

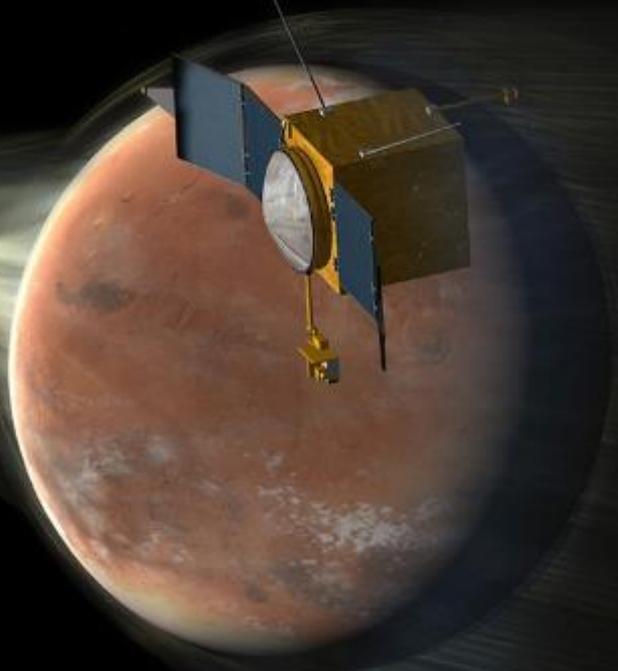
*NESS Steering Committee Meeting*

# Extrasolar Space Weather



Gregg Hallinan  
E-mail: [gh@astro.caltech.edu](mailto:gh@astro.caltech.edu)

**Caltech**



A fertility company that defies the textbooks p. 620

Multigenerational effects on development pp. 634 & 652

Microbial ecology and evolution pp. 640 & 653

# Science

510  
6 NOVEMBER 2015  
science.org

AAAS

## *MAVEN at Mars*

Probing a dynamic upper atmosphere p. 643





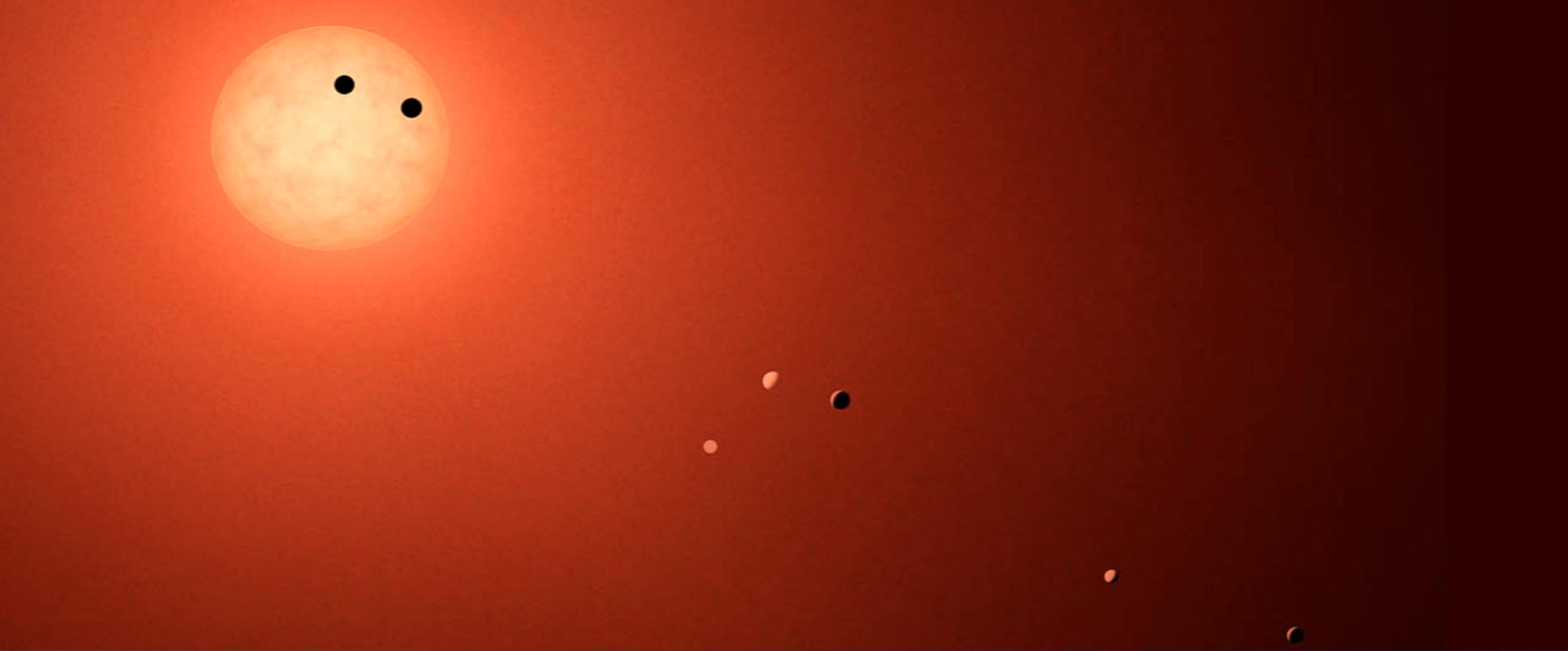
Magnetic activity can redefine habitability!



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!**



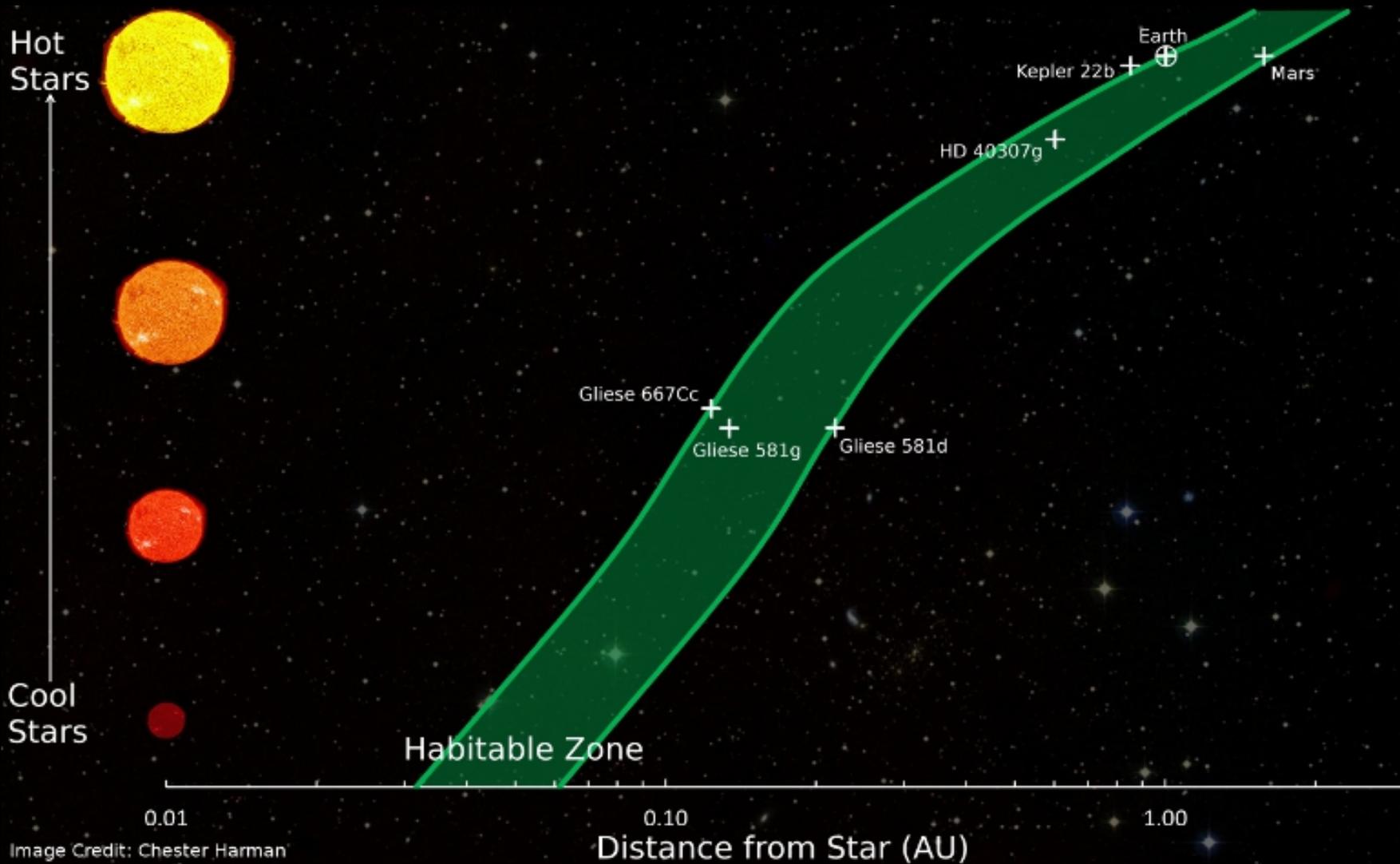
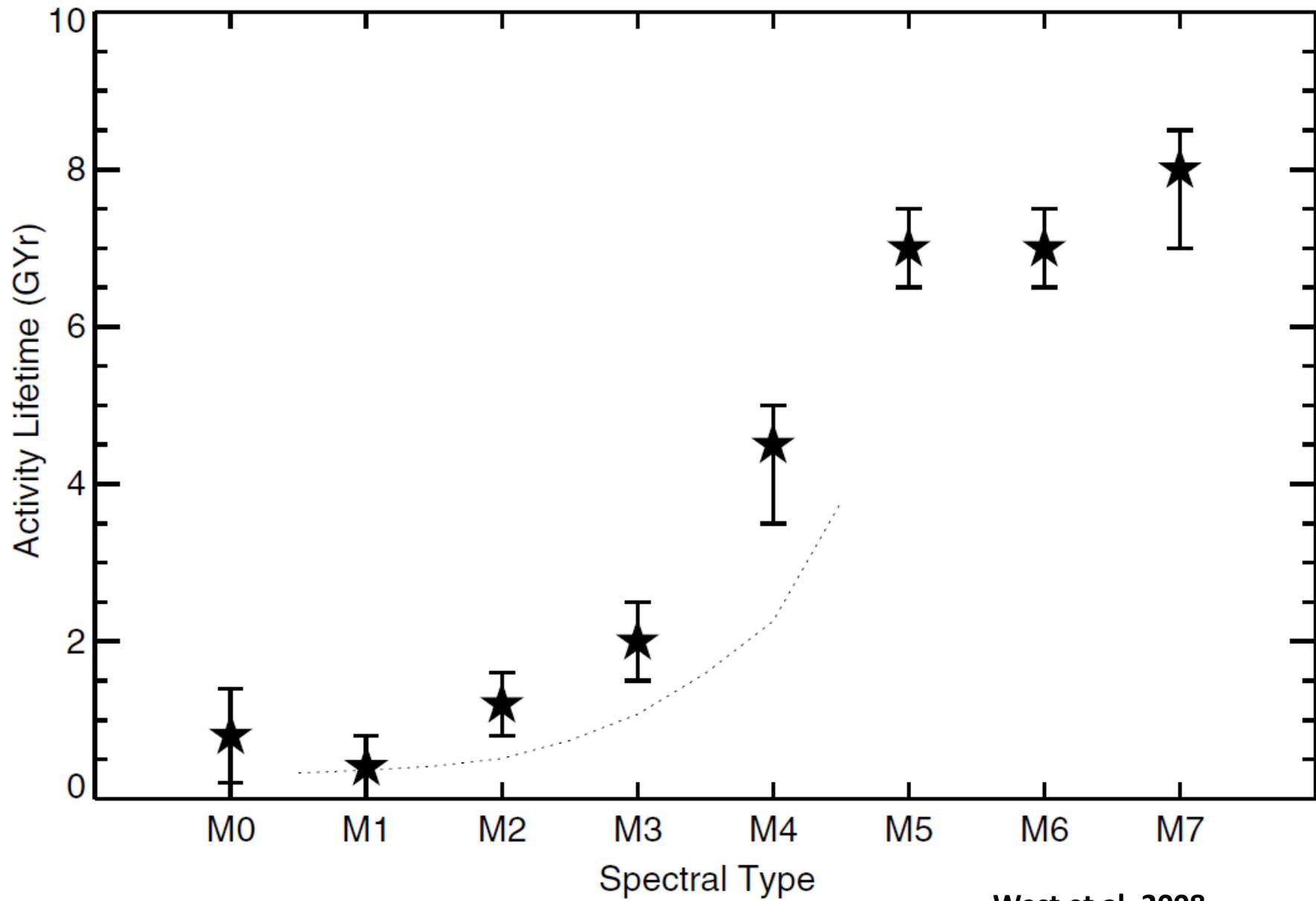


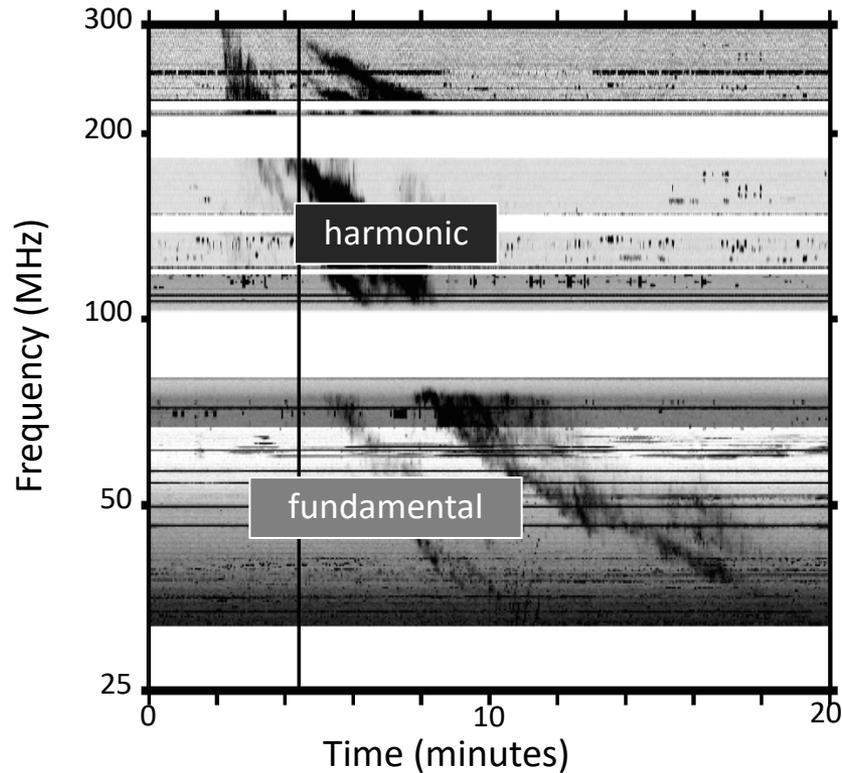
Image Credit: Chester Harman



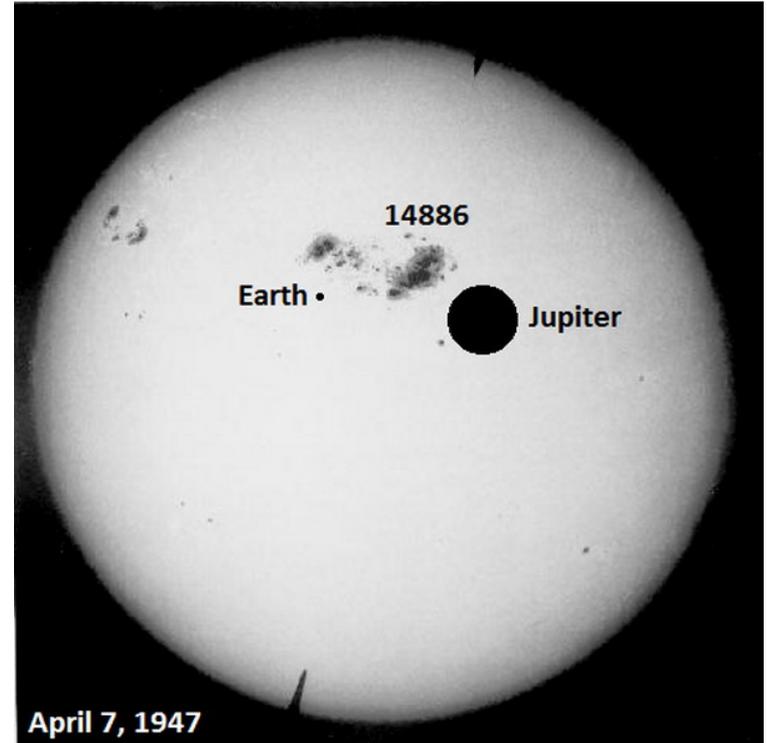
West et al. 2008



# 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)**

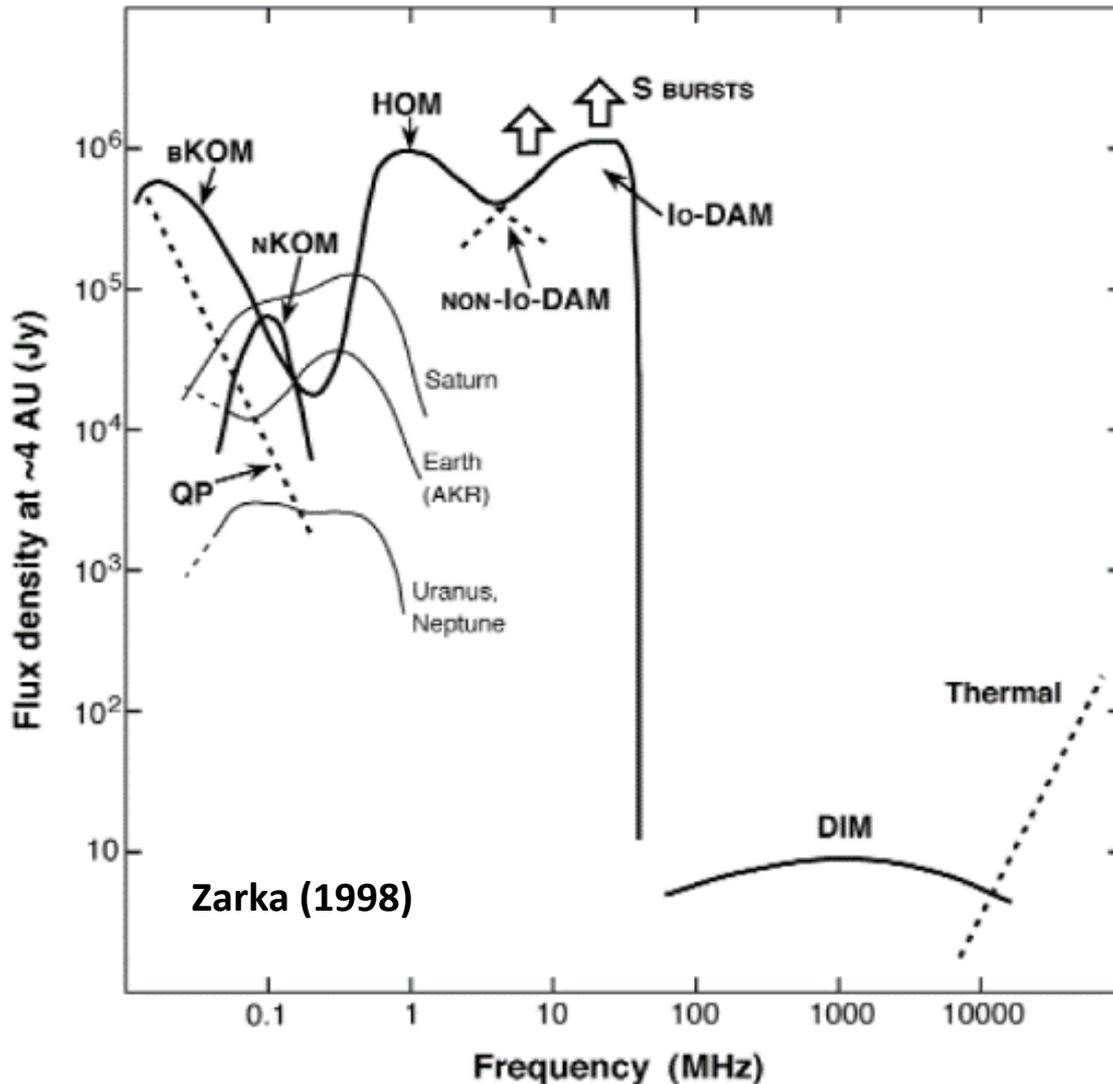
**Giant Type II burst detected in 1947 –  $10^{11}$  Jy brightest ever extra-terrestrial radio emission**

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

# Radio Emission from Solar System Planets

*Voyagers*: Opens up field

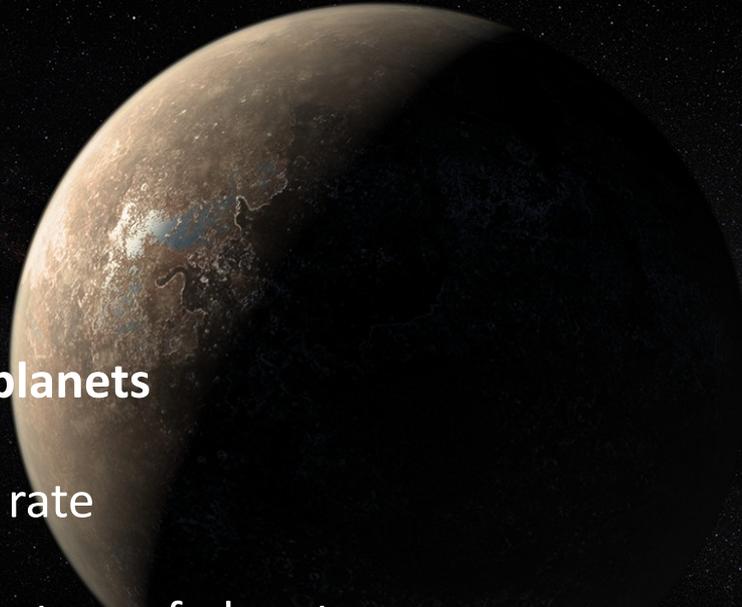
All gas giants and Earth have strong auroral radio emission



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

Jupiter at 5pc ~20  $\mu\text{Jy}$   
10% of the time – 0.2 mJy  
1% of the time – 2 mJy

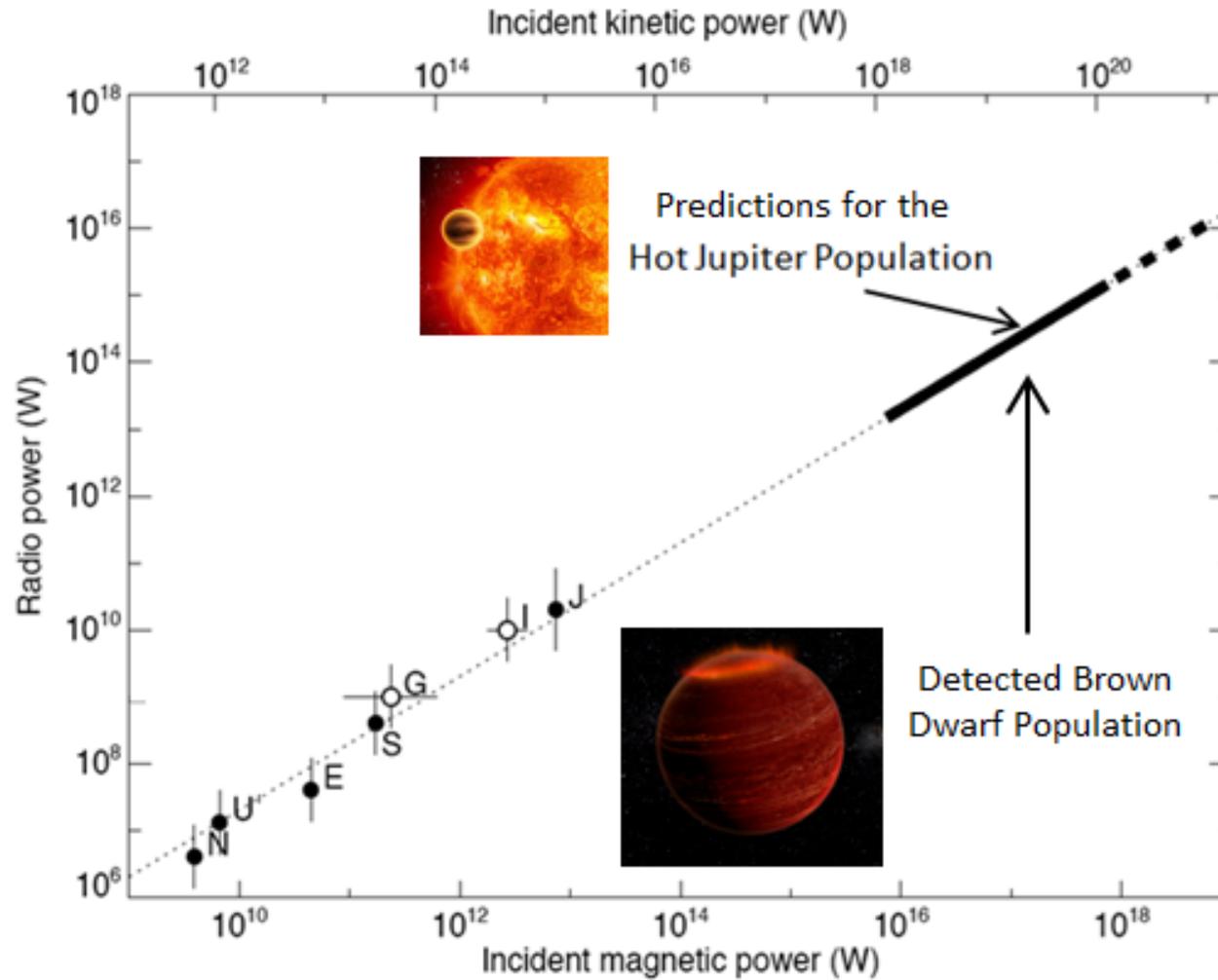
# Can we detect similar emissions from extrasolar planets?



- **Measure magnetic fields of exoplanets**
- Allows measurement of rotation rate
- Provides insight into internal structure of planet

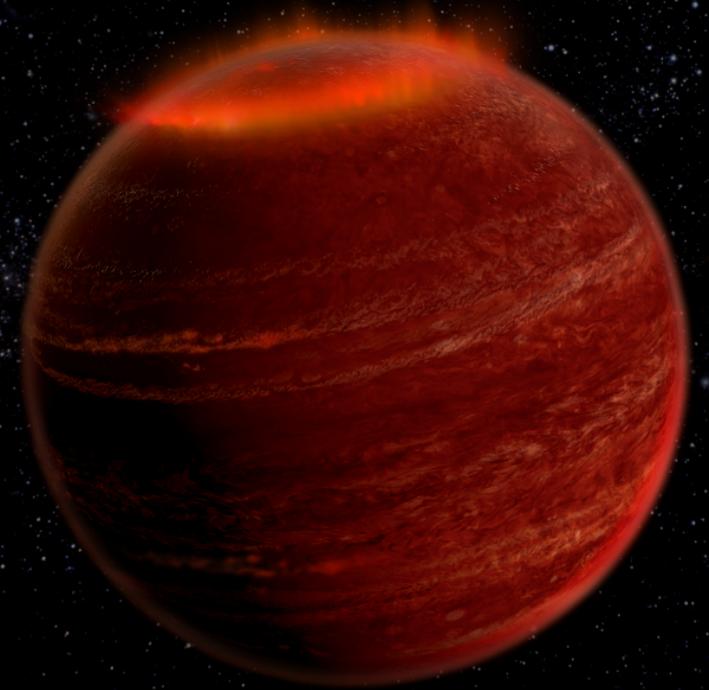
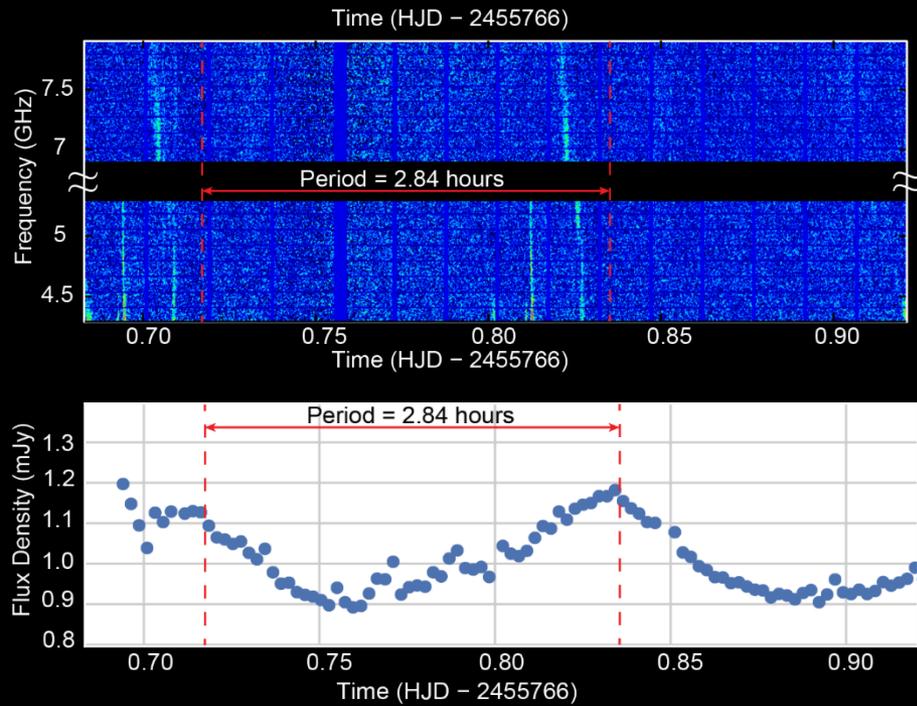
**Space-based observations will be crucial – particularly from the lunar far side**

# Radiometric Bode's Law



Adapted from Zarka (2007)

# Brown Dwarf Aurorae



Extensive program with VLA, Keck and HST

Hallinan et al. 2015, *Nature*, 523, 568

Kao et al. 2016, *ApJ*, 818, 24

Pineda et al. 2016 *ApJ*, 826, 73

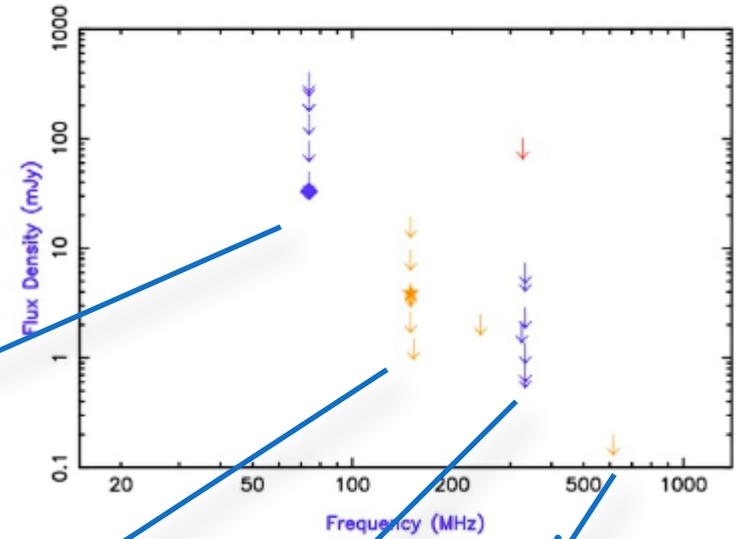
Kao et al. 2017a *ApJ* submitted

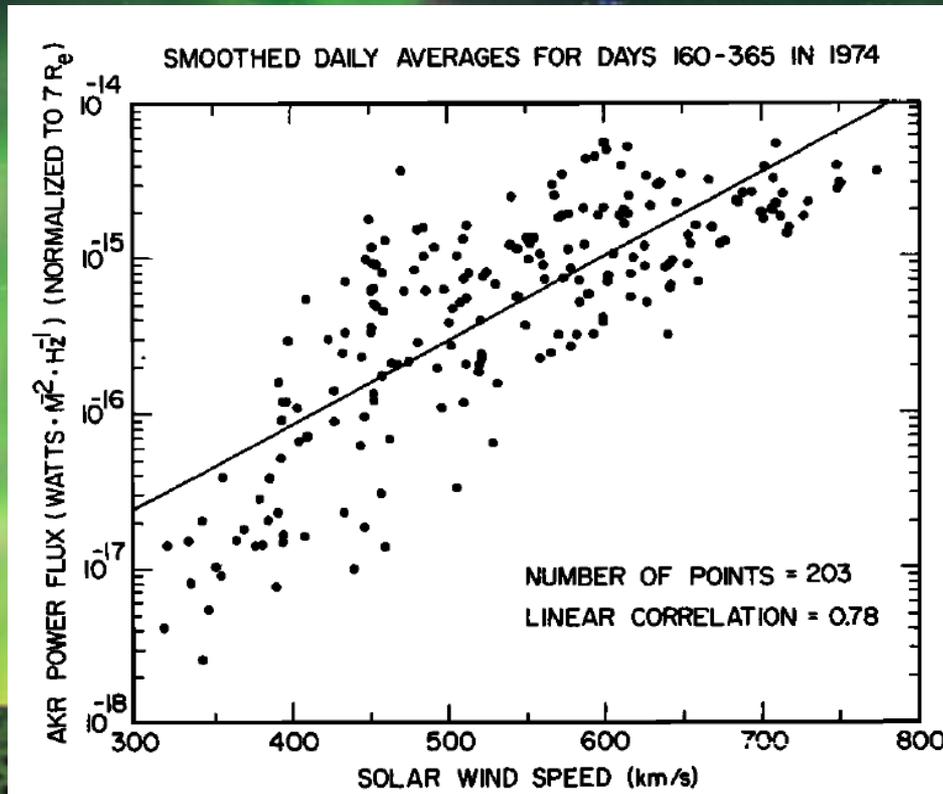
Kao et al. 2017b *ApJ* submitted

Pineda et al. 2017 *ApJ* submitted

# 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



# Concept

**25-85 MHz (2400 channels)**

**352 antennas across ~2.6 km (5 arcminute resolution)**

**Full cross-correlation = All-sky FOV**

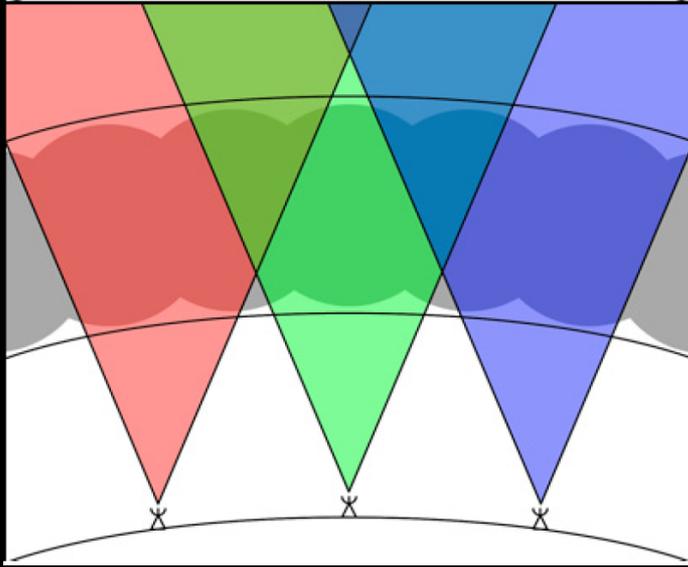
**Exquisite polarized imaging**



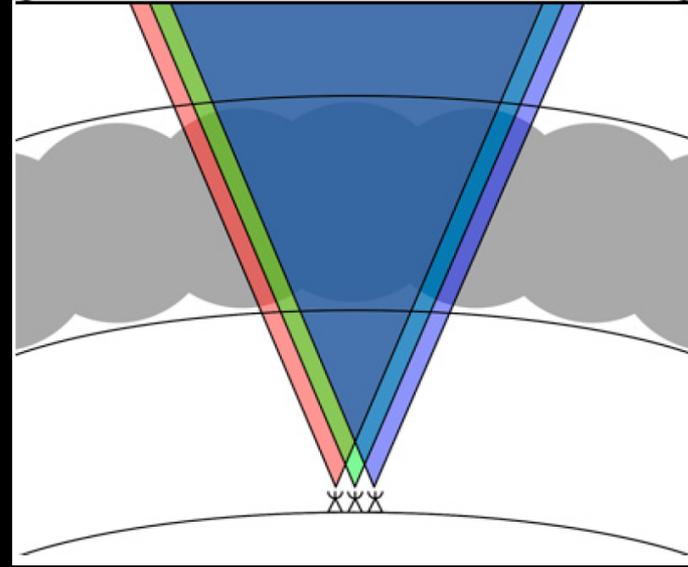
# Collaboration

- **Caltech, OVRO & JPL:**
- Gregg Hallinan, Michael Eastwood, Marin Anderson, Ryan Monroe, Harish Vedantham, Jonathon Kocz, Sandy Weinreb, Esayas Shume, Kate Clark
- David Woody, James Lamb + OVRO staff
- Joe Lazio, Dayton Jones, Larry D'Addario, Dave Hawkins, Attila Komjathy, Melissa Soriano, Andrew Romero-Wolf, Paul Ries
- **LWA Collaboration:** Greg Taylor, Joe Craig, Namir Kassim, Brian Hicks, Frank Schinzel, Steve Ellingson et al.
- **LEDA Collaboration:** Lincoln Greenhill, Danny Price, Ben Barsdell, Hugh Garsden, Frank Schinzel, Greg Taylor, Dan Werthimer, Steve Ellingson et al.
- **NJIT Solar:** Dale Gary, Bin Chen, Sijie Yu, Sherry Chhabra

# Avoiding the Ionospheric Problem



Baselines  $\gg$  10 km



Baselines  $<$  10 km

# Science with All-sky FoV

**Transients  
(Stellar CMES and  
Extrasolar Planets)**

**Cosmic Dawn**

**Monitoring of the Sun  
and Jovian System**

**Characterization  
of the Ionosphere**