

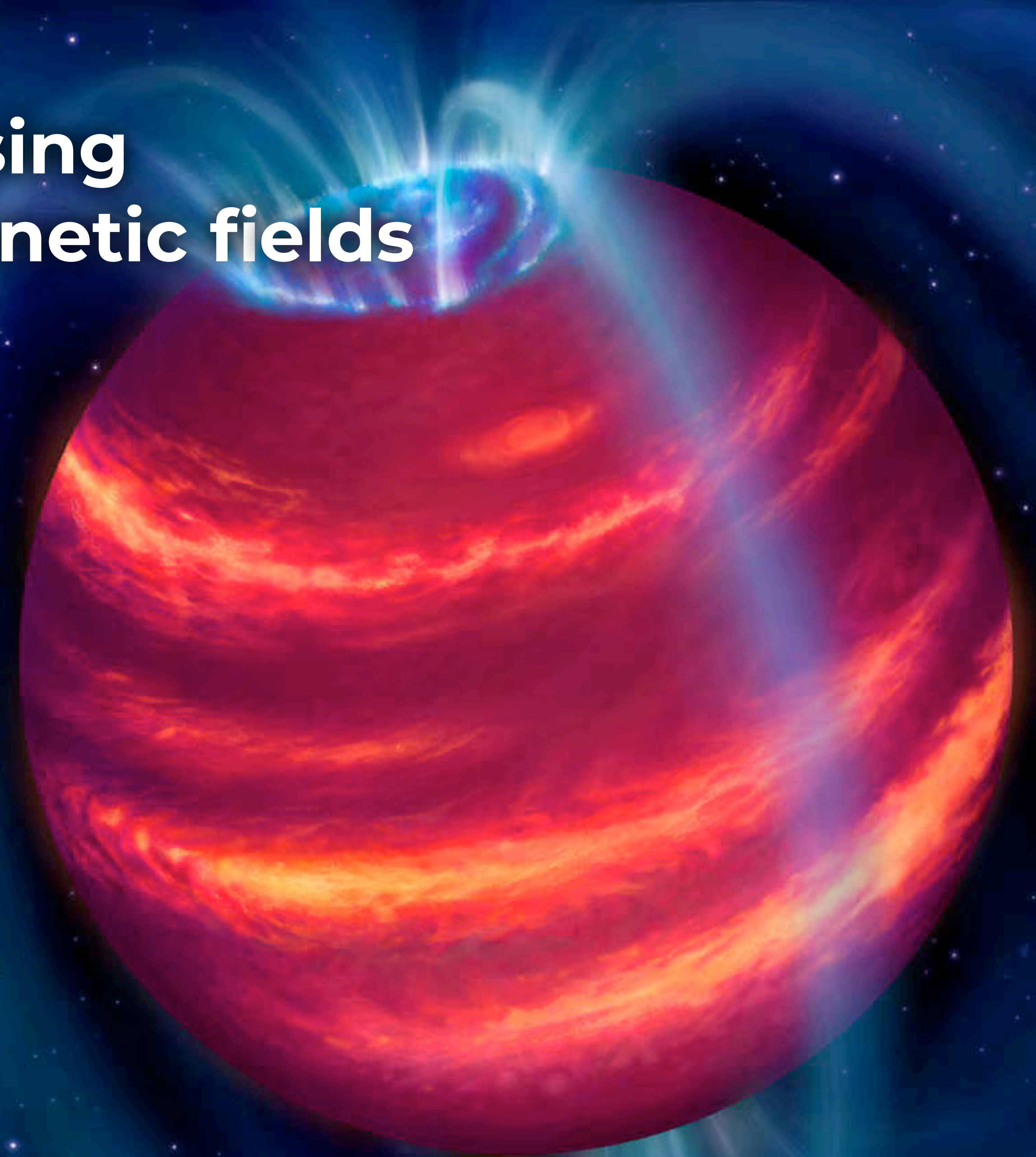
Discovering and characterising brown dwarfs via their magnetic fields

Dr Robert Kavanagh

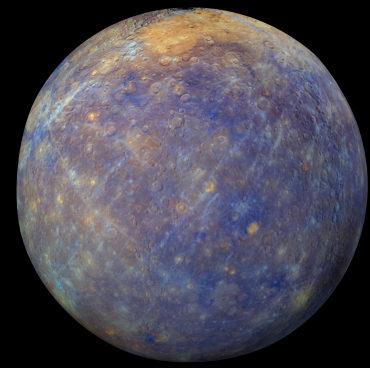
Senior Postdoctoral Researcher
University of Amsterdam

** Special thanks to José Carlos Guirado for his support
(grant PID2023-147883NB-C21 funded by MCIN/AEI)*

Image: D Futselaar



Planet diversity in our solar system



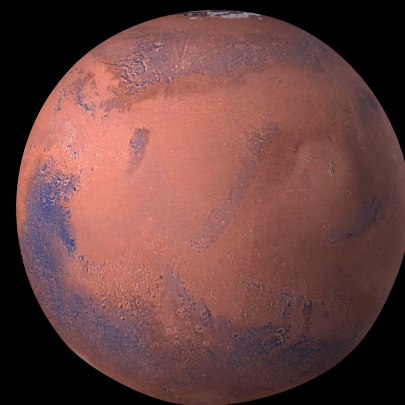
Mercury



Venus



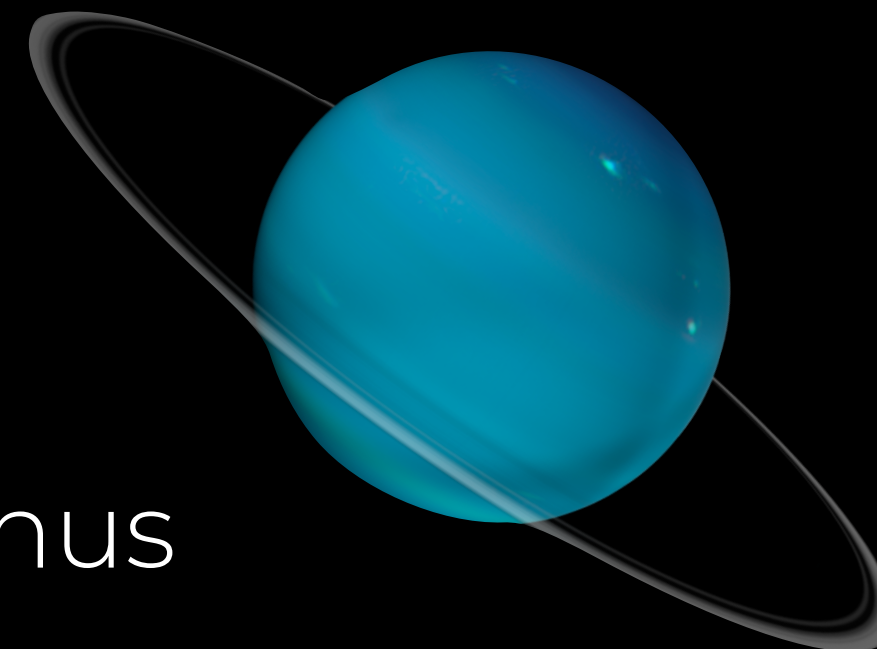
Earth



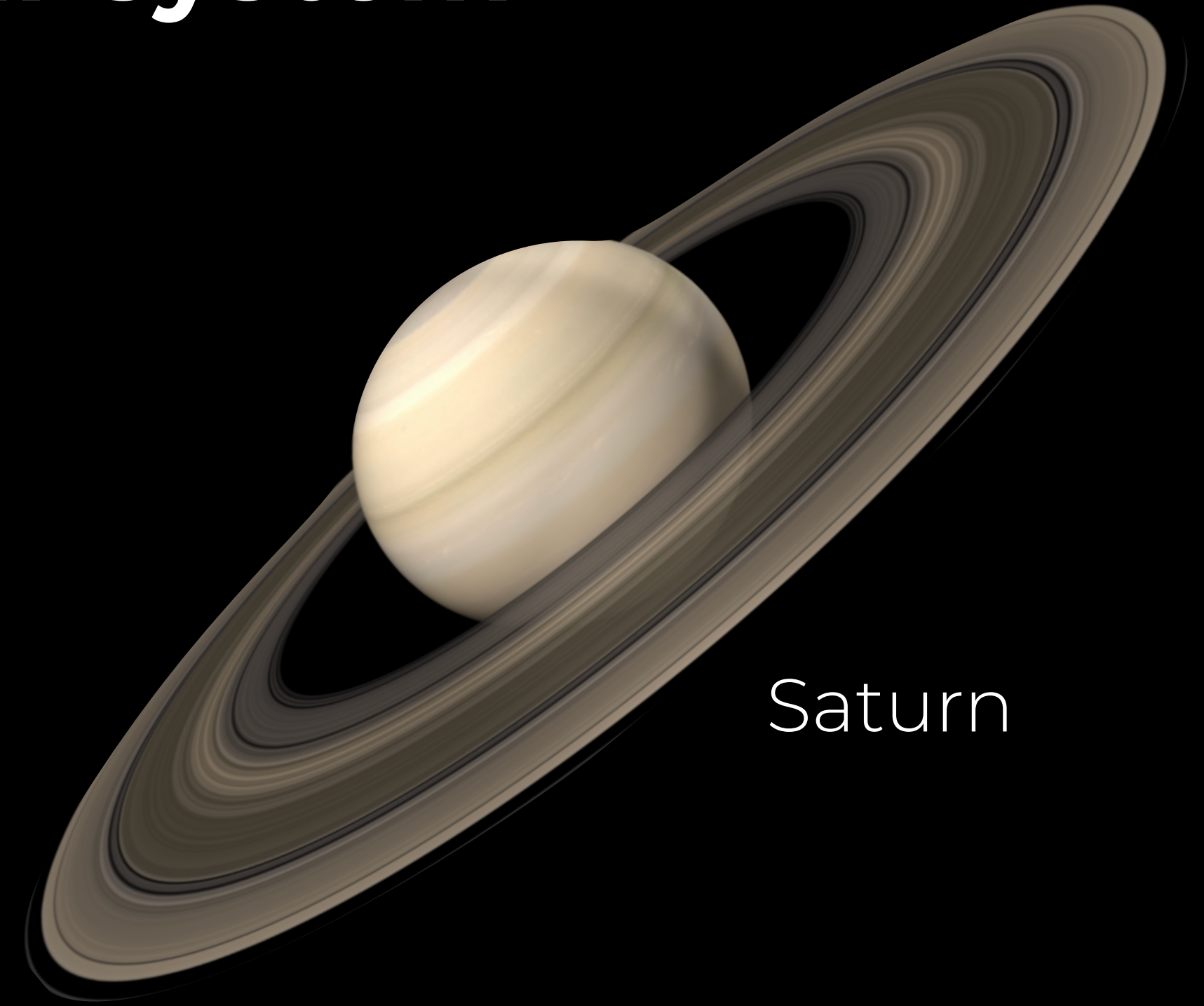
Mars



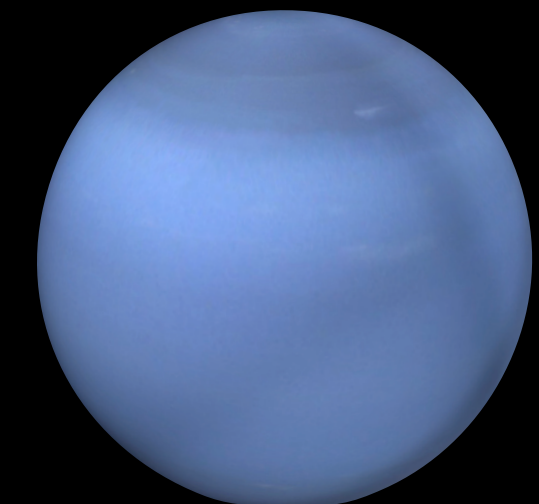
Jupiter



Uranus

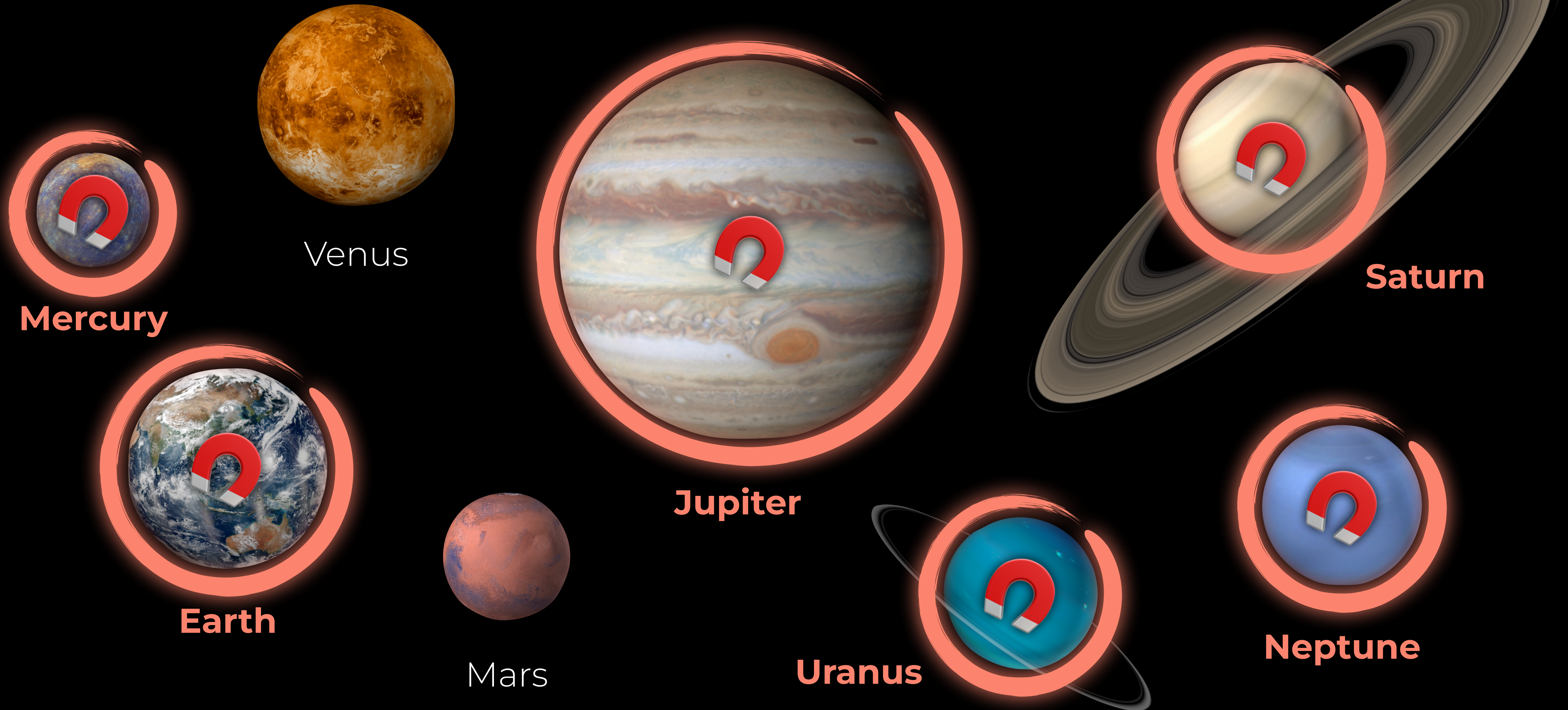


Saturn

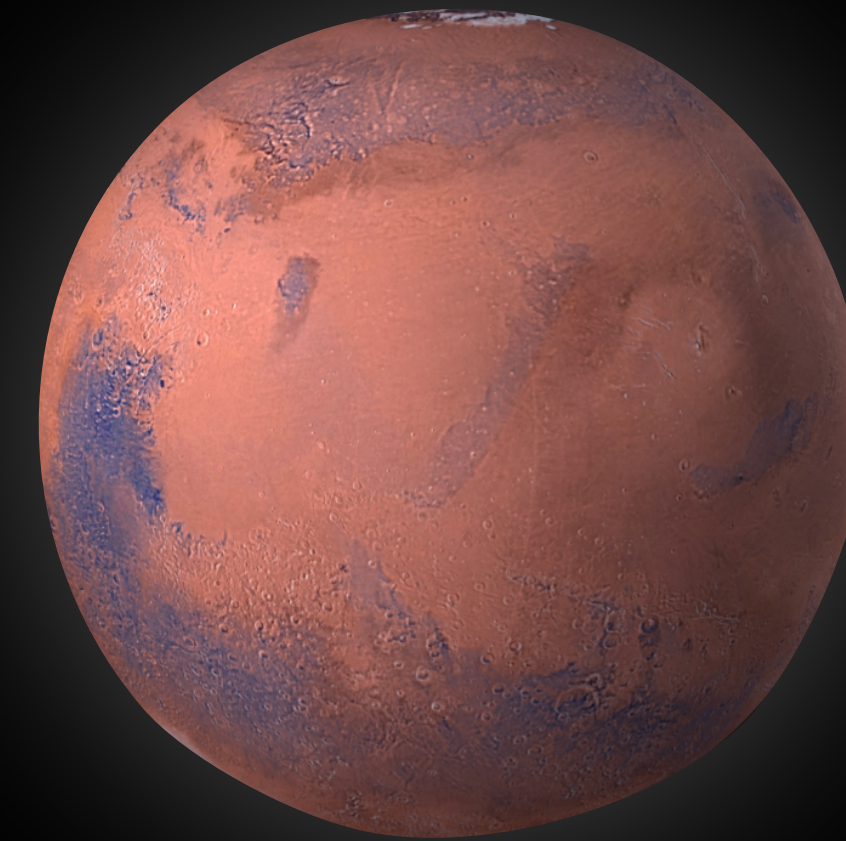


Neptune

Planet diversity in our solar system

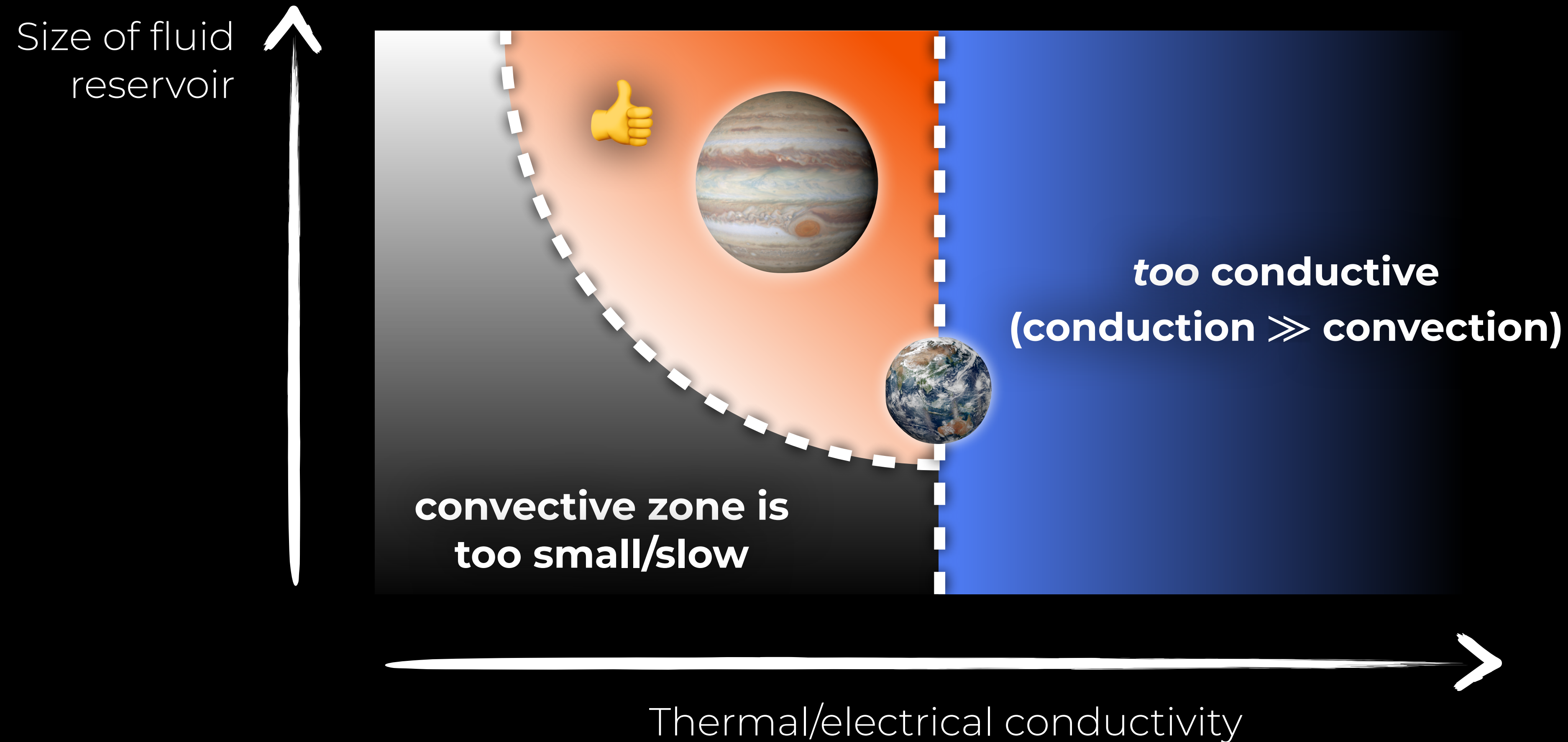


Consequences of no magnetic field

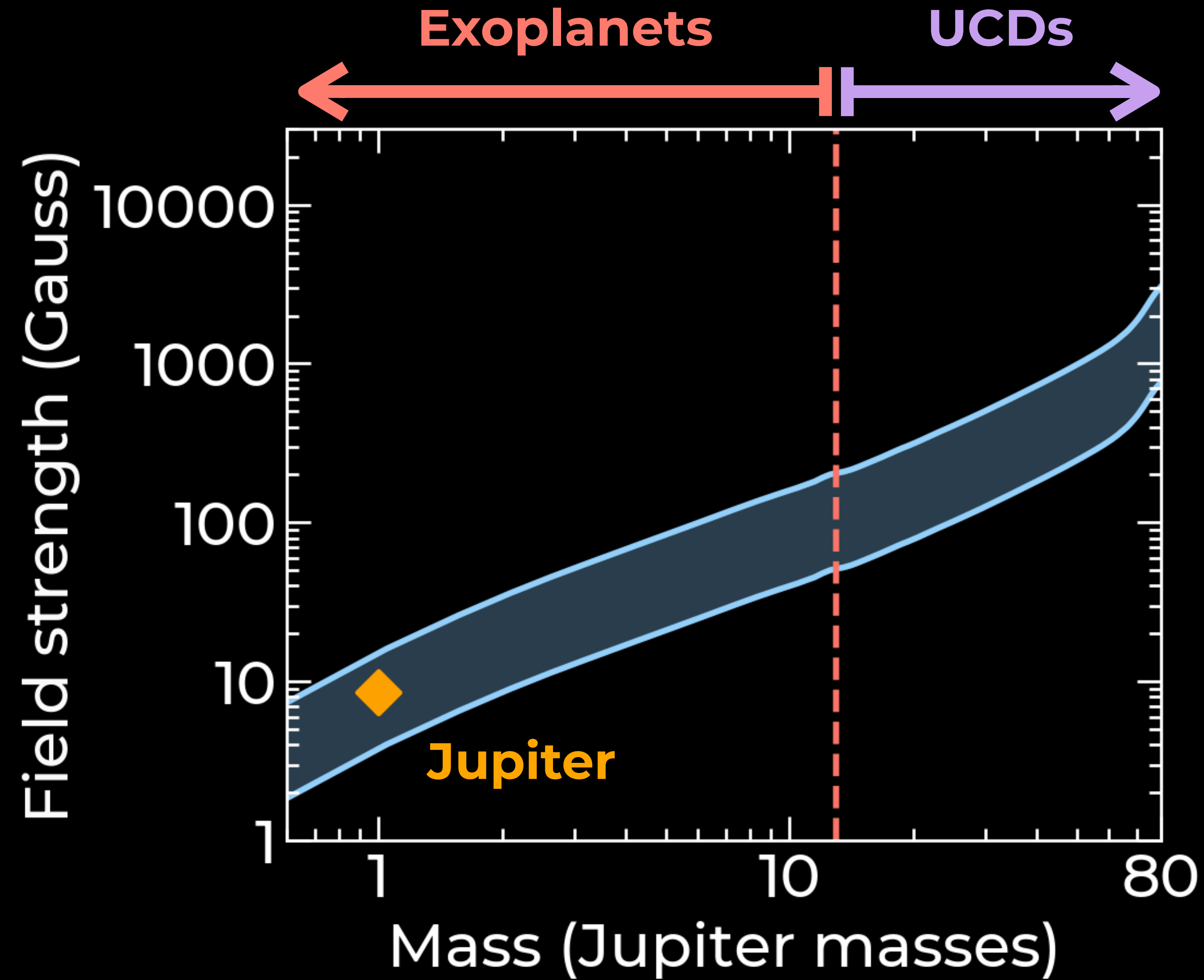


Conditional dynamos

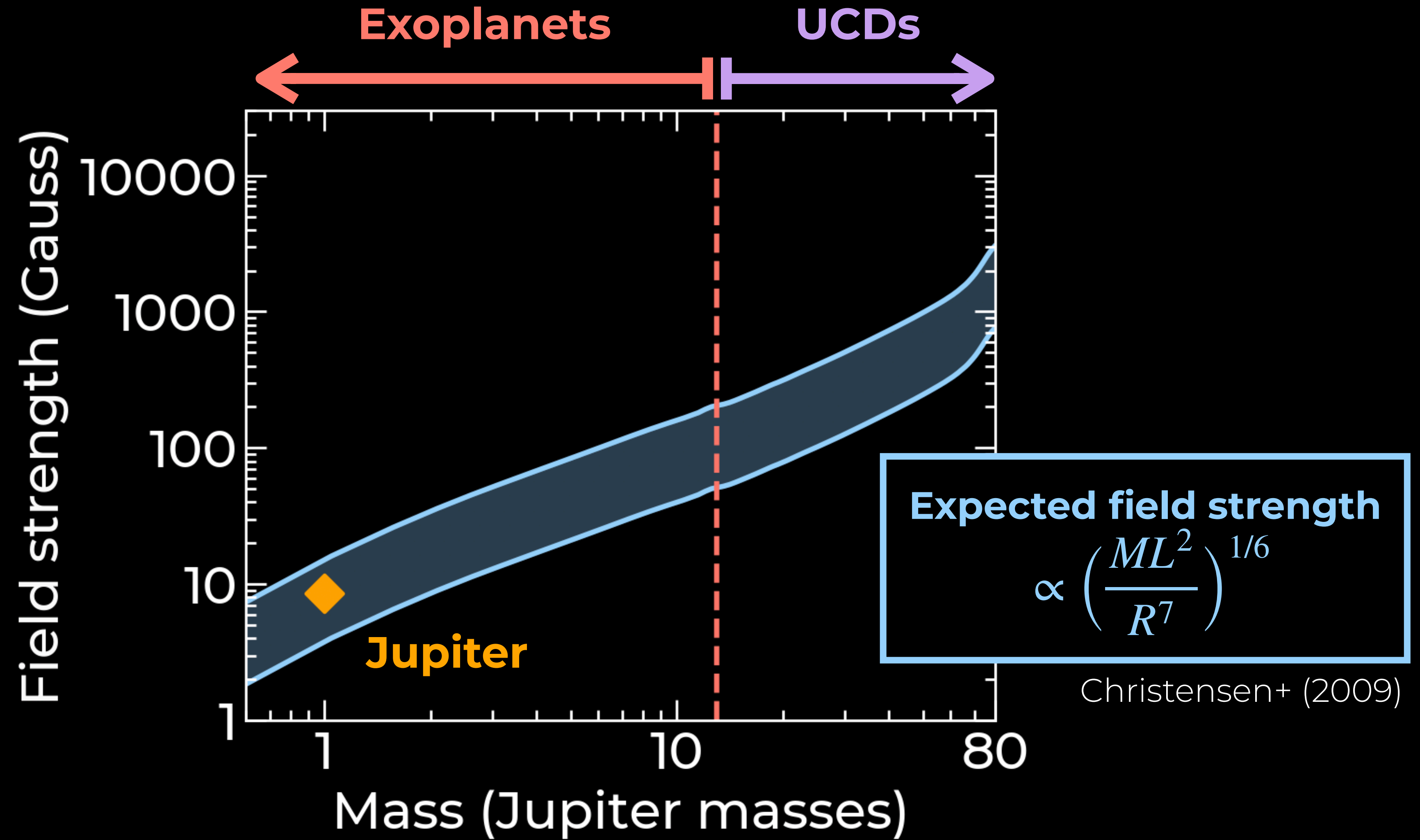
Adapted from Brain+ (2024)



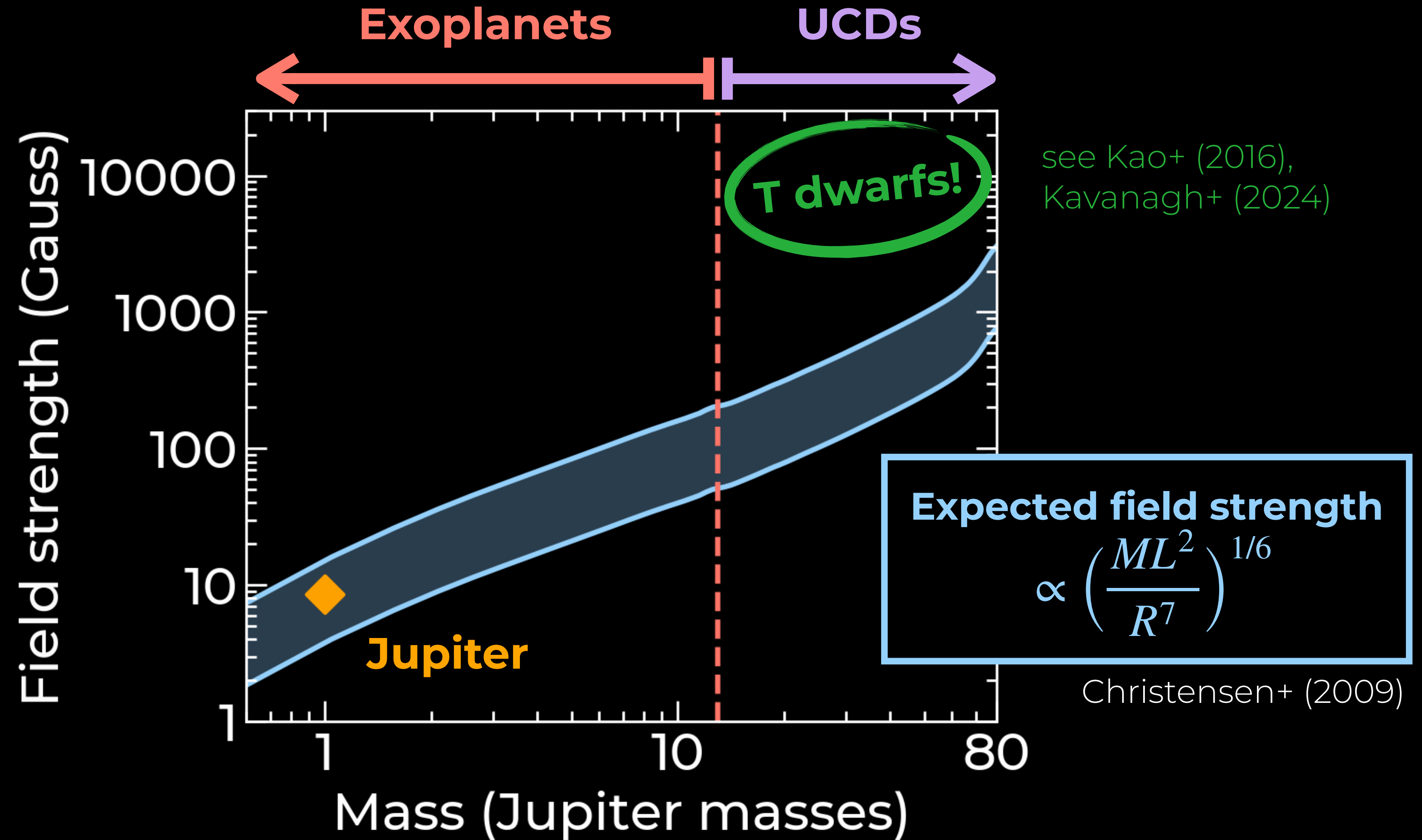
Refining dynamo models



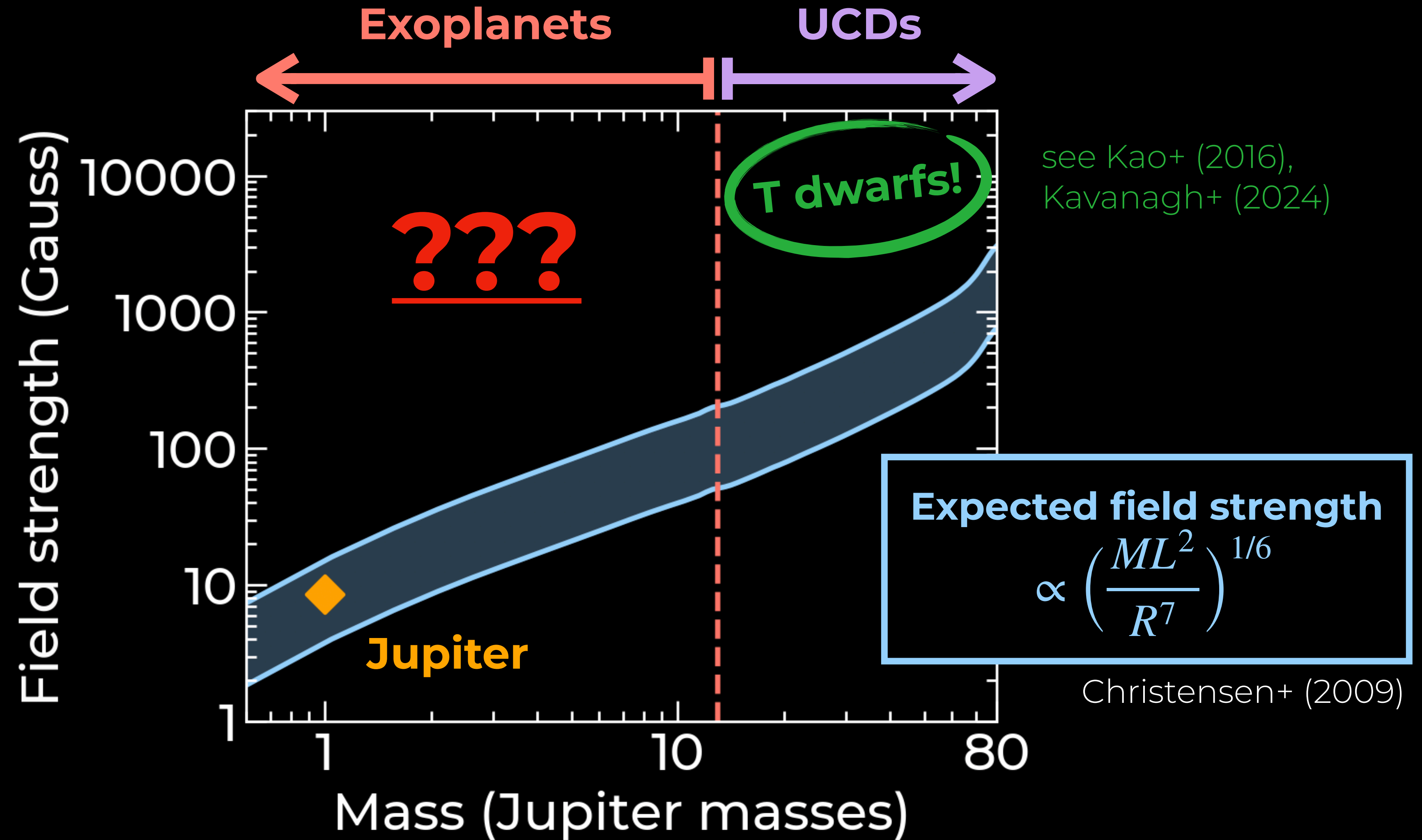
Refining dynamo models



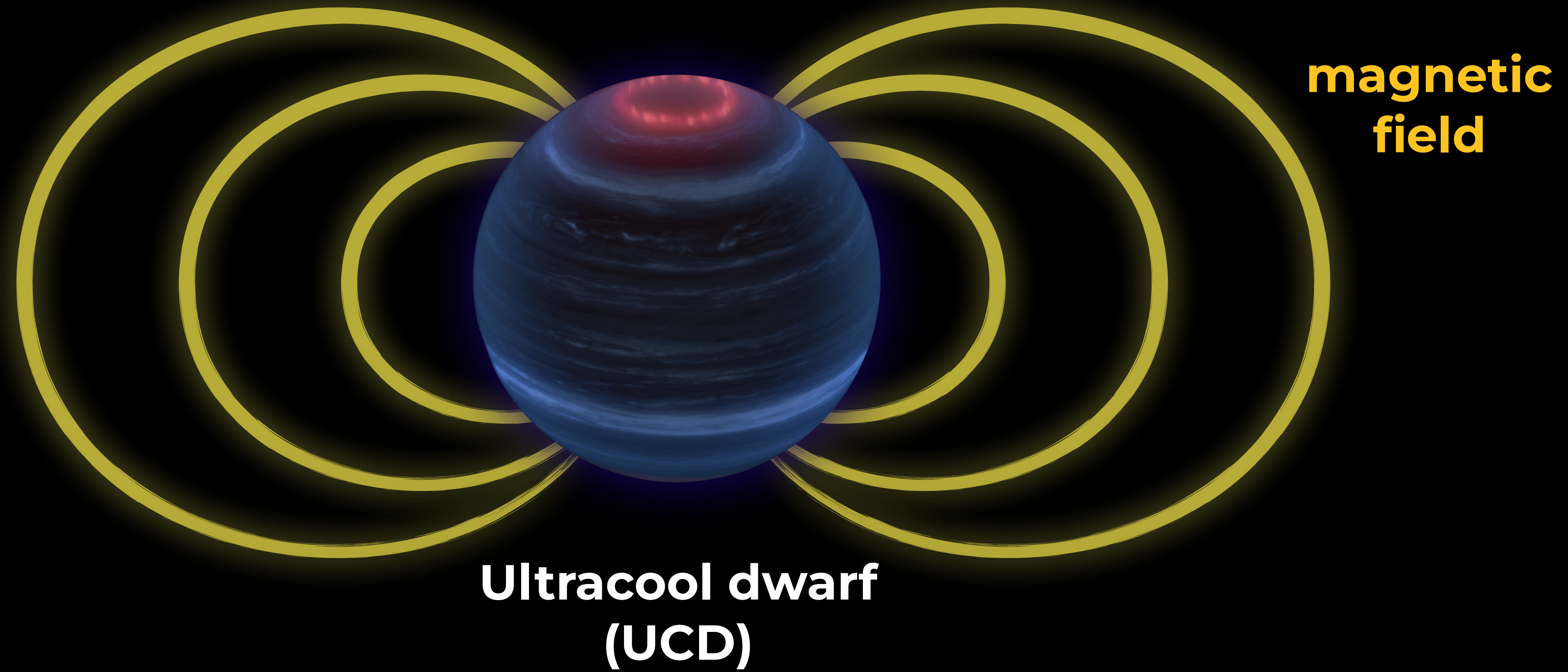
Refining dynamo models



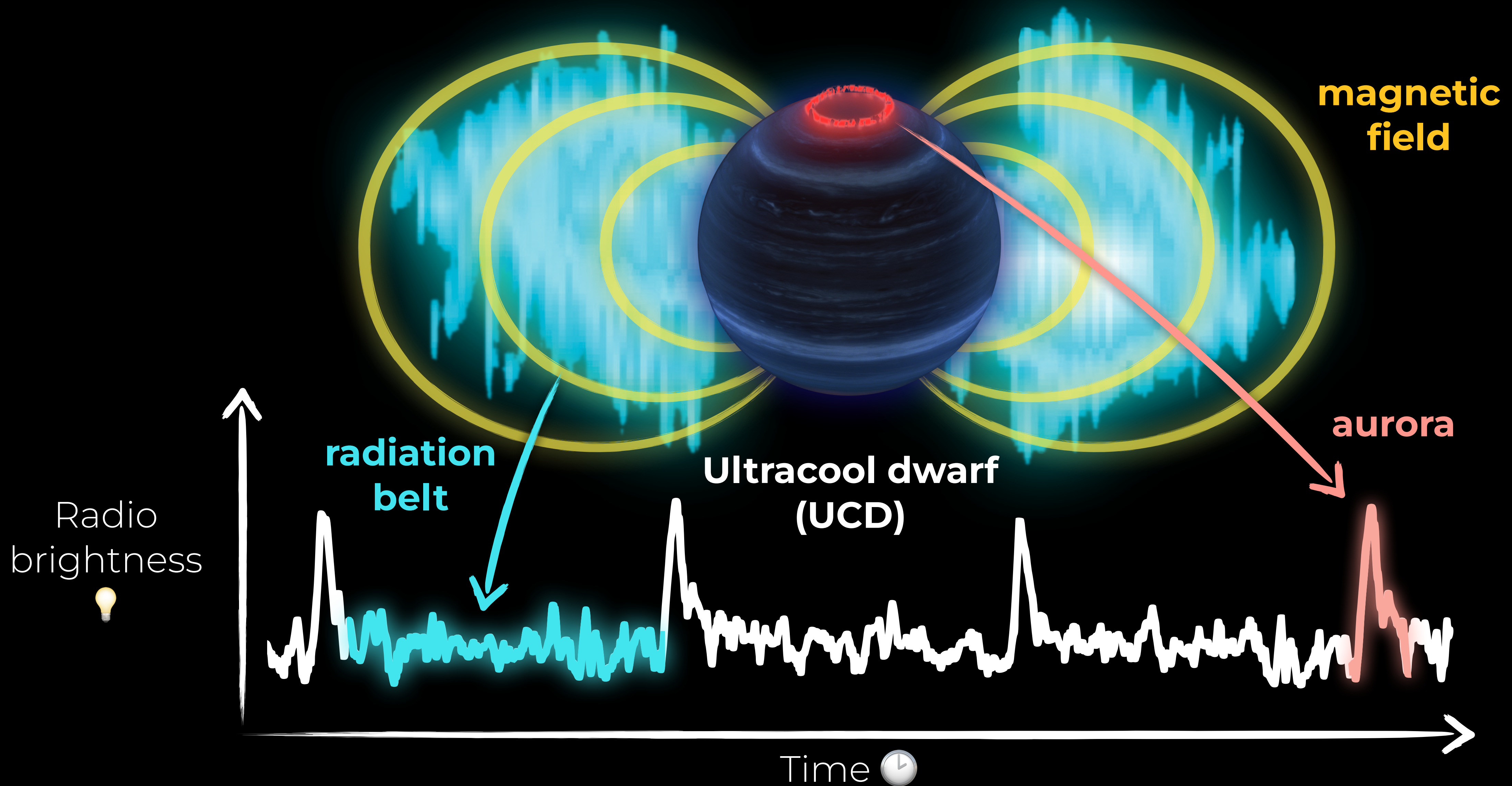
Refining dynamo models



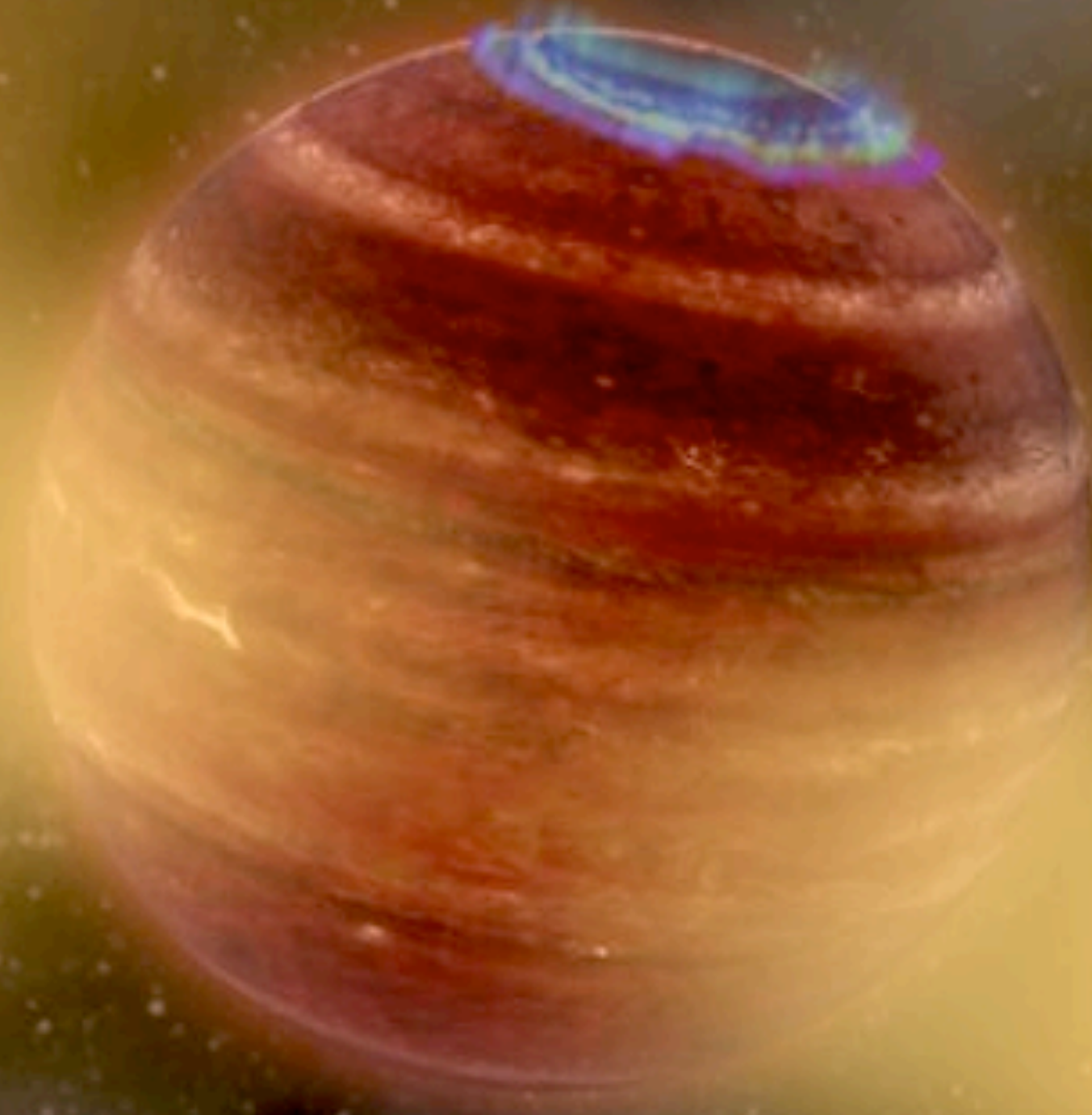
Radio emission from magnetised ultracool dwarfs



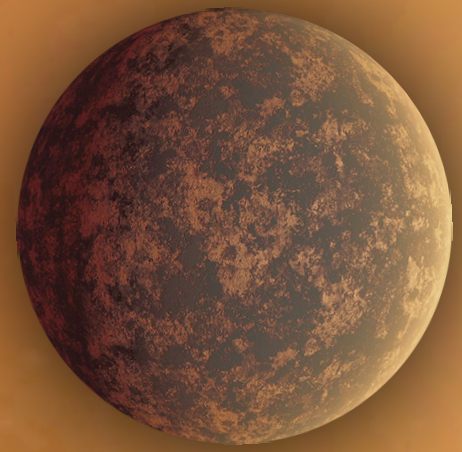
Radio emission from magnetised ultracool dwarfs



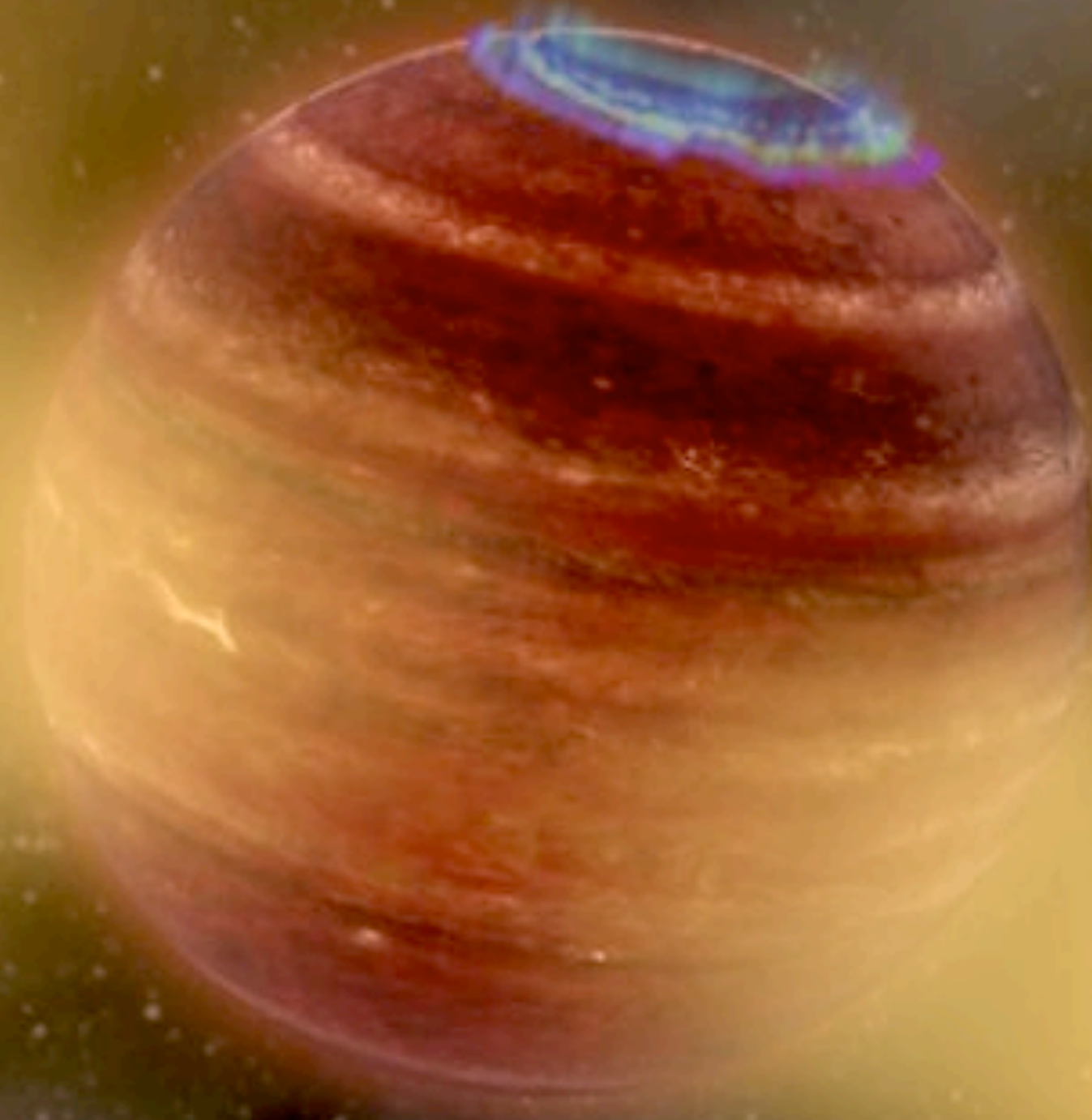
Source of plasma?



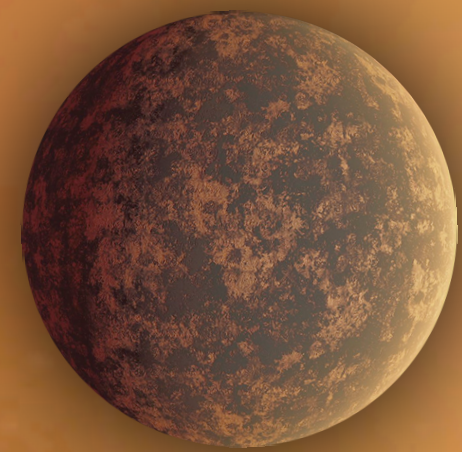
Source of plasma?



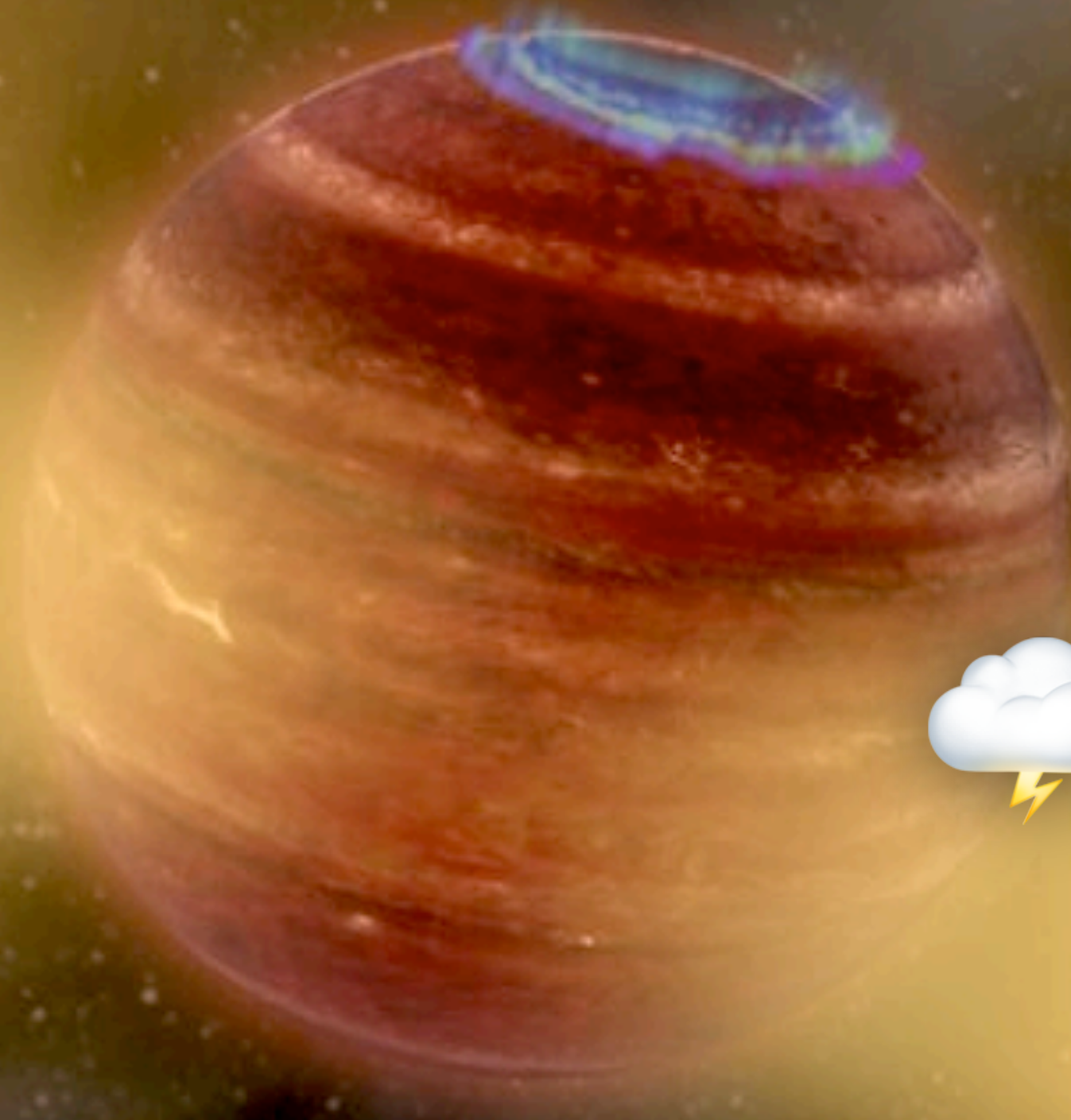
outgassing
planet/moon?



Source of plasma?

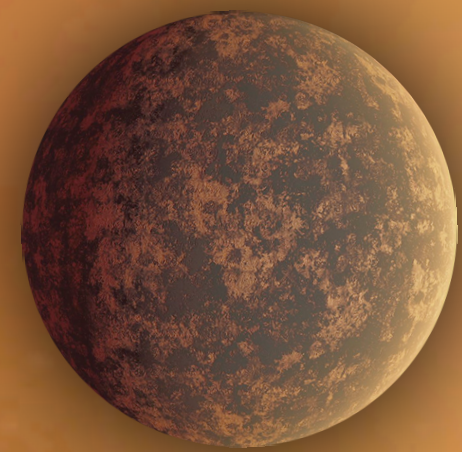


outgassing
planet/moon?



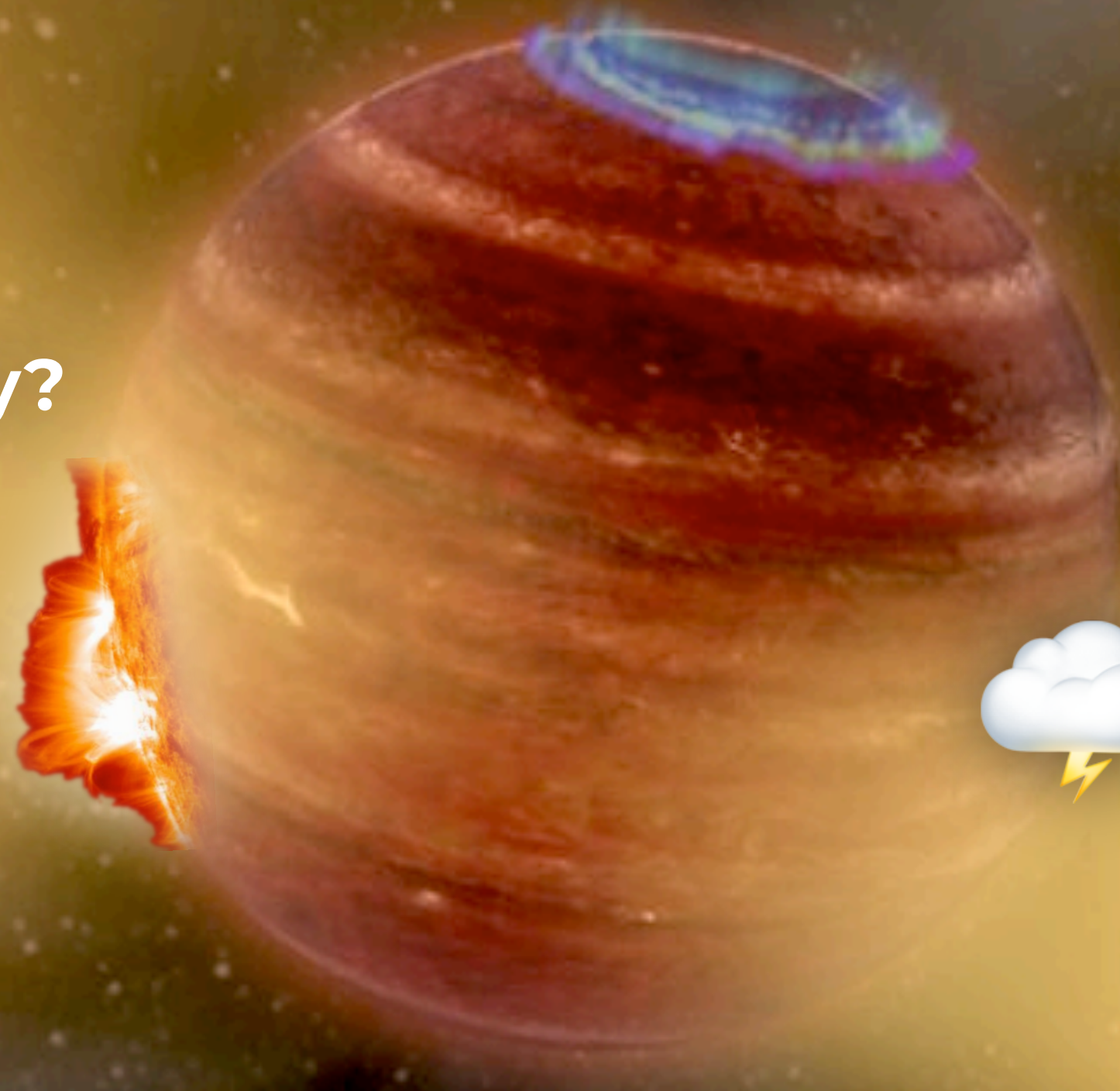
lightning?

Source of plasma?



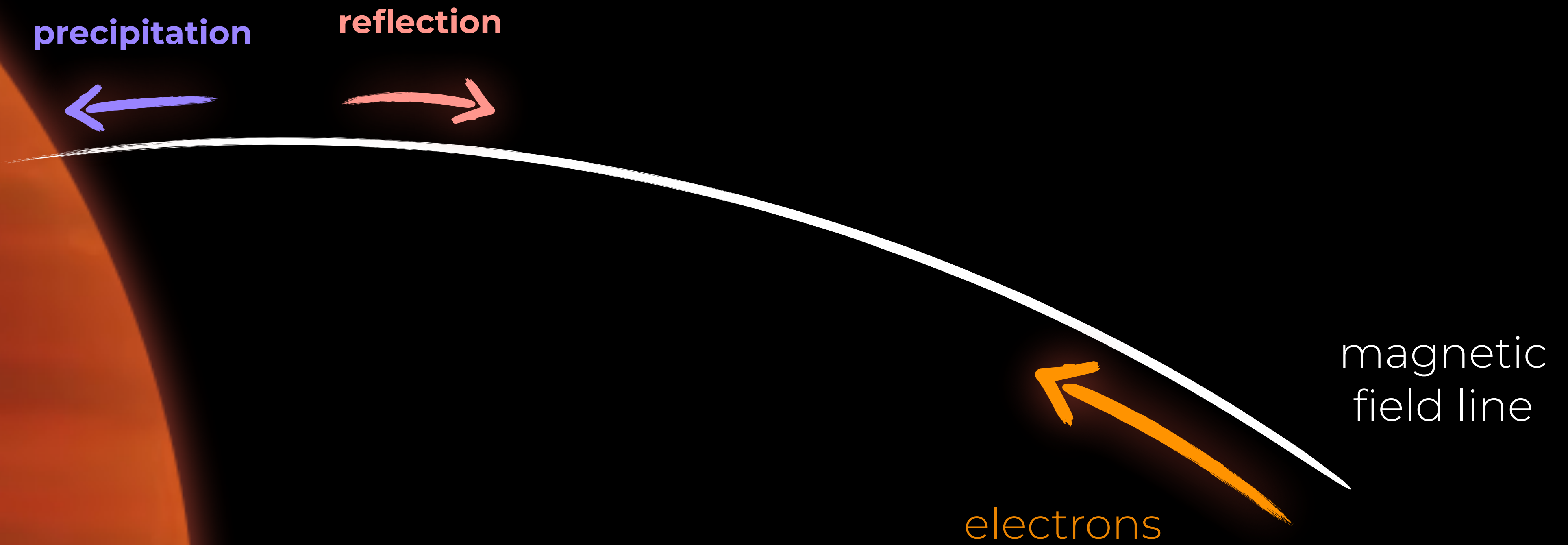
outgassing
planet/moon?

activity?

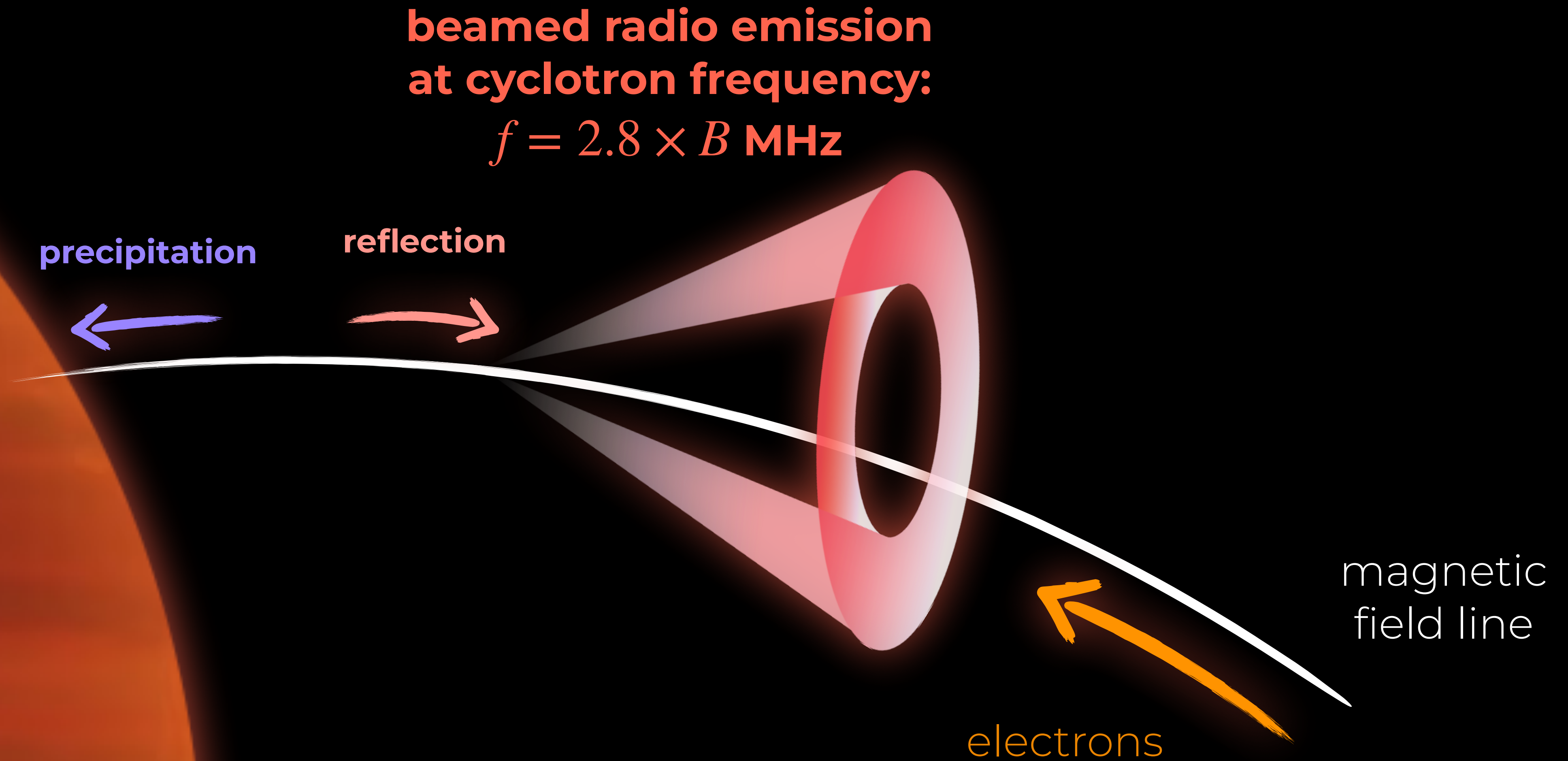


lightning?

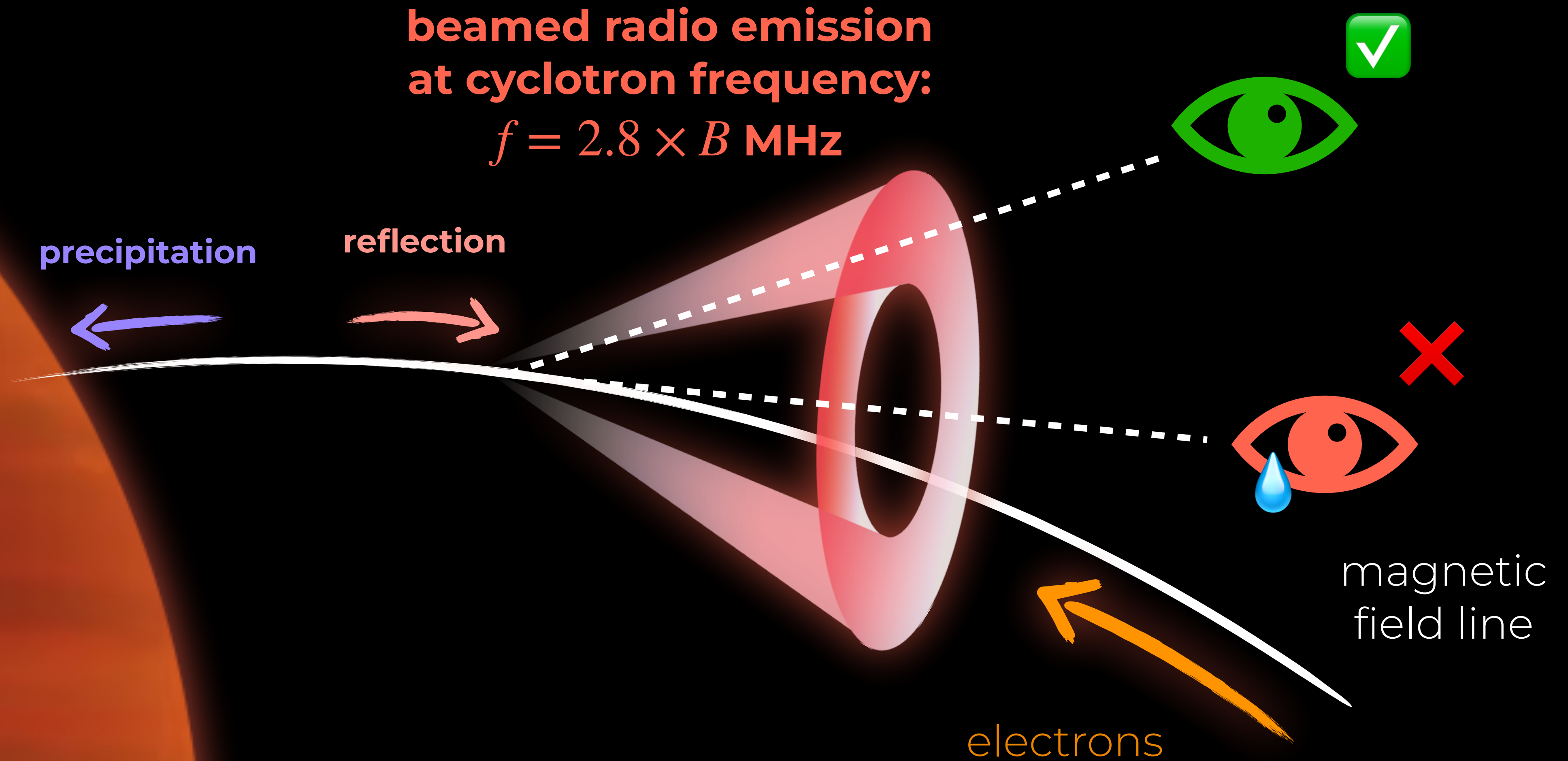
Magnetic characterisation from auroral emission



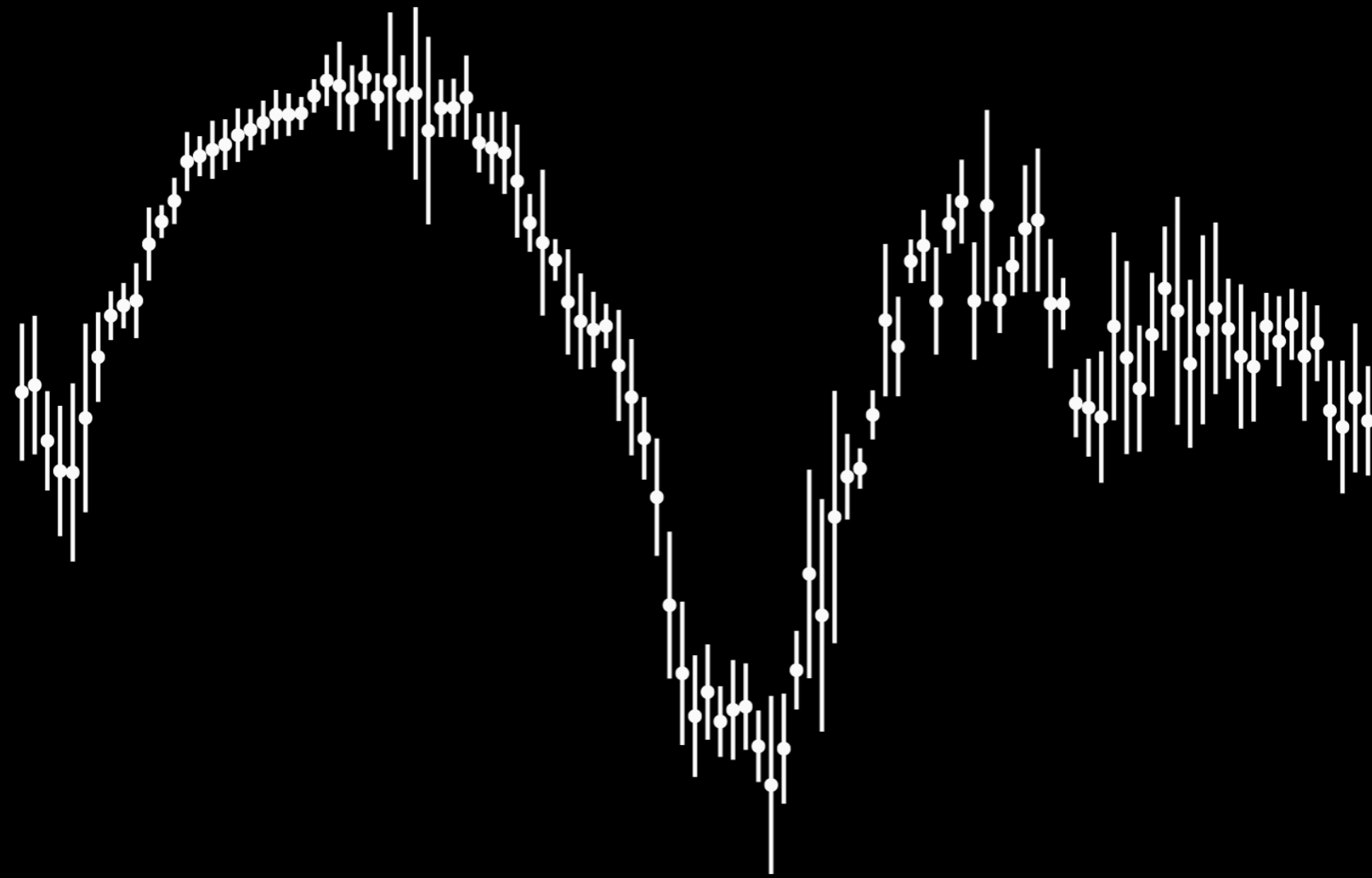
Magnetic characterisation from auroral emission



Magnetic characterisation from auroral emission

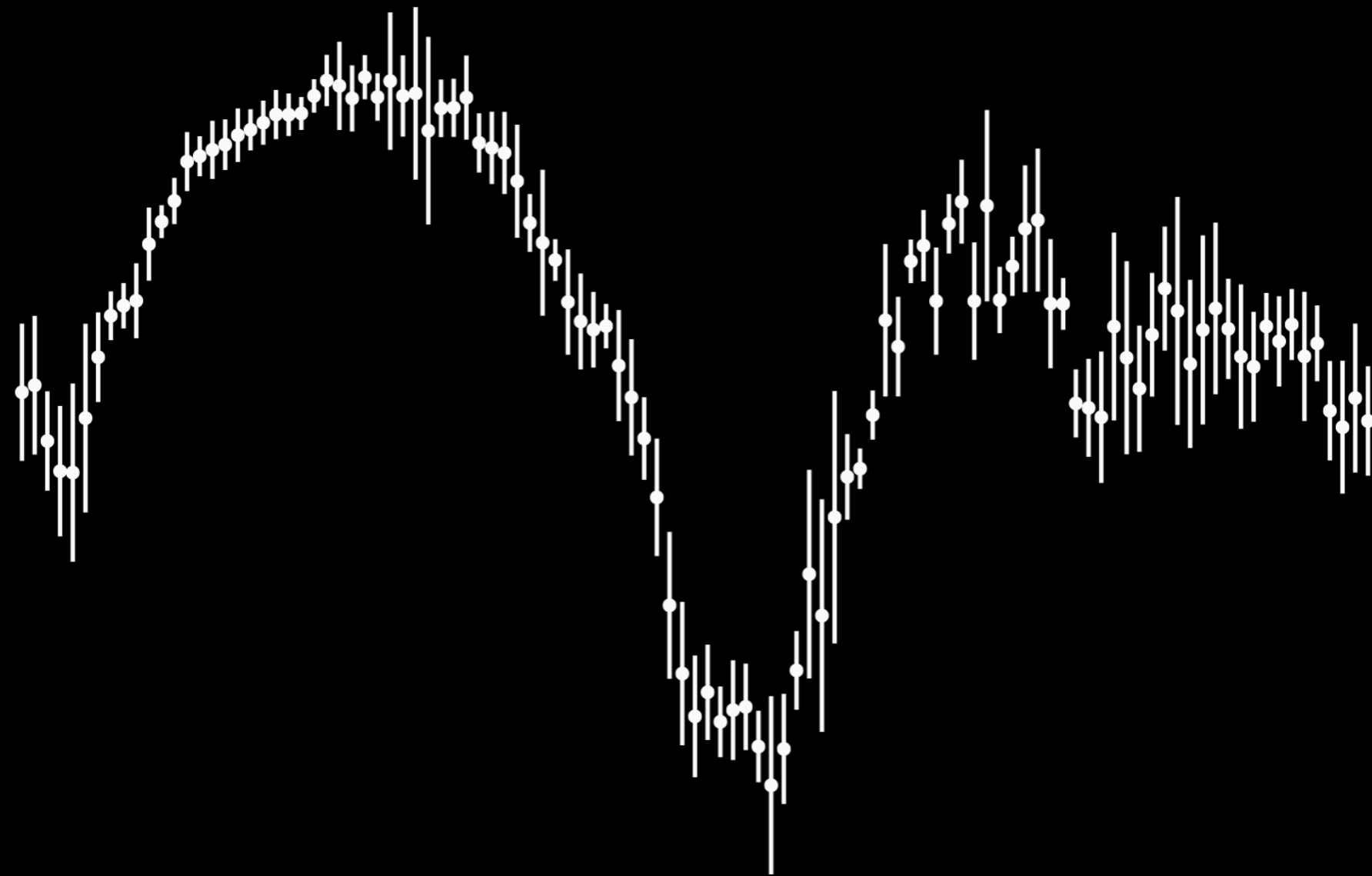


The magnetic field of the coldest radio-detected BD

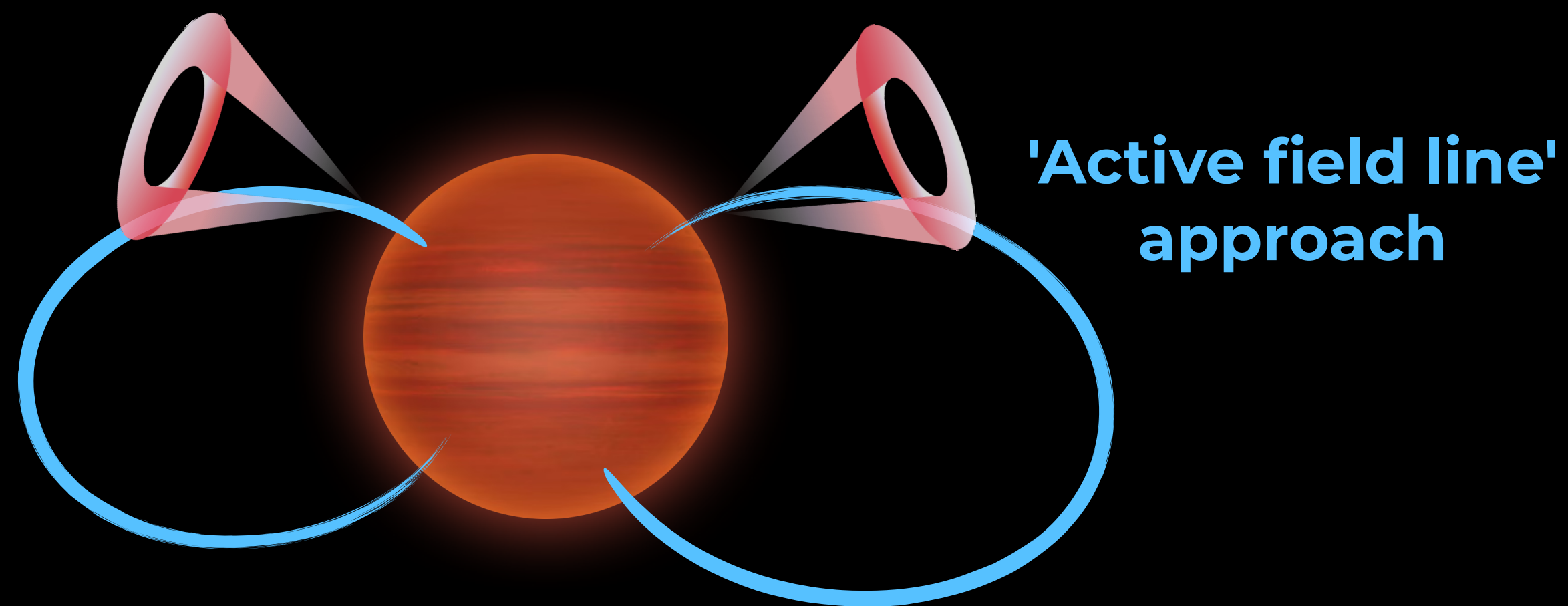


T8 dwarf WISE J062309.94-045624.6

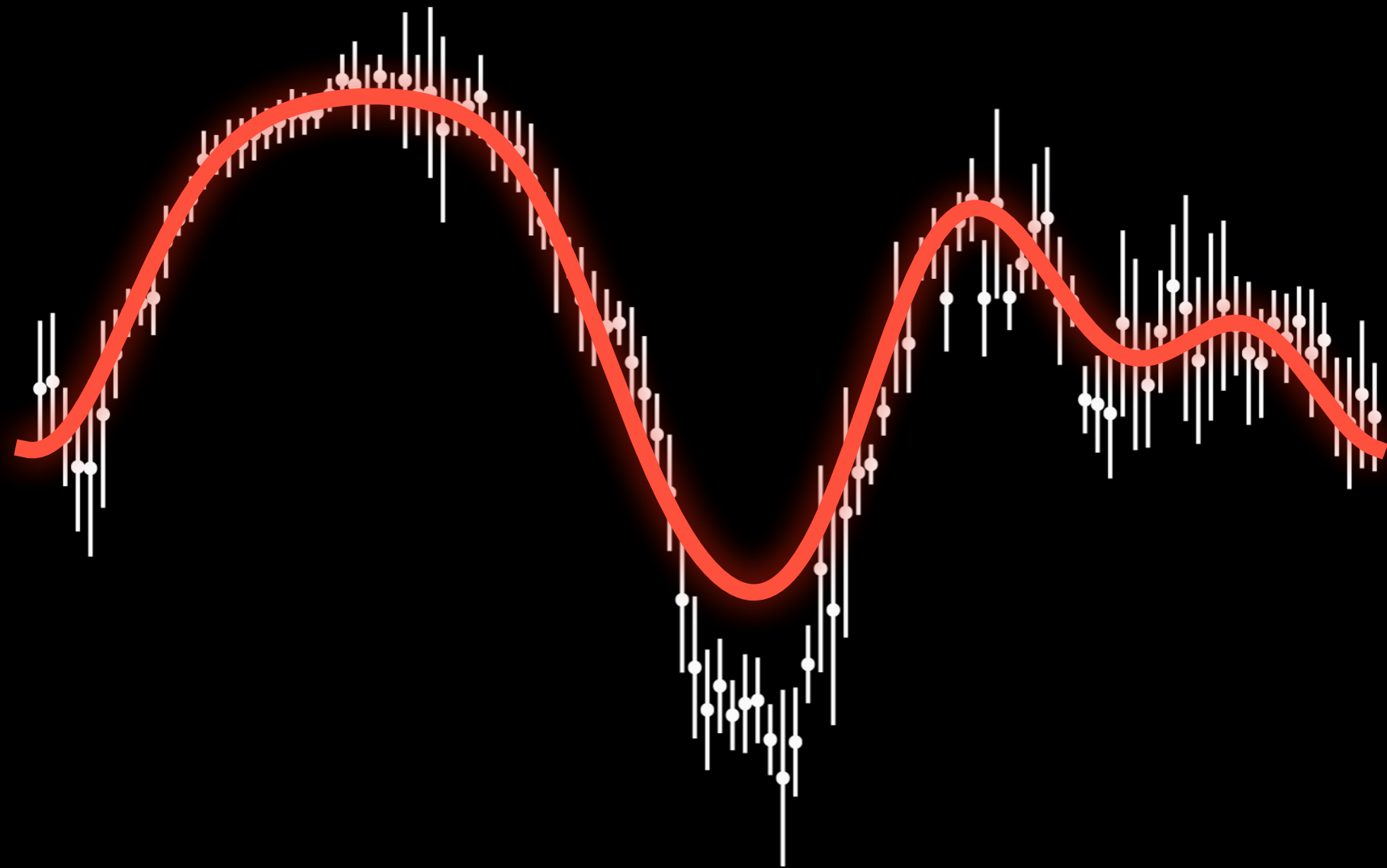
The magnetic field of the coldest radio-detected BD



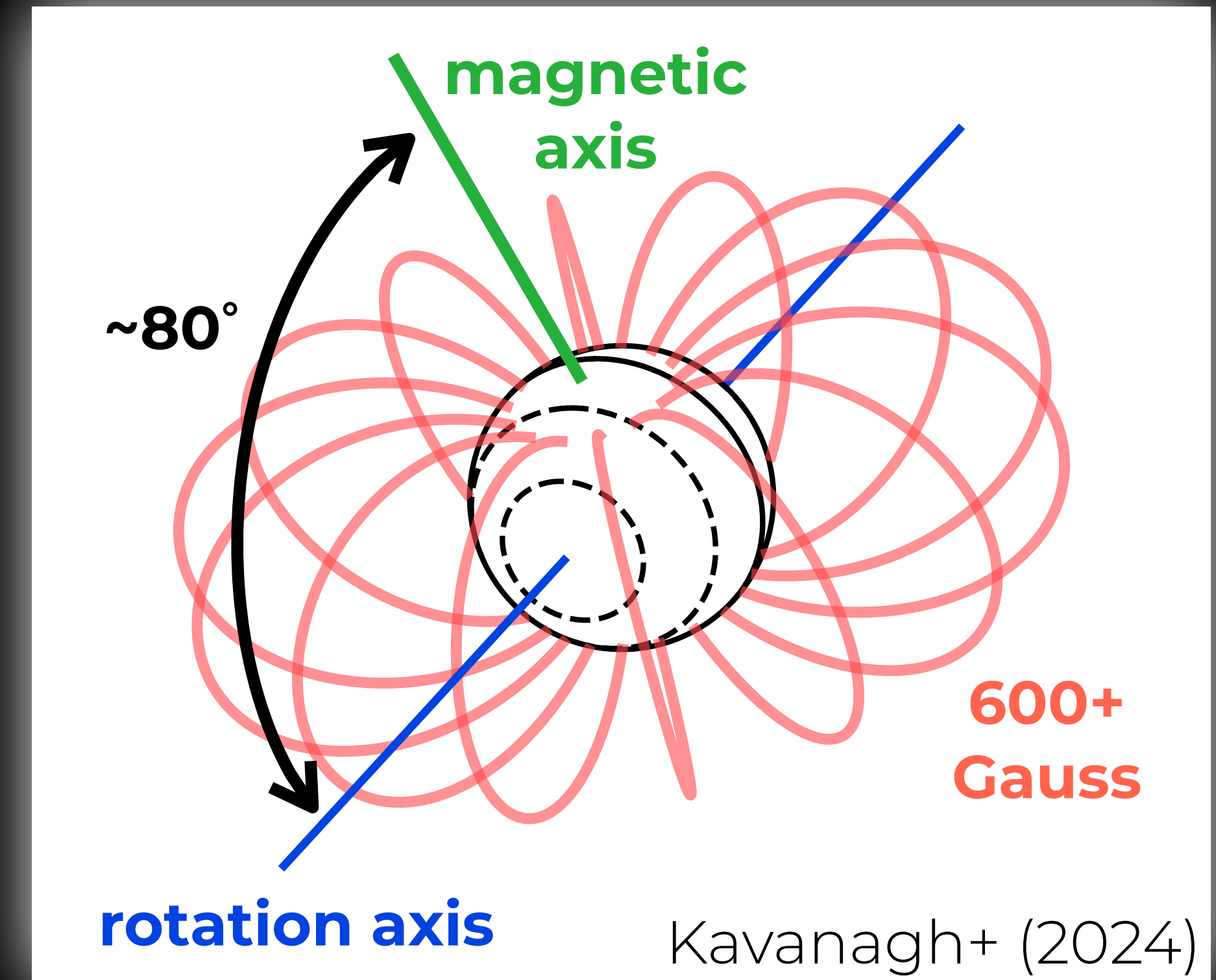
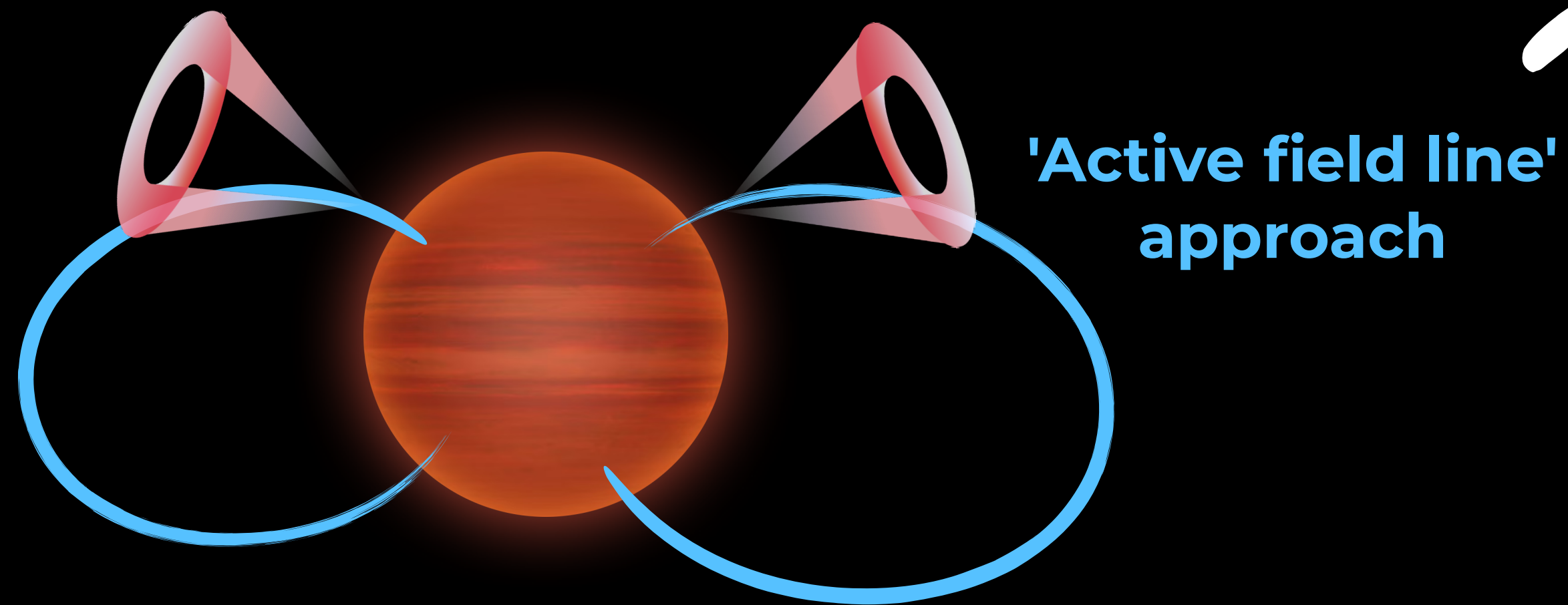
T8 dwarf WISE J062309.94-045624.6



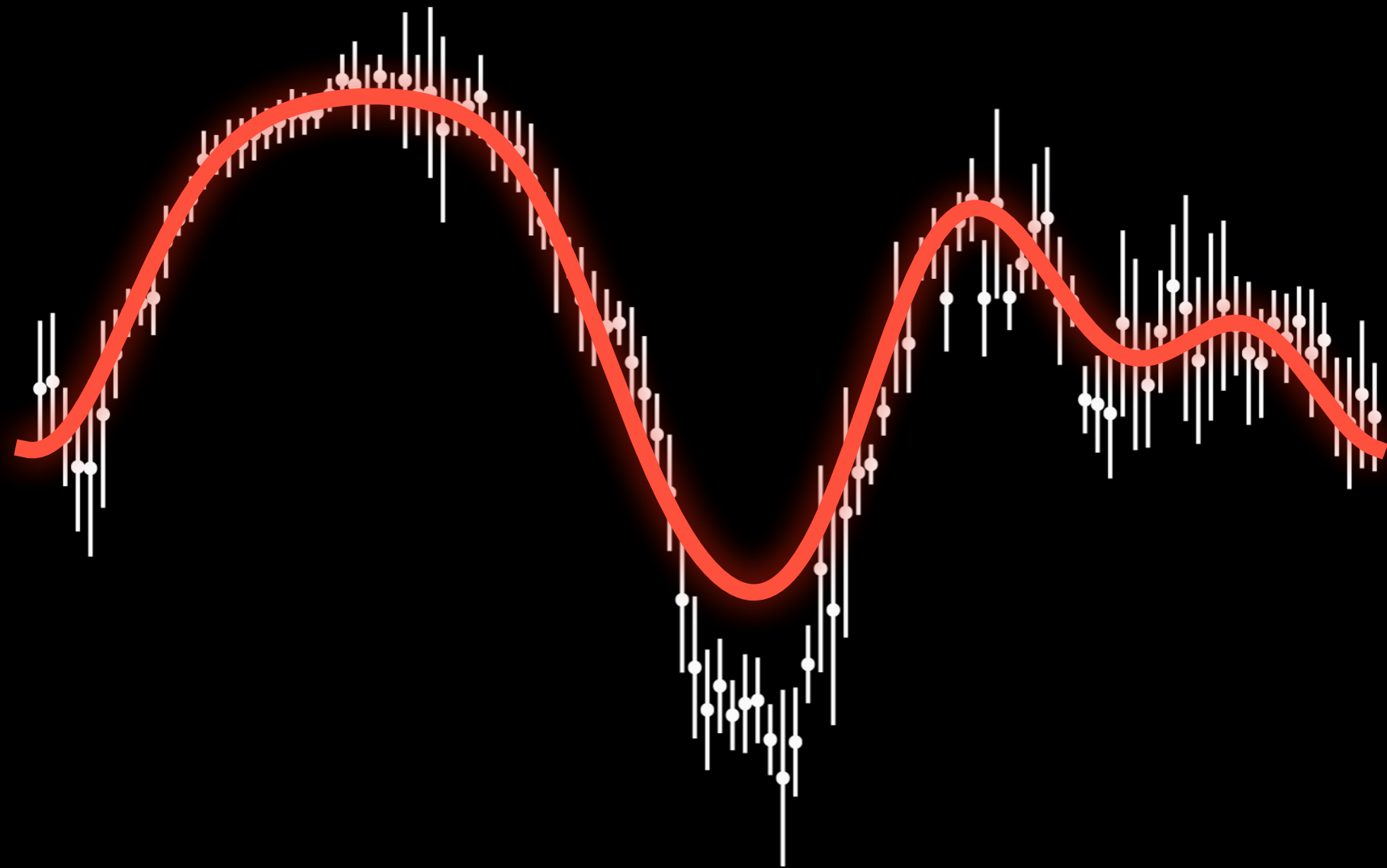
The magnetic field of the coldest radio-detected BD



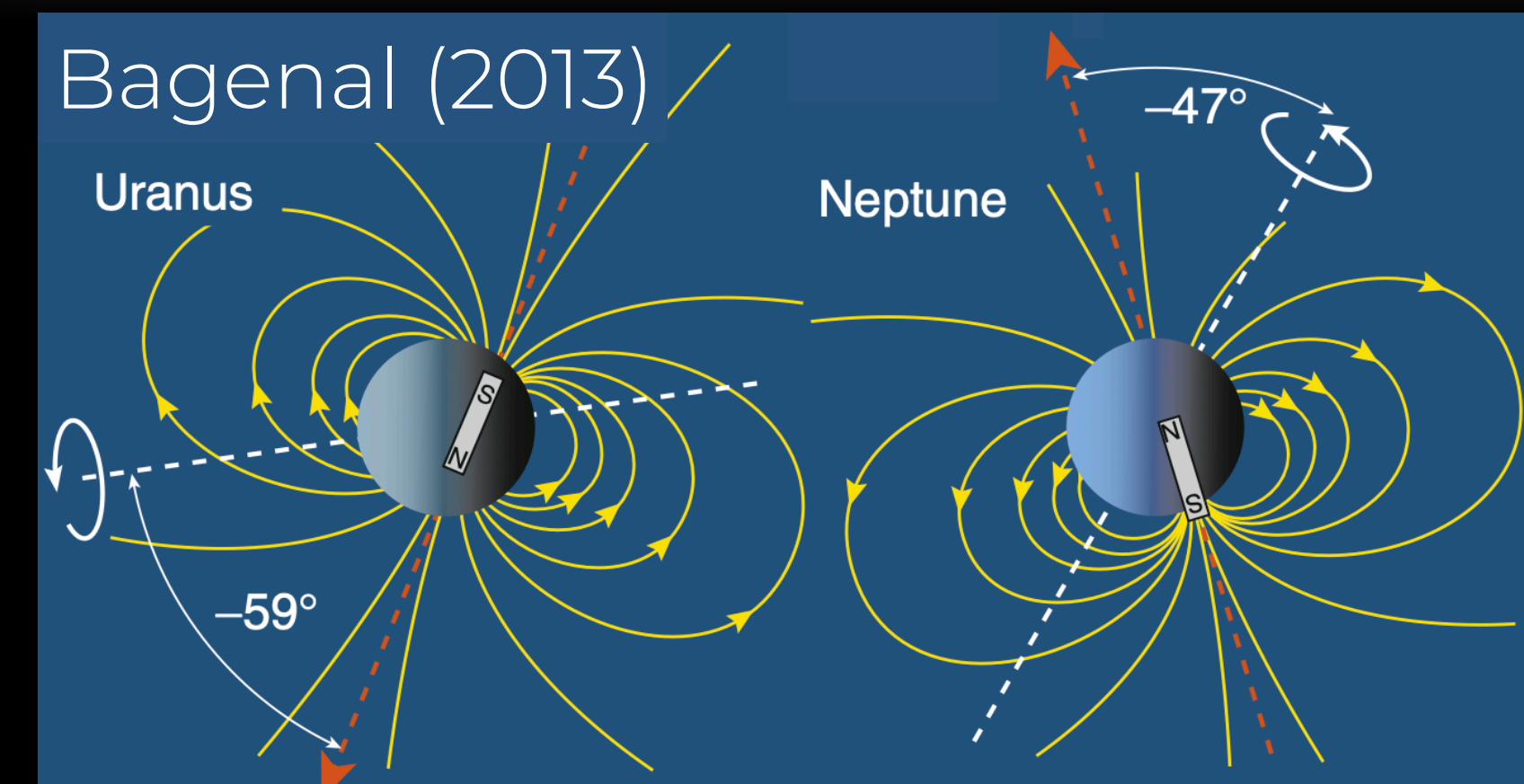
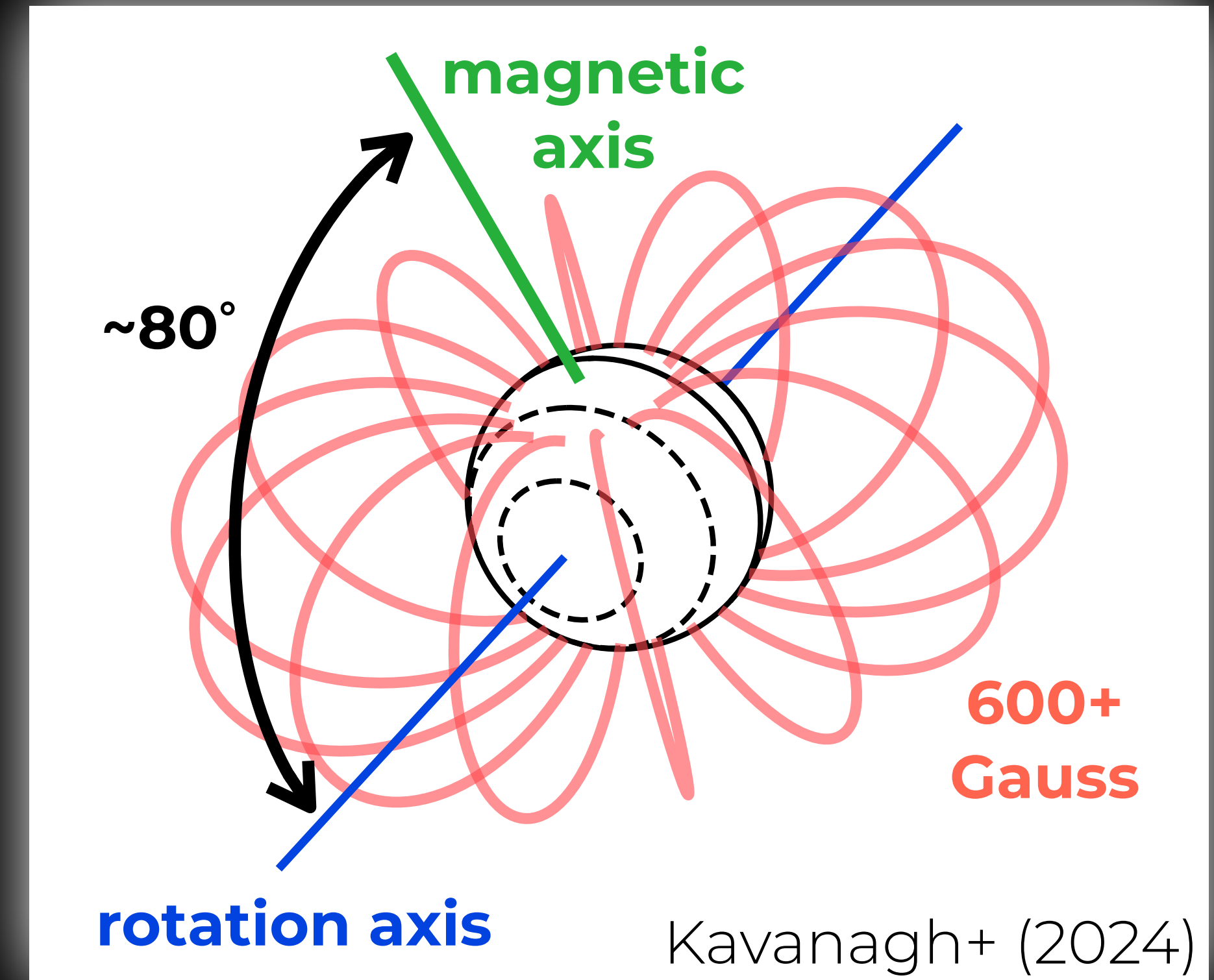
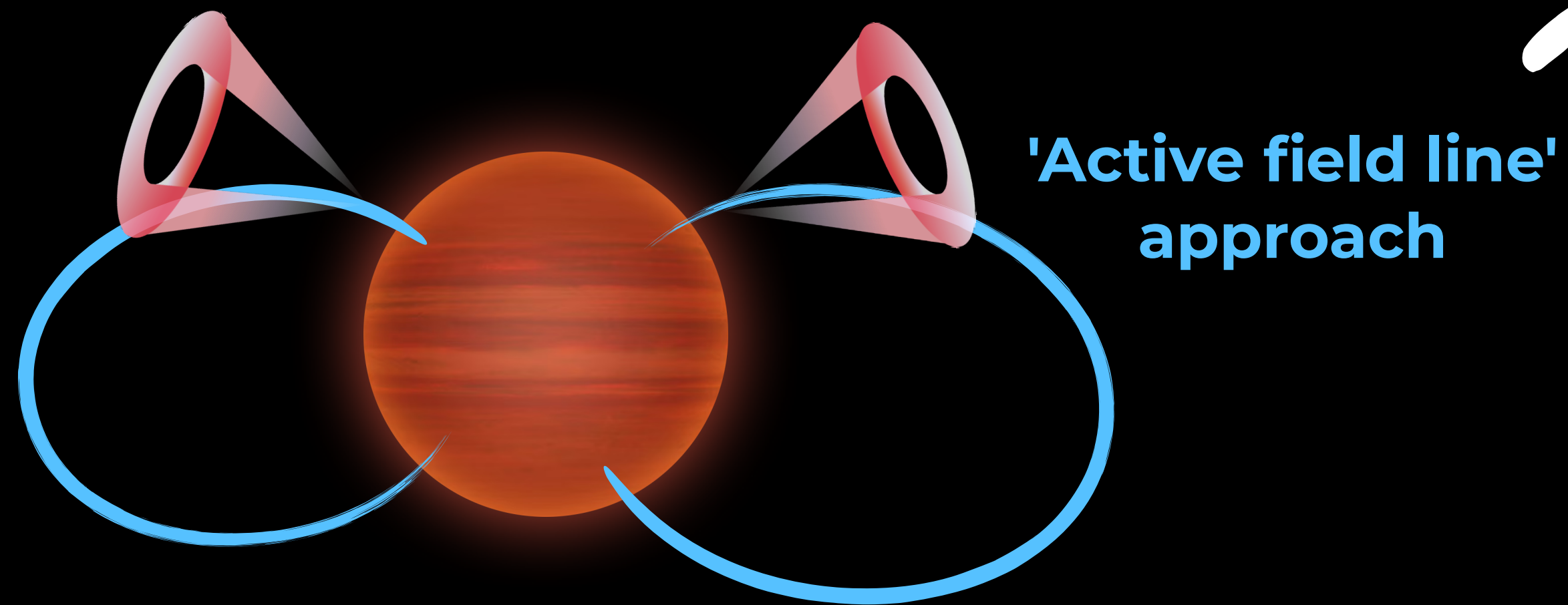
T8 dwarf WISE J062309.94-045624.6



The magnetic field of the coldest radio-detected BD

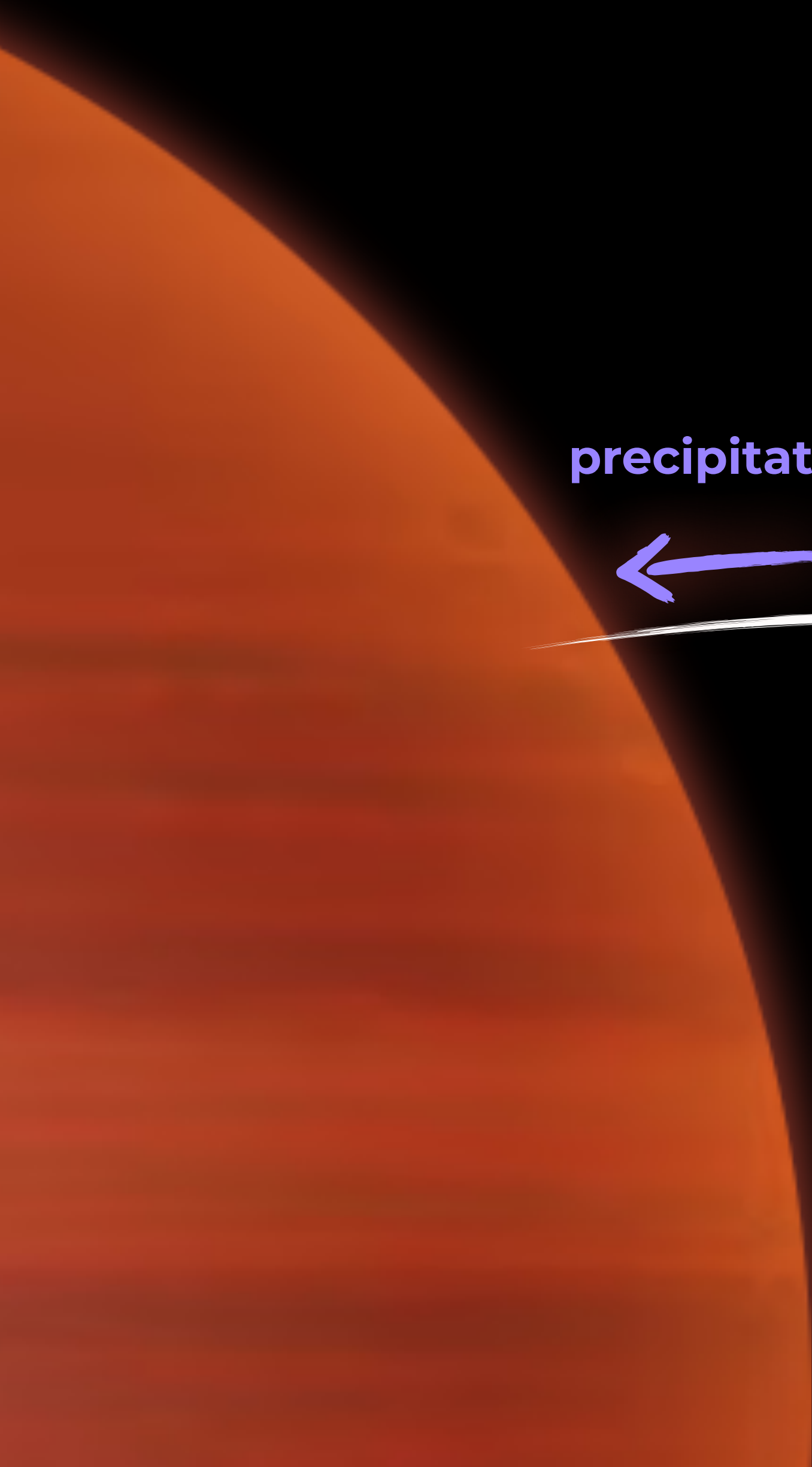
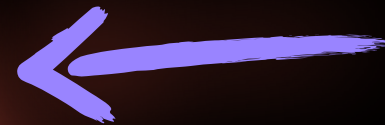


T8 dwarf WISE J062309.94-045624.6

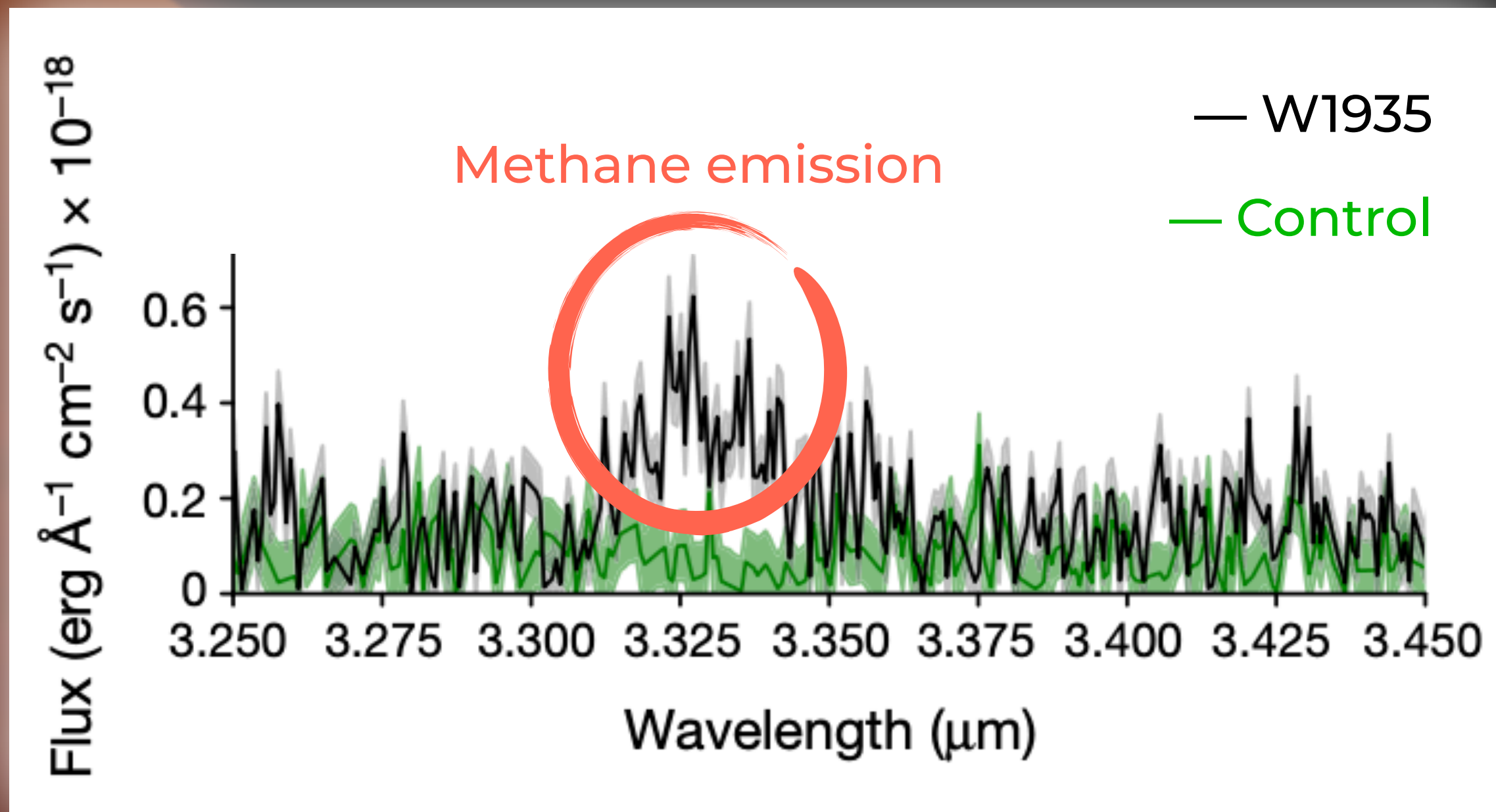


Auroral hints on the Y dwarf W1935 from JWST

precipitation

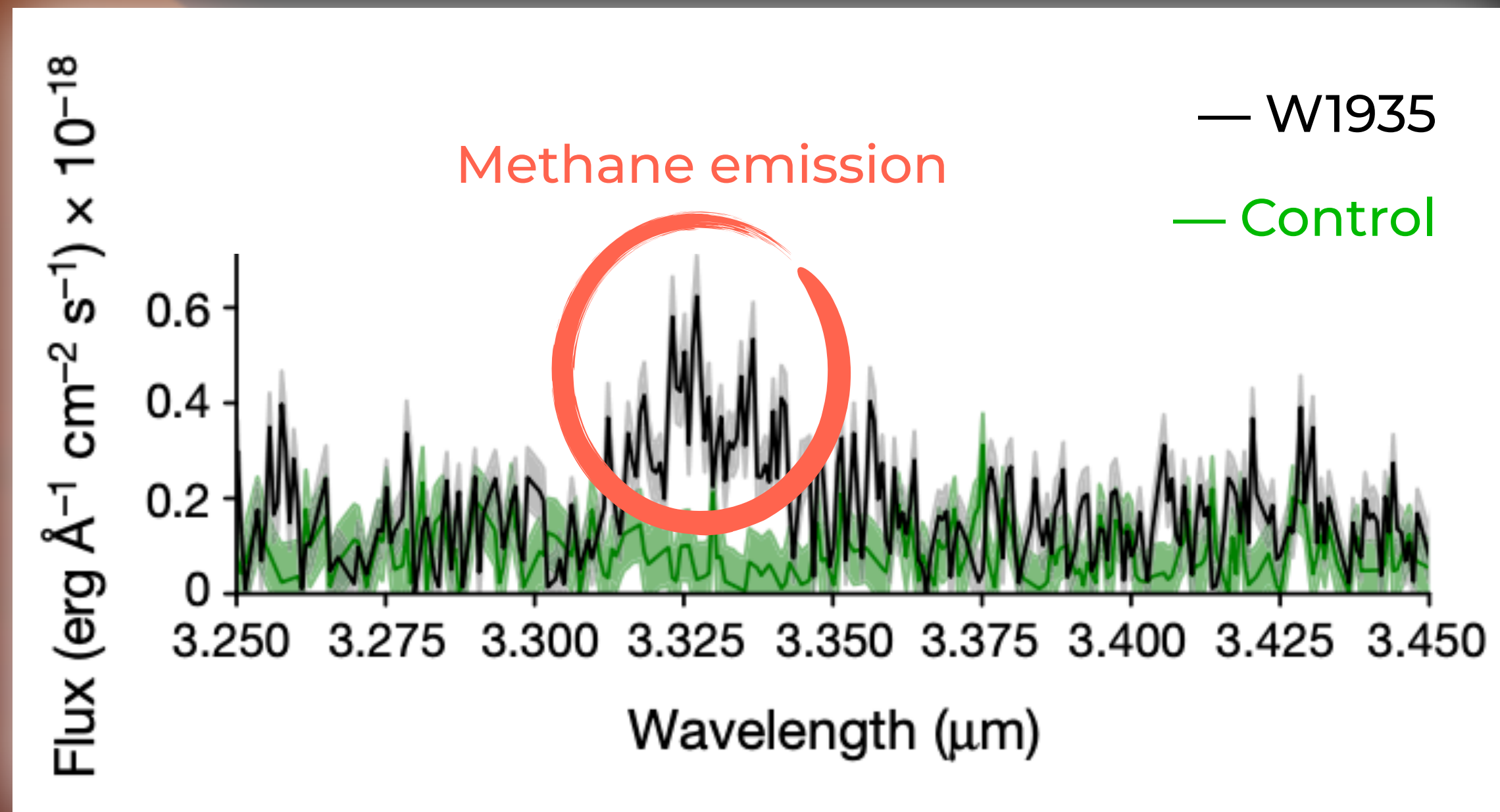


Auroral hints on the Y dwarf W1935 from JWST

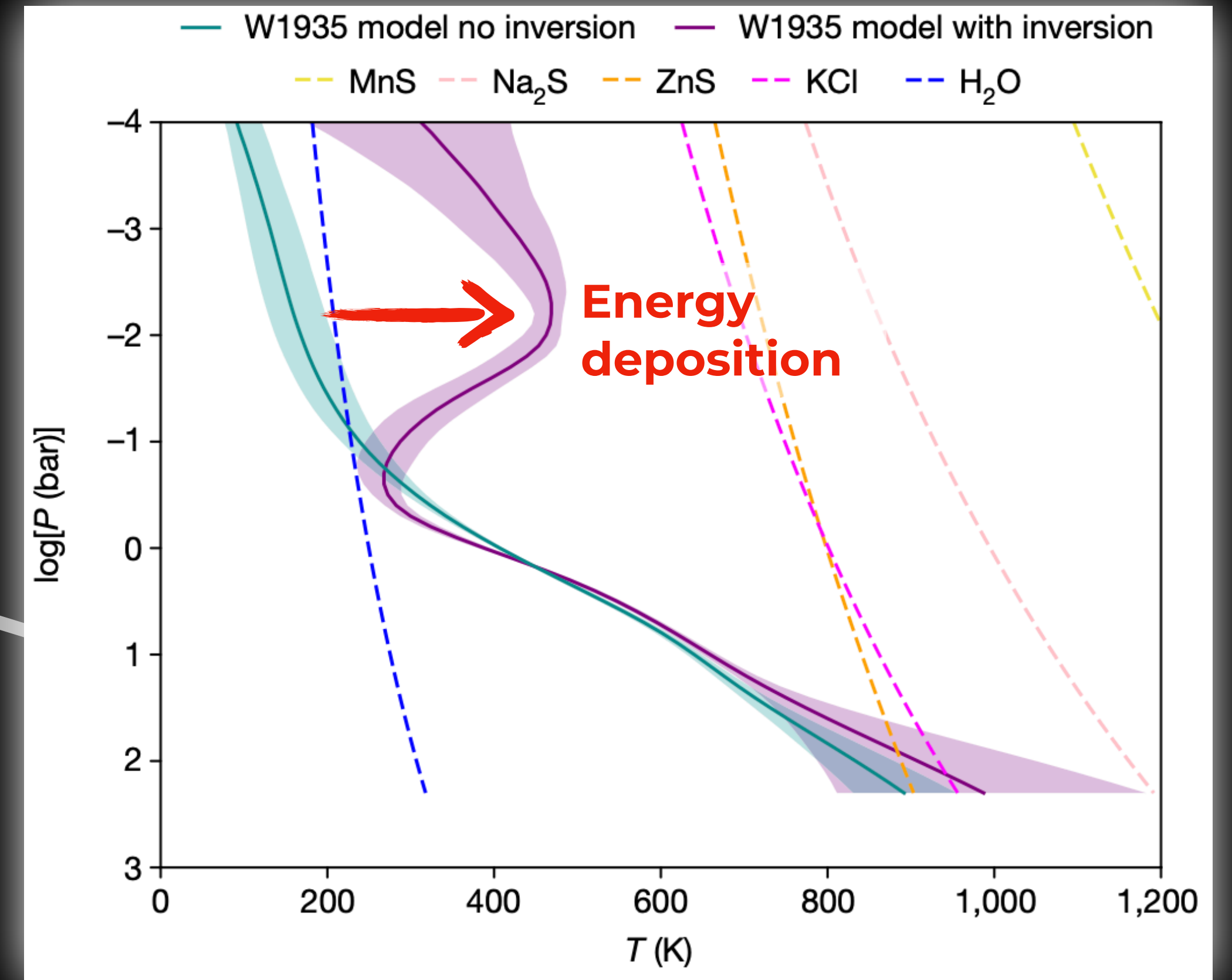


Faherty+ (2024)

Auroral hints on the Y dwarf W1935 from JWST



Faherty+ (2024)



Direct discovery of a BD at low frequencies

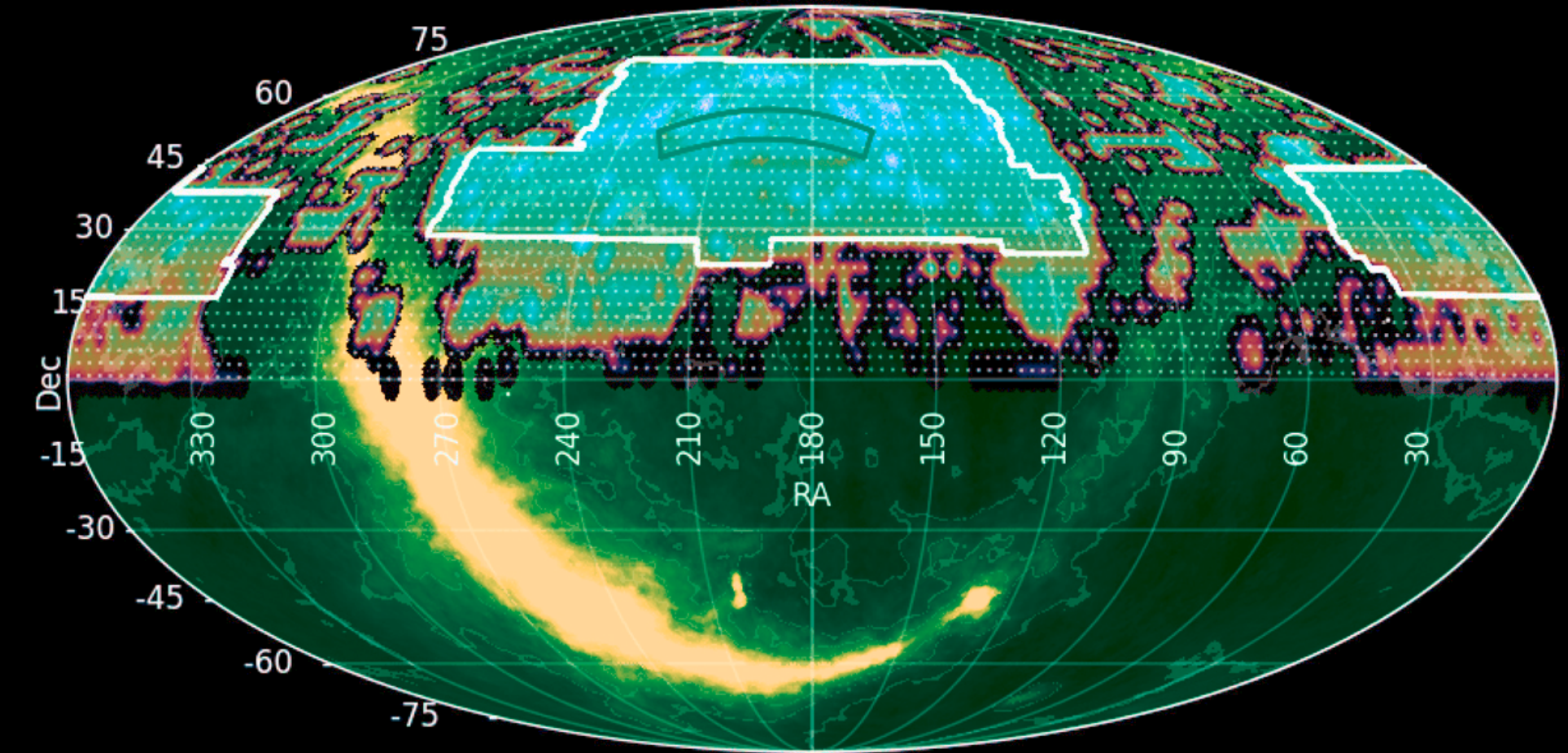


The LOFAR 'Superterp'

Direct discovery of a BD at low frequencies



The LOFAR 'Superterp'

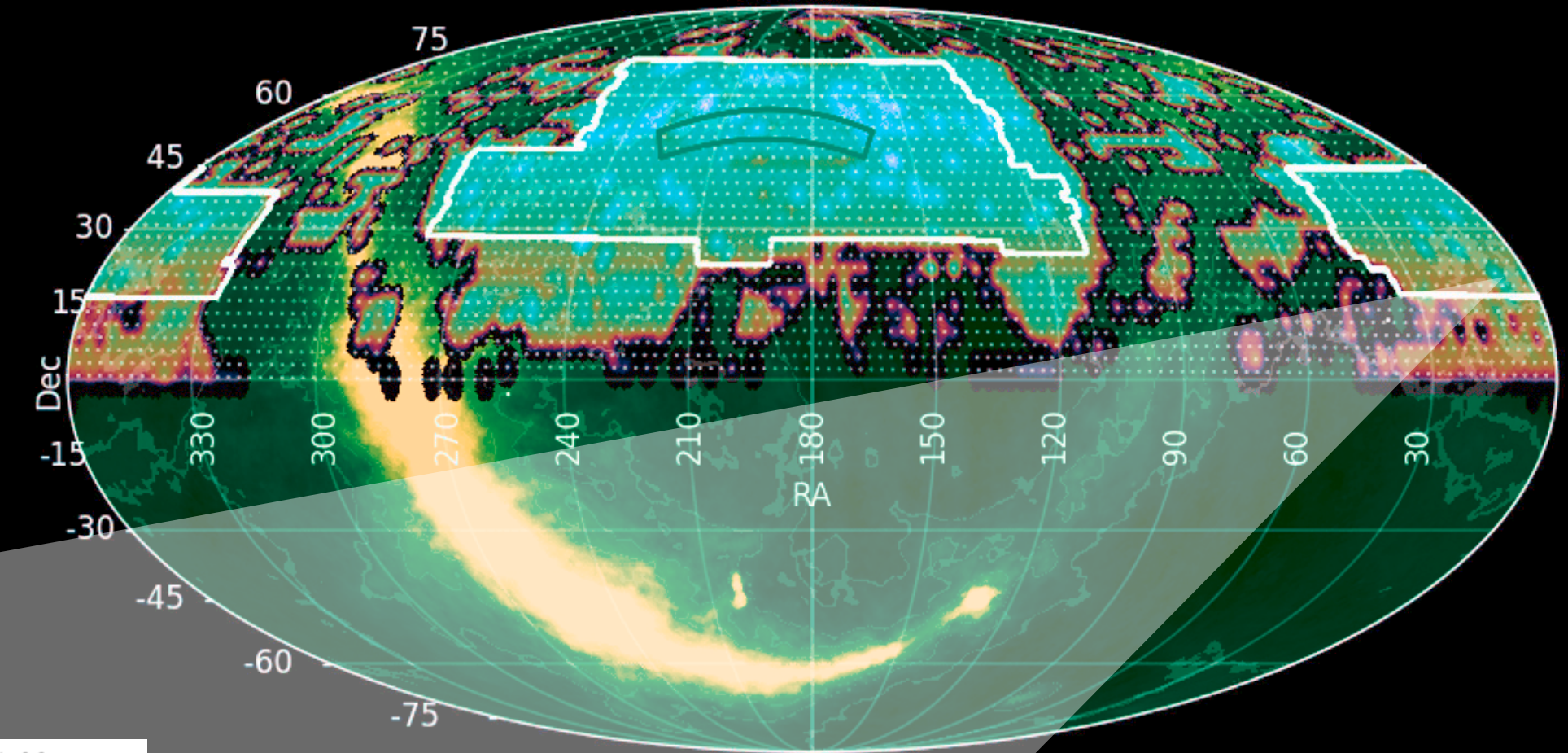


LOFAR Two-metre Sky Survey
(LoTSS, Shimwell+ 2022)

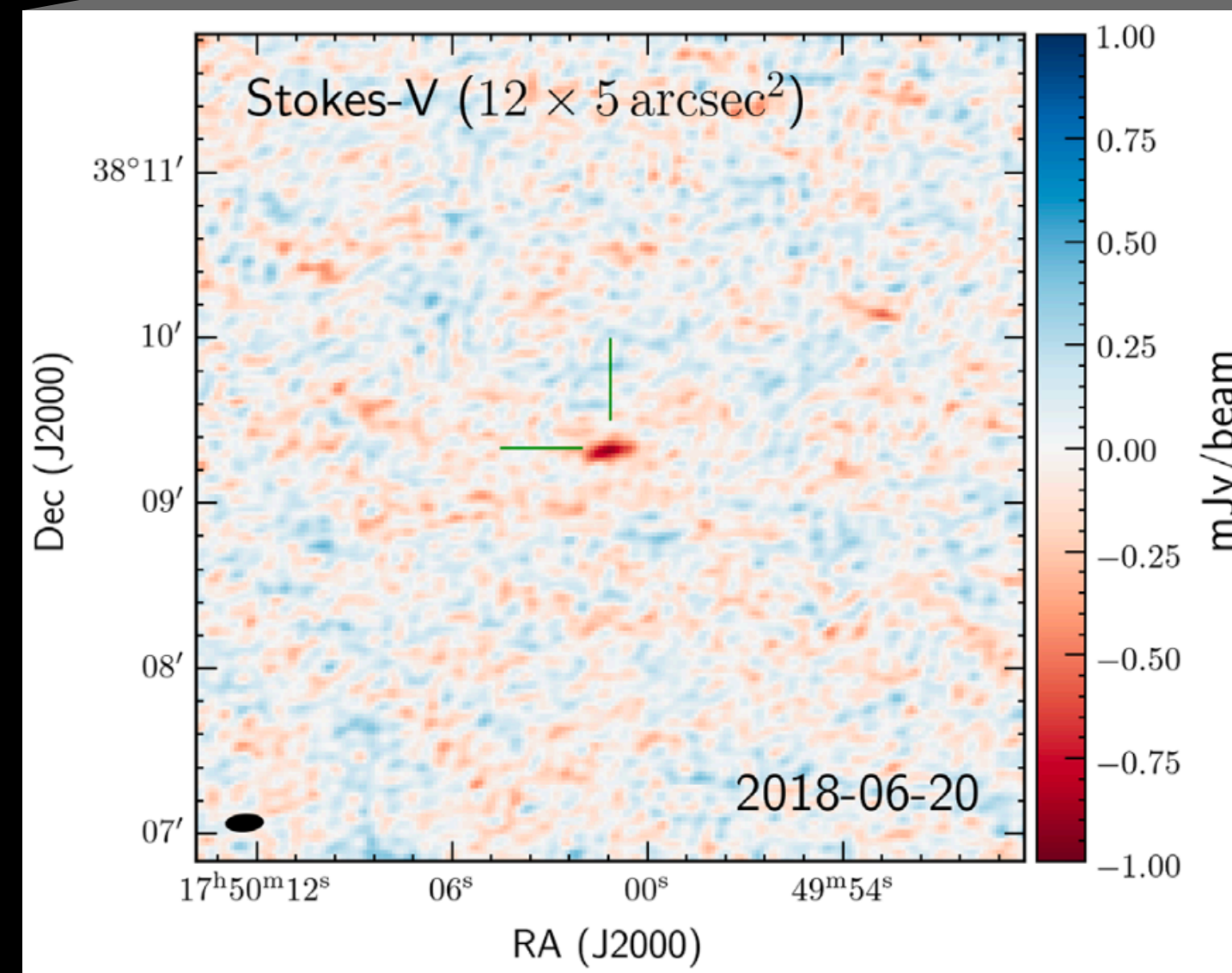
Direct discovery of a BD at low frequencies



The LOFAR 'Superterp'



LOFAR Two-metre Sky Survey
(LoTSS, Shimwell+ 2022)



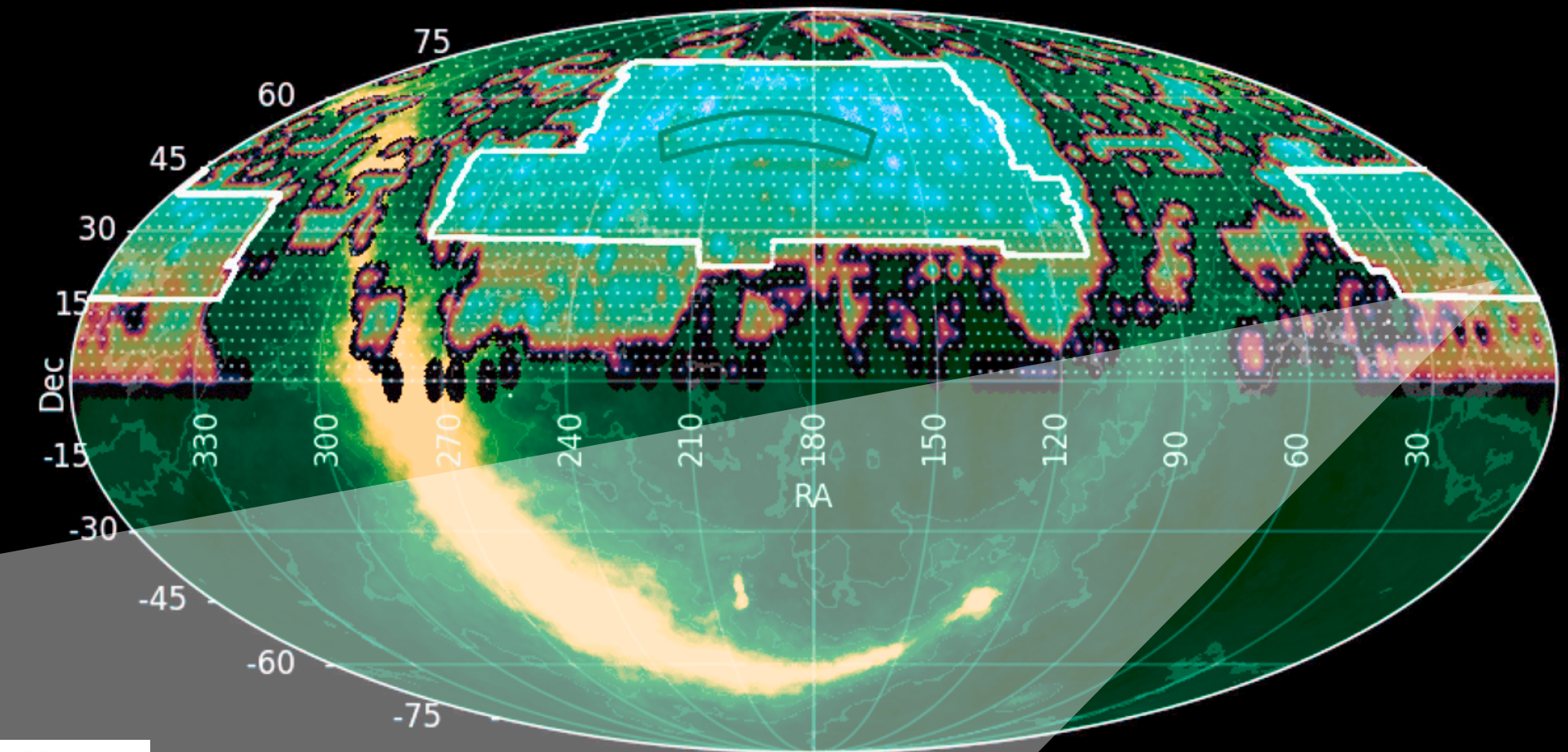
A previously unknown T6 dwarf at 65 pc! (Vedantham+ 2020)

Direct discovery of a BD at low frequencies

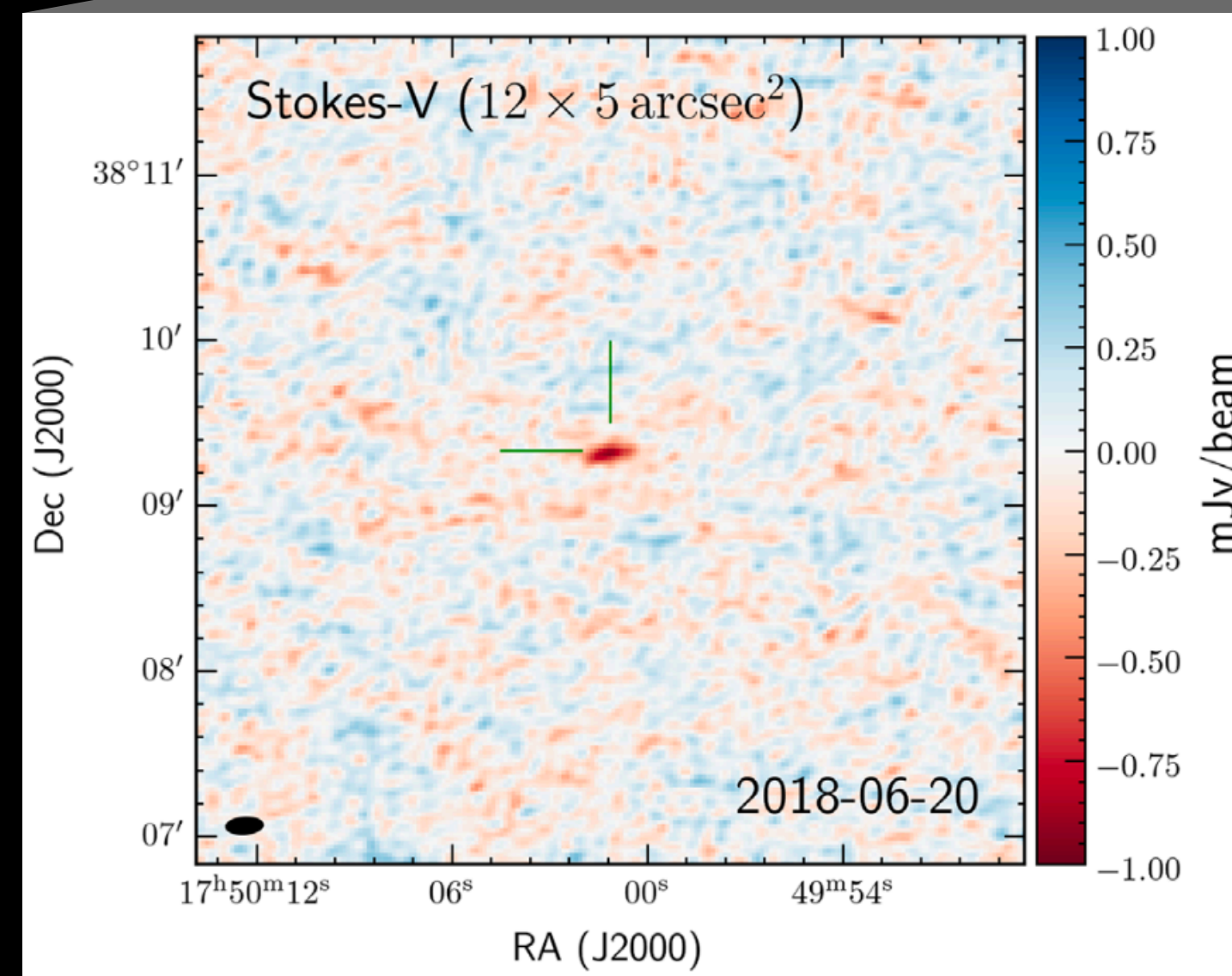


The LOFAR 'Superterp'

~50 Gauss field 🤔

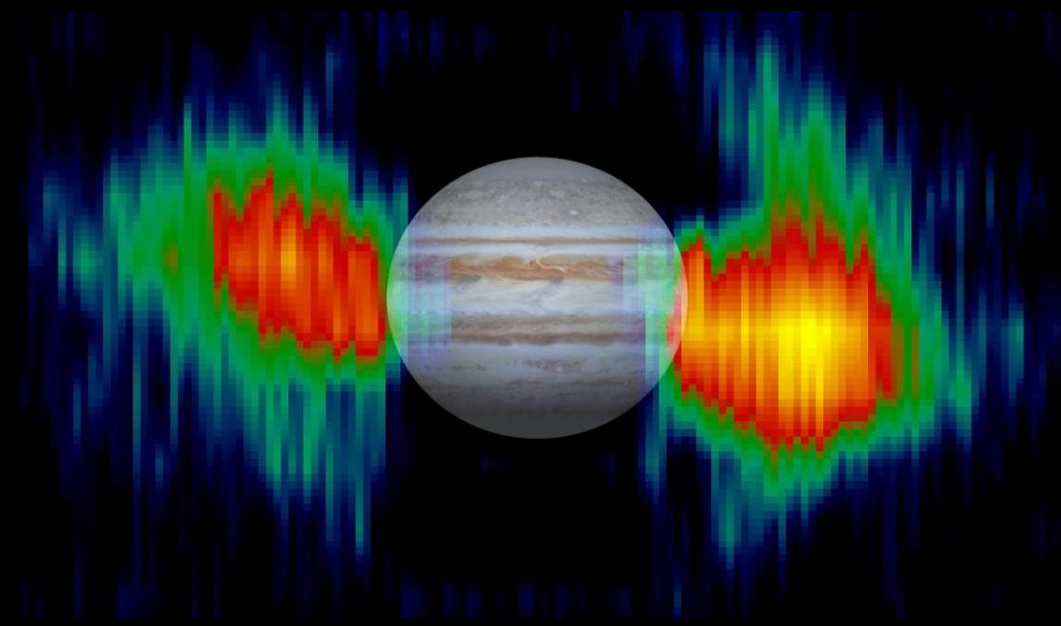


LOFAR Two-metre Sky Survey
(LoTSS, Shimwell+ 2022)

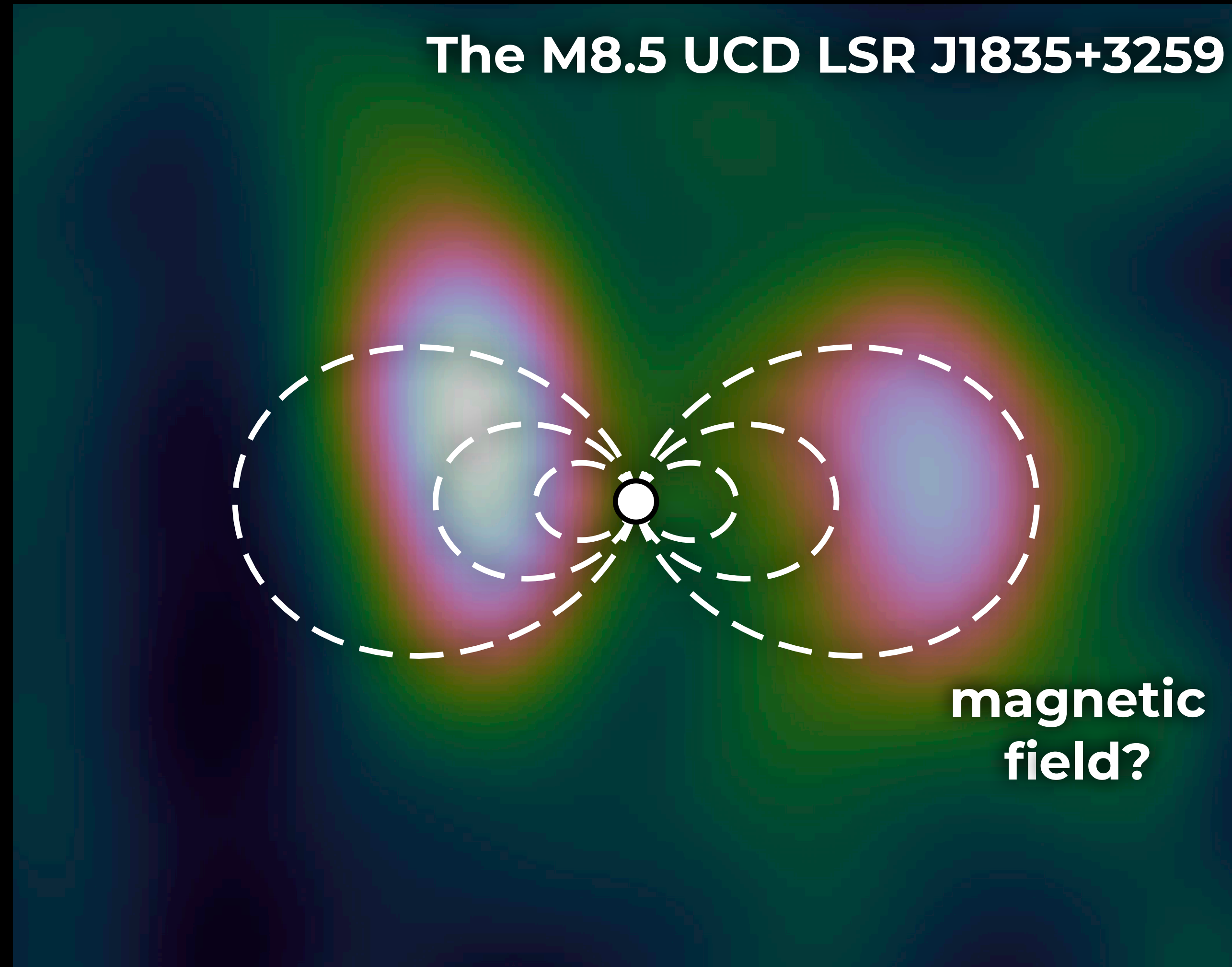


A previously unknown T6 dwarf at 65 pc! (Vedantham+ 2020)

The first spatially-resolved extrasolar radiation belt

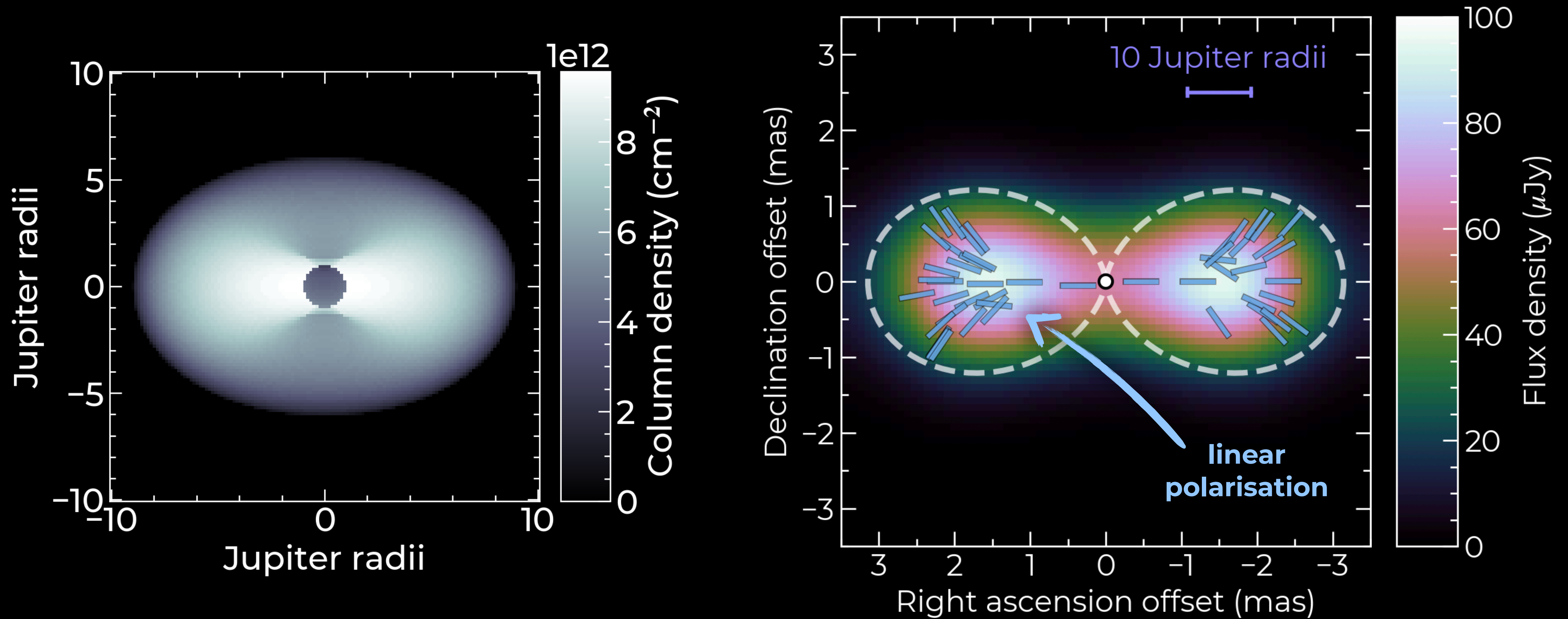


Jupiter



Climent+ (2023)
(see also Kao+ 2023)

Image synthesis for UCD radiation belts



Kavanagh+ (in prep.)

Prospects for upcoming facilities

Prospects for upcoming facilities

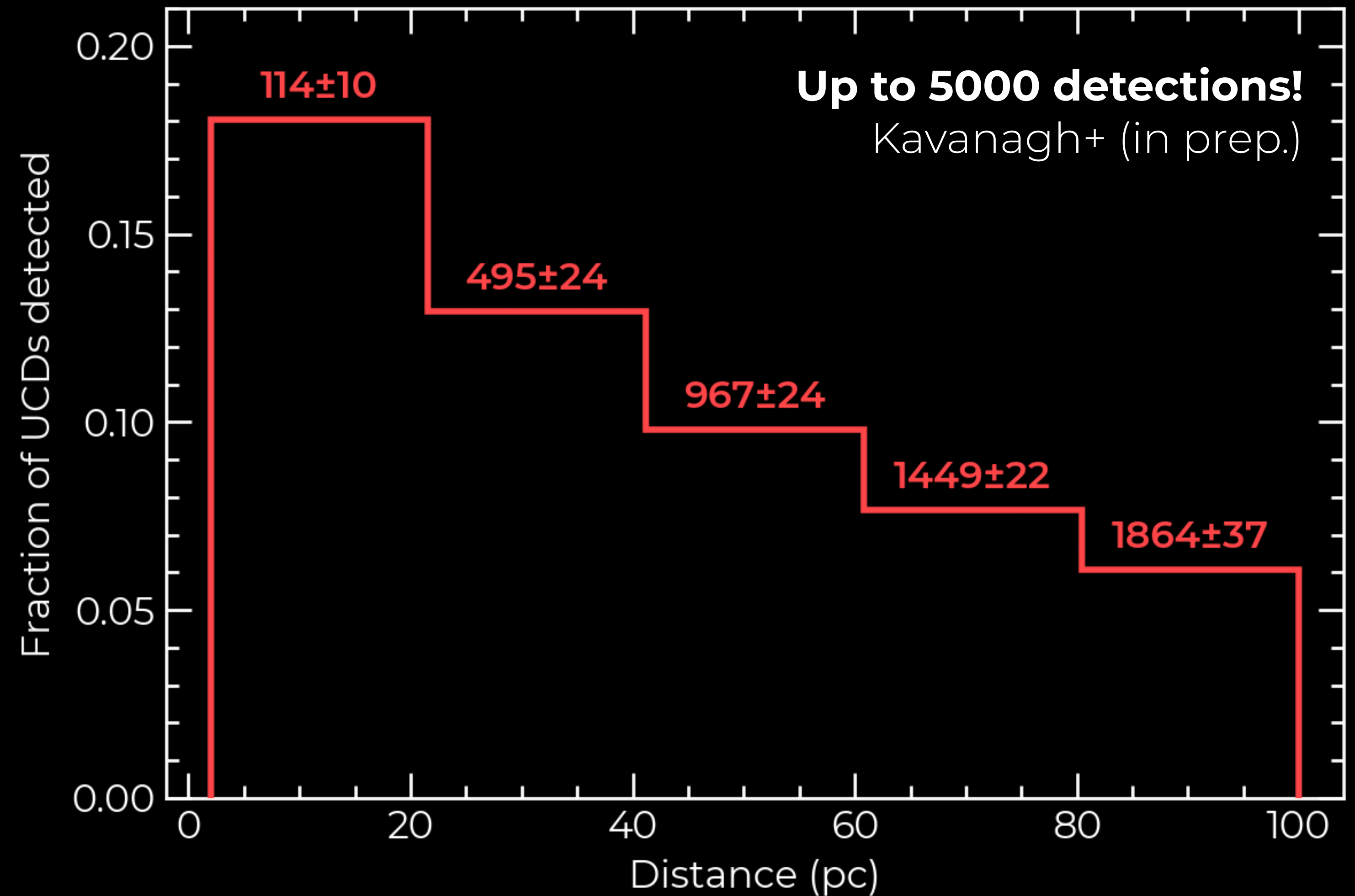


The Square Kilometre Array (SKA)

Prospects for upcoming facilities



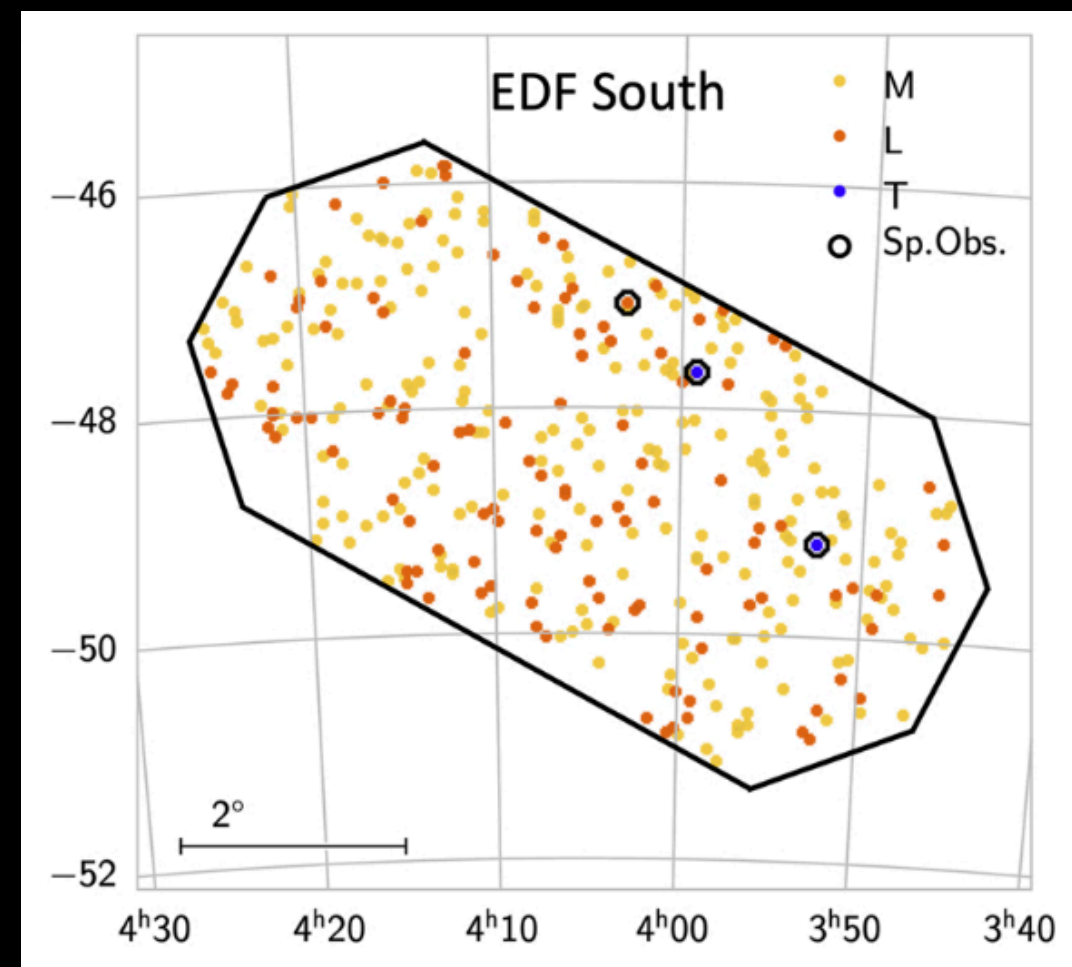
The Square Kilometre Array (SKA)



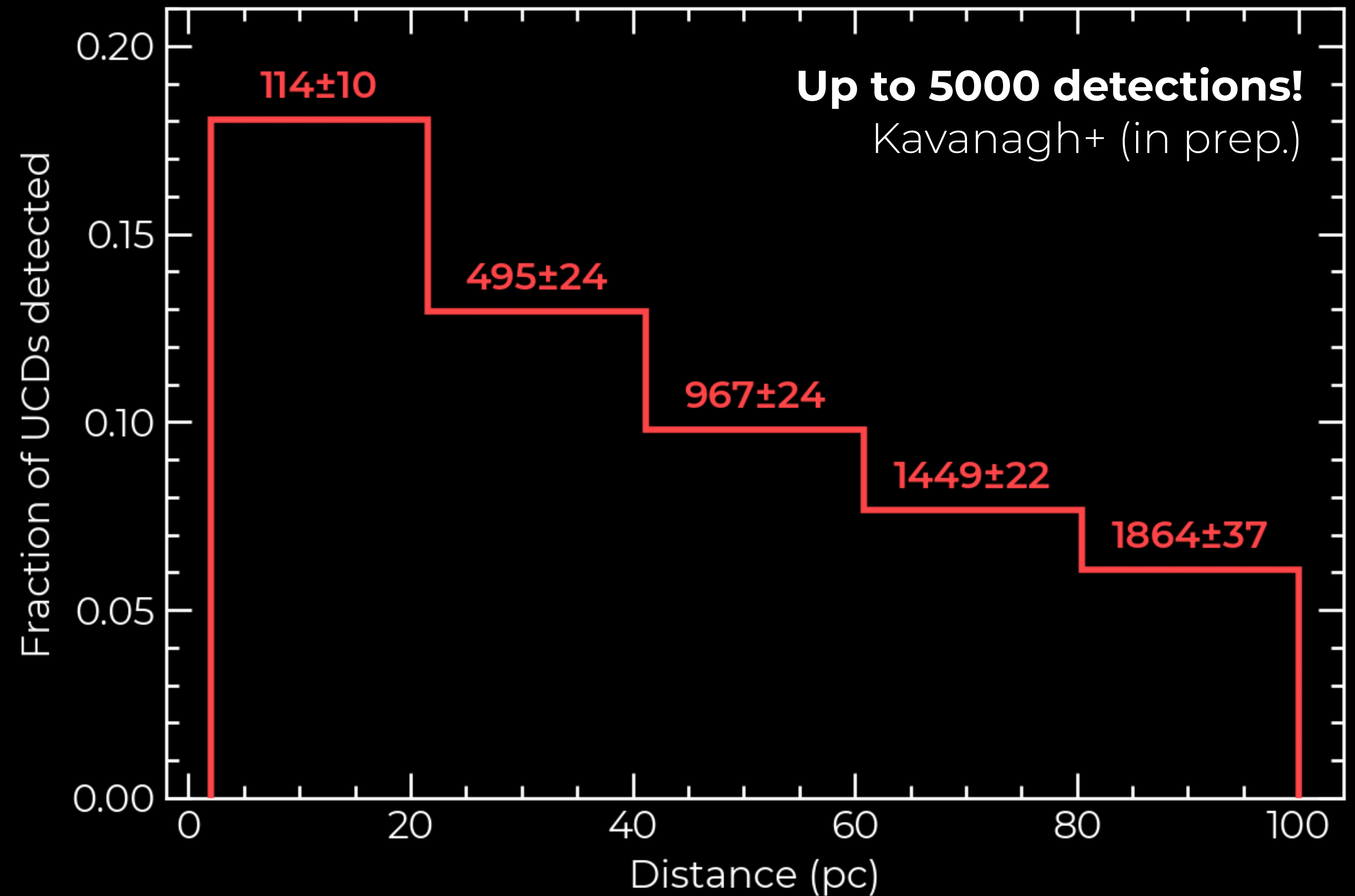
Prospects for upcoming facilities



The Square Kilometre Array (SKA)



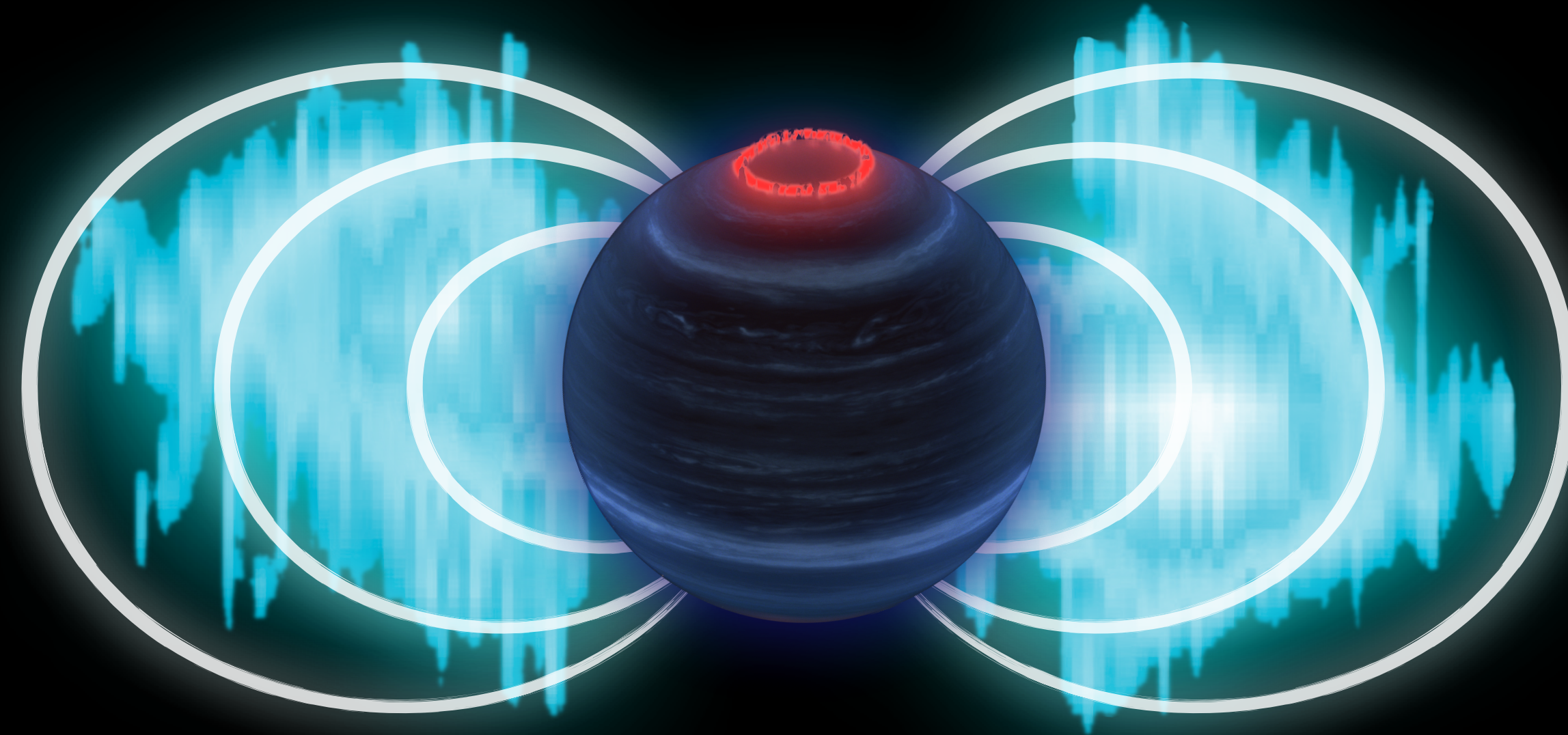
Euclid discovery space (Zhang+ 2024)



Conclusions

Radio observations of UCDs help us...

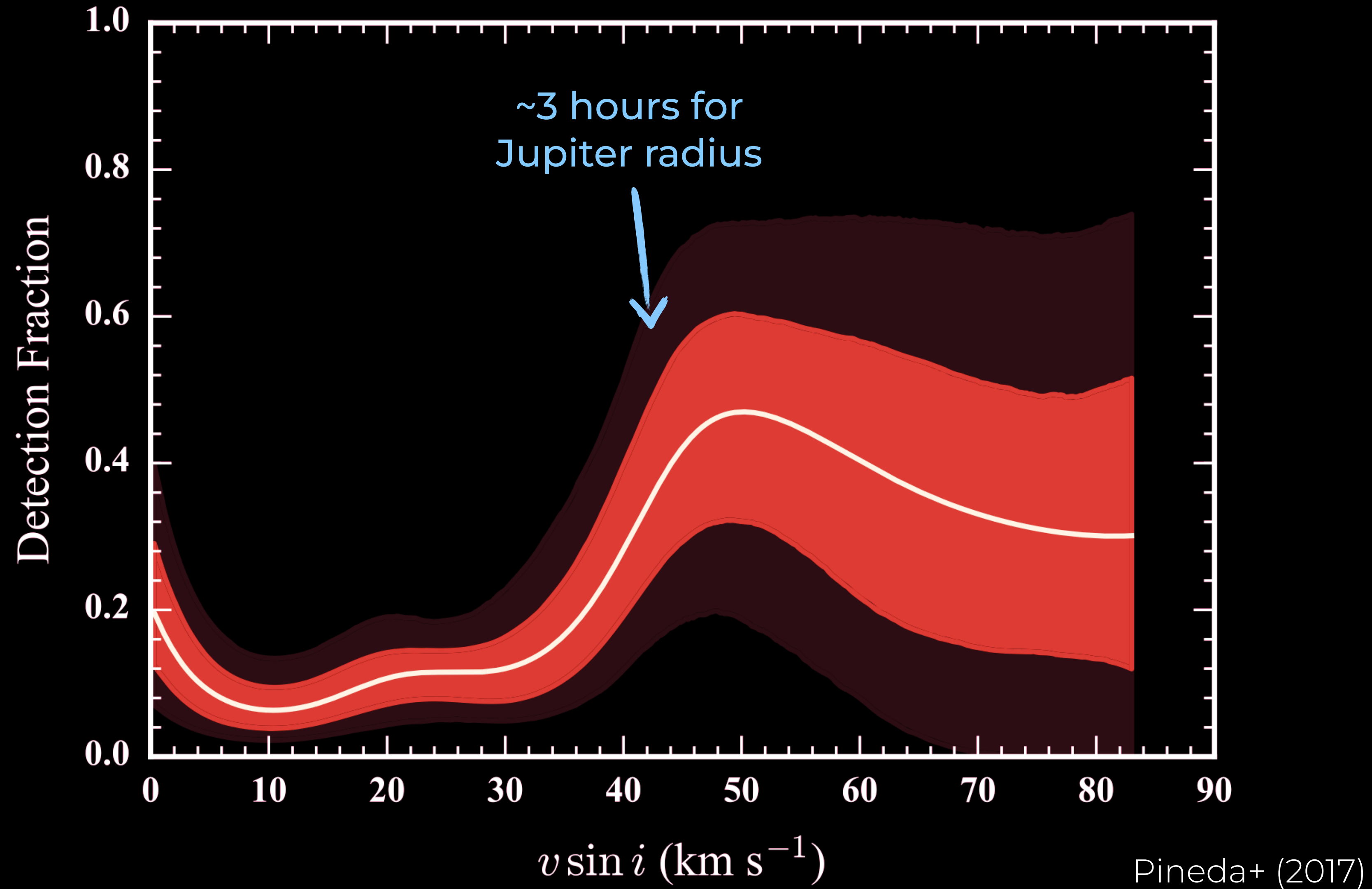
- Refine dynamo models – **unique probe of their interiors!**
- Informs us about **exoplanets**
- Constrain **energetic particles** trapped in their magnetospheres



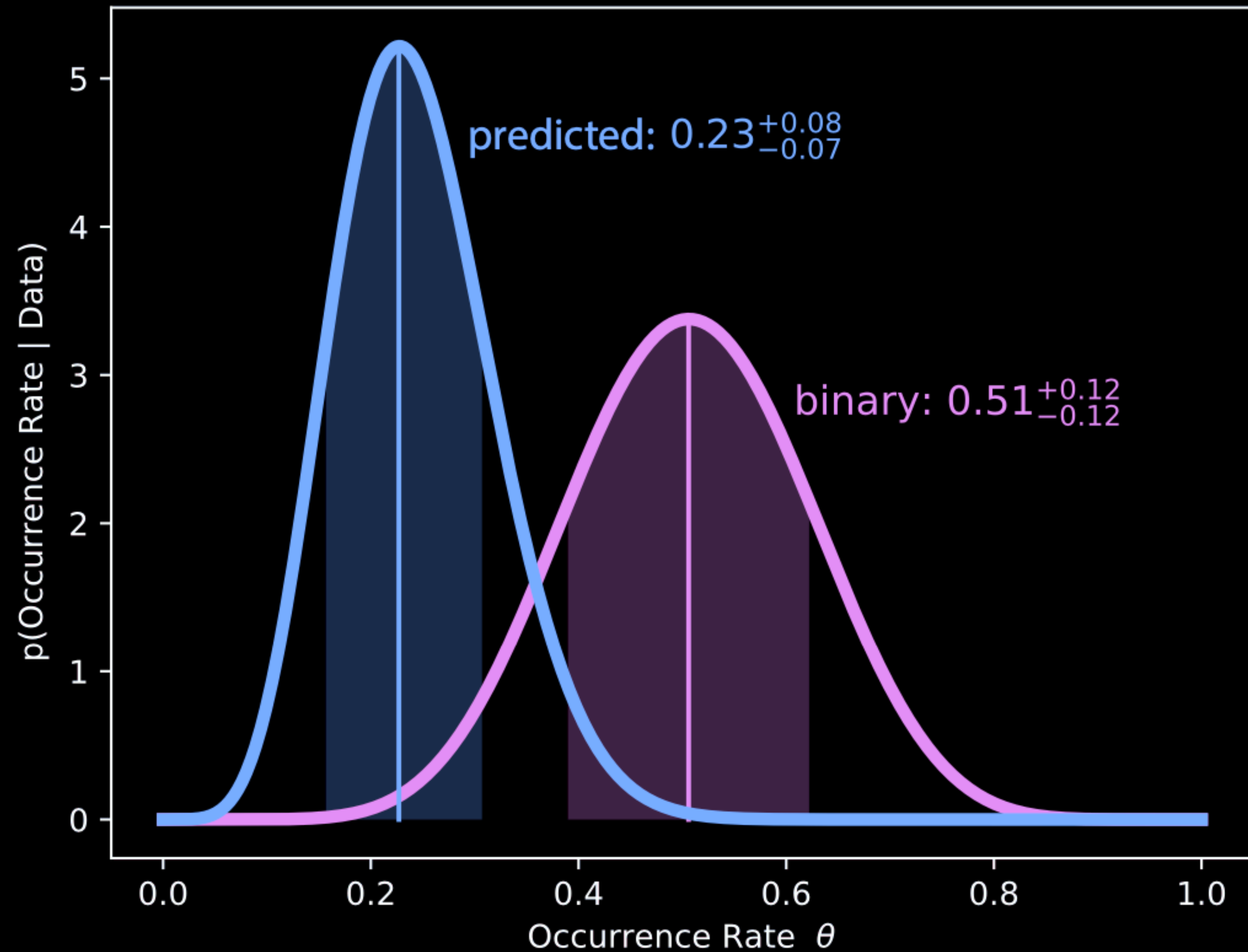
Consider radio synergies with your own work!

- JWST – independent constraint on **auroral processes**
- Euclid/Roman – **source association**

Emergence of radio emission with rapid rotation



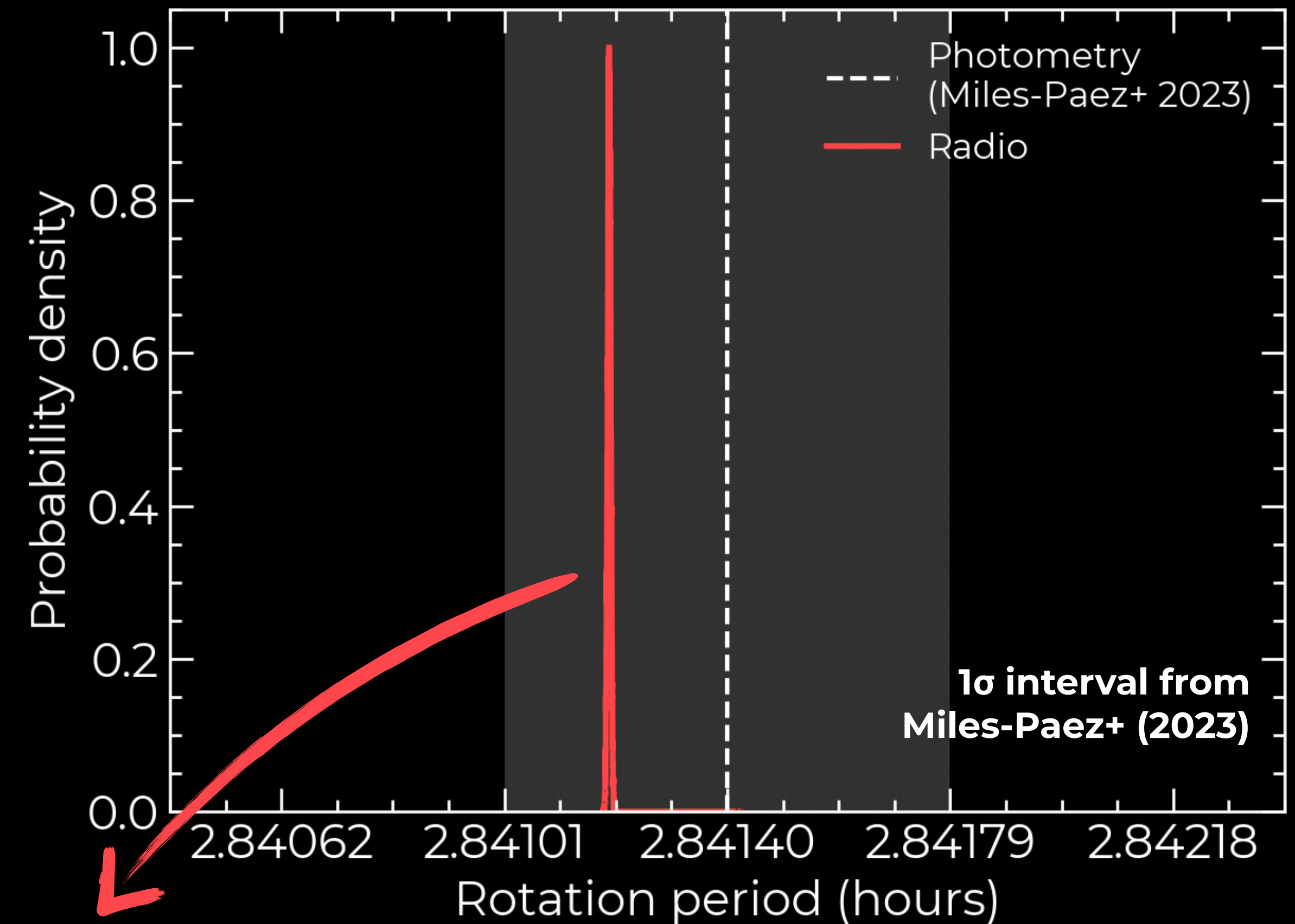
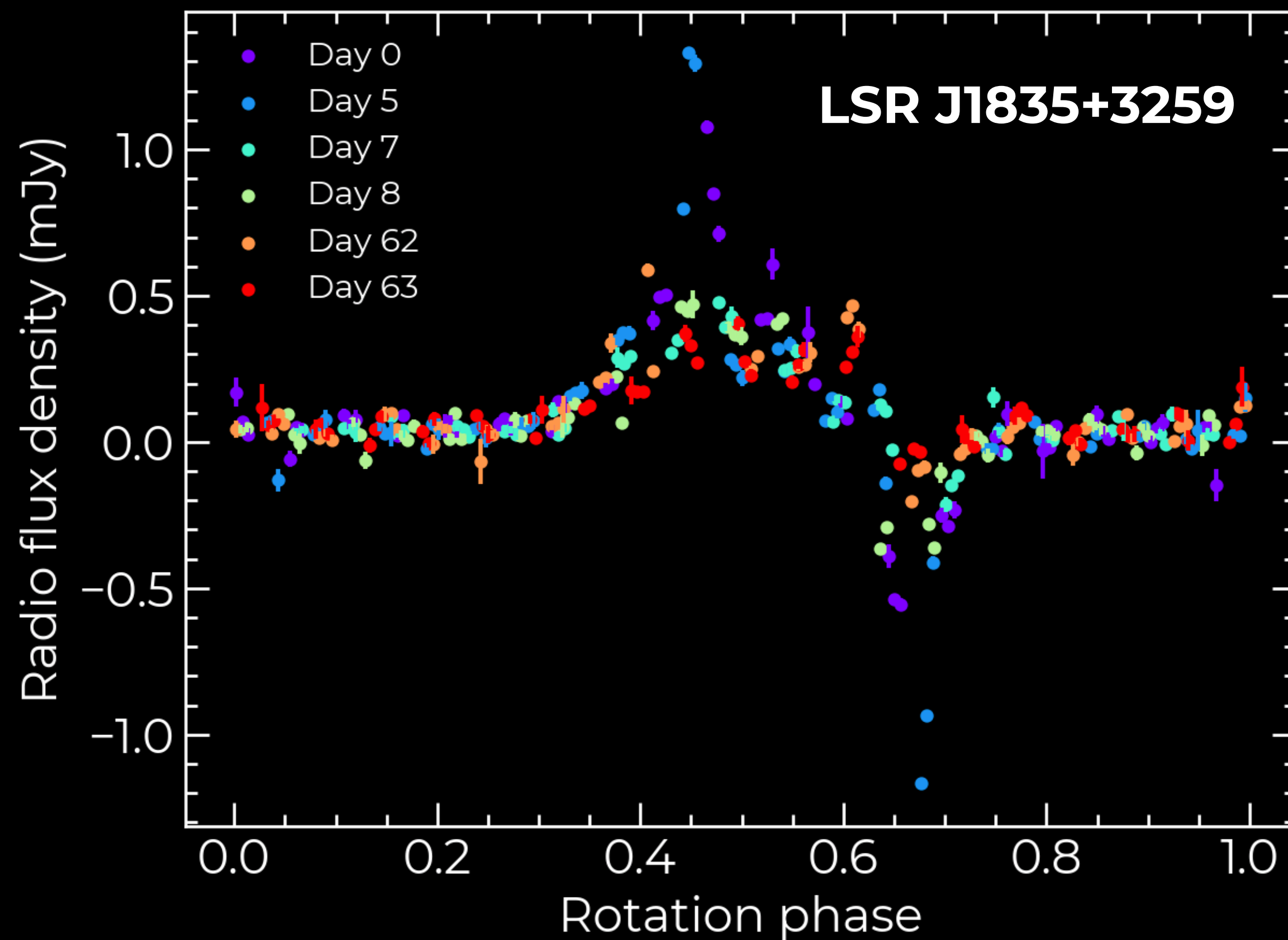
Binarity enhances (quiescent) radio emission



Kao & Pineda (2024)

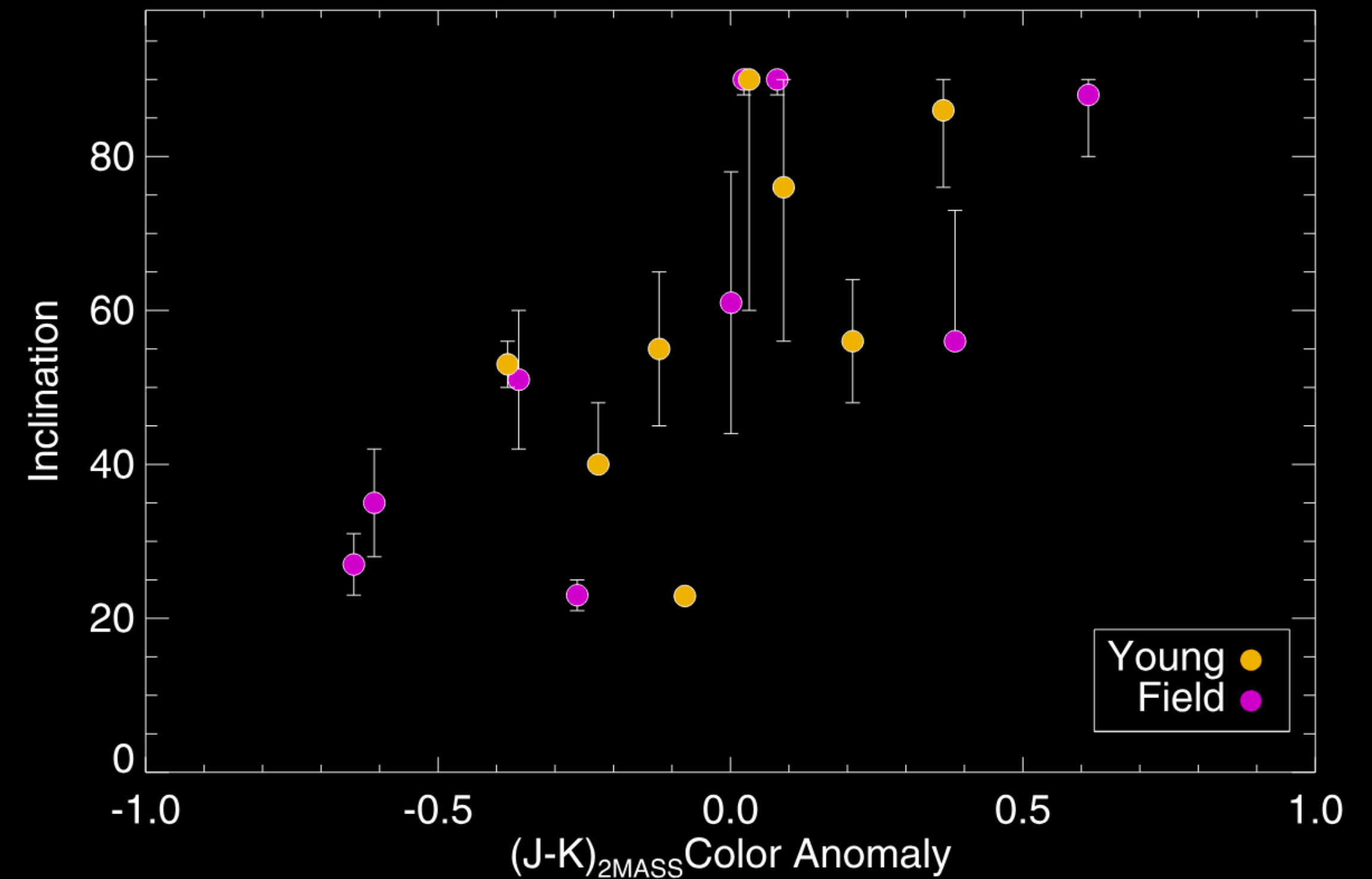
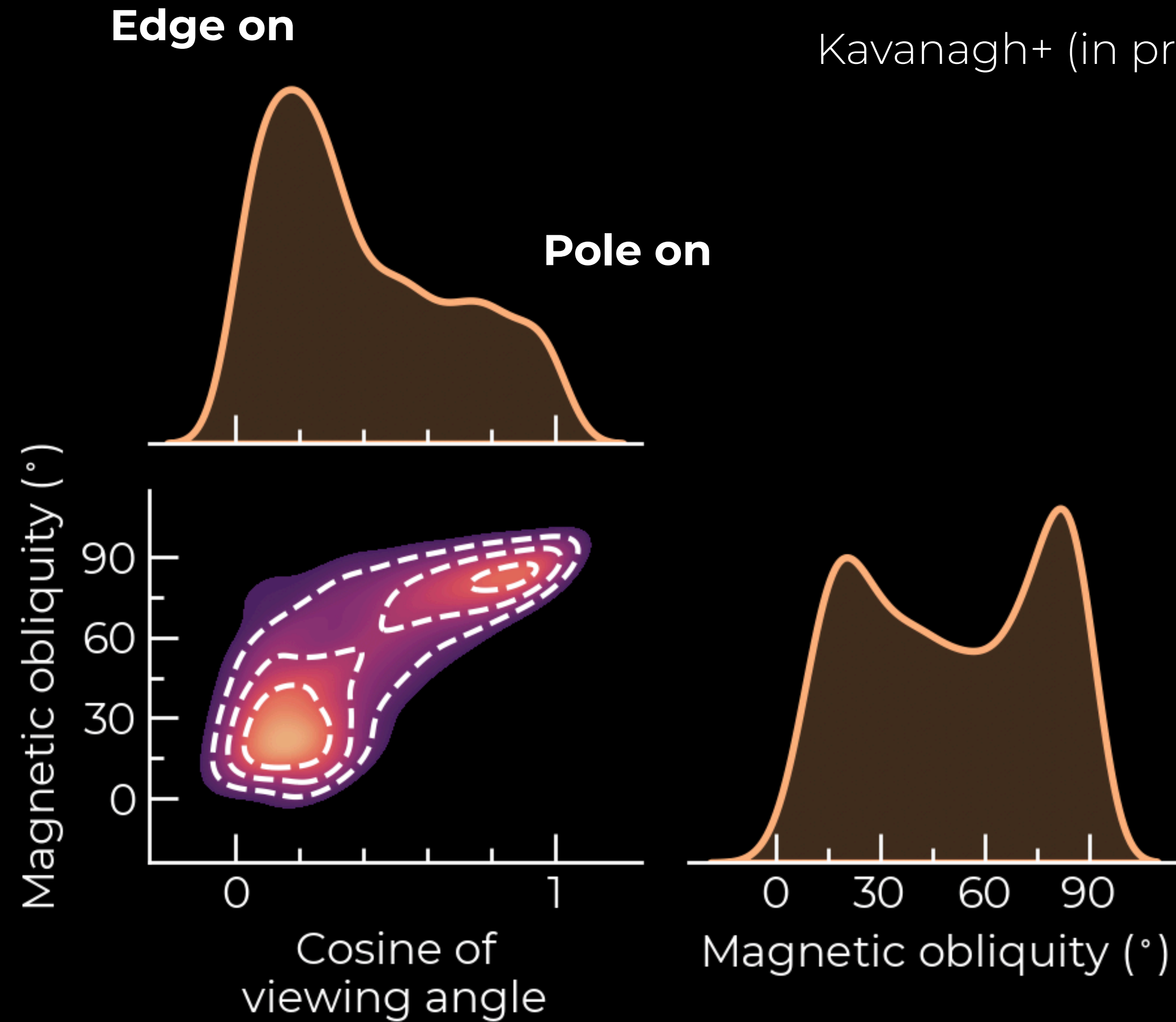
Precise rotation periods from radio monitoring

Kavanagh, Climent, Guirado+ (in prep.)



2.841194 $\pm$ 0.000003 hours

Geometric bias for radio detectability



Vos+ (2020)