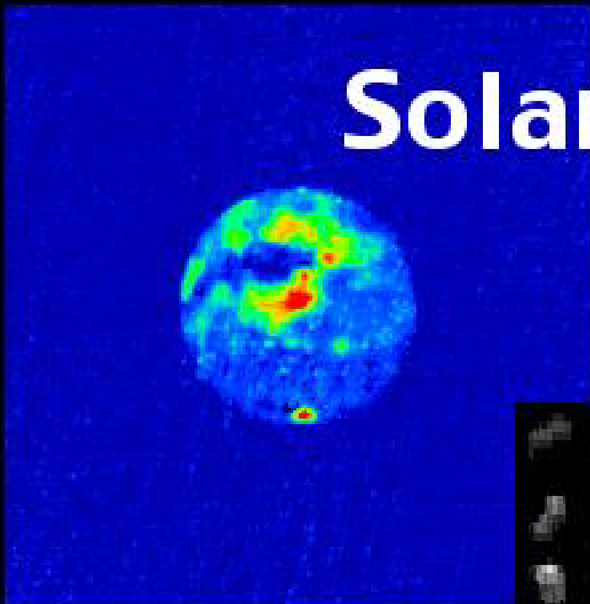
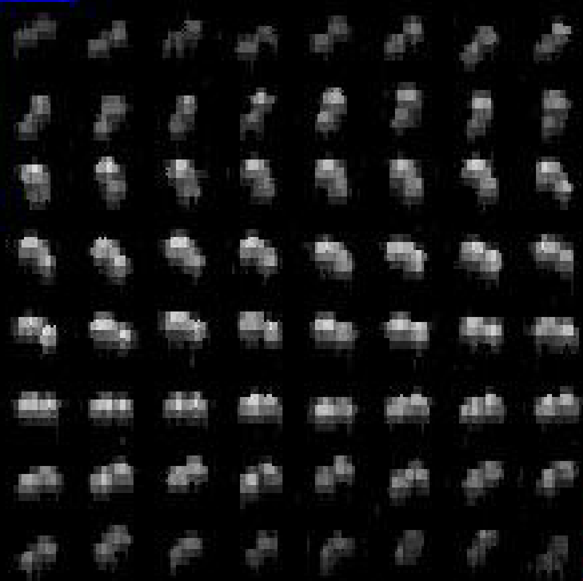
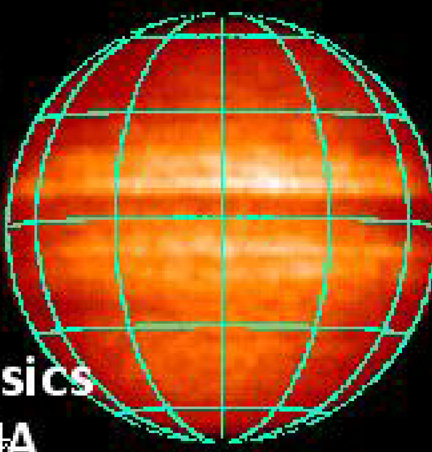
Solar System Science

The Impact of the SKA







Mark Gurwell

Harvard-Smithsonian Center for Astrophysics

SKA Workshop, 3 April 2001, Cambridge, MA

SKA: Solar System Radar Comparison*

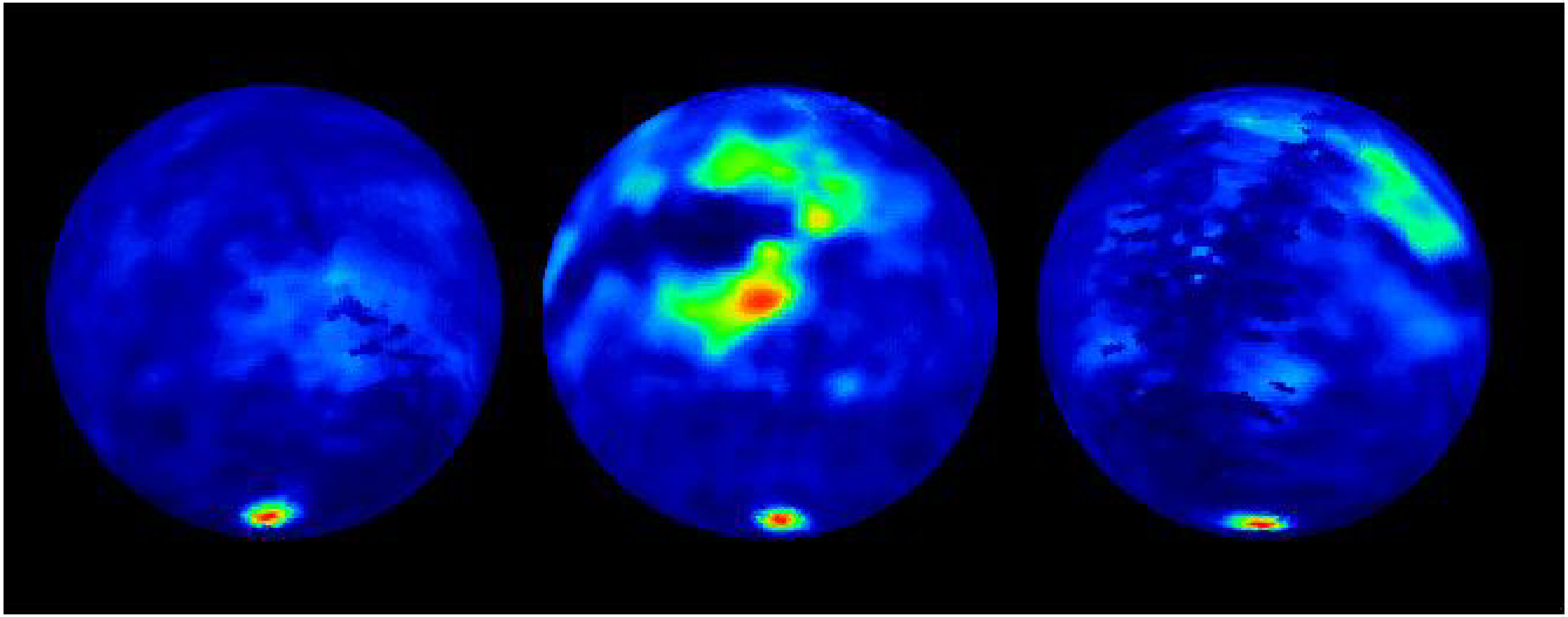
Arecibo is currently the most powerful radar in use
Tranmission capability of 1 megawatts at 12.6 cm

For the SKA:
Sensitivity (assumes Arecibo equivalent transmitter)
at 3 GHz, SKA ~ 25 x Arecibo
at 10 GHz, SKA ~ 150 x Arecibo

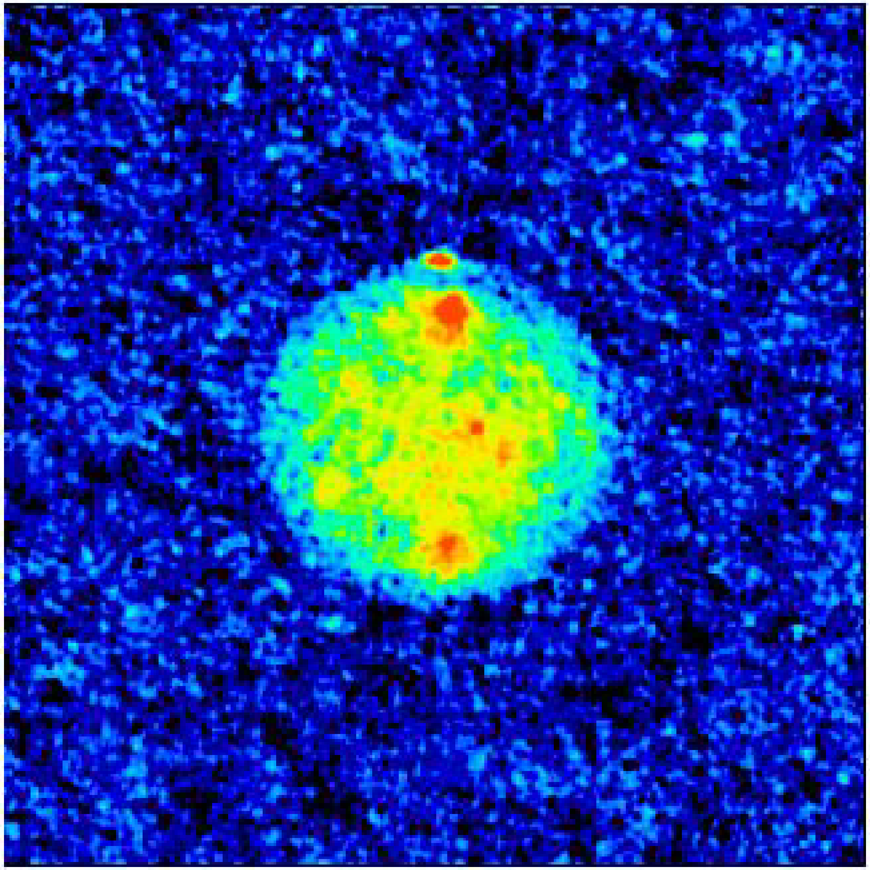
Expanded range allowed (SNR scales as d^{4})
at 3 GHz, detect objects ~2.2 x Arecibo
at 10 GHz, detect objects ~3.5 x Arecibo

Cases: Titan (Arecibo SNR 100; SKA SNR 15000)
Pluto (Arecibo n/a; SKA SNR 16)

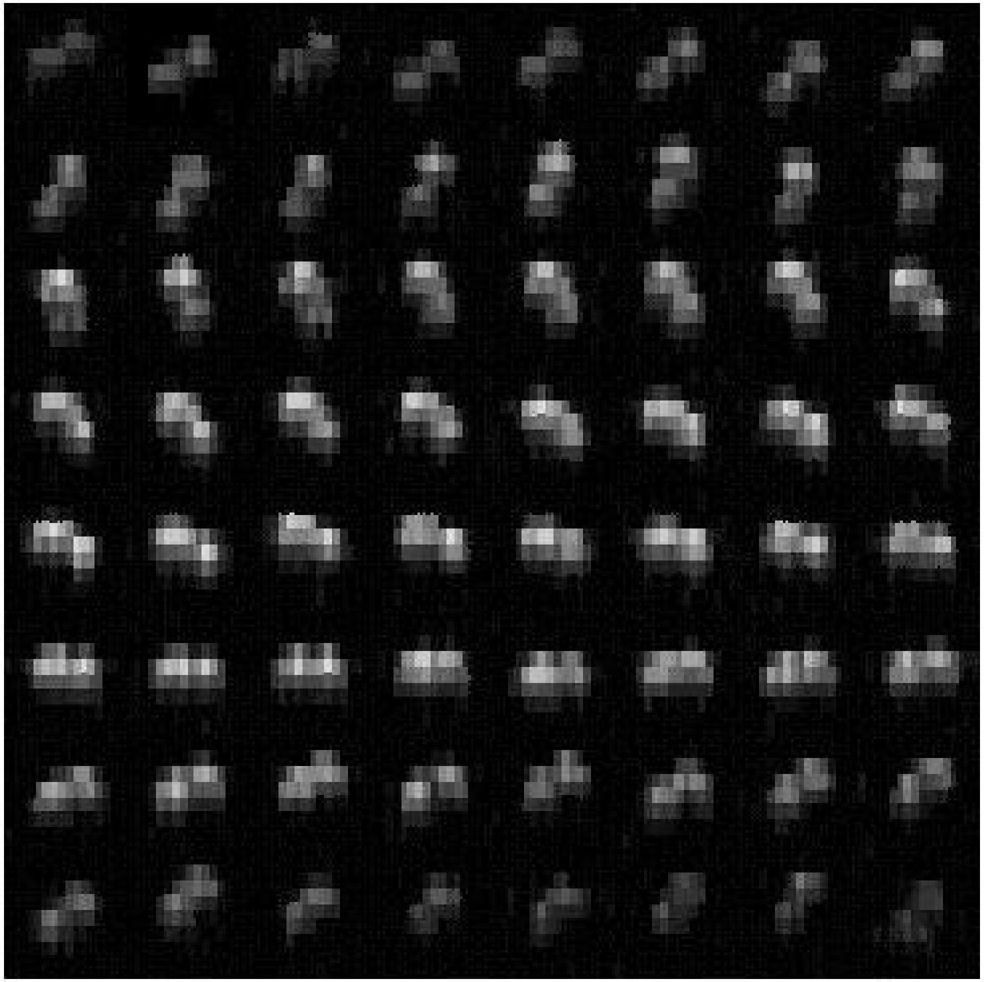
*Based on a presentation last year by Don Campbell, Cornell



Mars model radar reflectivity maps derived from 1988 bistatic radar experiments performed with the VLA/ Goldstone system at 3.5 cm. Red areas indicate regions of high radar reflectivity (from surface composition and/or roughness). The south polar cap is exceptionally strong, and other bright regions are associated with the giant shield volcanoes of the Tharsis ridge and their lava flows. The dark region extending to the west of the Tharsis bulge is a unique region with almost no radar reflectivity, and has been dubbed 'Stealth'. Image courtesy B.J. Butler, NRAO.



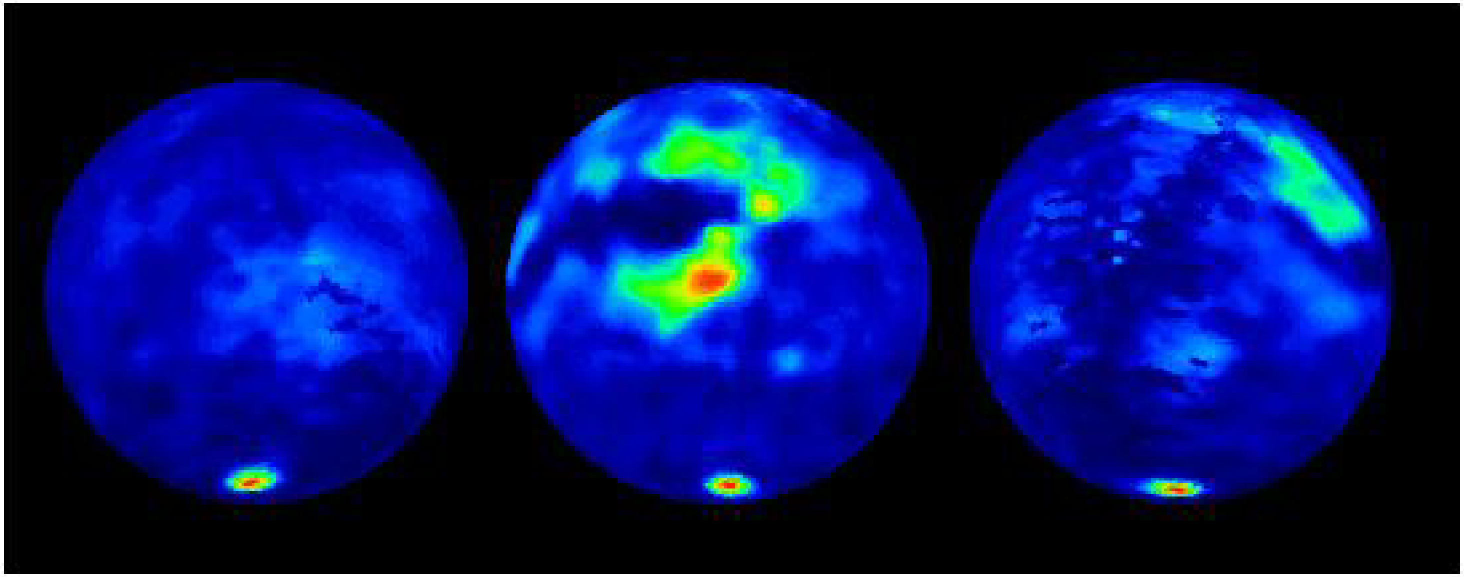
Mercury radar reflectivity map obtained from 1991 bistatic radar experiments performed with the VLA/ Goldstone system at 3.5 cm. Red areas indicate regions of high radar reflectivity (from surface composition and/or roughness). The north polar cap is exceptionally strong and is theorized to be reflection from significant deposits of water ice, hidden from solar illumination in permanently shadowed polar craters. Other bright regions are of unknown origin, since this face of Mercury has never been imaged. Image courtesy B.J. Butler, NRAO.



This series of of delay- doppler radar images of the asteroid 4769 Castalia (also known as 1989 PB) were taken at approximately two-minute intervals on 22 August 1989 at Arecibo Observatory. The high precision of this technique allowed the researchers to obtain a spatial resolution of approximately 150 m (horizontal) by 300 m (vertical) (Ostro et al., 1990, Science 248:1523). Imaged obtained from Mike Nolan, Arecibo Observatory.

Planetary Science with the SKA

- Thermal Studies of Solid Surfaces
- Thermal Studies of Planetary Atmospheres
- Magnetospheric Studies of Jupiter and Environs
- Radar Imaging



Mars radar reflectivity model maps courtesy Bryan J. Butler (NRAO)

SKA Specifications in Solar System Units*

	2 GHz	20 GHz
Angular Resolution (mas)	70	7
Linear Resolution (km at Δ AU)	50Δ	5Δ
Thermal Sensitivity (K hr $^{-1/2}$)	1.4	1.2
Sample Resolution (km)		
Mars	25	2.5
Asteroid Belt	120	12
Galilean Satellites	210	21

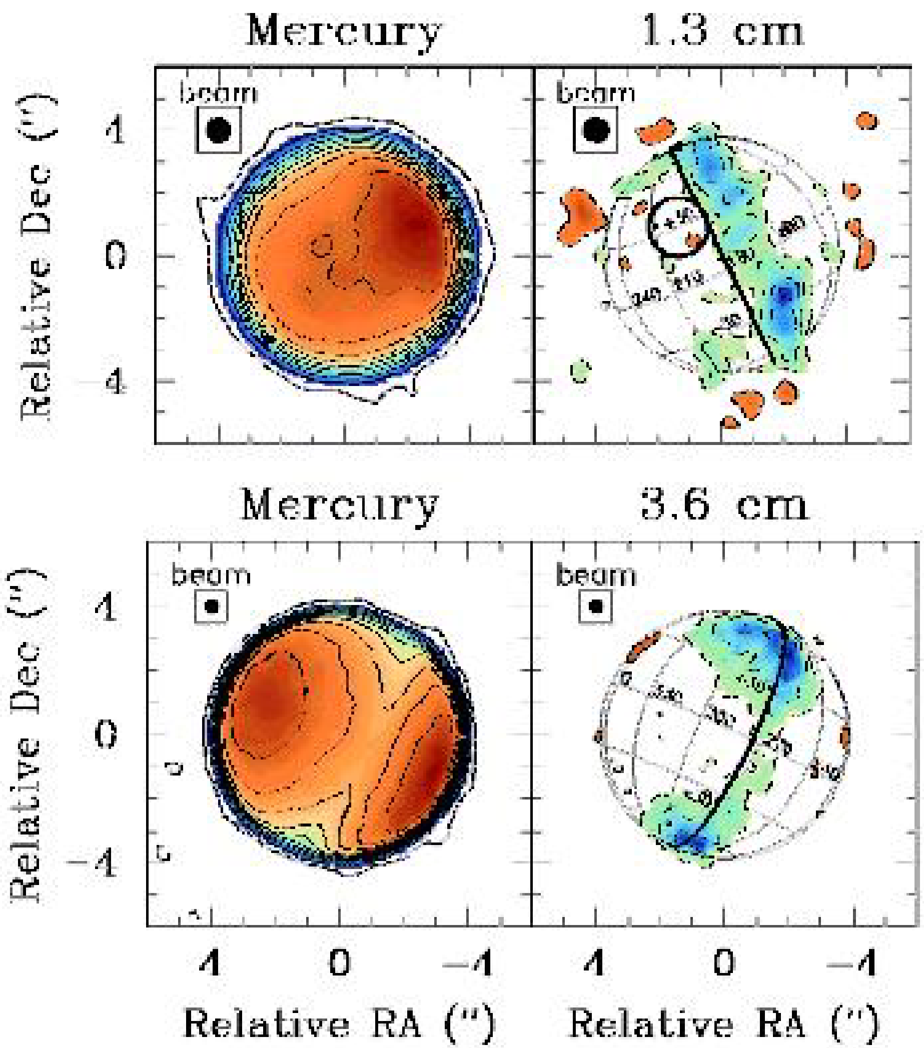
*adapted from Table 4.1 in "Science with the Square Kilometre Array" (1999, Taylor and Braun, eds.) and from a table by Lynn Carter, Cornell

SKA: Thermal Studies of Solid Surfaces

Different wavelengths emerge from different depths
(typical skin depth is ~ 10 λ)

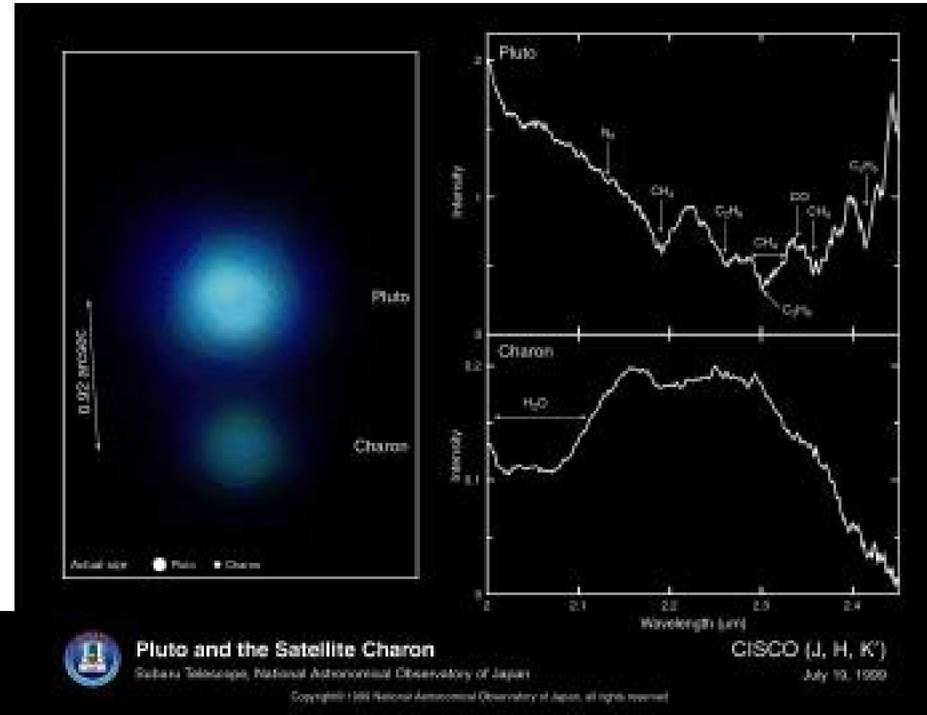
Comparison of data with models provides information on surface temperature and temperature at depth, dielectric constant and thermal inertia, particle sizes

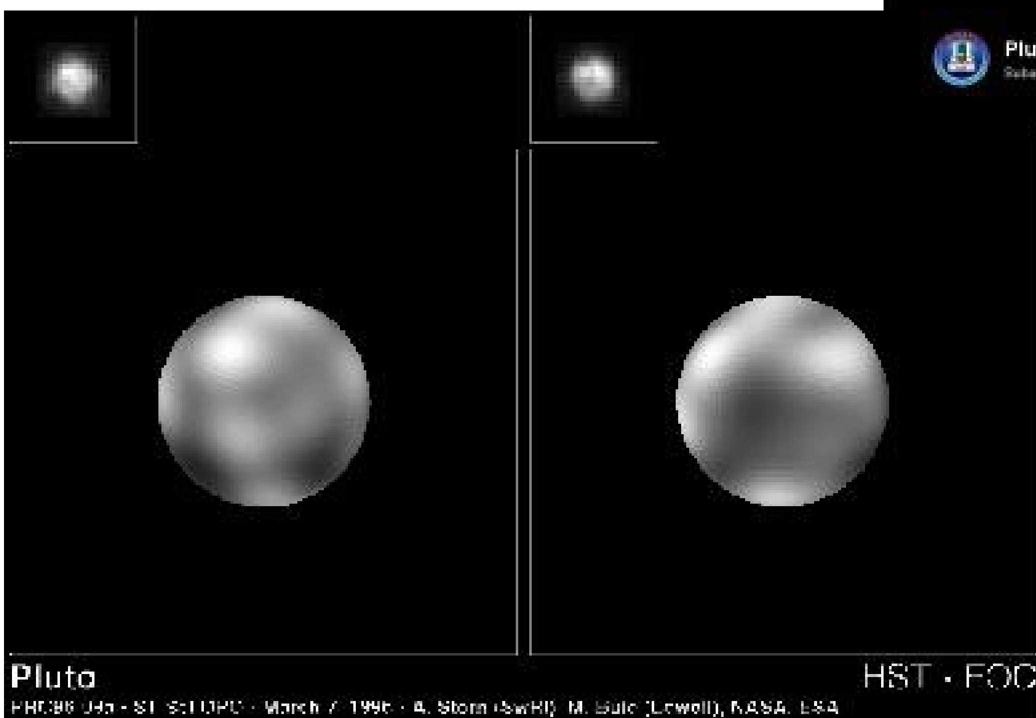
Targets:
- Terrestrial Planets
- Planetary Satellites
- Asteroids (including Near Earth Objects)
- Cometary Nuclei
- Kuiper Belt Objects (KBOs)



Near surface thermal emission from Mercury imaged with the VLA. Mitchell and de Pater, Icarus 110, 1994.

Pluto and Charon show different near-IR spectra, and likely have different microwave temperatures



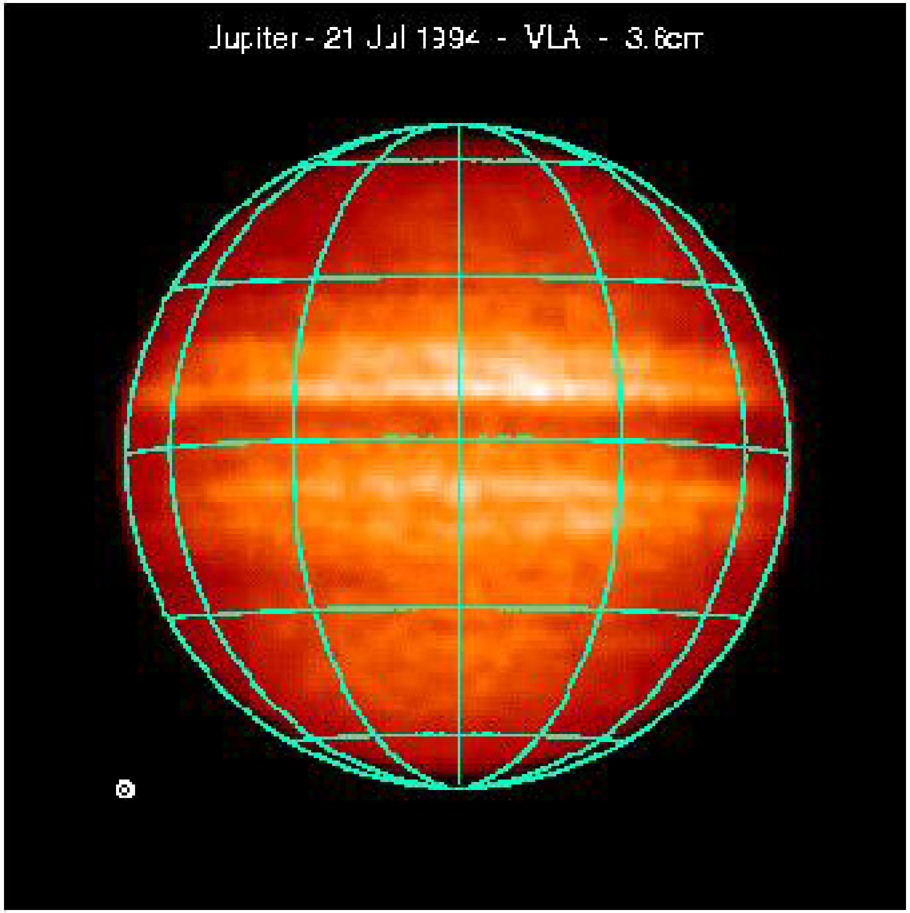


At its highest frequencies, the SKA will have both the resolution and sensitivity to image the thermal emission across the surfaces of Pluto and Charon
(~100 and 50 mas diameter)

SKA: Thermal Studies of Atmospheres

Thermal emission from gas giants governed by local thermal profile, ammonia abundance, and distribution, which are related to vertical transport and global circulation.

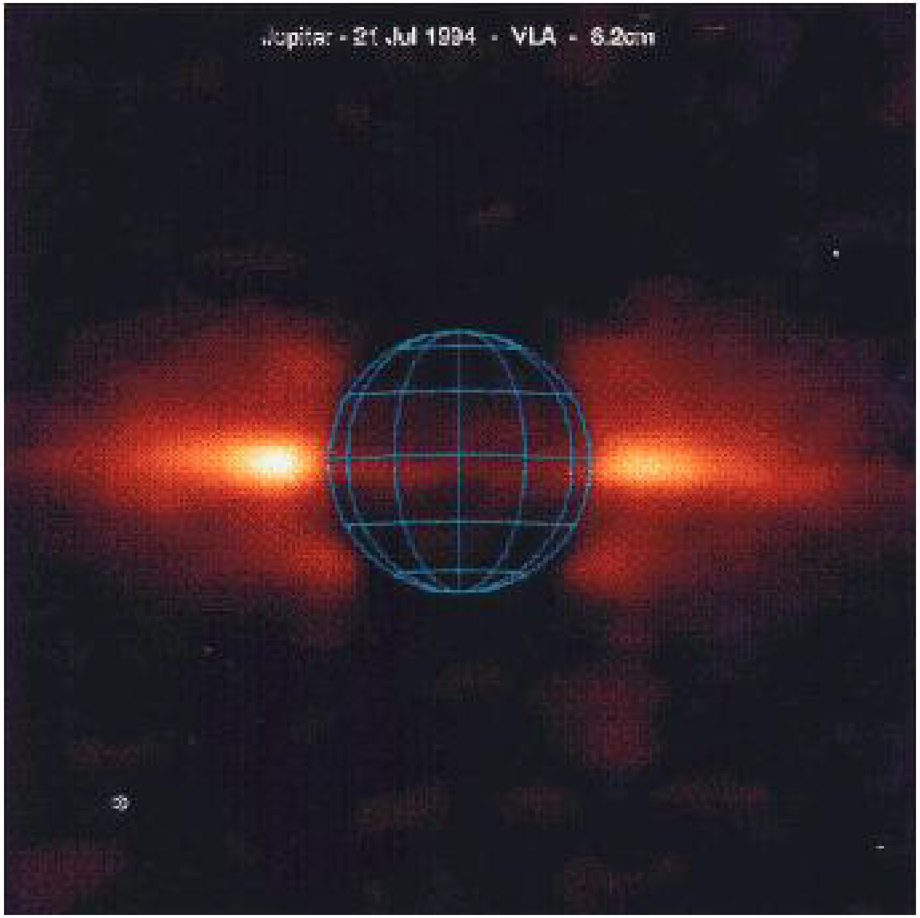
Spectral line studies (OH, H_2O, CH_3OH) from cometary comae will also be of great interest.



VLA Image obtained during impact of Comet SL/9. Courtesy A.W. Grossman

SKA: Magnetospheric Studies of Jupiter

Synchotron emission is detected longward of 2cm from high energy electrons in a Jovian Van Allen Belt. Studies of variability with time could provide a strong handle on physical processes active in Jupiter's magneto-sphere, such as dust-electron interaction.



VLA Image obtained during impact of Comet SL/9. Courtesy A.W. Grossman

SKA: Solar System Radar Experiments

Radar is a truly unique remote sensing technique; its astronomical application is limited to the solar system

SNR dependence scales as d^{-4}

Current Radar Programs:

- Arecibo and Goldstone (delay-doppler technique)
- Goldstone/VLA (bistatic radar tranmitter-imager)

Major Targets of Interest:

- Terrestrial Planet Surfaces (Mercury, Mars, Venus)
- Outer Planet Satellites (Galilean Satellites, Titan)
- Asteroids
- Cometary Nuclei
- Pluto