, EPSC-DPS2019-1657-3, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Tuning in to the radio environment of HD189733b

R. D. Kavanagh (1), **A. A. Vidotto** (1), D. O Fionnagain (1), V. Bourrier (2), R. Fares (3), M. Jardine (4), Ch. Helling (4), C. Moutou (5), J. Llama (6) and P. J. Wheatley (7)
(1) Trinity College Dublin, Ireland, (2) Université de Genéve, Switzerland, (3) United Arab Emirates University; (4) University of St Andrews, UK; (5) CNRS/CFHT; (6) Lowell Observatory, USA; (7) University of Warwick, UK

Abstract

Here, we model the radio environment of the hot Jupiter HD189733b, considering radio emission from both the stellar wind and from the exoplanet. Winds of low mass stars, such as that of the K dwarf star HD189733, are sources of free-free emission at radio wavelengths. Additionally, stellar winds are believed to power exoplanetary radio emission, similarly to what occurs in the Solar system for Earth, Jupiter, Saturn, Uranus, and Neptune. By modelling the radio environment of HD189733, we find that the planet orbits through regions of the stellar wind that are optically thick to the emitted frequency from the planet. As a result, unattenuated planetary radio emission can only propagate out of the system and reach the observer for only a fraction of the orbit, corresponding to when the planet is approaching and leaving primary transit. This could be useful information in planning radio observing campaigns of exoplanetary systems.

1 Stellar wind powering planetary radio emission

We simulate the stellar wind of HD189733 with the 3D magnetohydrodynamics code BATS-R-US [4]. Our stellar wind models incorporate surface stellar magnetic field maps as boundary conditions [1]. As can be seen in Figure 1, our models show that the planet experiences a non-uniform wind as it progresses through its orbit. Variability is also seen over the three modelled epochs from mid-2013 to mid-2015.

Stellar winds are believed to power exoplanetary radio emission, similarly to what occurs in the Solar system for Earth, Jupiter, Saturn, Uranus, and Neptune. The observed linear relationship between the solar wind power dissipated at these planets and their emitted radio power (radiometric Bode's law) is used to predict the radio emission of HD189733b. Using our derived stellar wind properties at the planetary orbit and assuming planetary magnetic field strengths of 1, 5, and 10 G, we find that the HD189733b emits at peak cyclotron frequencies of 2, 12, and 25 MHz, with flux densities of up to ~ 200 mJy (Figure 2).

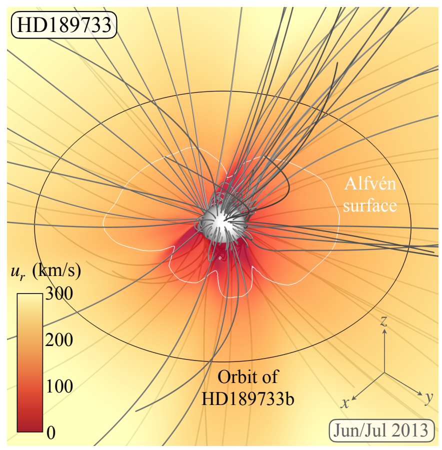

Figure 1: Simulated stellar wind of HD189733. Magnetic field lines are shown in grey and colours denote wind radial velocity in the orbital plane of the planet. The orbit at 8.8 $R_\star$ is shown with a black circle, and Alfvén surface is shown in white. From [2].

2 Can planetary radio emission escape the system?

The detection of planetary radio emission can be inhibited in the presence of dense stellar winds, which can absorb emission at radio wavelengths [3]. As a result, if a planet emitting its own radio emission orbits through regions of the wind that are optically thick to the planetary frequency, the planetary emission will be absorbed. In the case of HD189733b, we find that the planetary emission above $\sim$ 12 MHz can only prop-

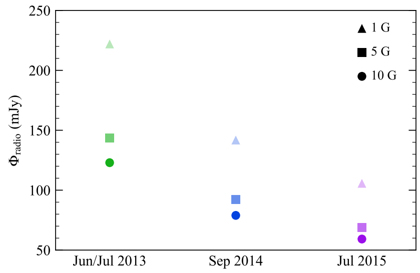

Figure 2: Peak radio flux densities calculated for HD189733b, for planetary field strengths of 1, 5, and 10 G at each modelled epoch. From [2].

agate out of the system unattenuated for a fraction of the orbit. This region corresponds to when the planet is approaching and leaving primary transit, as can be seen in Figure 3. This could be useful information in planning future radio observing campaigns of exoplanetary systems.

Figure 4 shows the radio spectrum of the wind of the host star and the predicted radio flux densities and frequencies of HD189733b, along with the sensitivities of LOFAR and SKA2. We see that for a planetary field strength of 5 G, the corresponding cyclotron frequency of 12 MHz is below the lower frequency limit of LOFAR, however, the propagation of emission below 21 MHz is unlikely. For the stellar wind, we see that SKA2 is likely to have sufficient sensitivity to determine at which frequency the wind becomes optically thin.

Acknowledgements

This work received funding from the Irish Research Council through the Government of Ireland Postgraduate Scholarship Programme and the Laureate Awards 2017/2018, the Swiss National Science Foundation in the frame of the National Centre for Competence in Research PlanetS, and from the European Research Council (grant agreement No 724427). We used the BATSRUS tools developed at The University of Michigan Center for Space Environment Modeling and made available through the NASA Community Coordinated Modeling Center. We acknowledge the SFI/HEA Irish Centre for High-End Computing (ICHEC) for computational facilities and support.

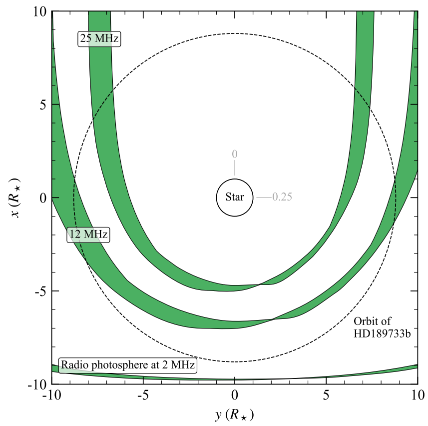

Figure 3: Radio photospheres of the stellar wind calculated at emitted planetary frequencies corresponding to field strengths of 1, 5, and 10 G. The planetary orbit is shown as a dashed circle. From [2].

References

[1] Fares, R., Bourrier, V., Vidotto, A. A., et al. 2017, MNRAS, 471, 1246.

[2] Kavanagh, R. D., Vidotto, A. A., Ó. Fionnagáin, D., et al. 2019, MNRAS, 485, 4529.

[3] Vidotto, A. A., & Donati, J.-F. 2017, A&A, 602, A39.

[4] Vidotto, A. A., Fares, R., Jardine, M., et al. 2015, MNRAS, 449, 4117.

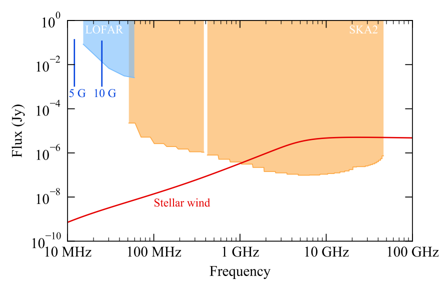

Figure 4: Predicted radio flux densities and frequencies of HD189733b (blue bars) and the spectrum of the stellar wind (red). The sensitivities of LOFAR and SKA2 for a 1 h integration time are shown. From [2].