Tuning in to the radio environment of HD189733b

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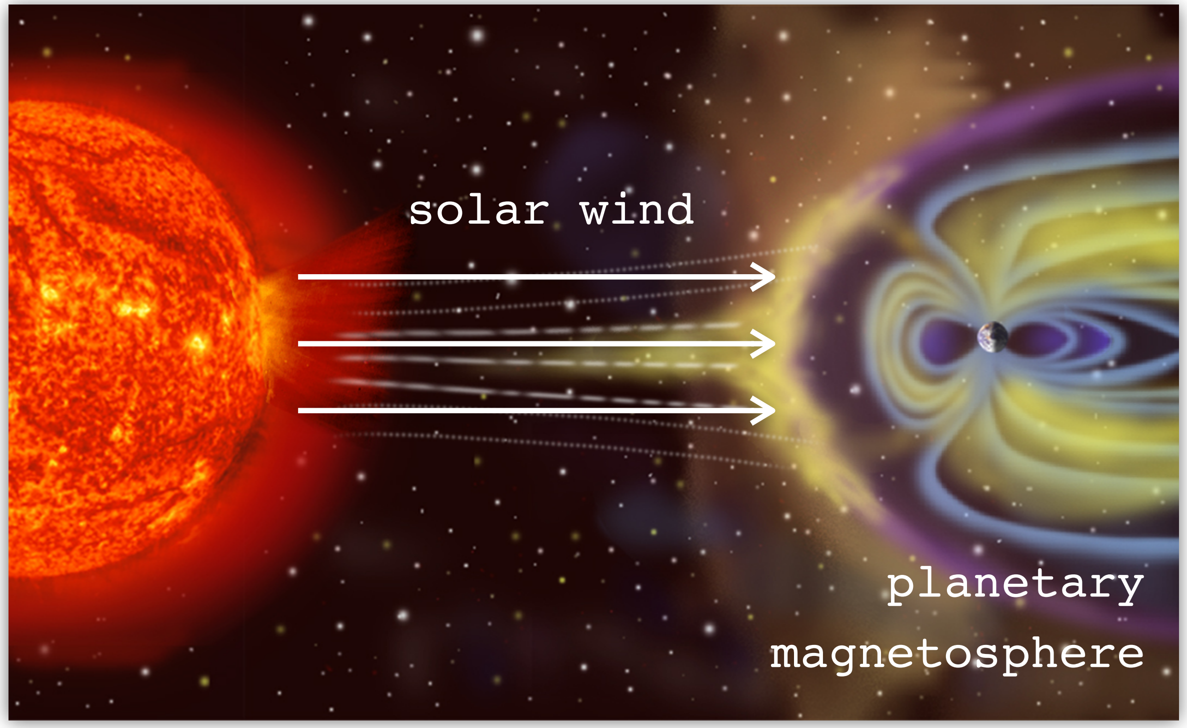
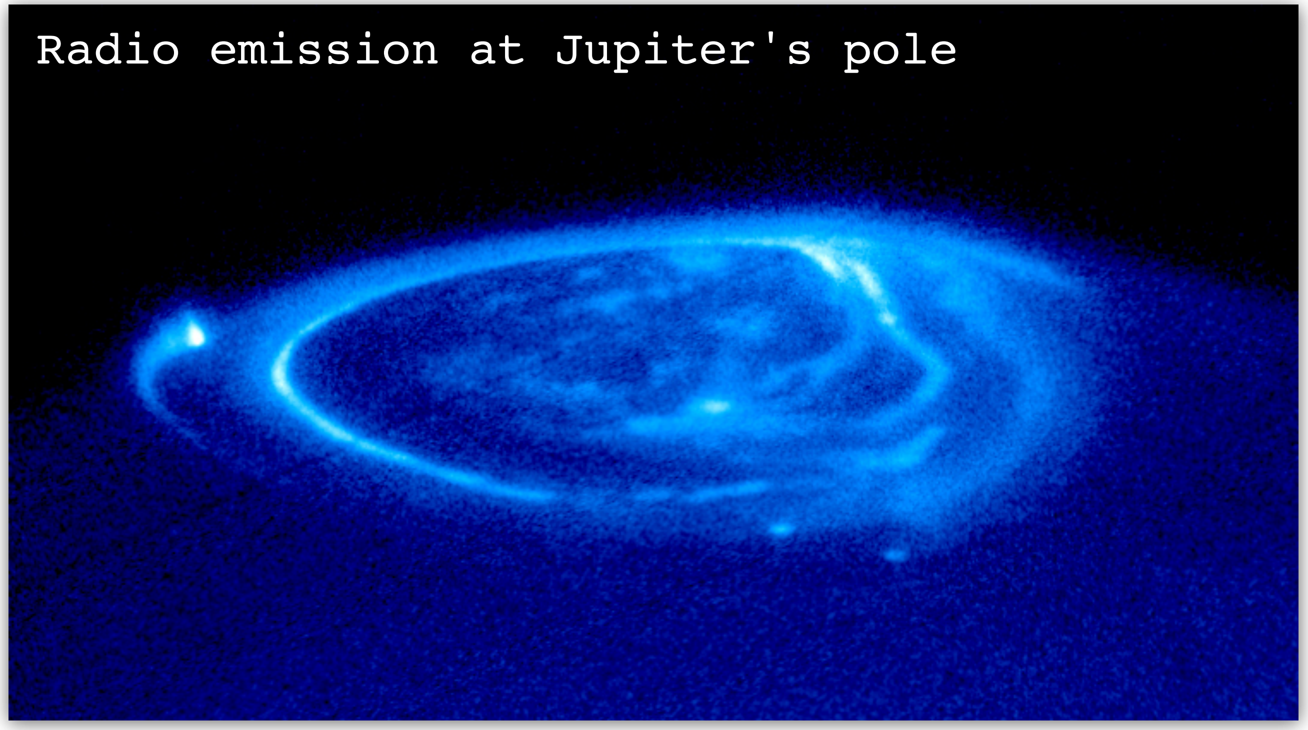
Outline

- Radio emission from magnetised planets
- Stellar winds of low-mass stars
- HD189733b - a close in hot Jupiter
- Modelling the stellar wind of the host star
- Modelling the planetary radio emission
- Predicted radio emission from HD189733b

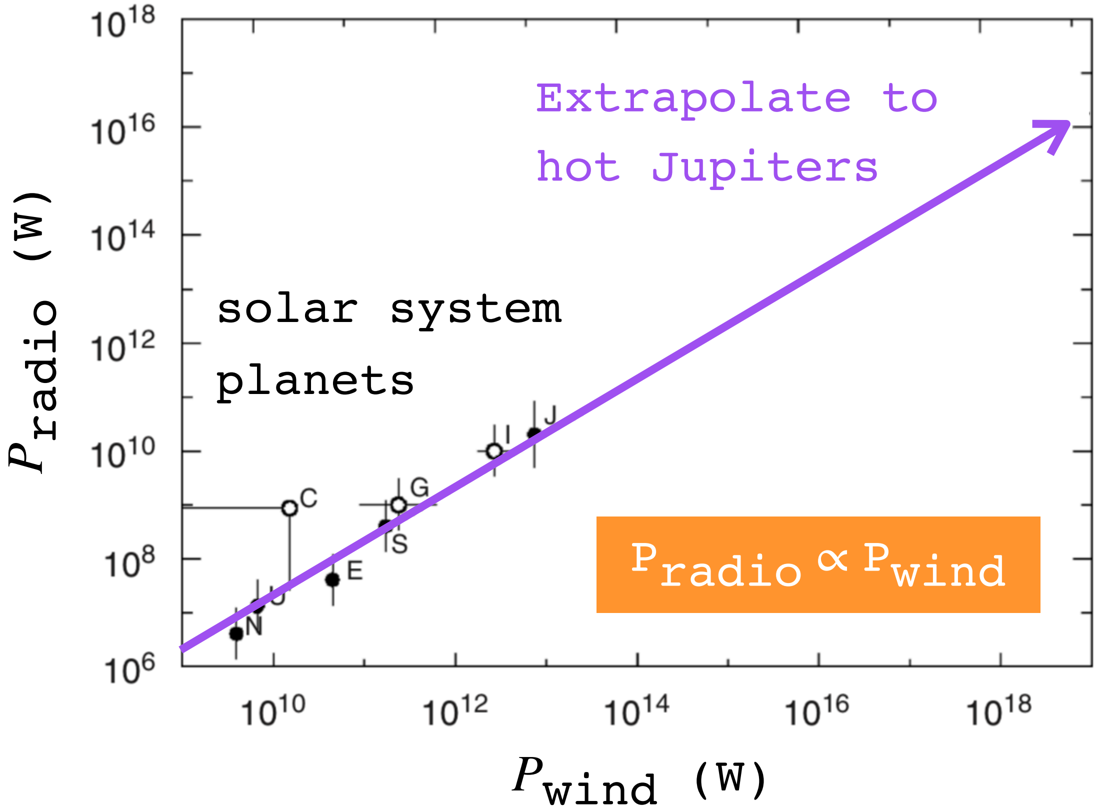
Radio emission from magnetised planets

The solar wind dissipates magnetic flux onto the planet's magnetosphere, producing radio emission at the poles:





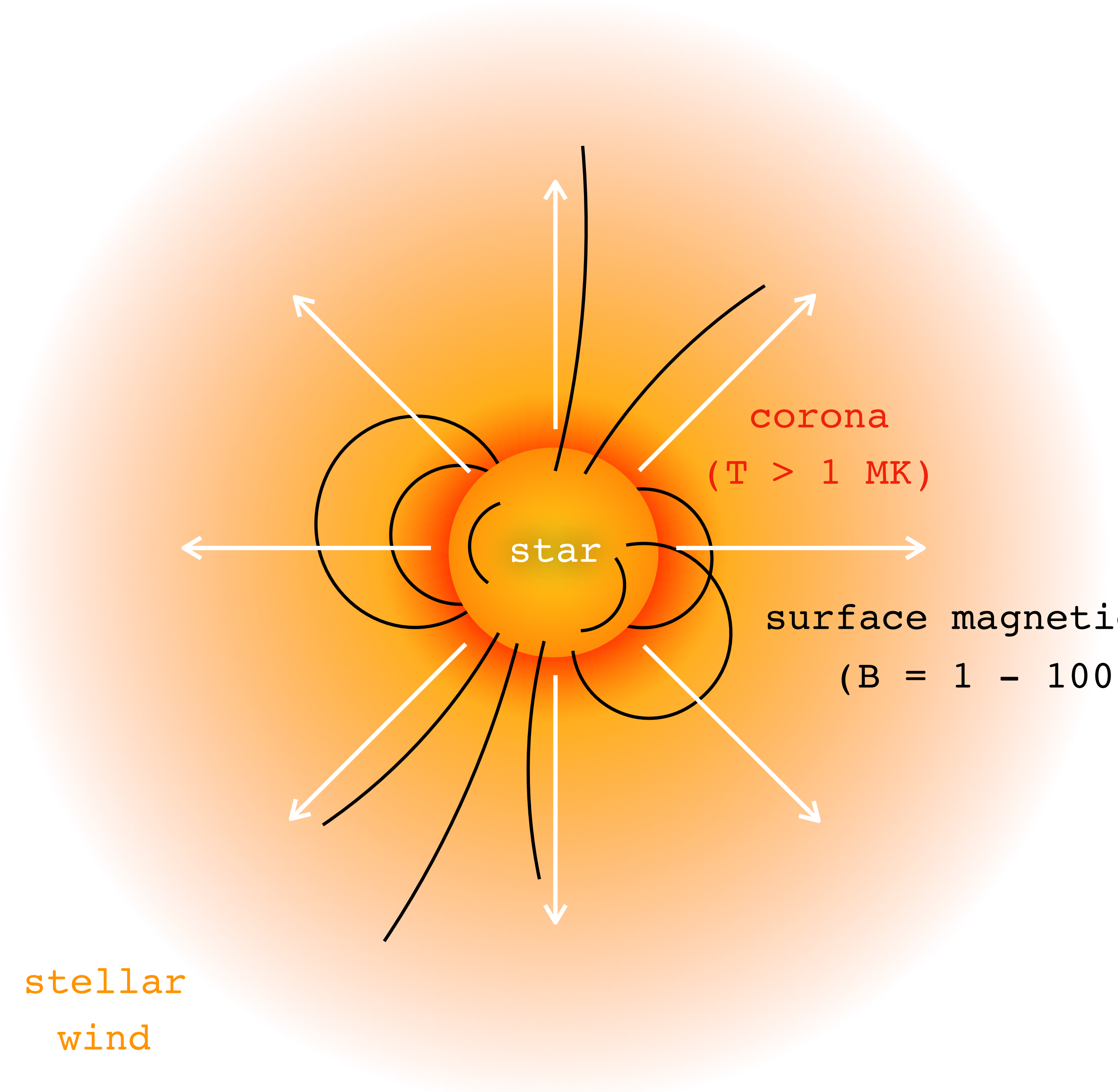
The power of the radio emission is **directly proportional** to the incident magnetic power of the solar wind (Zarka 2007):



Why search for exoplanetary radio emission?

- New method for **directly detecting exoplanets**.
- Tells us **exoplanets are magnetised** - what are their field strengths?
- Can probe **properties of the stellar wind** of the host star (in theory).

Stellar winds of low-mass stars

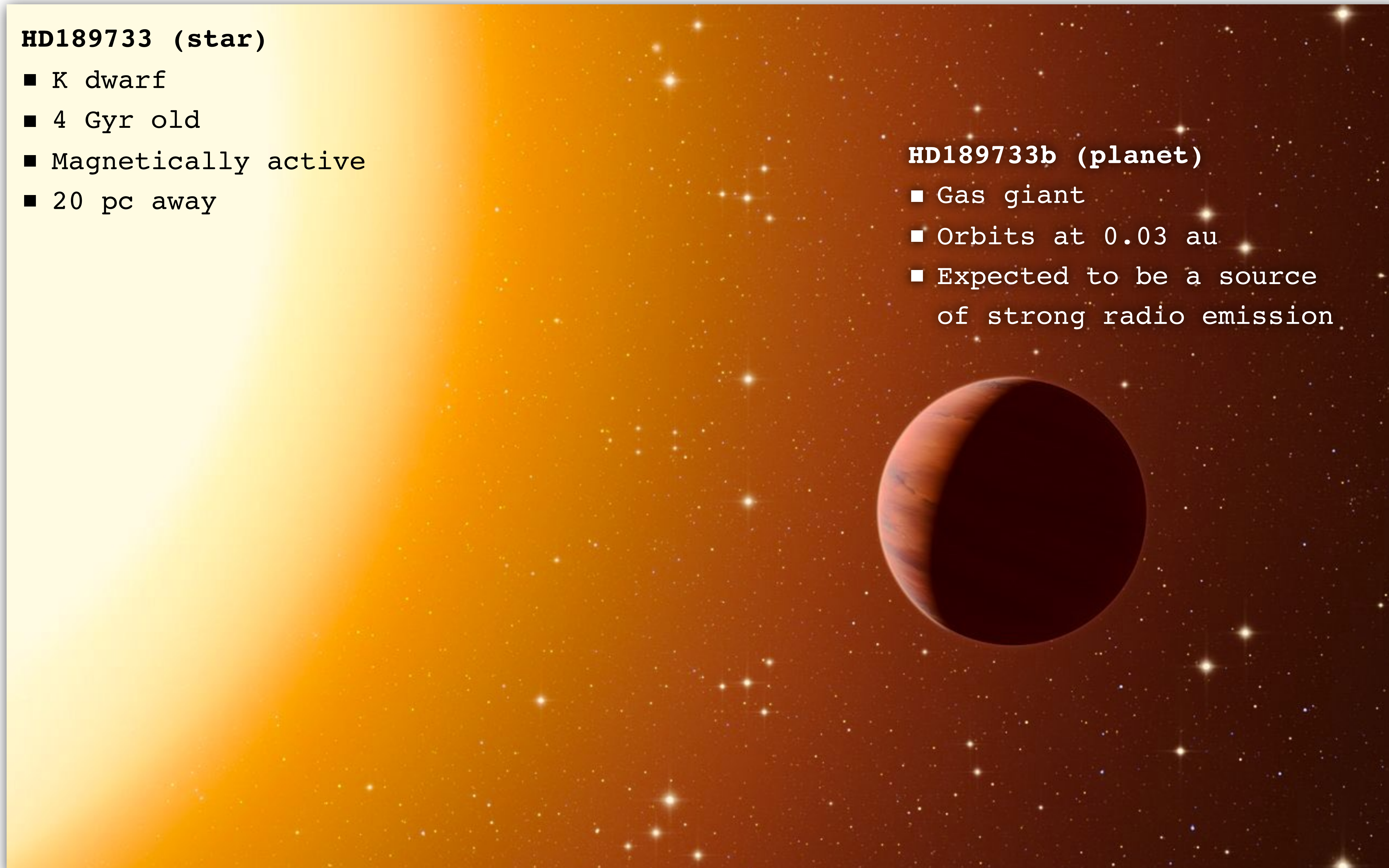


Main drivers:

- Surface magnetic field
- Hot corona

The stellar wind is the thermal expansion of a hot magnetised plasma into the interplanetary environment.

HD189733b - a close in hot Jupiter



HD189733 (star)

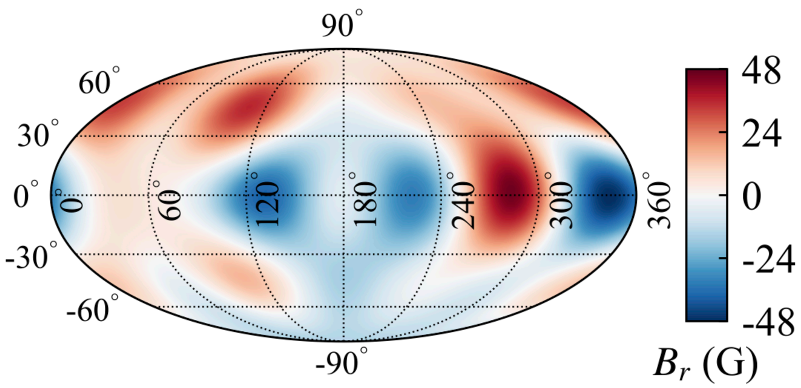
- K dwarf
- 4 Gyr old
- Magnetically active
- 20 pc away

HD189733b (planet)

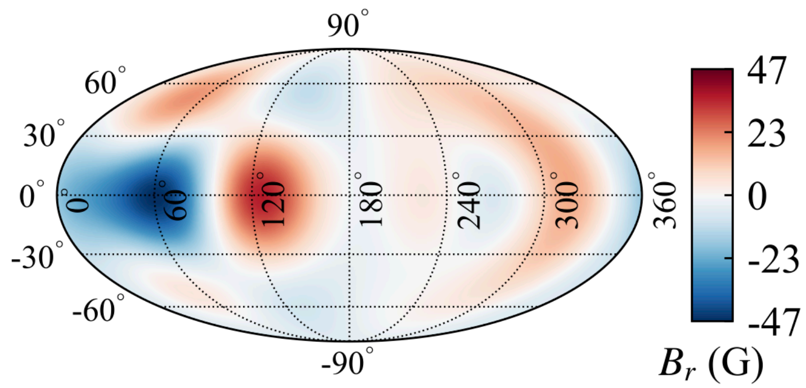
- Gas giant
- Orbits at 0.03 au
- Expected to be a source of strong radio emission

Modelling the stellar wind of the host star

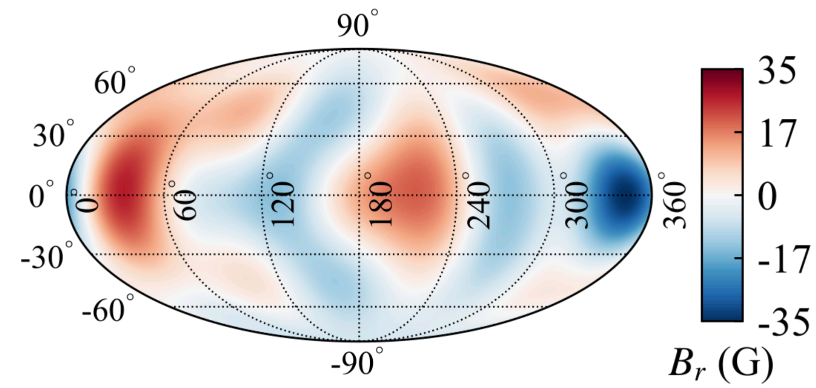
We perform 3D magnetohydrodynamics simulations of the stellar wind, based on reconstructed surface magnetic field maps (Fares+ 2017):



Jun/Jul 2013

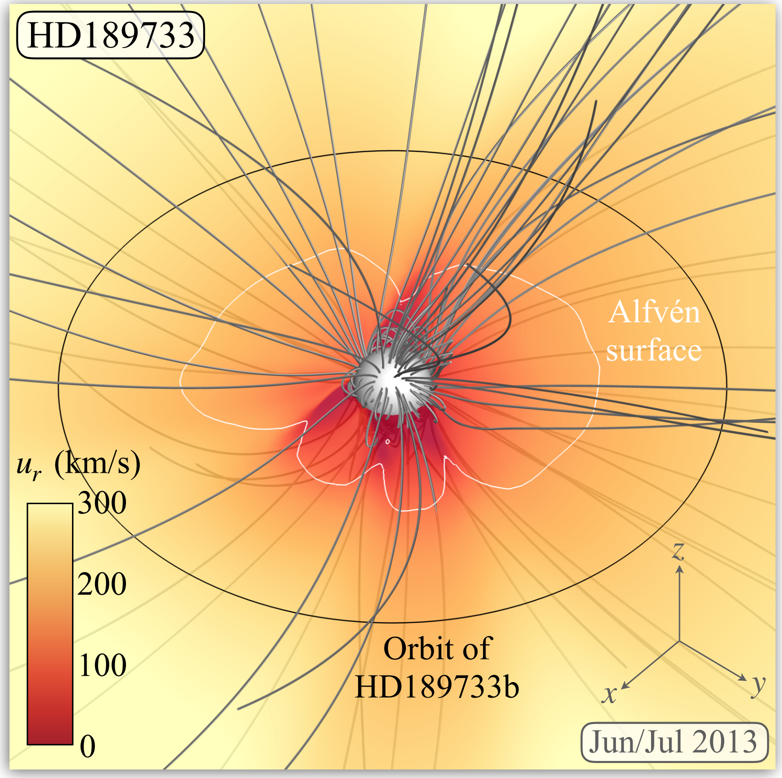


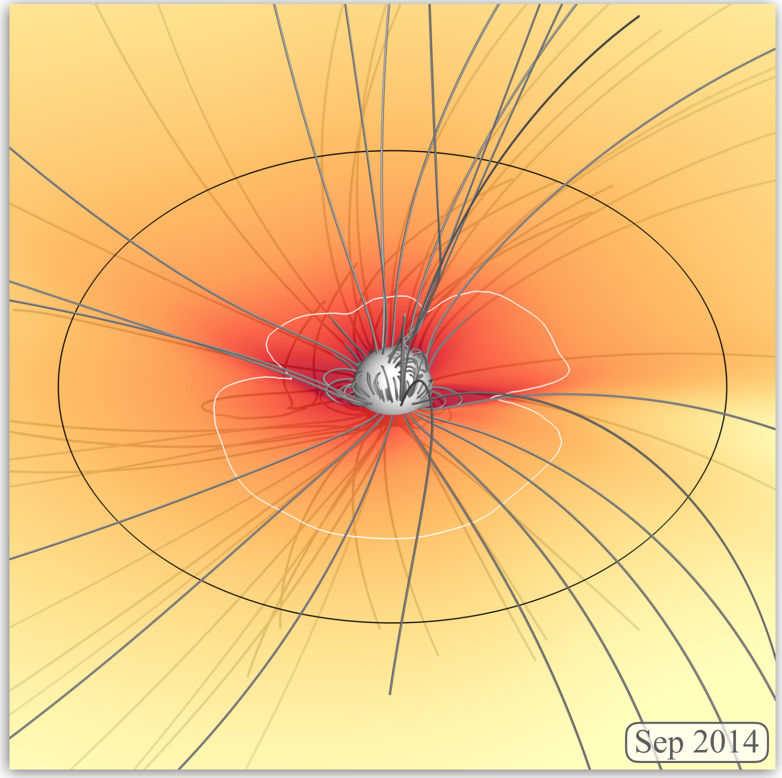
Sep 2014

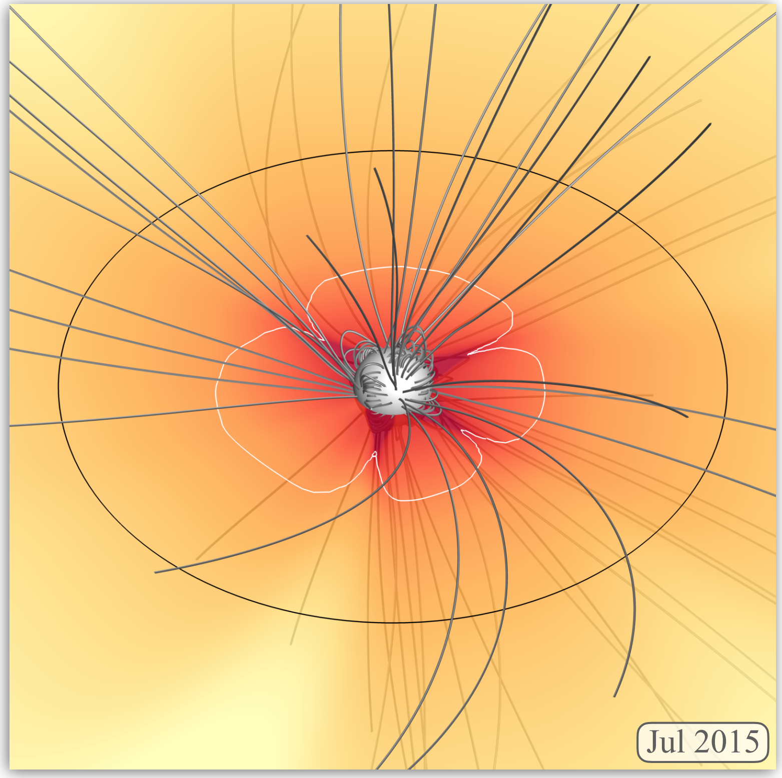


Jul 2015

Our models provide us with the magnetic power of the stellar wind at the planetary orbit:







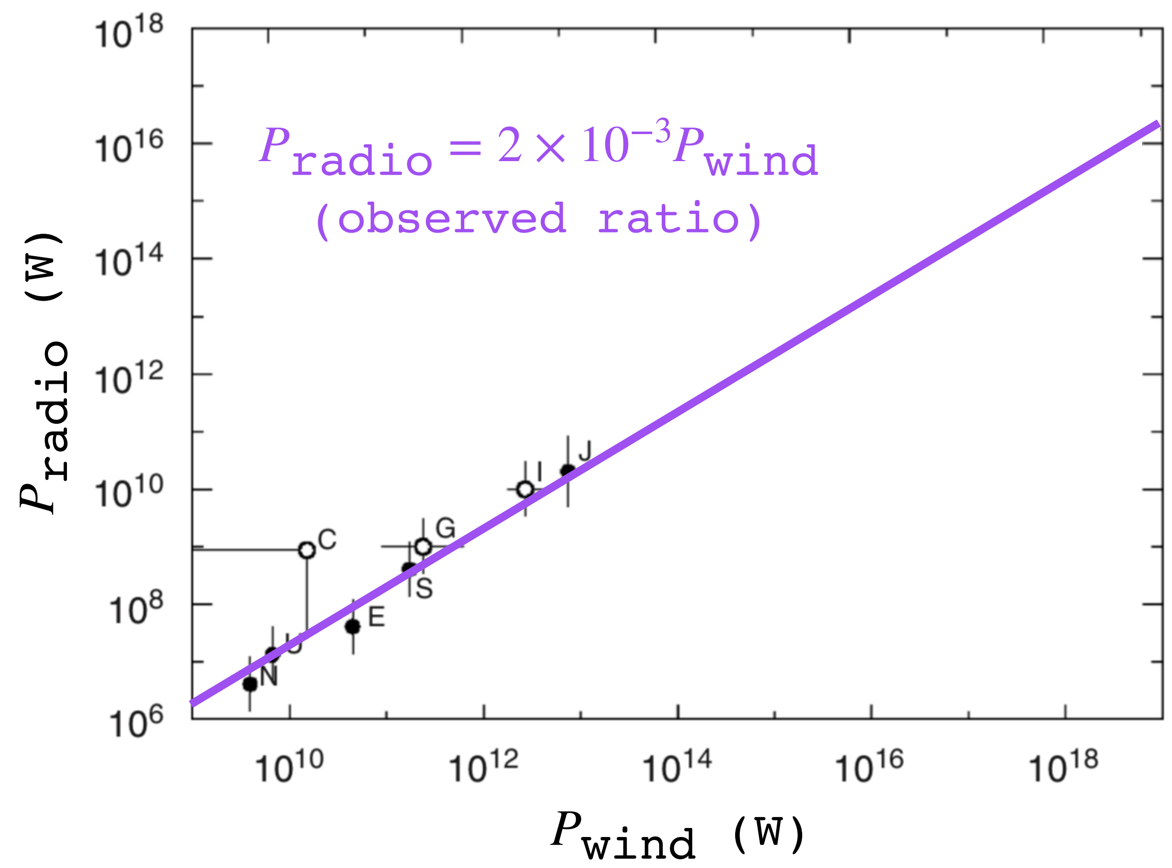
Modelling the planetary radio emission

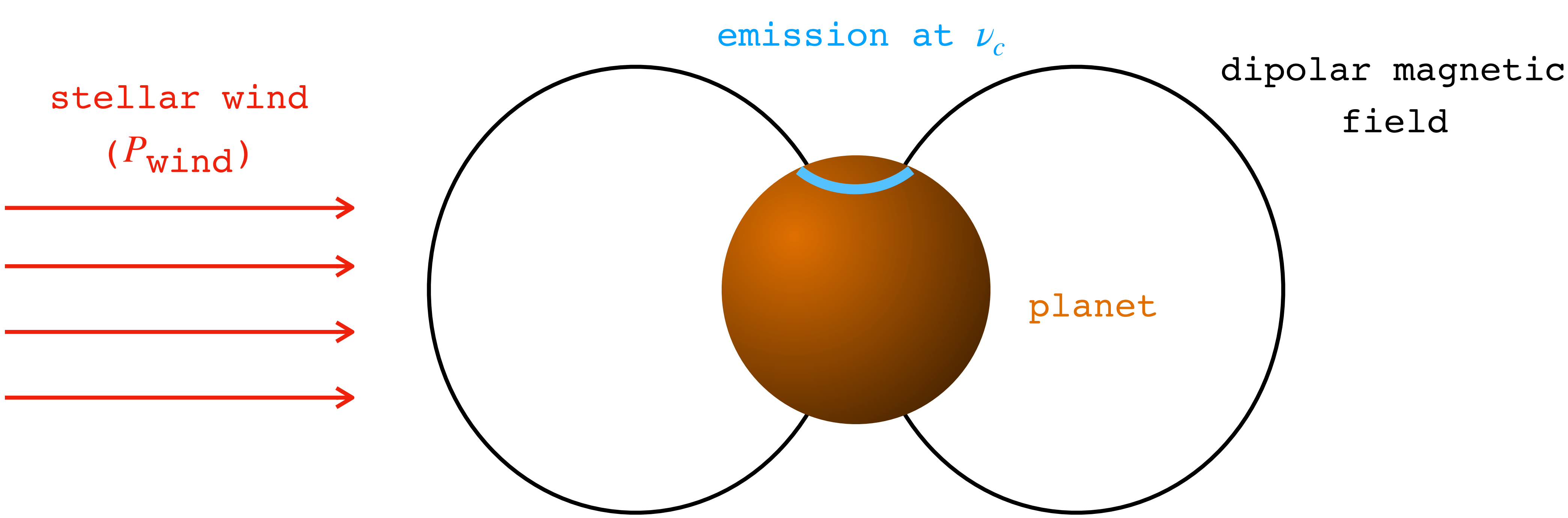
Emission occurs at the local cyclotron frequency:

$$\nu_c = 2.8B \text{ MHz (B in gauss)}$$

The flux density of the emission is:

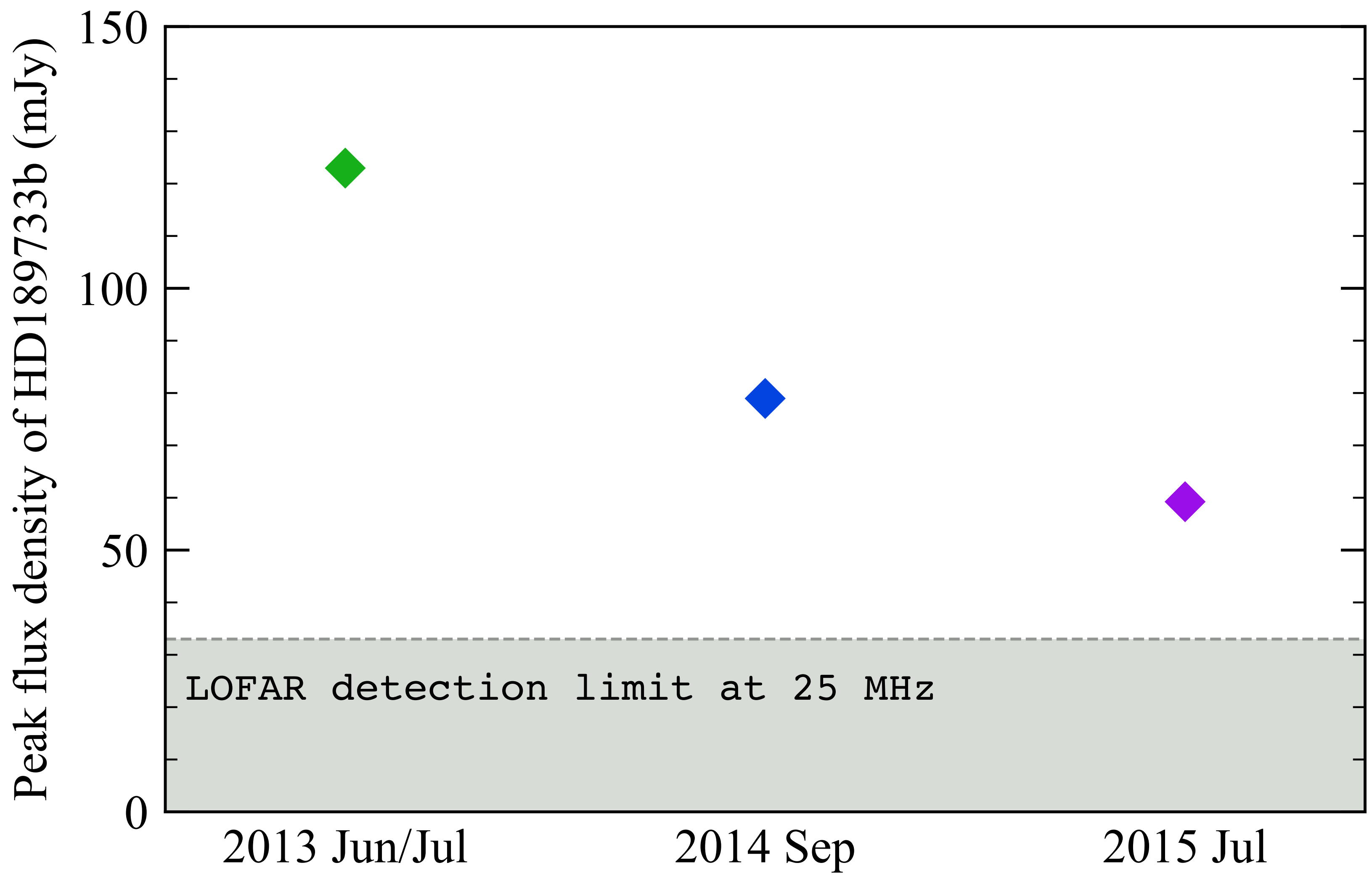
$$F_\nu \propto \frac{P_{\rm radio}}{d^2 \nu_c}$$





Predicted radio emission from HD189733b

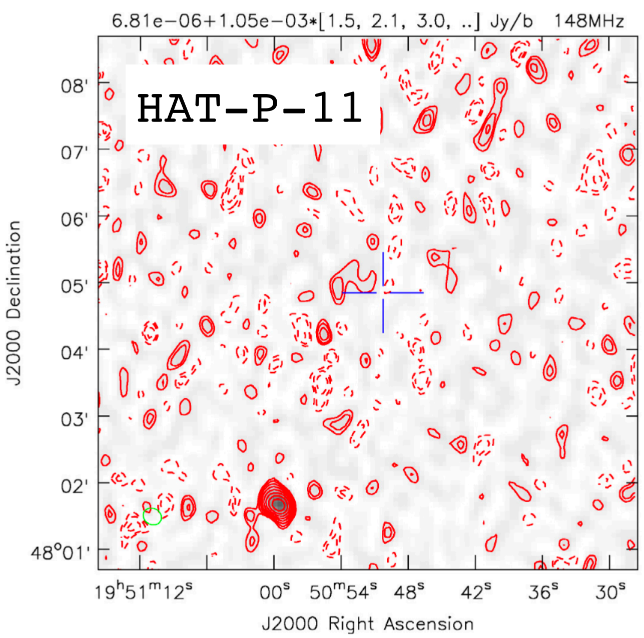
- For an assumed planetary magnetic field strength of 10 G, the planet emits at 25 MHz.
- The planet emits peak flux densities above the detection limit of LOFAR (1 hour integration at 25 MHz).



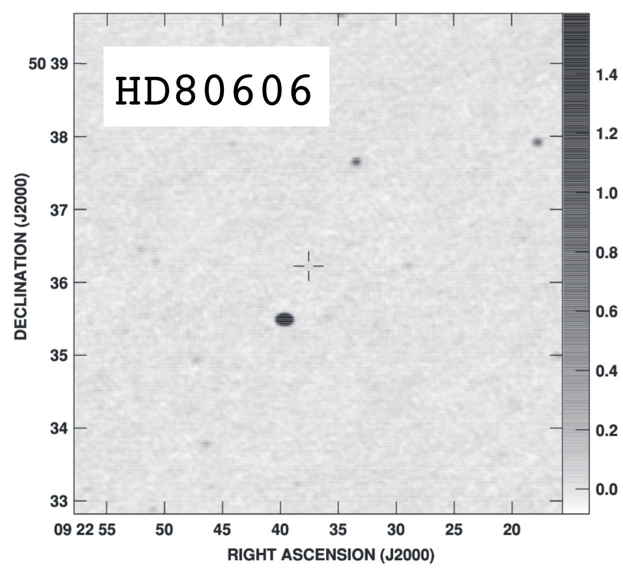
Where is the radio emission?

- Hot Jupiters such as HD189733b are the most common type of discovered exoplanet to date.
- However, surveys have failed to find a single source of exoplanetary radio emission:

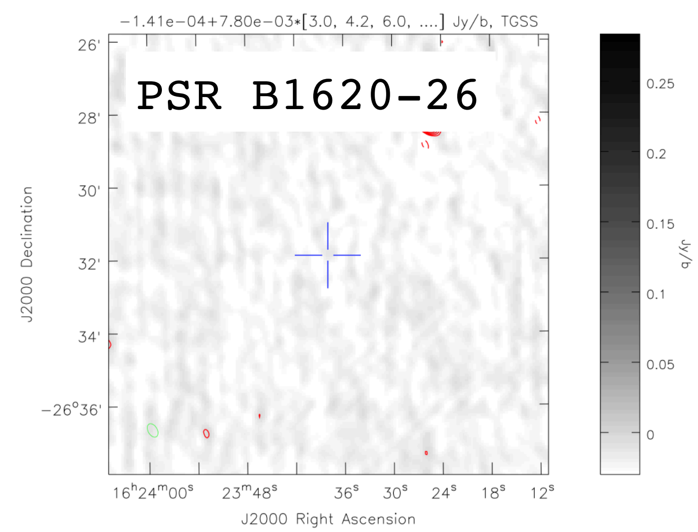
No detections (so far)!



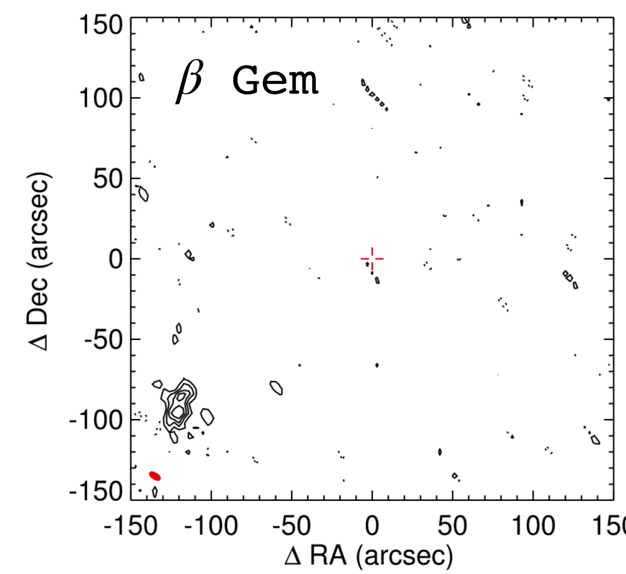
(Lecavelier des Etangs+ 2013)



(Lazio+ 2010)



(Sirothia+ 2014)



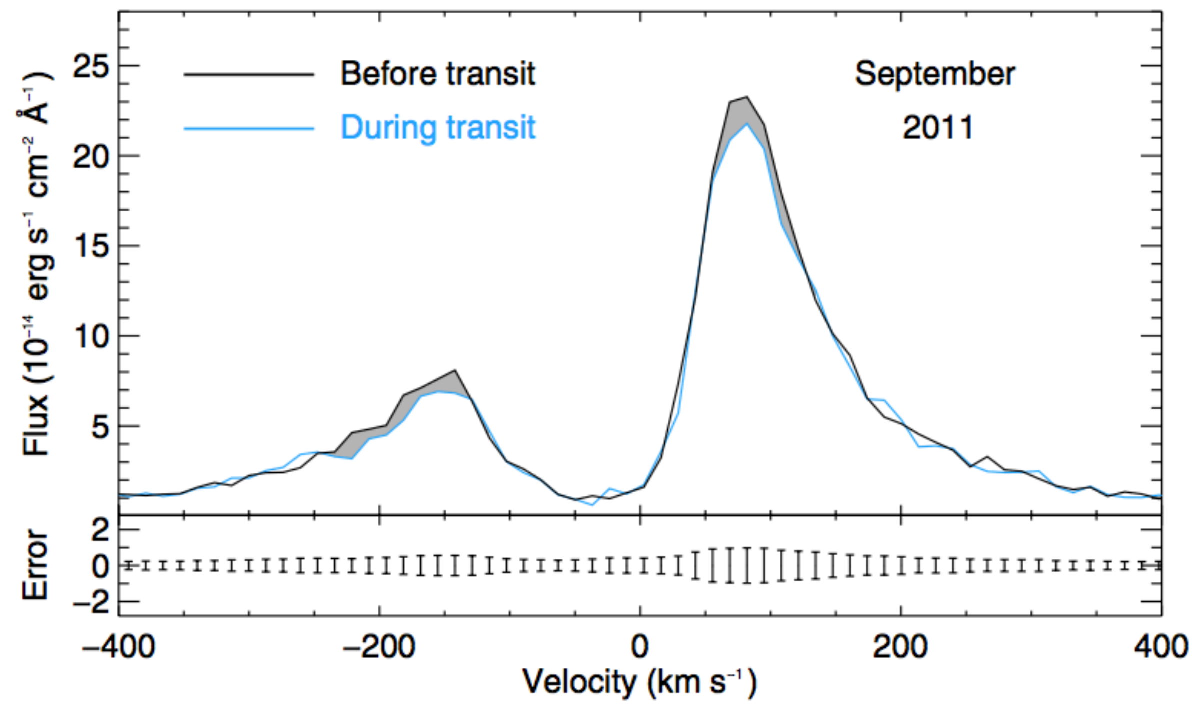
(O'Gorman+ 2018)

Is there something **preventing the escape/generation** of exoplanetary radio emission?

Where is the radio emission? Three possible options

1) No generation in a dense planetary atmosphere:

Lyman α observations shows that the planet's atmosphere is very extended.



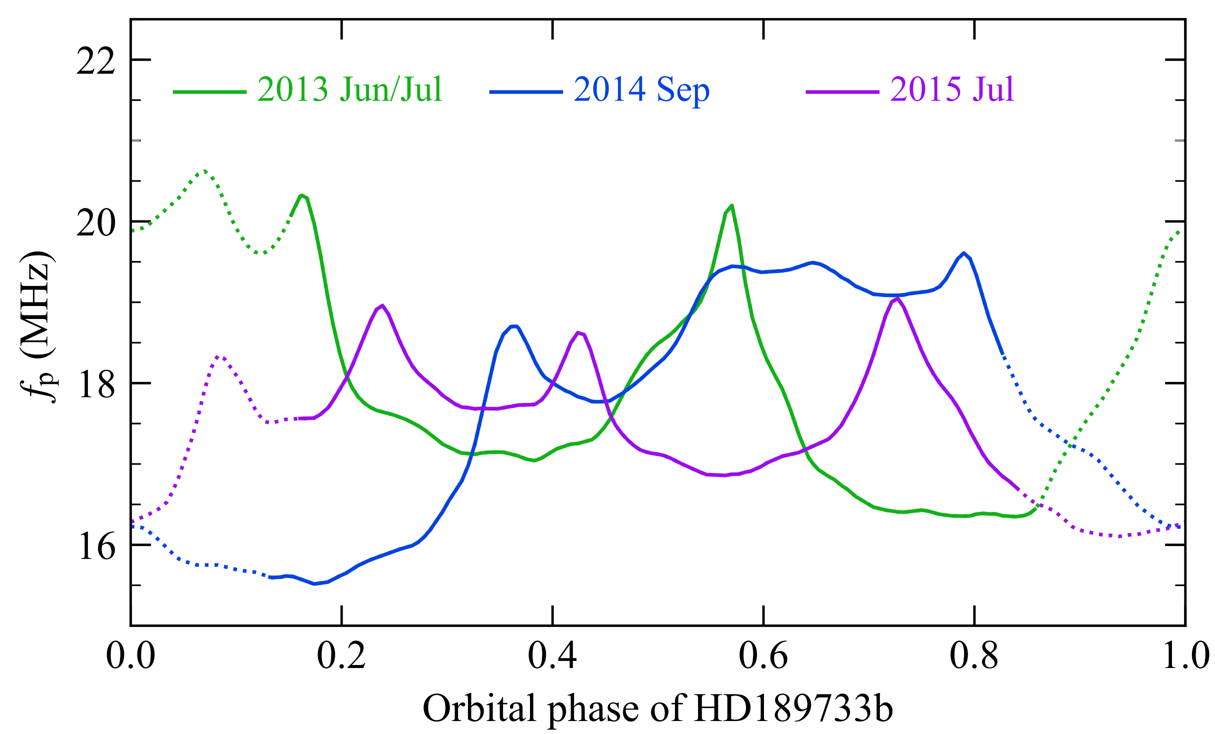
No generation if $\nu_p > \nu_c$:

$$n_e > \frac{B^2}{4\pi n_e m_e c^2}$$

> The planetary atmosphere may prevent generation.

2) No generation in a dense stellar wind plasma:

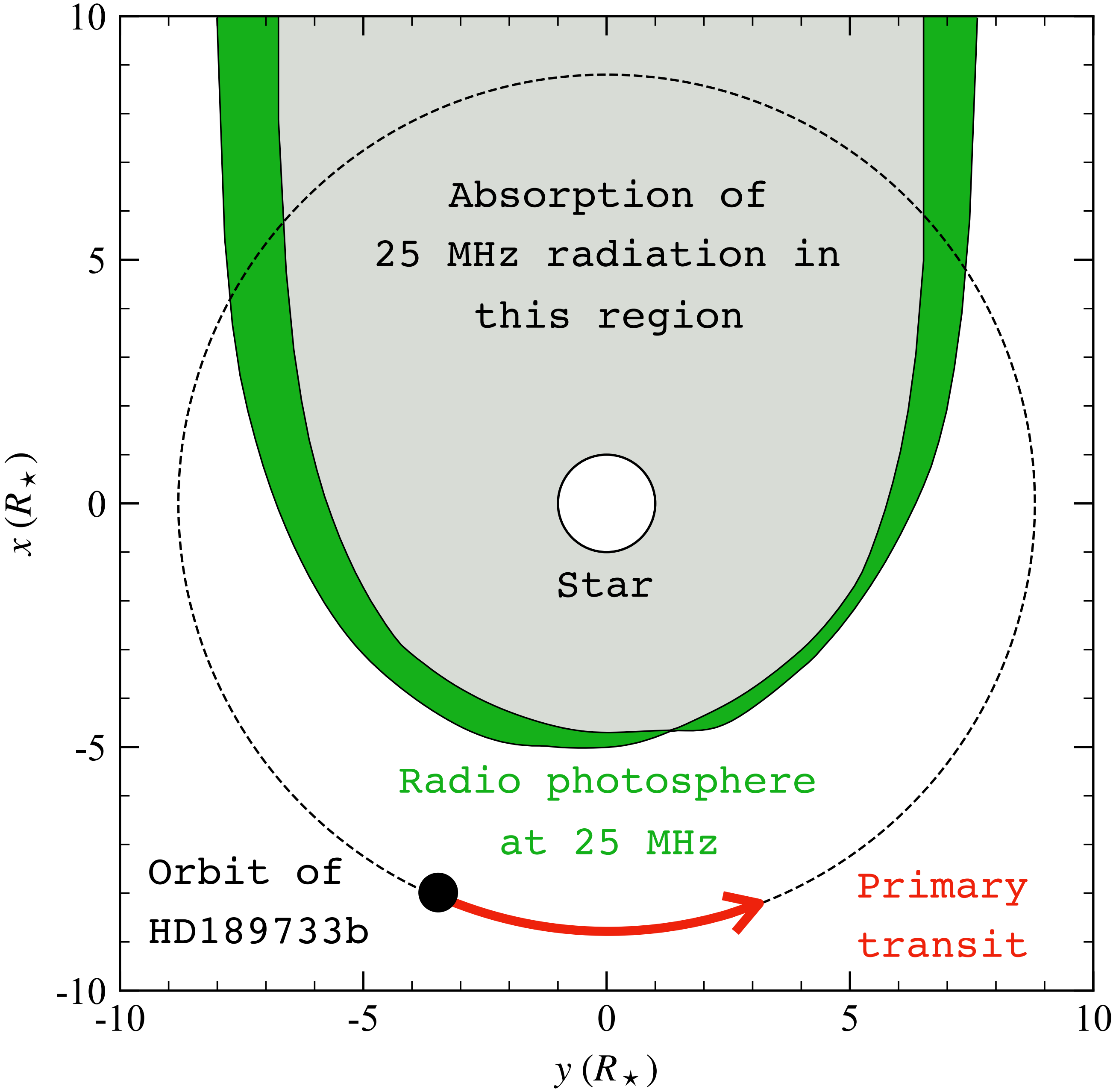
The stellar wind may also prevent generation.

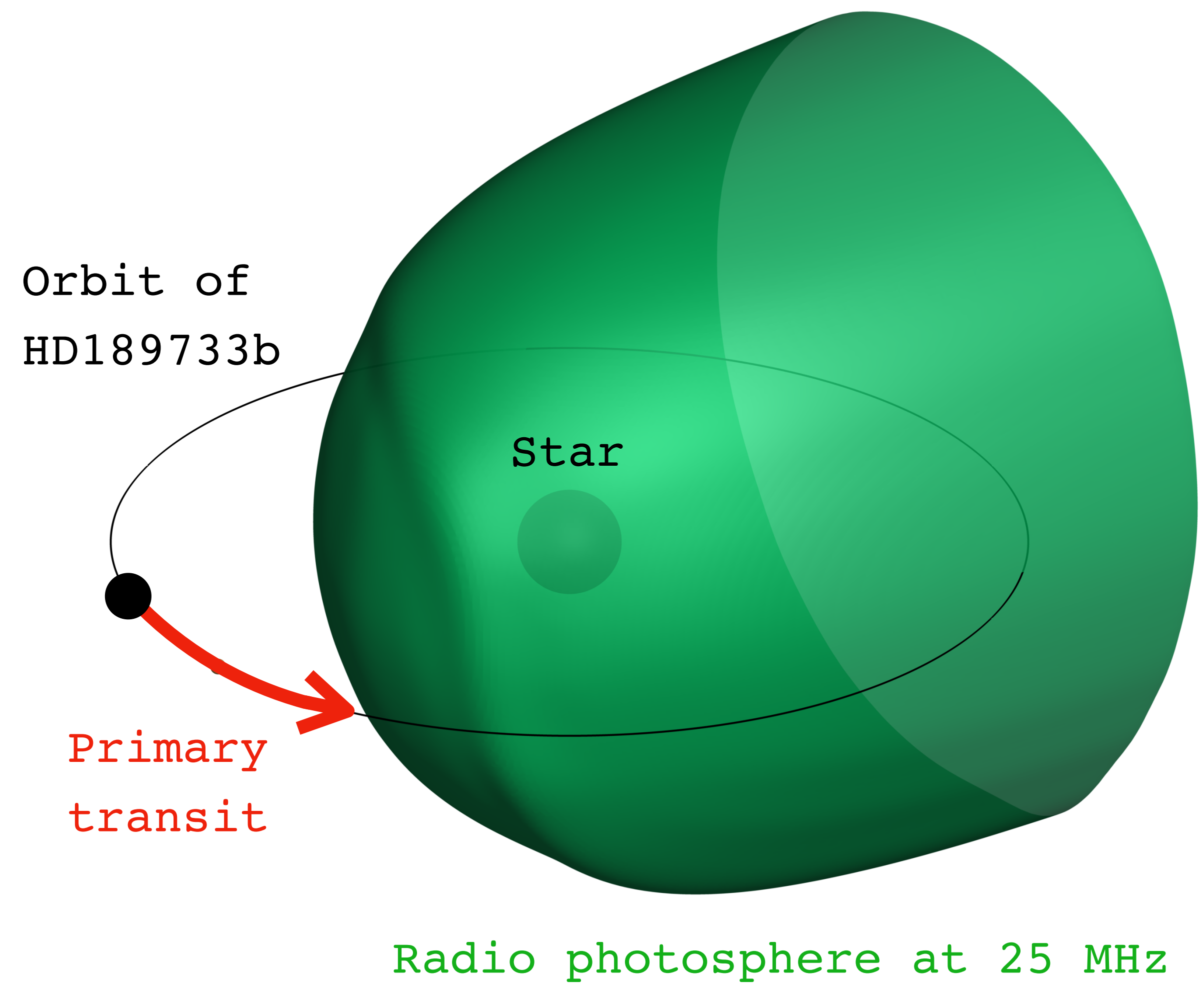


Where is the radio emission? Three possible options

3) Free-free absorption in the stellar wind:

The planet orbits through the region of the stellar wind that is optically thick at 25 MHz:





The best time to observe is near primary transit!

Conclusions

- Hot Jupiters such as HD189733b are good candidates for exoplanetary radio emission.
- There are various scenarios where the escape/generation of exoplanetary emission cannot occur however.
- Observing systems such as this near primary transit of the planet may be the best time to observe.

Thanks!

Find out more:

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MOVES – II. Tuning in to the radio environment of HD189733b

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