Exoplanetary radio emissions: a future observation method

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Definitions

Extrasolar planets

extrasolar: outside the solar system

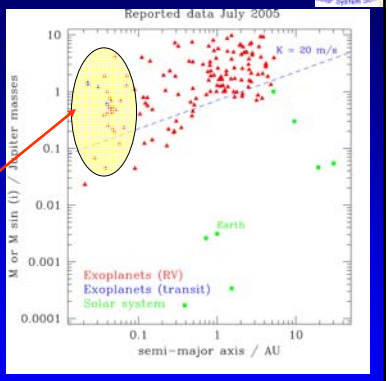
planet: object with $M \leq 13\,M_{Jup}$
(no nuclear fusion)
around star (or stellar remnant)

star: object with $M \geq 80\,M_{Jup}$
(nuclear fusion of hydrogen)

Orbital radii

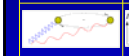
Total:
169 planets
(03.11.2005)
[http://www.obspm.fr/encycl/encycl.html]

"Hot Jupiters":
40 planets
with d<0.1 AU



[http://jilawww.colorado.edu/~pja/planets/extrasolar.html]

Exoplanets: Observations

Doppler shift	Transit	Astro-metry	Micro-lensing	Direct obs.	Second. Transit
					
1995 (51 Peg b)	2000 (HD209458b)	2002 (Gl 876 b)	2003 (O235/M53)	2004 (2M1207)	2004 (HD209458b)
>100	9	1	2	0-3	2

Radio emission as additional source of information?

Radio search motivation

Why to search for planetary radio emission?

- good intensity ratio ⇒ detection technique
- modulation ⇒ planetary rotation
- cutoff-frequency ⇒ magnetic field

Best candidates

Where to search for planetary radio emission?

- systems close to solar system
- large planets (magn. moment)
- close-in planets (Hot Jupiters)
- young systems

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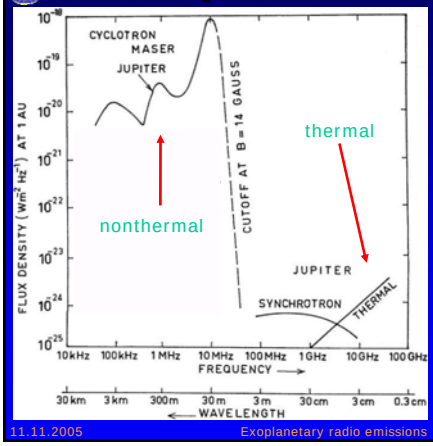
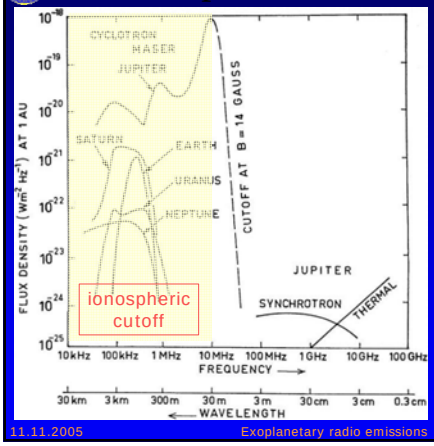
Radioplanets: Solar system



flux normalized to 1 AU

[adapted from Bastian, Dulk and Leblanc, ApJ, **545**, 1058, (2000)]

Radioplanets: Solar system



Jupiter: strong magnetic moment

⇓

emission above ionospheric cutoff

flux normalized to 1 AU

[adapted from Bastian, Dulk and Leblanc, ApJ, **545**, 1058, (2000)]

Magnetic moments: Scalings

require cutoff frequency > 10 MHz

$f_c \propto \frac{eB_p}{m_e}$ ⇒ requires large magnetic field

$B_p \propto \frac{\mathcal{M}}{R_p^3}$ ⇒ req. large magnetic moment

theoretical models e.g. $\mathcal{M} \propto \rho^{1/2} \omega_r^{7/2}$

density rotation size

Best candidates

Where to search for planetary radio emission?

- systems close to solar system
- large planets (magn. moment)
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- young systems

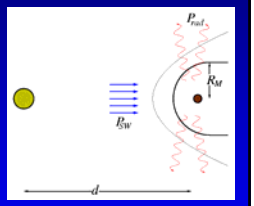
Planetary radio emissions

Emitted radio power: $P_{rad} \propto P_{input}$

[Zarka et al, Astrophys. Space Sci., **277**, 293, 2001]

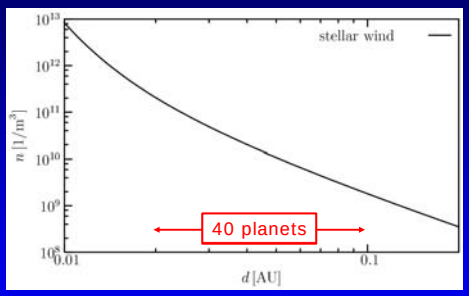
Power input (solar wind): $P_{input} \propto nv^3 R_M^2$

[Farrell et al, JGR, **104**, 14025, 1999]



dense and fast stellar wind
⇒ strong radio emission

Stellar wind: Parker model



dependence of stellar wind density on orbital distance

Best candidates

Where to search for planetary radio emission?

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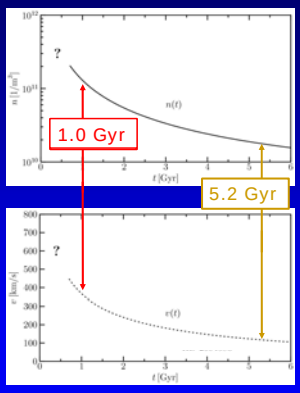
- young systems

Stellar wind evolution



strong age dependence of stellar wind density and velocity

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age dependent energy input

Best candidates

Where to search for planetary radio emission?

- systems close to solar system
- close-in planets (Hot Jupiters)
- large planets (magn. moment)
- young systems

Candidates?

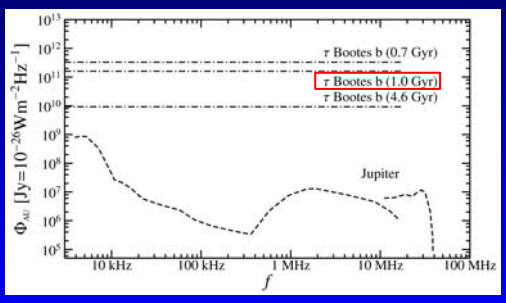
Best candidates

τ Bootes b = a good candidate!

- systems close to solar system 15.6 pc
- close-in planets (Hot Jupiters) 0.05 AU
- large planets (magn. moment) 2.7 M_J
- young systems 1 Gyr

Candidate planet: tau Bootes

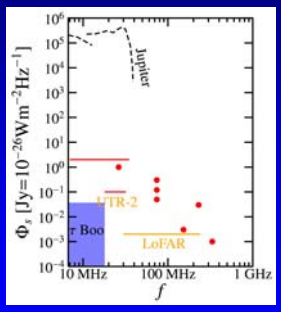
Flux normalized to 1 AU



strong age dependence of stellar wind parameters ⇒ varying radio emission levels

Radioplanets: Detection

Flux reaching Earth



Non-detections (1977-2005): sensitivity not sufficient too high frequency

UTR-2: improved sensitivity at 10-35 MHz ready 2006?

LoFAR: sensitivity 0.3-1.0 mJy at 30-240 MHz ready 2006/08?

Summary

- Why to search for planetary radio emission?
- Where to search for planetary radio emission?
- τ Bootes b as a promising candidate
- Comparison to detection limits