The Space Environment of Close-in Exoplanets and its Implications for Planet Habitability

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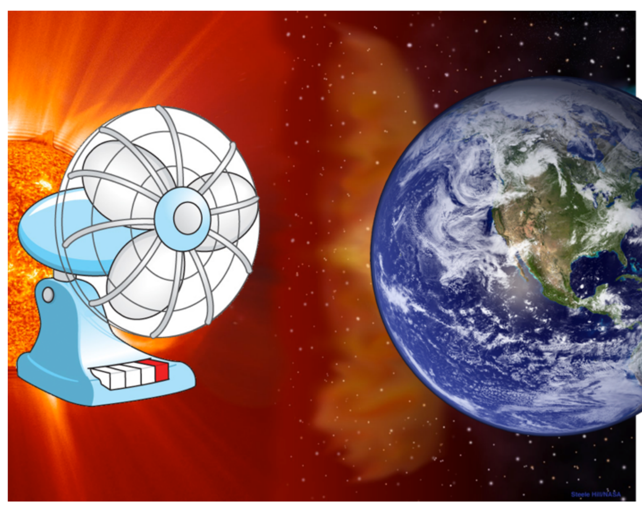
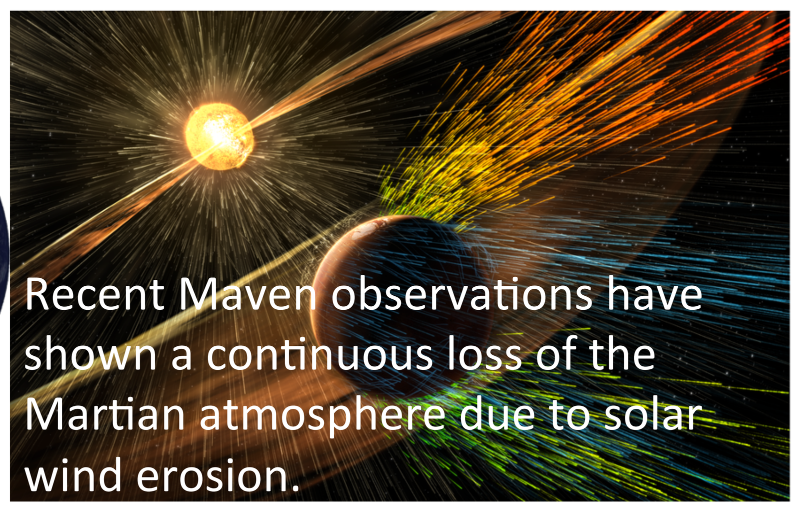
References: Cohen et. al ApJ, 790, 13, 2014; Cohen et. al ApJ, 806, 41, 2015.

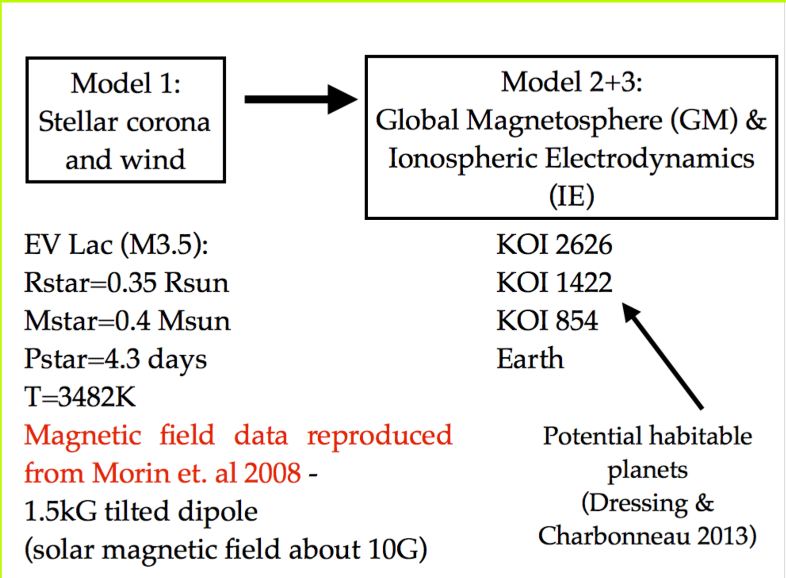
1. Can close-in planets sustain their atmosphere?





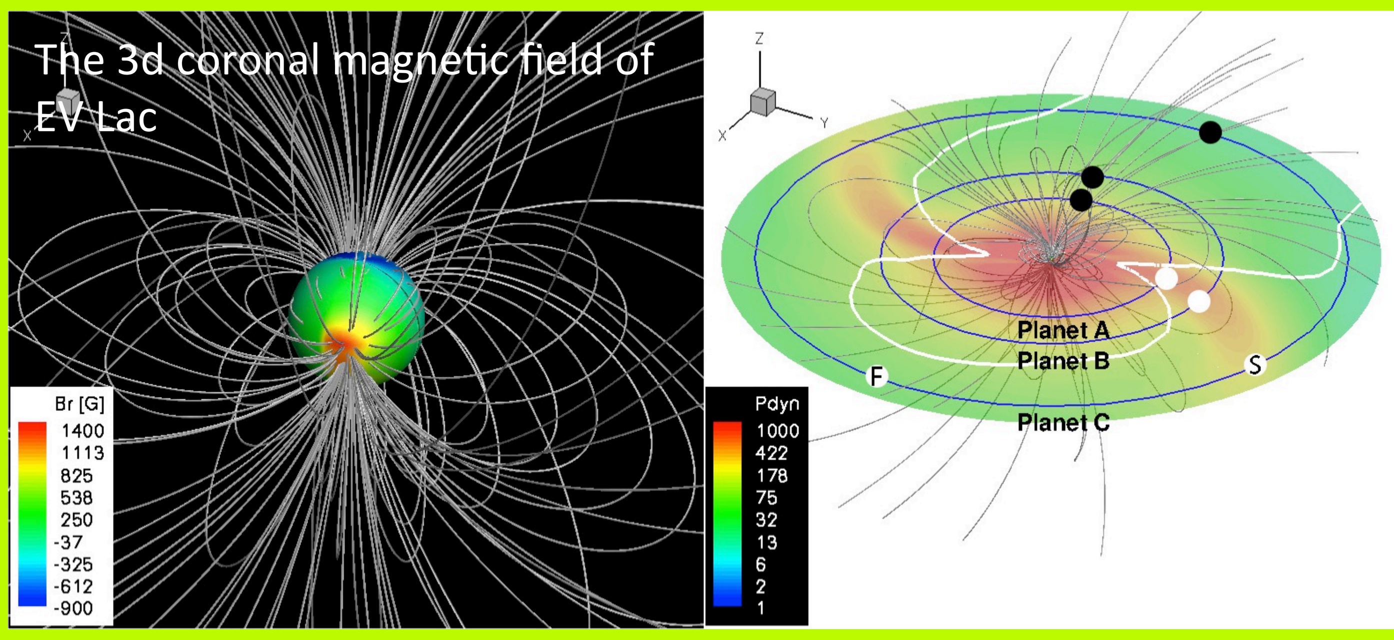
2. Let's model this and we'll find out!!!

3. We can simulate the stellar wind of an M-dwarf star (EV Lac) and use the wind solution to simulate the interaction between the wind and the planetary upper atmosphere



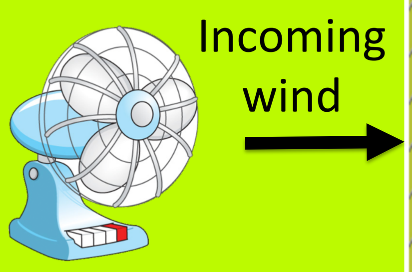
Planet A – KOI 2626.01 (0.06AU)
Planet B – KOI 1422.02 (0.085AU)
Planet C – KOI 854.01) (0.15AU)

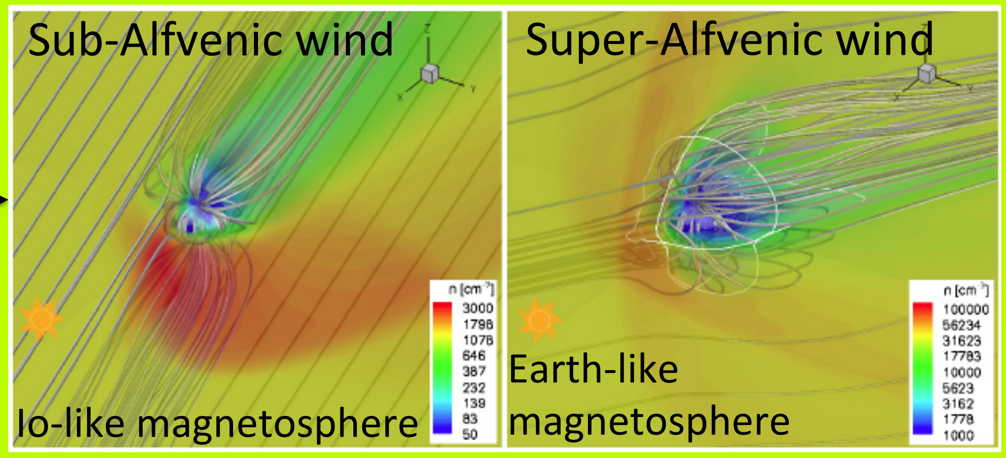
4. Let's look at three potentially habitable KOIs from Dressing and Charbonneau 2013. We can extract the wind conditions along their orbits

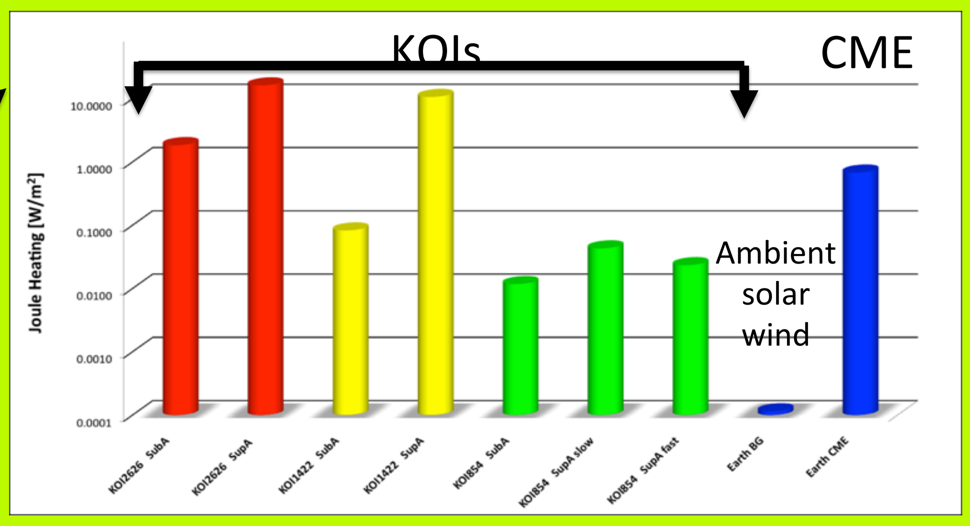


5. Look!!! the planets transition between sub- to super Alfven wind conditions along their orbit. The white line is the Alfven surface and the blue circles are the orbits

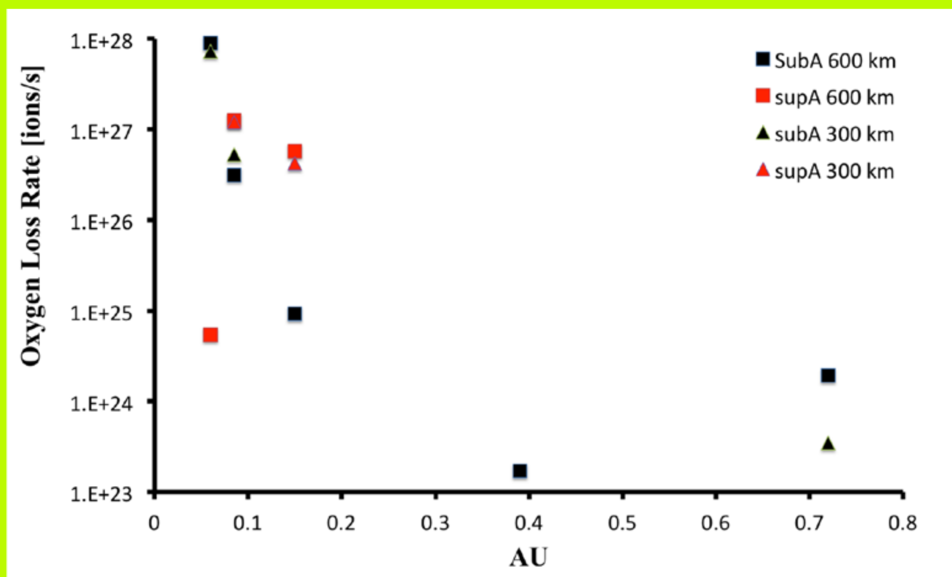
Magnetized (Earth-like) Planet







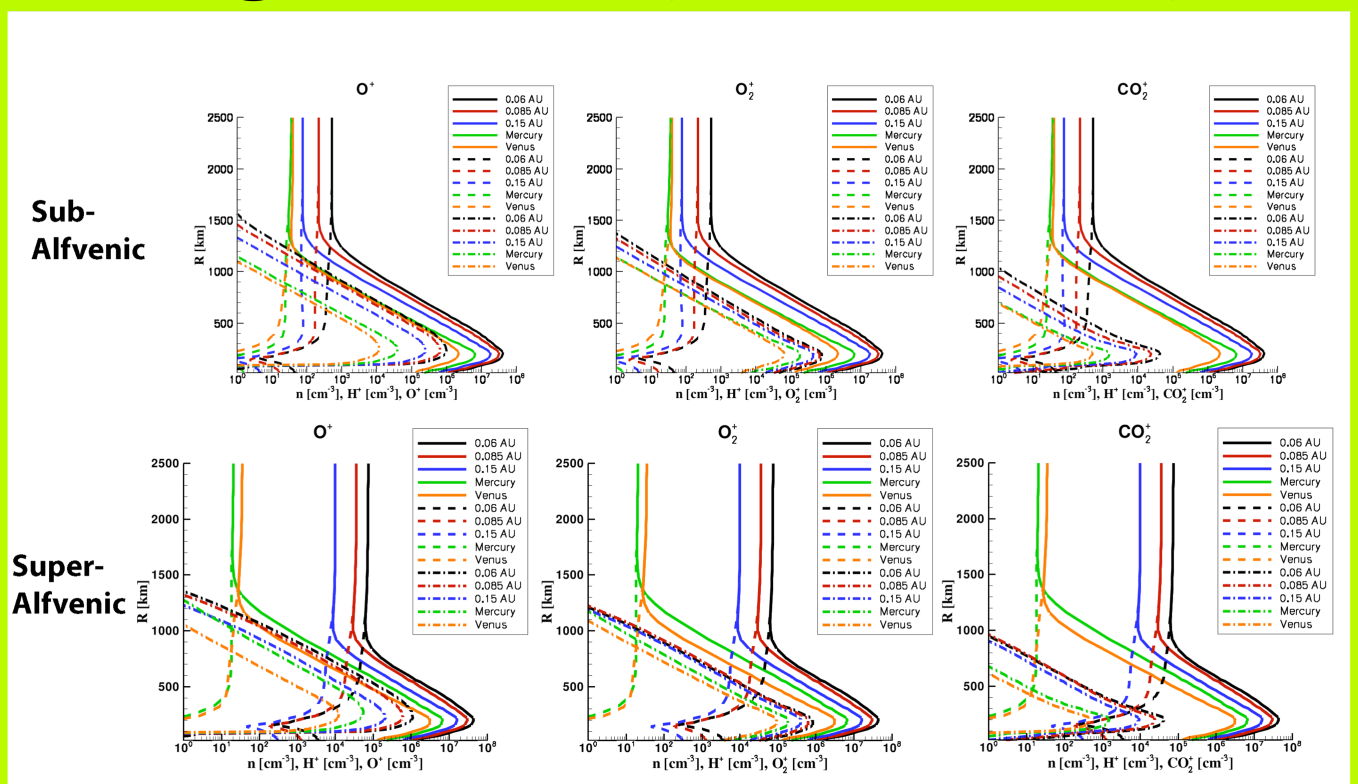
6. The transition between sub- and super-Alfvenic wind conditions leads to a dramatic change in the magnetospheric topology along the short orbit, and to an intense Joule heating at the top of the planetary atmosphere of magnetized planets.



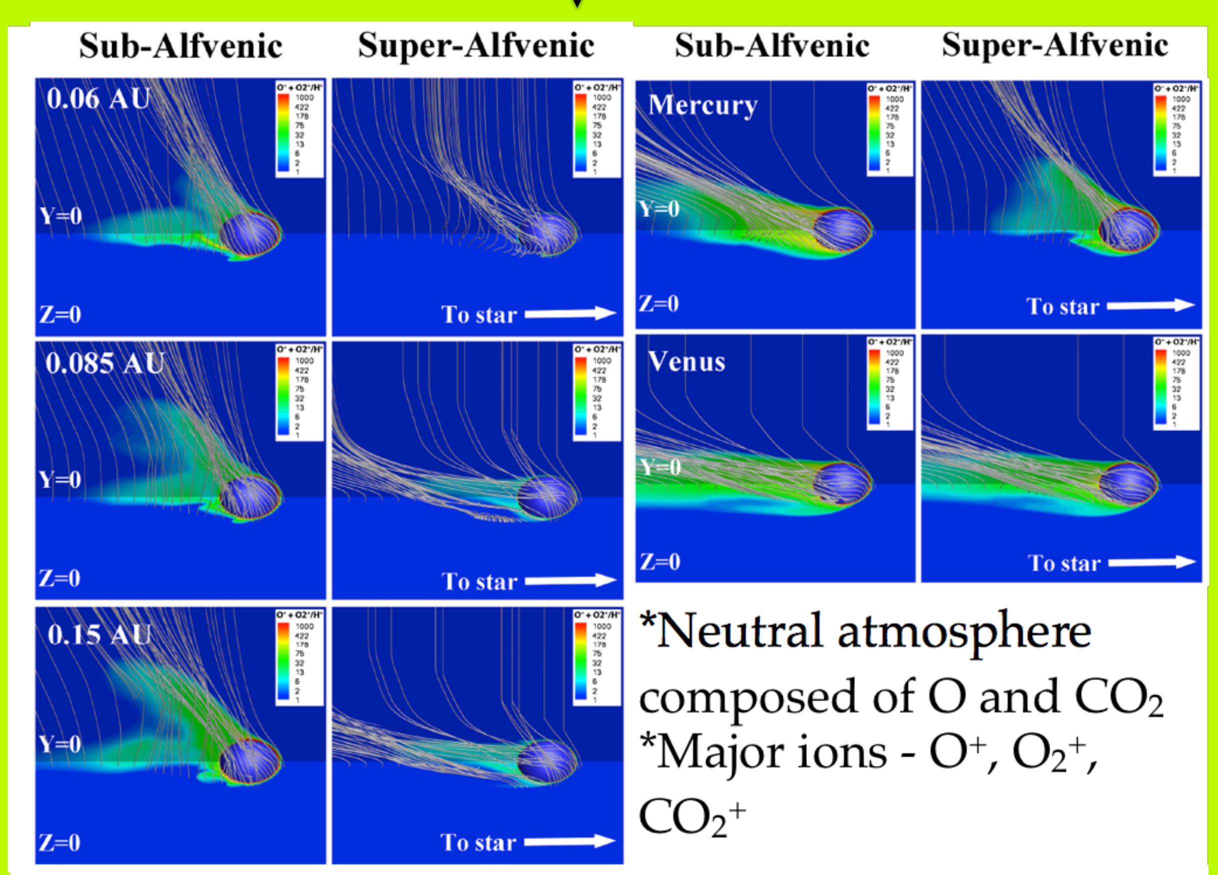
8. The loss rate of Oxygen ions is 4 orders of magnitude higher in close-in planets than that of Venus. With such a rate, a complete Venus atmosphere could be loss over the course of a billion years if we account for all the atmospheric escape processes.

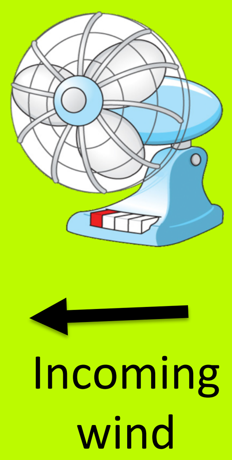
Our study shows that a magnetic field is crucial in order to protect the atmospheres of close-in planets from stellar wind stripping and erosion.

Non-magnetized (Venus-like) Planet



7. In the case of a non-magnetized planet, the stellar wind penetrates up to 1000 km above the surface, and the intense EUV flux leads to strong photoionization of Oxygen and CO_2, which escape the atmosphere. Look at all the O^+ and O_2^+ in the magnetosphere





*Neutral atmosphere composed of O and CO_2
*Major ions - O^+, O_2^+, CO_2^+

Contours show ratio of Oxygen to hydrogen ions