Vector Antenna Array Configurations for Advanced Synthesis Imaging on the Moon

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My diploma thesis

Started my work this semester

Will probably finish it in January 2007

Objectives of my work

- The concept of interferometry
- Spatial methods for signal processing
- Applications for low frequency arrays

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Scientific objectives

- **Neutrino Detection**

  Possible neutrino detection?

  Cherenkov radiation

- **Extrasolar Planet Detection**

  Direct detection of extrasolar planets possible

  More information available then prior methods

- **Low frequency solar emission**
- **Radio galaxies, extragalactic sources**
- **Probing the interstellar medium**

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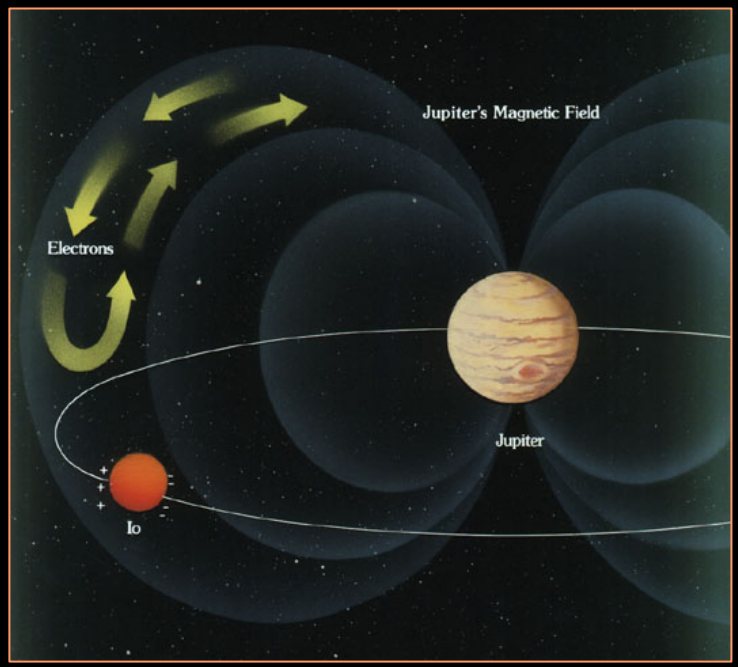
Nonthermal Cyclotron Radio Emission



- All planets in our solar system with magnetic field emit radio waves

  Earth – liquid iron
  Jupiter, Saturn – metallic hydrogen
  Uranus, Neptune – salty ocean

- Driven by interaction between the solar wind and the magnetosphere

- Io-induced radio emission

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The Radiometric Bode's Law

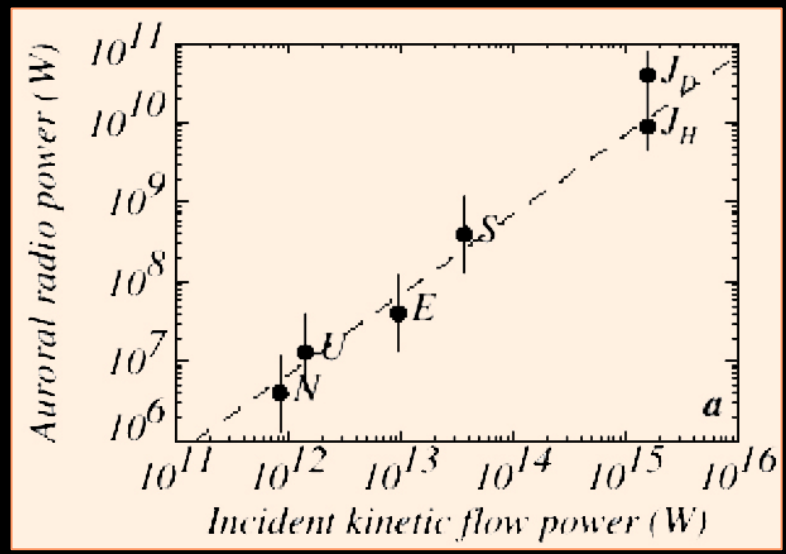
- Coupling between the solar wind and the planet's magnetic field

$$P_{rad} \approx \varepsilon P_{sw}^{x}$$

$\varepsilon \sim 10^{-5}$ to 10^{-6}, $x \approx 1$

- Characteristic emission frequency related to the planetary magnetic dipole moment

$$f_c \sim 23.5 MHz \left(\frac{\omega}{\omega_J}\right)\left(\frac{M}{M_J}\right)^{5/3} R_J^3$$



Known extrasolar planets should emit in frequencies 10-1000 MHz

Flux densities as large as 1 mJy

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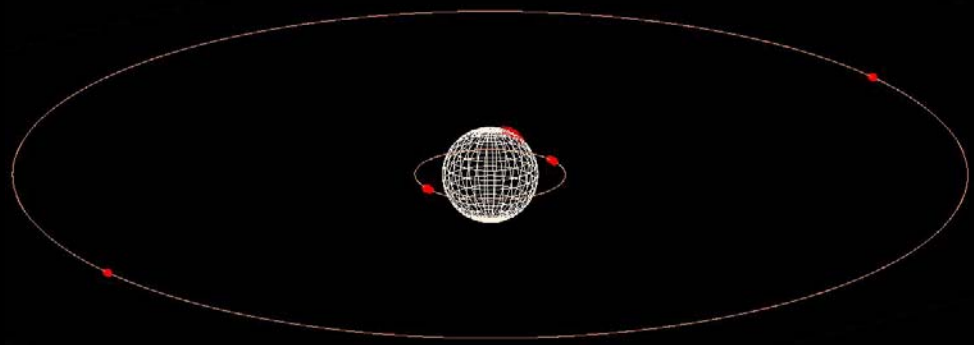
Sensitivity and Resolution

- Dense array located on the ground → improved sensitivity
- Stations in orbits for longer baseline → high angular resolution

D_{max} = 23476 km ⇒ 0.26 arcsec

Antenna Array Configuration



f_c [MHz]	λ [m]	Δf [MHz]	A_{em} [m²]	T_{sky} [K]	$\Delta S_{N=100}$ [Jy]	$\Delta S_{N=1000}$ [mJy]
5	60	2	900	2 053 000	0.33	32.8
10	30	3	225	351 000	0.18	18.3
15	20	5	100	125 000	0.11	11.3
20	15	7	56	60 000	0.08	8.2
25	12	9	36	34 000	0.06	6.4

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Sensitivity and Resolution

Improving Sensitivity

- More antennas
- Longer integration time
- Dual polarization data
- Averaging

$$\Delta S = \frac{2T_{sys}k_b}{A_{em}\sqrt{N(N-1)\Delta f \Delta t}}$$

$$\Delta I = \frac{\Delta S}{\sqrt{2}}$$

$$R \approx \frac{\lambda}{D_{\max}}$$

Higher Angular Resolution

- Longer baseline

$$T_{sky} \sim \lambda^{2.55}$$

$$A_{em} \sim \lambda^{2}$$

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Super Long Baseline Array

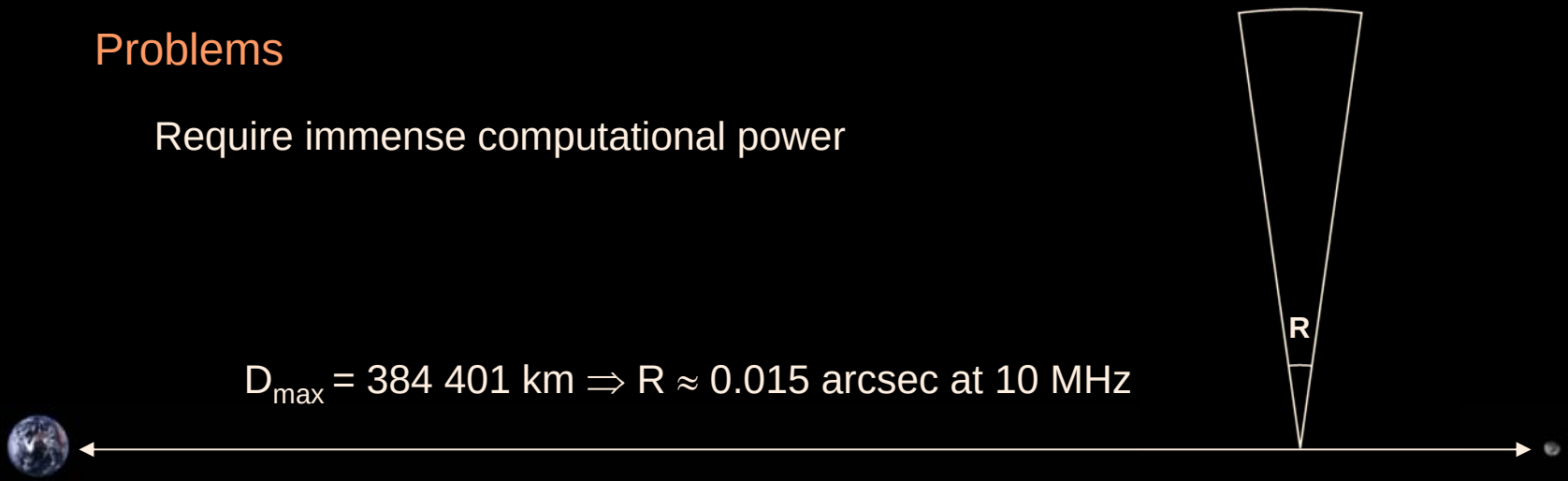
The future for radio astronomy

- Dipole array is easy to expand
- Cost effective

Distance [pc]	Resolution [AU]
10	0.16
100	1.60

Problems

- Require immense computational power



D_{max} = 384 401 km $\Rightarrow$ R $\approx$ 0.015 arcsec at 10 MHz

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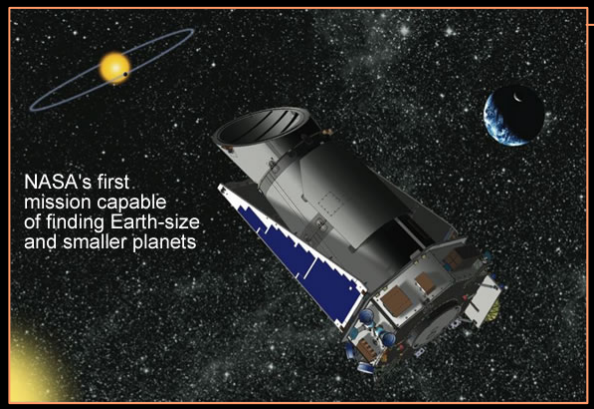
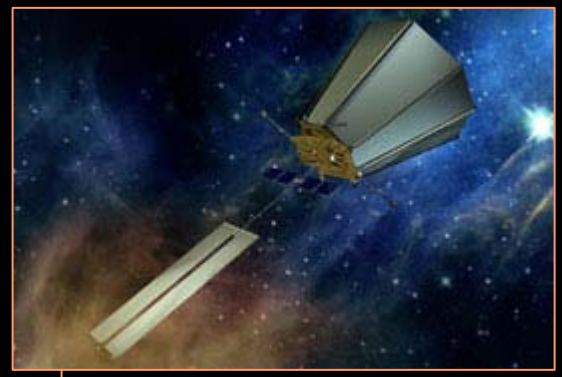
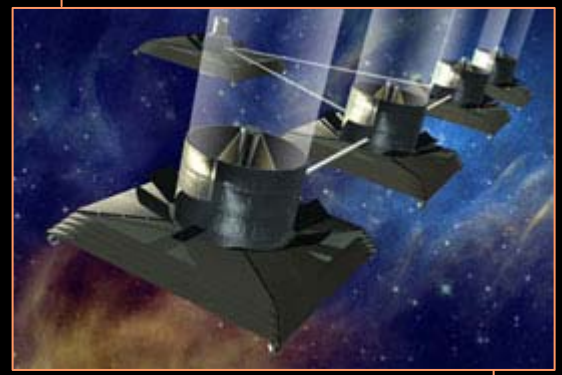
The Future of Extrasolar Planet Searches

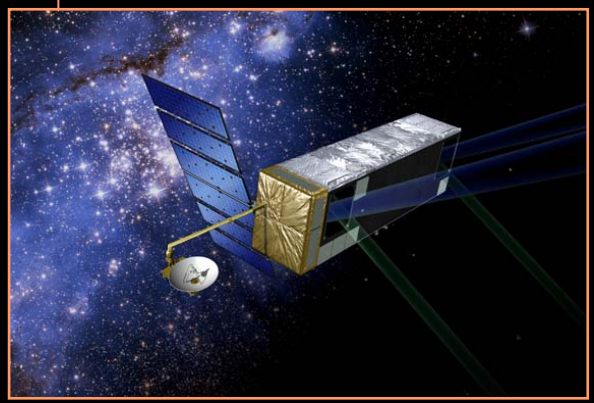


Kepler Mission
- Launch 2008
- Transits
- Earth Mass
- $ 467 000 000



SIM
- Launch 2015
- Astrometry
- Earth Mass
- >$300 000 000





TPF
- Launch 2014/2020
- Direct Imaging
- Mars Mass
- $2-4 000 000 000

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Thank you for listening

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