NASA Exploration Science Forum

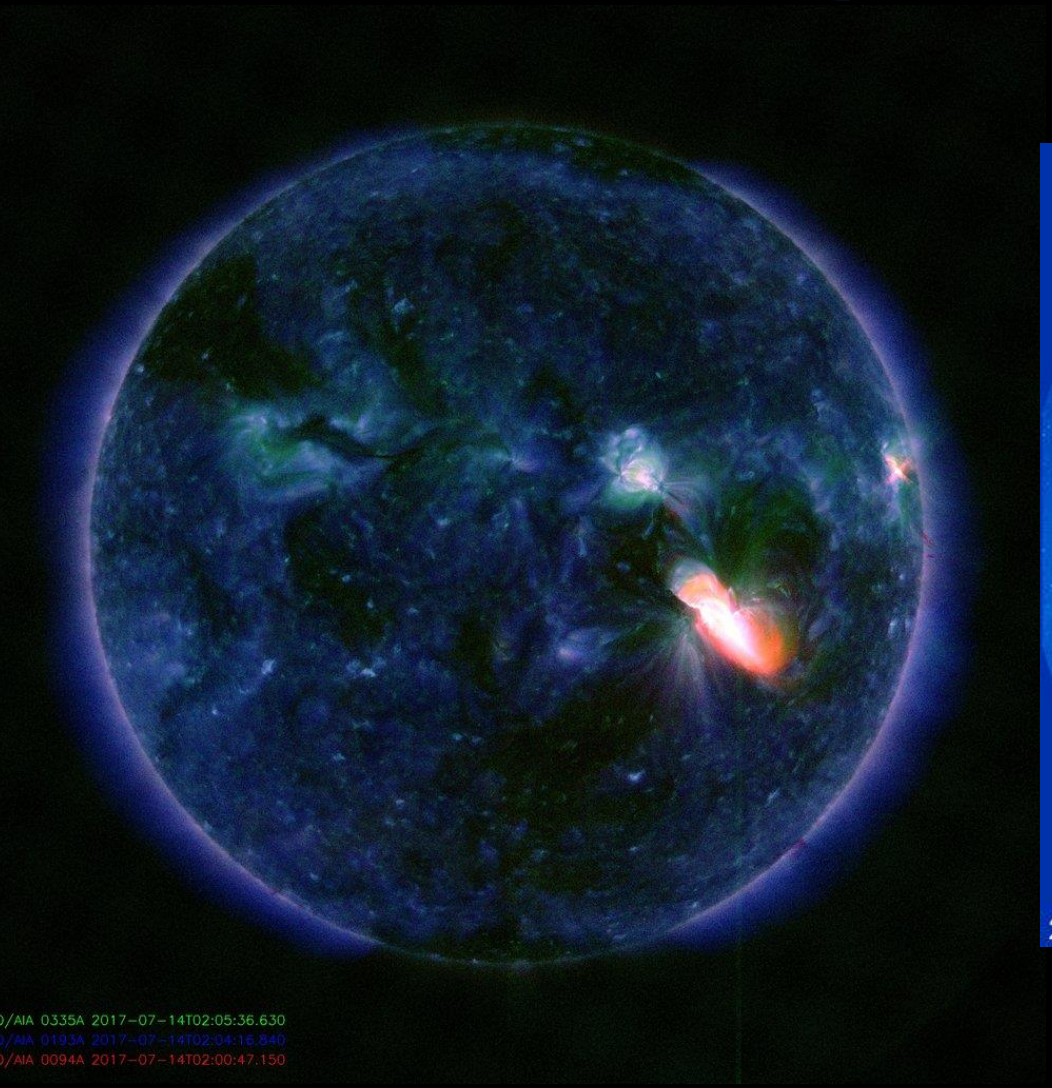
Prospects for Detecting Radio Emission from Exoplanets from the Moon

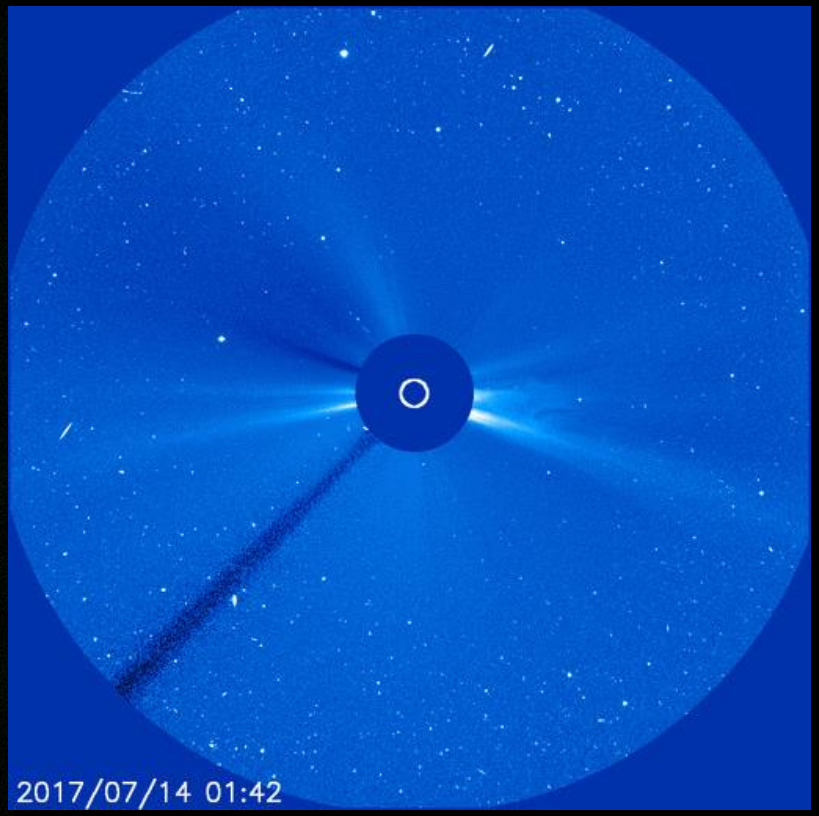
Gregg Hallinan
E-mail: *gh@astro.caltech.edu*

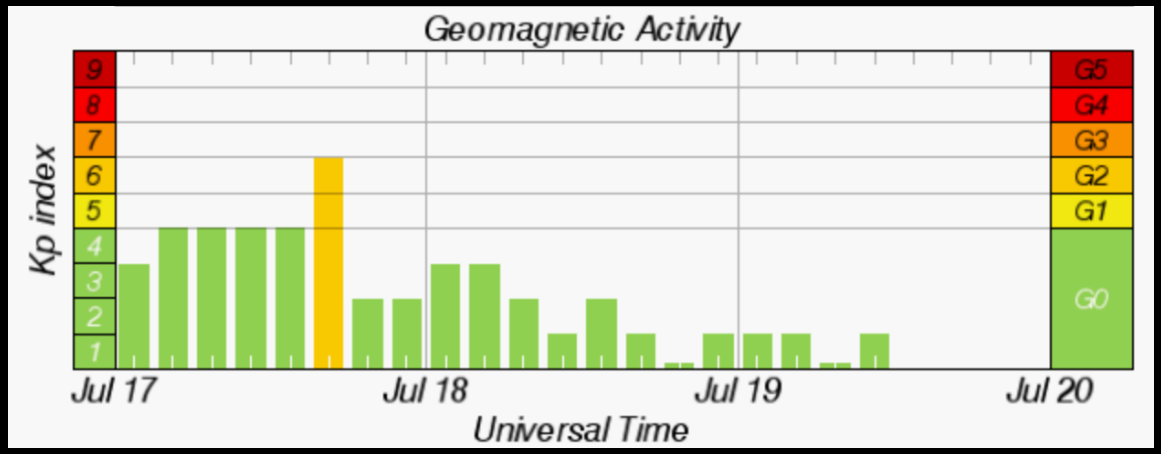
Caltech

NESS
Network for Exploration and Space Science

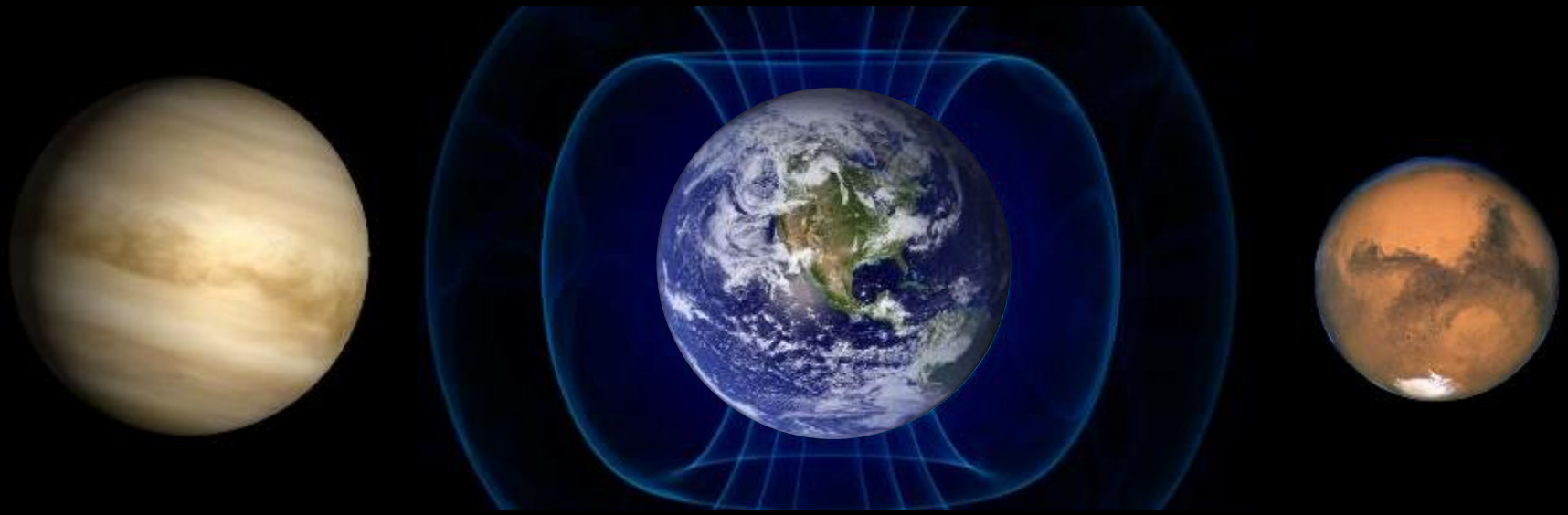
July 14, 2017


/AIA 0335A 2017-07-14T02:05:36.630
/AIA 0193A 2017-07-14T02:04:16.840
/AIA 0094A 2017-07-14T02:00:47.150


2017/07/14 01:42


Geomagnetic Activity
Kp index
9
8
7
6
5
4
3
2
1
G5
G4
G3
G2
G1
G0
Jul 17
Jul 18
Jul 19
Jul 20
Universal Time


A fertility company that defies the textbooks p. 629
Multigenerational effects on development pp. 634 & 651
Microbial ecology and evolution pp. 649 & 663
Science
$10
6 NOVEMBER 2015
sciencemag.org
AAAS
MAVEN at Mars
Probing a dynamic upper atmosphere p. 643



Magnetic activity can redefine habitability!

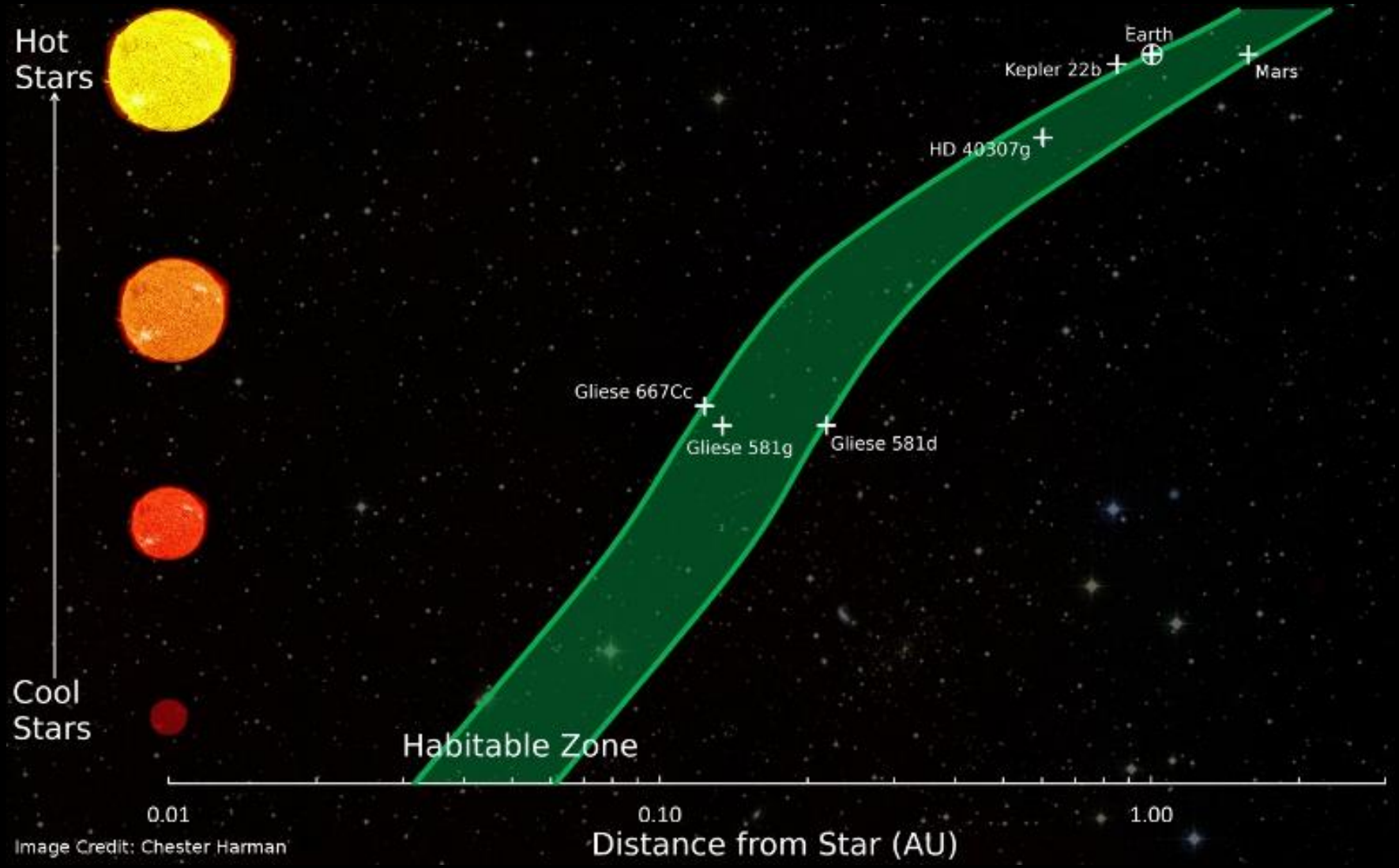
95% of stars that can host evolved exoplanets (age > 1 Gyr) are M dwarfs

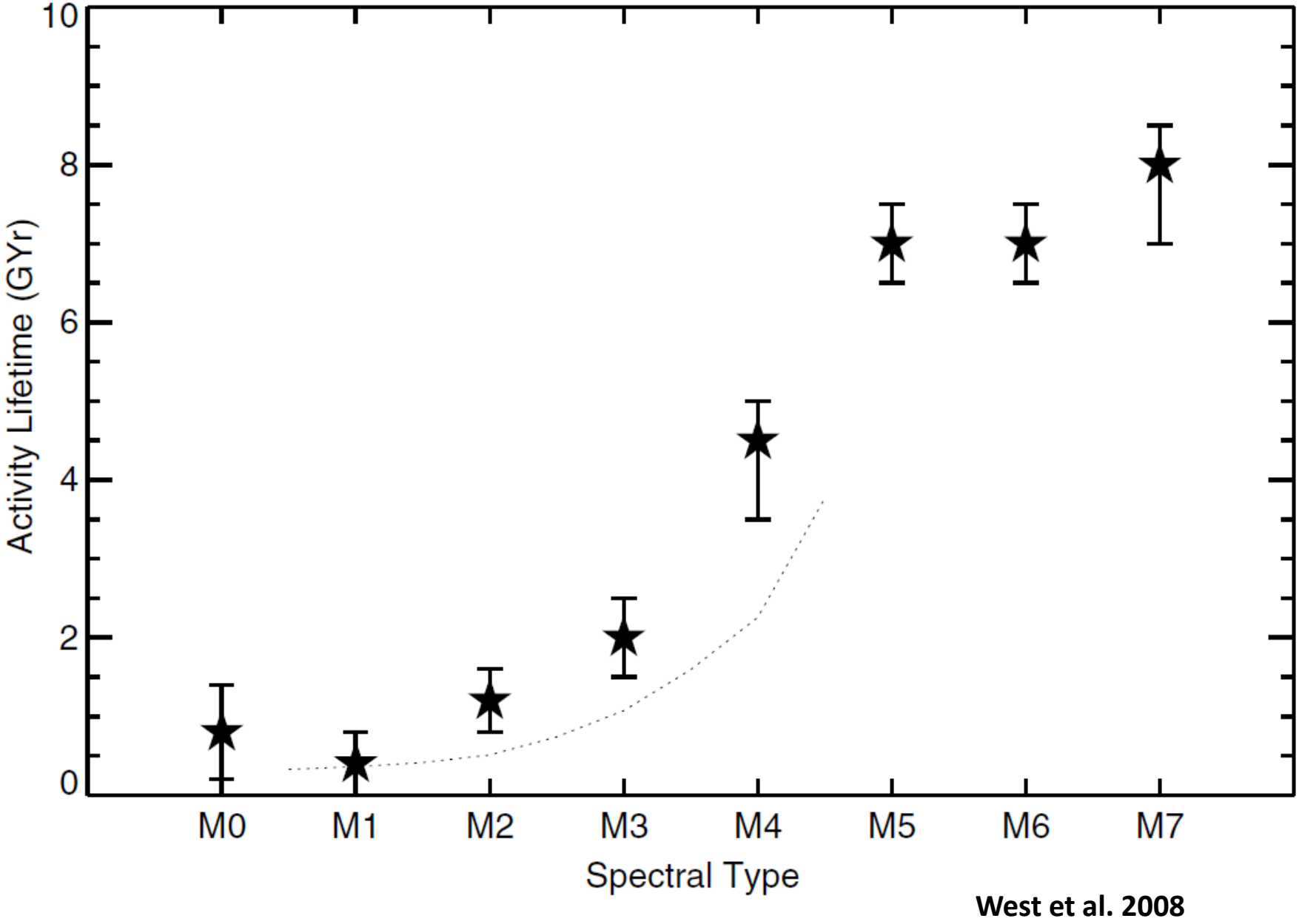
Rocky planets are frequent around M dwarfs (Dressing & Charbonneau 2013, 2015)

The nearest habitable planet orbits an M dwarf at 2.6 +/- 0.4 pc!


Trappist-1

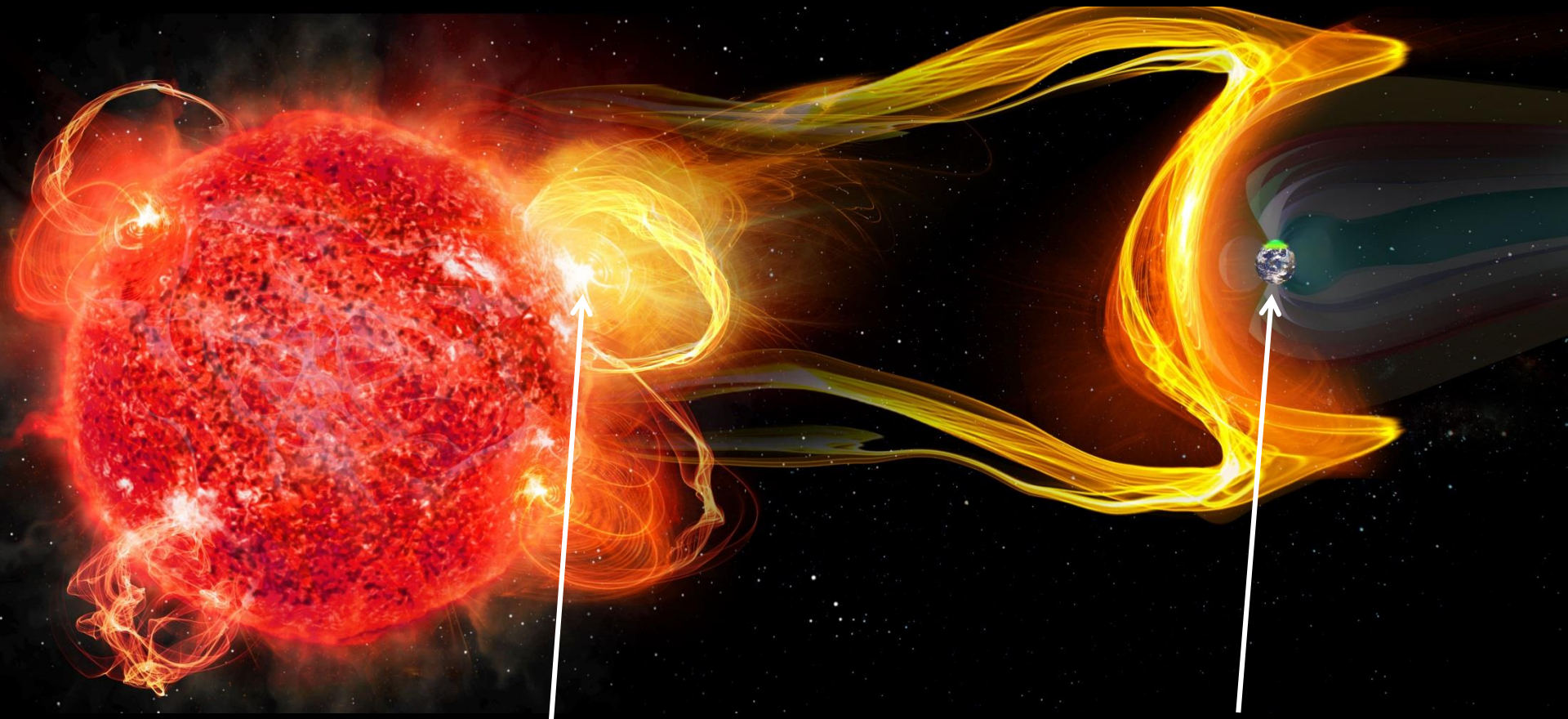

Proxima b


Hot
Stars
Cool
Stars
Earth
Kepler 22b
Mars
HD 40307g
Gliese 667Cc
Gliese 581g
Gliese 581d
Habitable Zone
0.01
0.10
1.00
Distance from Star (AU)
Image Credit: Chester Harman



West et al. 2008

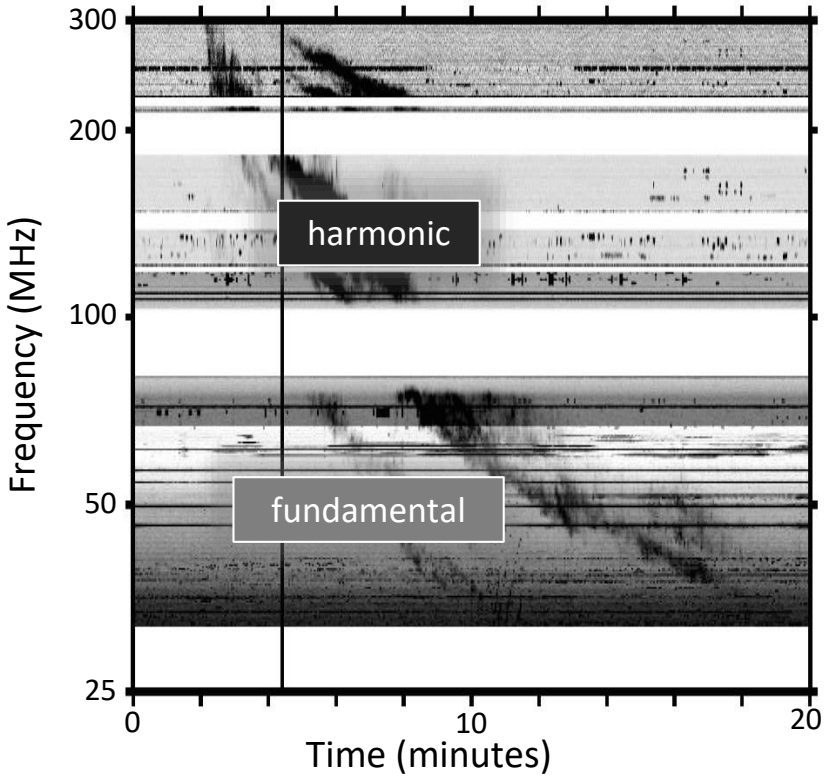
Low Frequency Radio Emission

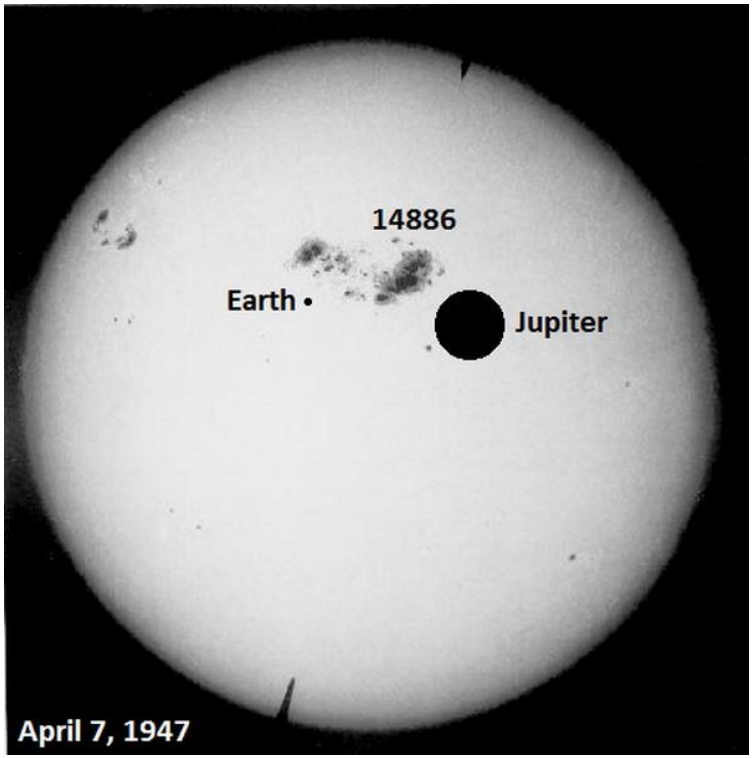


Type II radio emission associated with CMEs

Planetary auroral radio emission

Type II Radio Bursts





Kouloumvakos et al. 2014
Figure c/o J. Villadsen

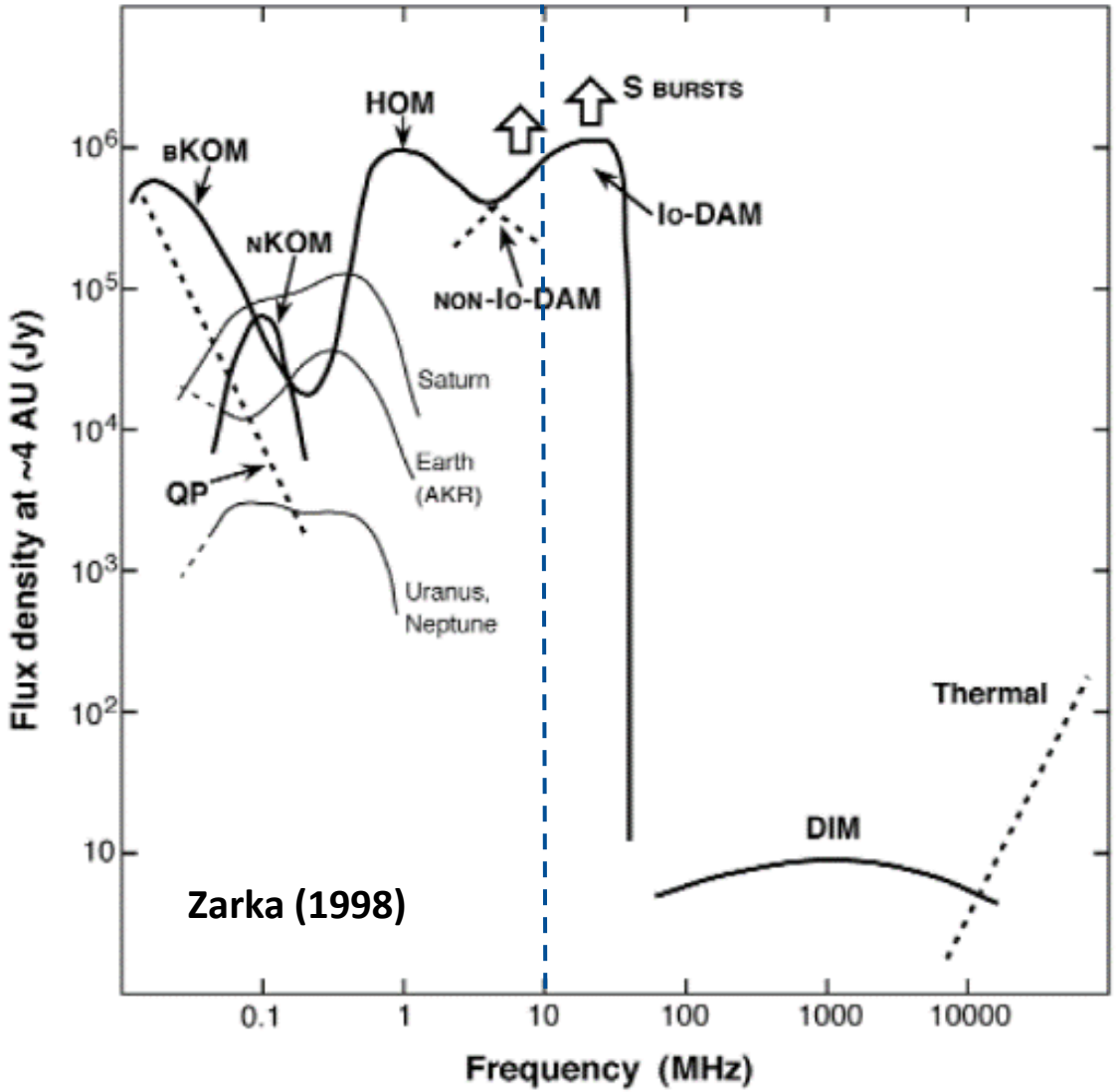
Bursts mostly confined to <100 MHz – lowest frequencies are crucial (Bob's talk)

Giant Type II burst detected in 1947 – 10^{11} Jy brightest ever extra-terrestrial radio emission

~100 mJy at 5 pc but *rare event!*

Radio Emission from Solar System Planets

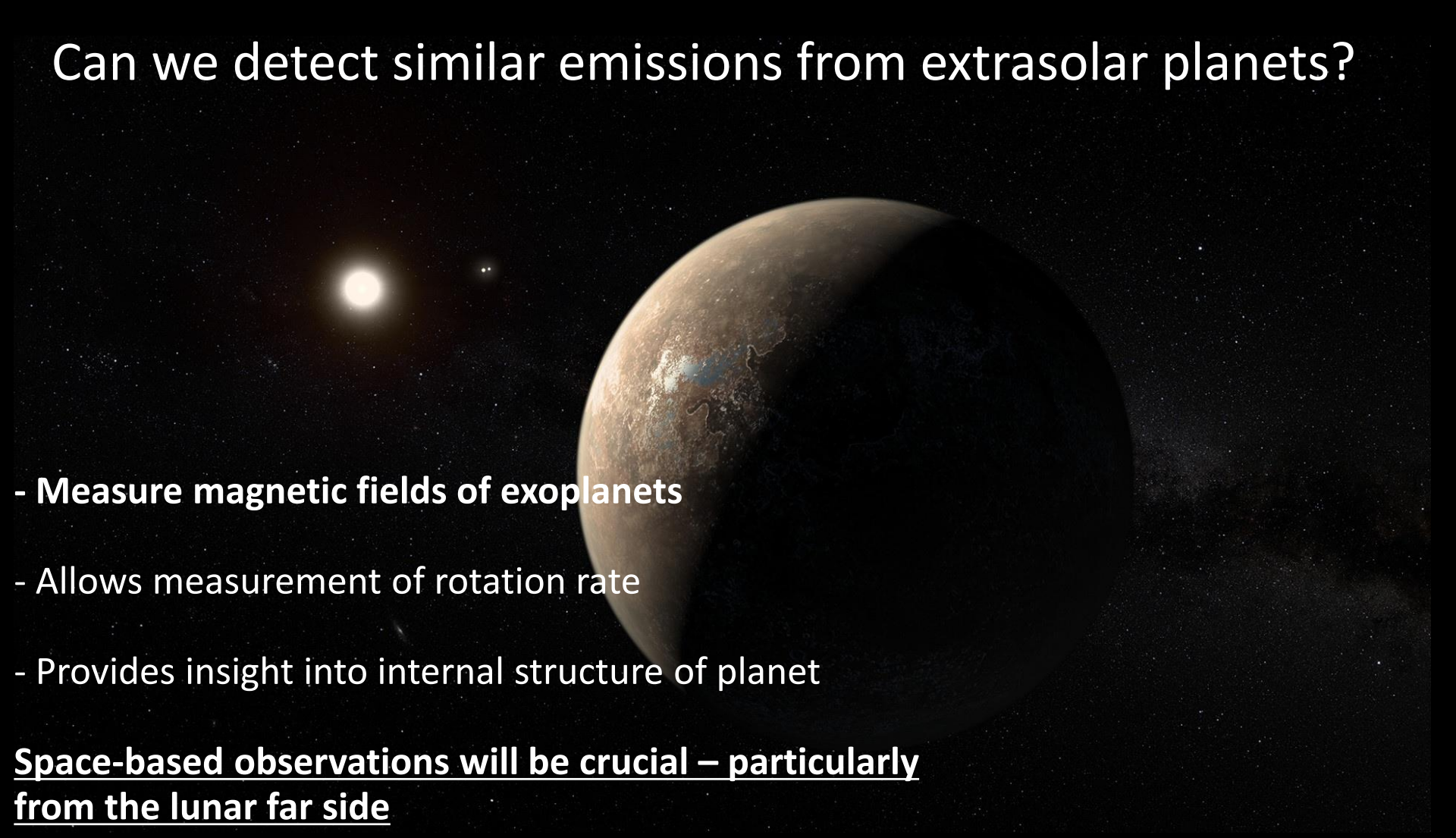
- *Voyagers*: Opens up field
- All gas giants and Earth have strong auroral radio emission



$$B_{Gauss} = \nu_{MHz} / 2.8$$

Only Jupiter detectable with ground-based observations

Can we detect similar emissions from extrasolar planets?



- Measure magnetic fields of exoplanets

- Allows measurement of rotation rate

- Provides insight into internal structure of planet

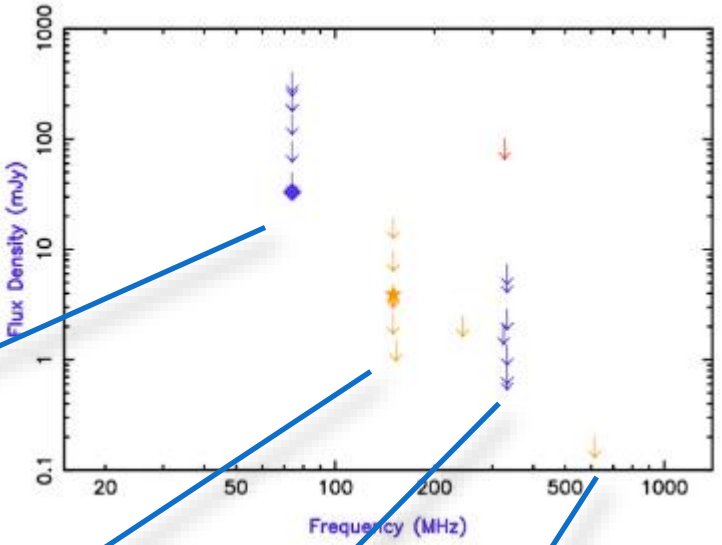
<u>Space-based observations will be crucial – particularly from the lunar far side</u>

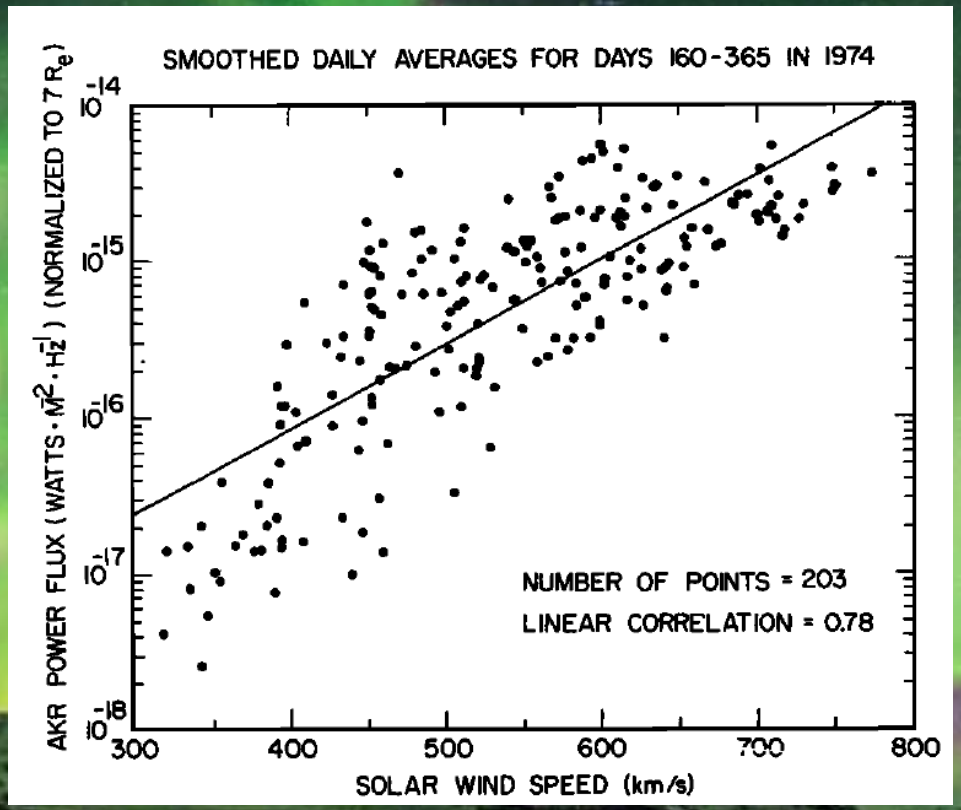
Exoplanet Searches

- **Searches have been ongoing for > 30 years**

- **No detections**

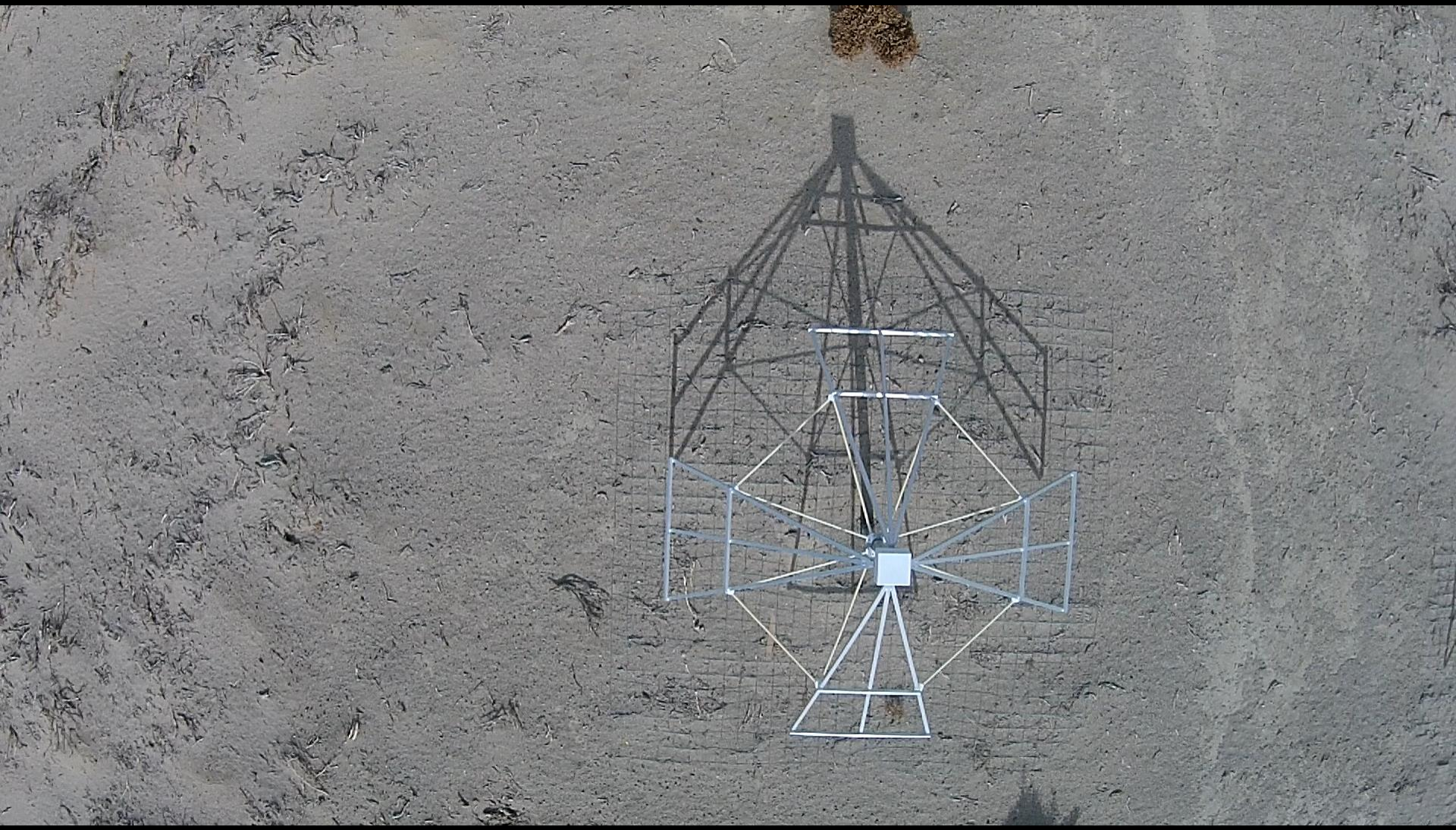
- **See Lazio et al. 2009 for review**

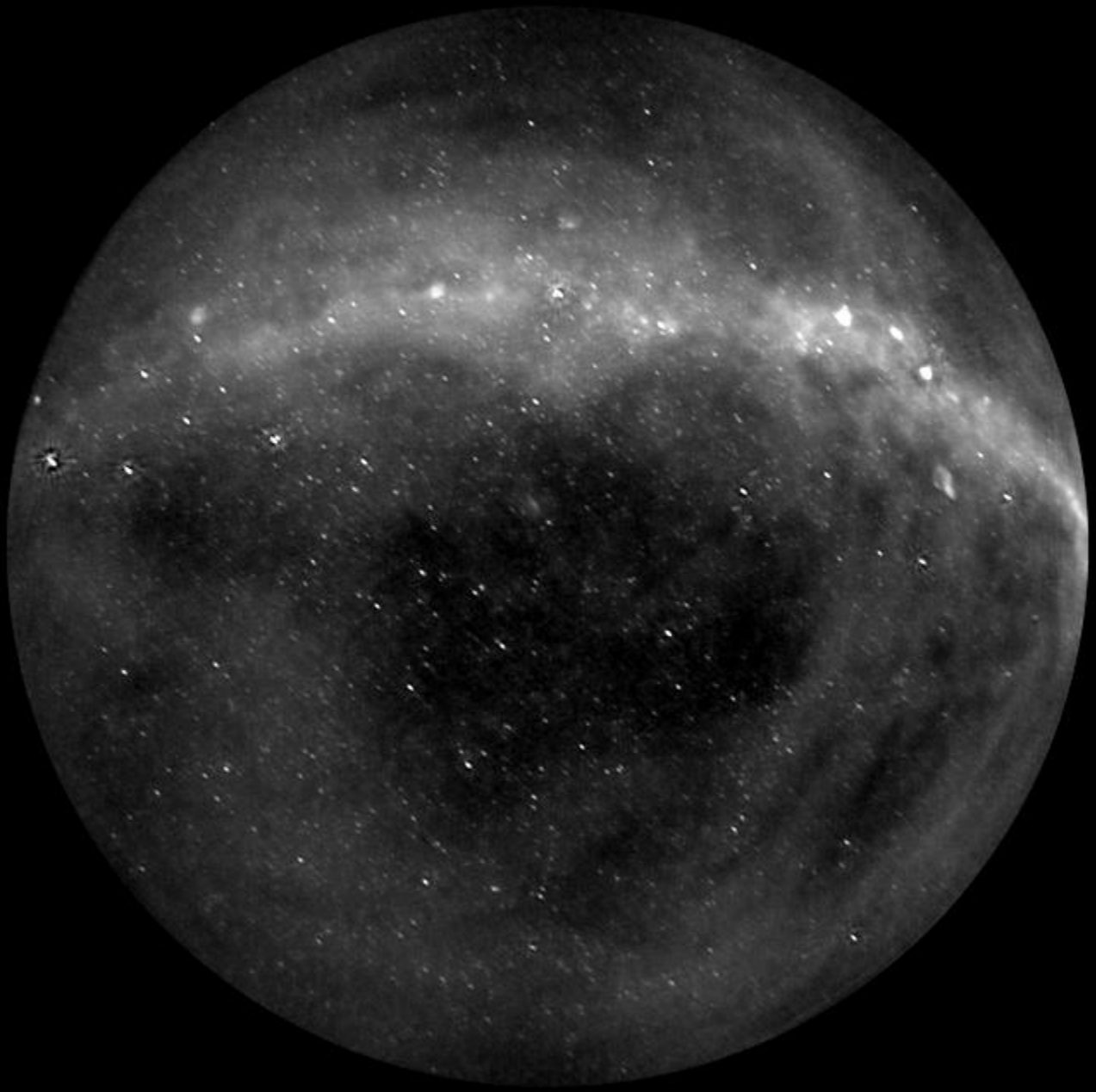


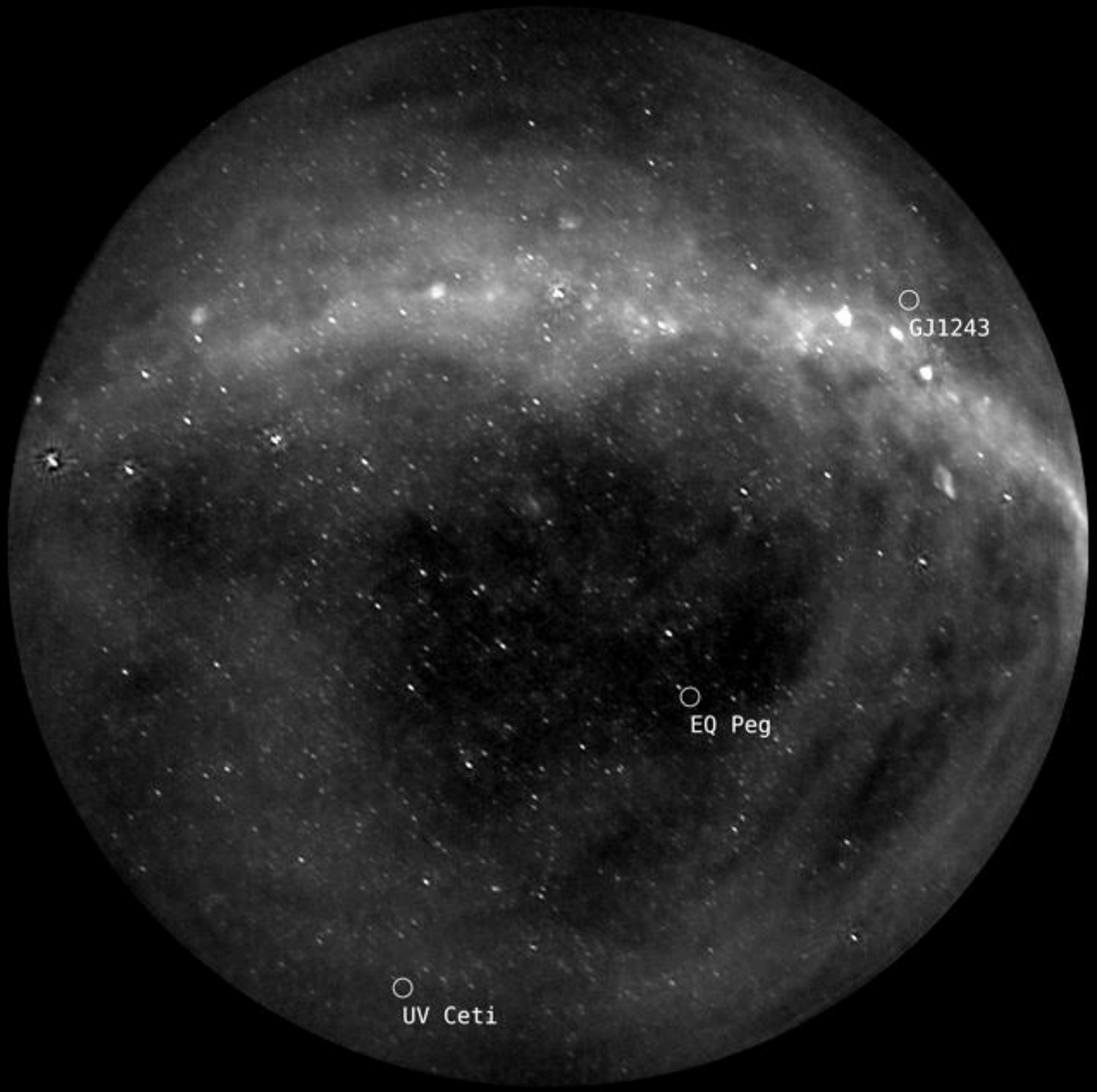


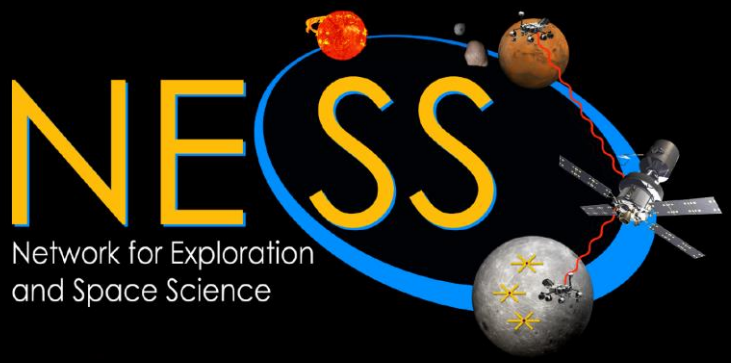
Gallagher & D'Angelo 1981

The Owens Valley LWA:
An Extrasolar Space Weather Telescope






GJ1243
EQ Peg
UV Ceti



Studies of terrestrial planets require space-based observations!

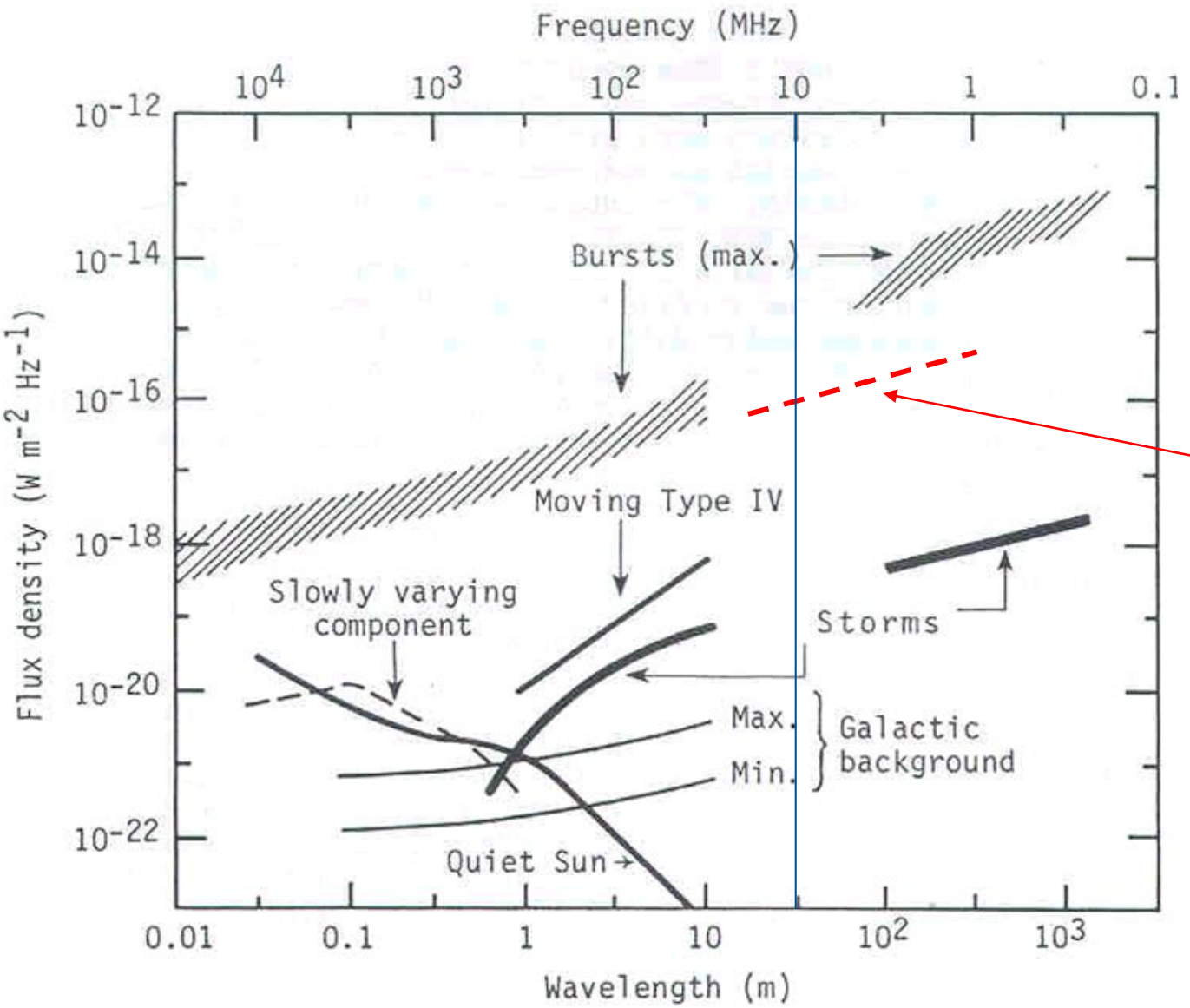
Establish requirements for a lunar-based array to detect extrasolar space weather [frequency, sensitivity, baselines, polarization, antenna design]

Define strategy – monitoring of stellar systems is key

Alpha Cen AB and Proxima are initial targets; grow sample with increasing capability

Prioritization of the nearest exo-Earths

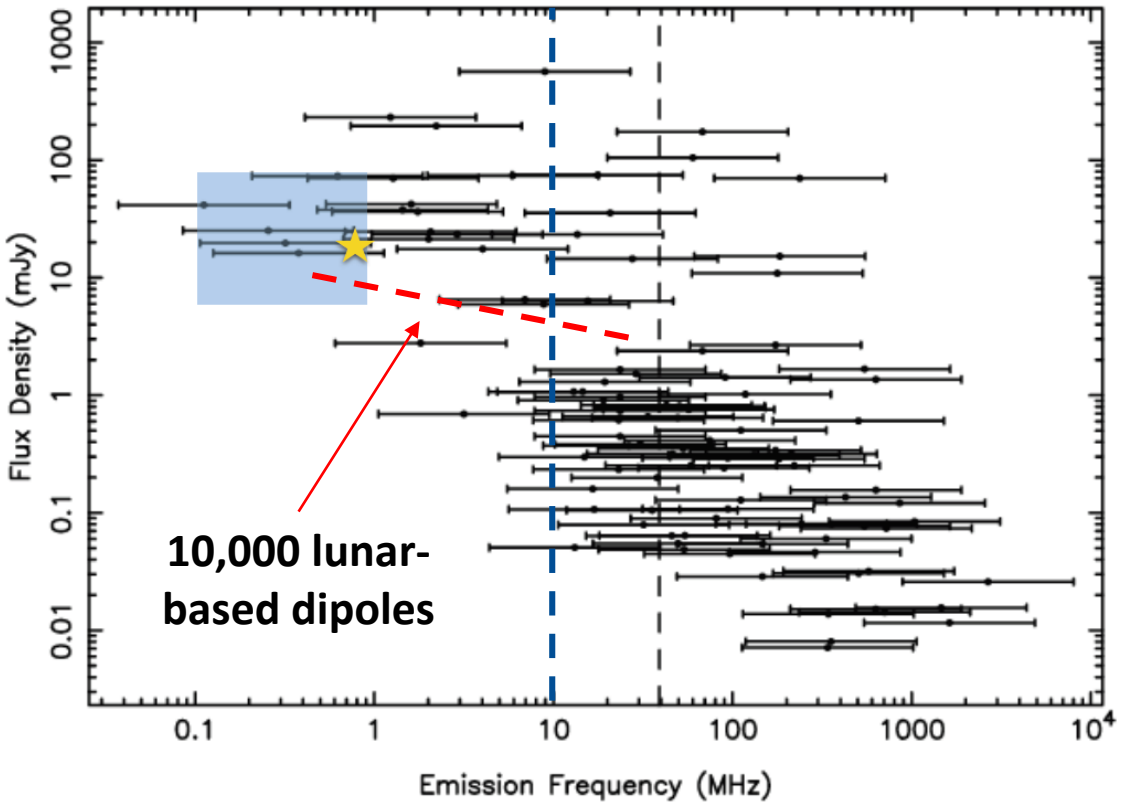
Solar Bursts at the Distance of Proxima



100 lunar-based dipoles

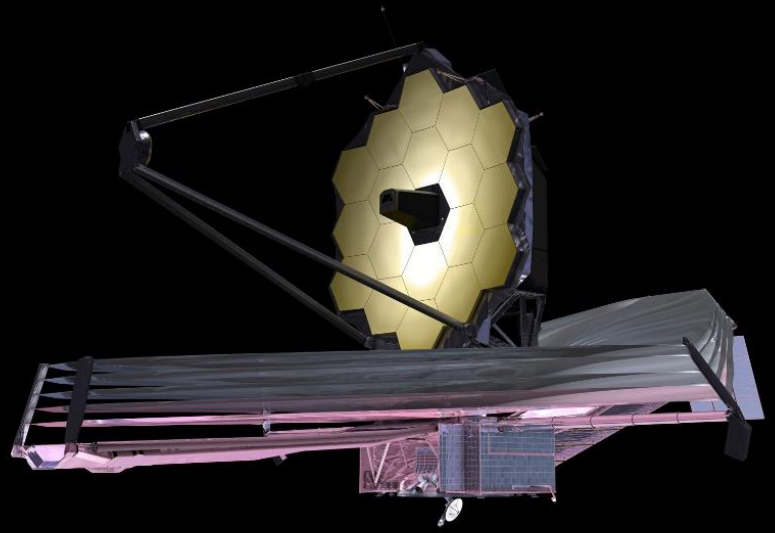
Radio Emission from Proxima b

Planetary radio emission subject to scaling laws for magnetic field strength and input solar wind power (e.g. see Farrell et al. 1999)

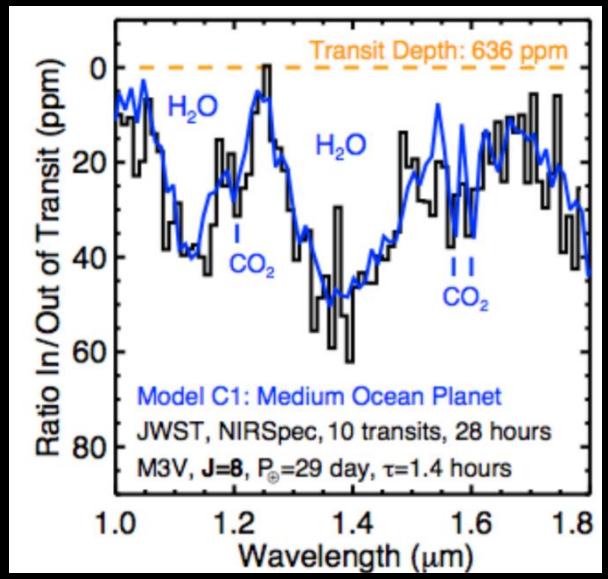


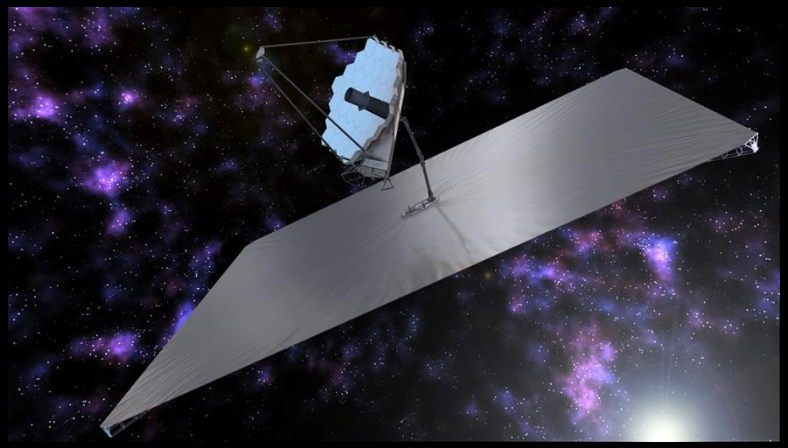
Adapted from Burkhart & Loeb 2017

Essential Data in the Search for Habitability

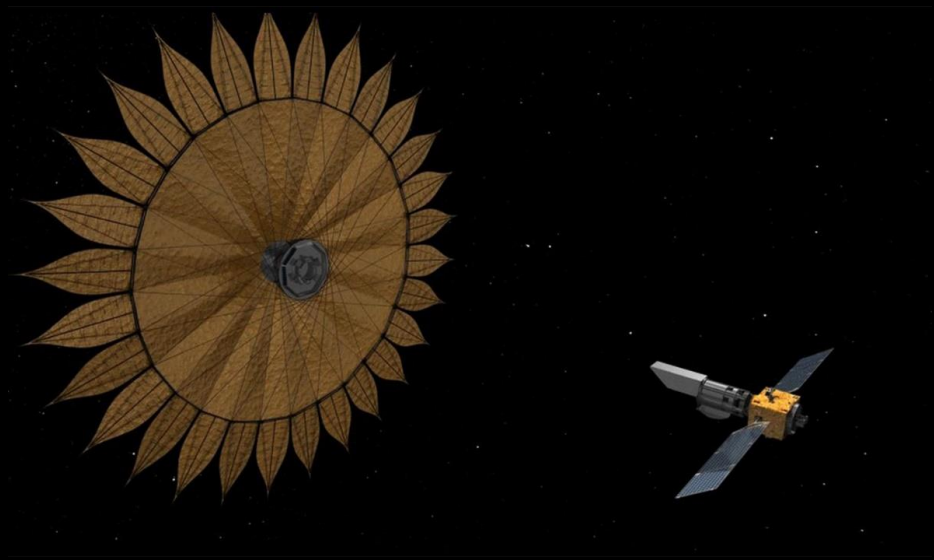


JWST





LUVOIR



HabEx

Summary

Understanding the impact of stellar activity and the presence of planetary magnetic fields is becoming increasingly important for defining planetary habitability

Low frequency radio observations are key

<u>The long-term future is from the lunar far-side</u>

NESS effort will incorporate key design choices to enable this science

Alpha Centauri (Alpha Cen AB and Proxima) will be the first target

Sample will grow as capability grows