“Polarimetry of Solar System objects”

4: Polarimetry of planets and satellites

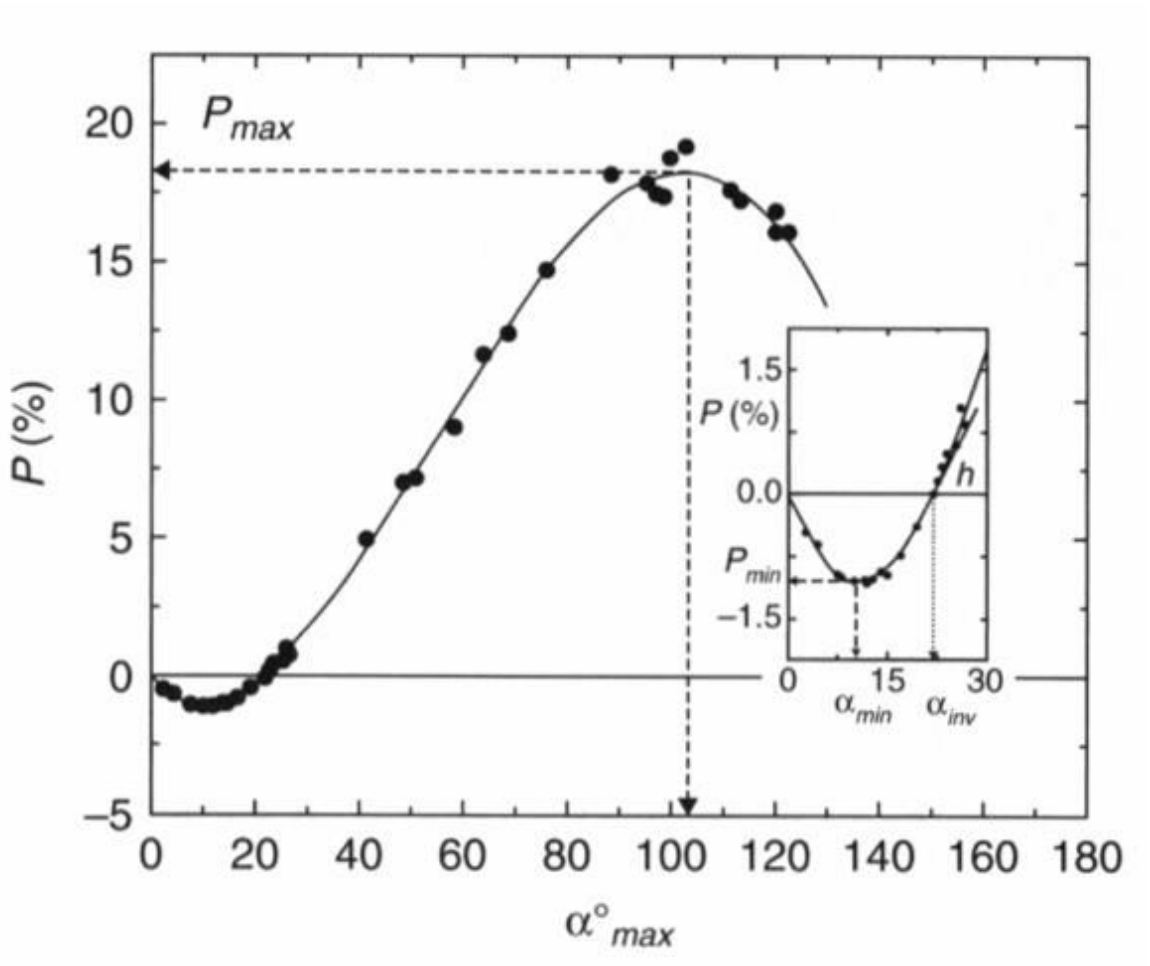
R. Gil-Hutton

Planetary Science Group, FCEFN, UNSJ - CONICET

Polarimetry of the Moon

- Arago observe the Moon using polarimetry in 1858.
- Imaging polarimetry has been carried out since the 1970s.
- Usually, only I and Q are used to characterize the lunar surface.
- These Stokes parameters strongly depend on phase angle and wavelength.
- Polarimetry of the Moon has never been conducted from lunar orbit.
- Today, the Moon is a laboratory to test scattering theories.

Polarimetry of the Moon



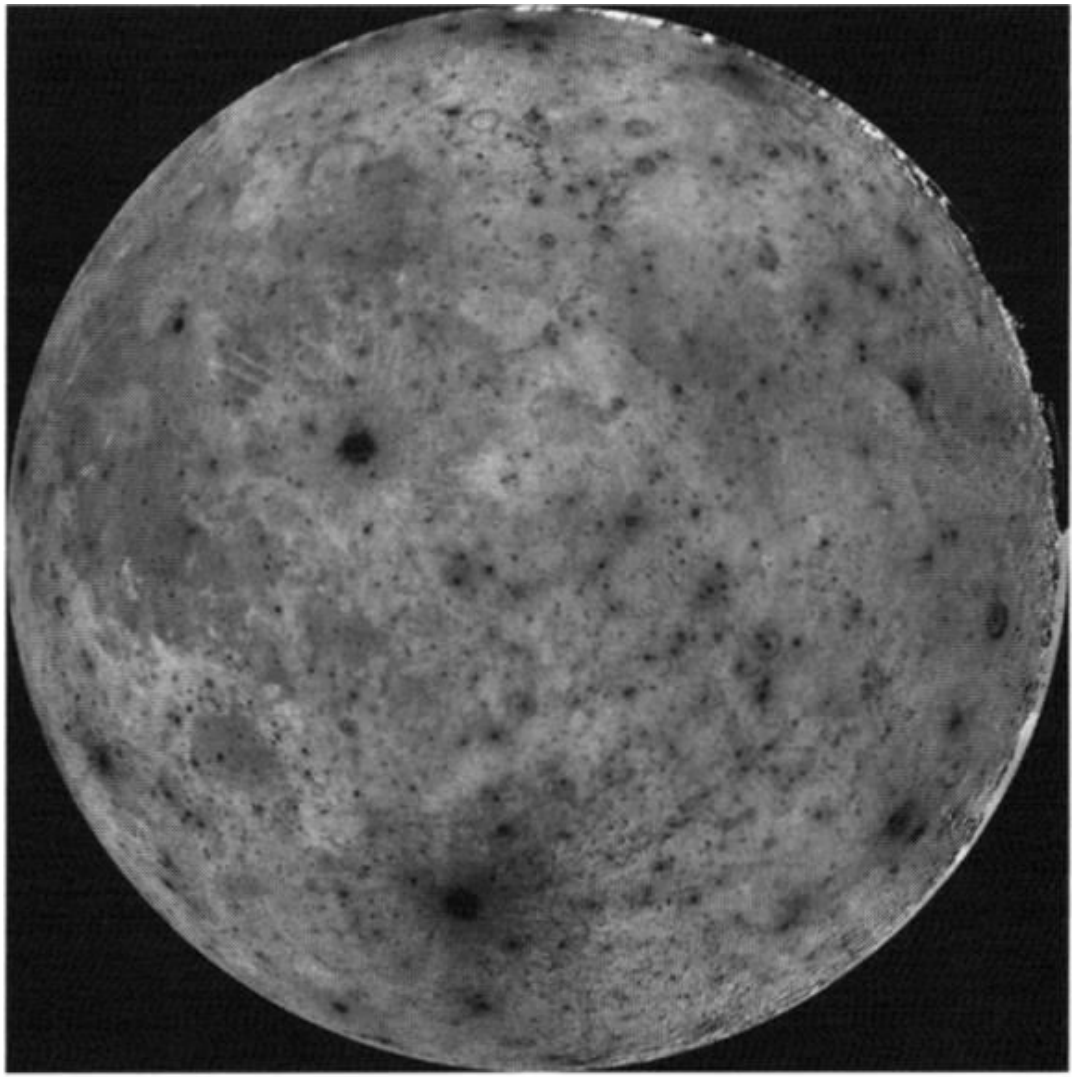
Luna-16 landing site

P_{min} = -1.1%
α_{min} = 11°
α_0 = 23°
h = 0.14 %/degree
P_{max} = 18%
α_{max} = 105°

λ= 430 nm

Kvaratskhelia (1988)

Polarimetry of the Moon

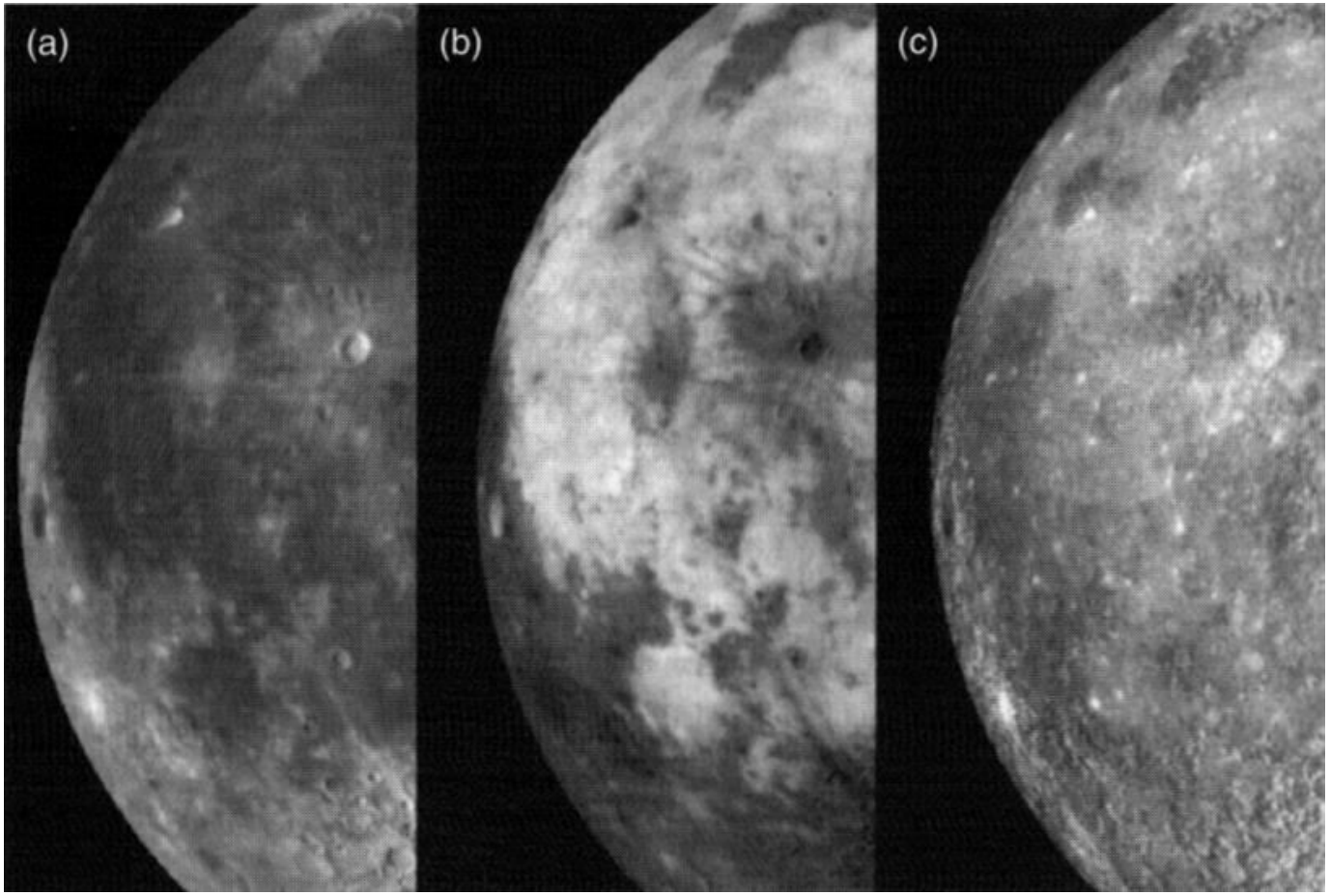


Mosaic of polarization near
P_{min} at
λ= 550 nm

|P| ~ 0.6-0.8%

Opanasenko et al. (2013)

Polarimetry of the Moon



a) Albedo map

b) P%

c) $B=\log p + A \log P_{max}$

Shkuratov et al. (2007)

Polarimetry of terrestrial planets

- It is important to obtain polarimetric observations in different wavelengths.

- Could improve using high-resolution observations by orbiters.

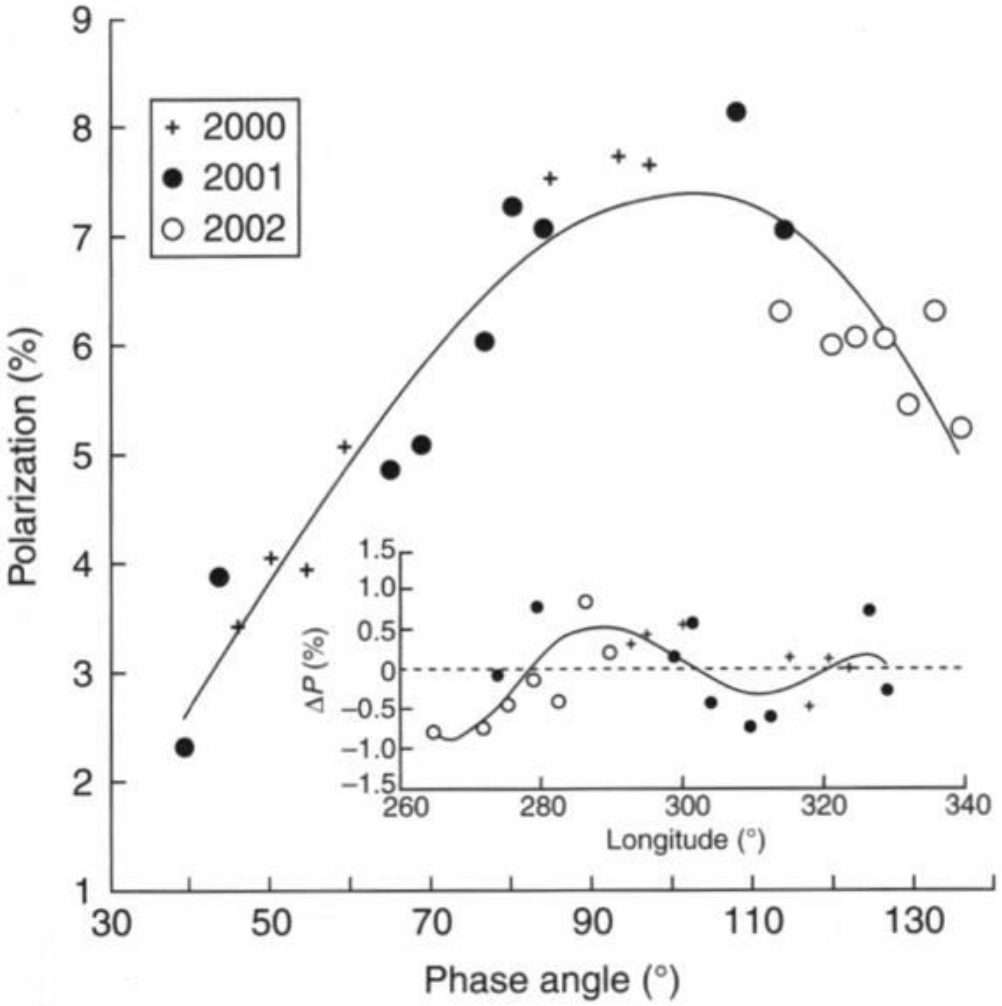
- The main problem is how to provide simultaneous measurements of Q, U and V at different illumination angles.

- The most interesting planet is Venus, for which it is possible to propose several experiments.

- The polarimetry of Mercury and Mars has the common problems of the objects with surfaces formed by arbitrary particles.

- Here only studies made from Earth are commented.

Polarimetry of terrestrial planets



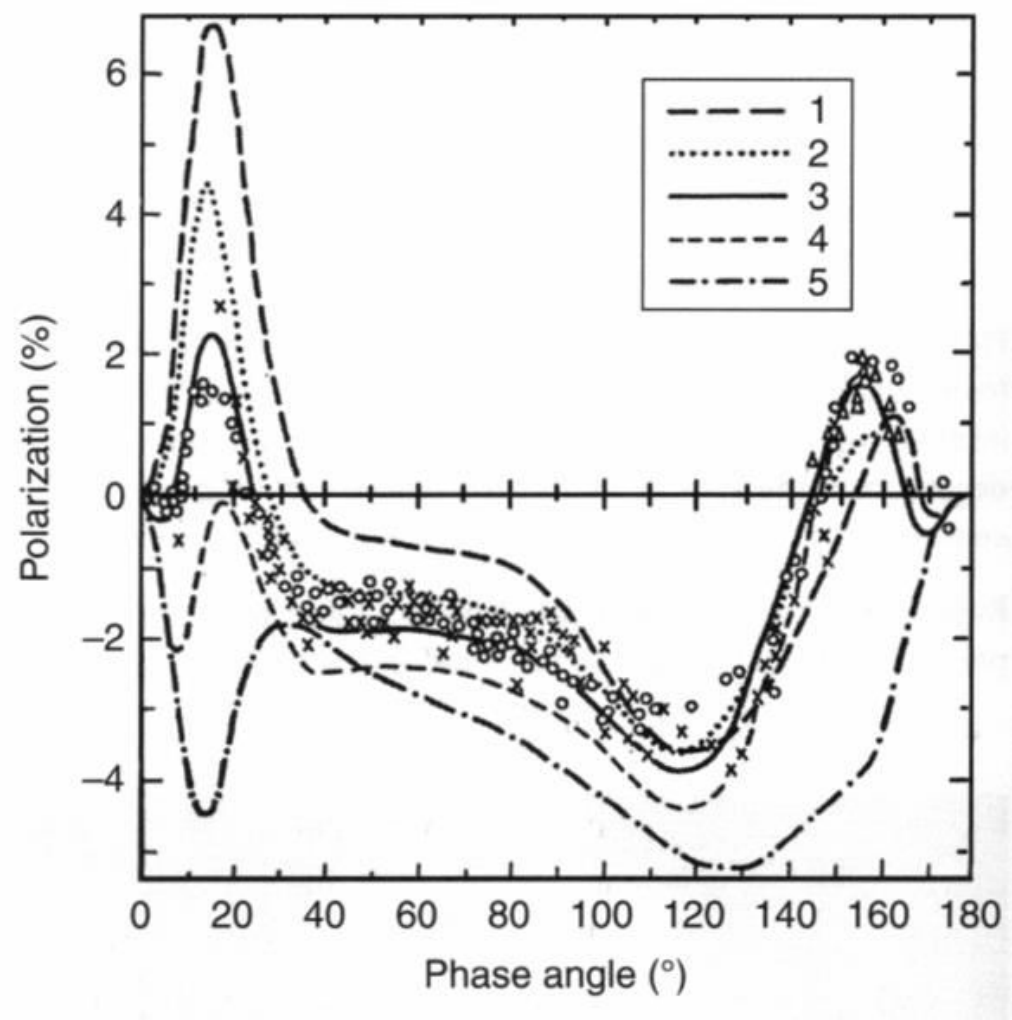
Mercury

2000-2002
whole-disk polarization

$\Delta p \sim 1.5\%$ produced by the planet surface (composition ?)

Lupishko & Kiselev (2004)

Polarimetry of terrestrial planets



Venus

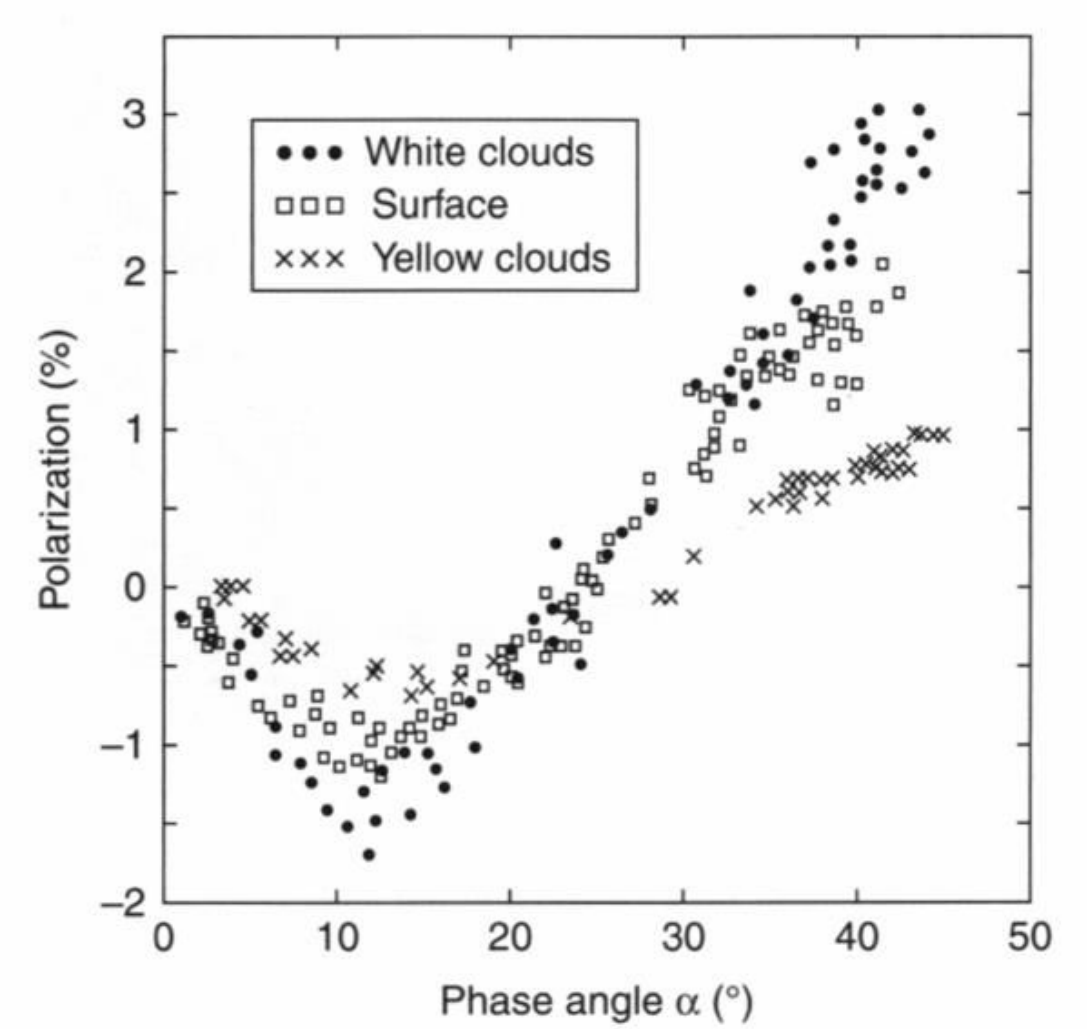
whole-disk polarization
λ= 550 nm

Small spherical particles
in the atmosphere
at 50 mbar

r_{eff} ~ 1050 nm
n = 1.43 – 1.46

Hansen & Hovenier (1974)

Polarimetry of terrestrial planets



Mars

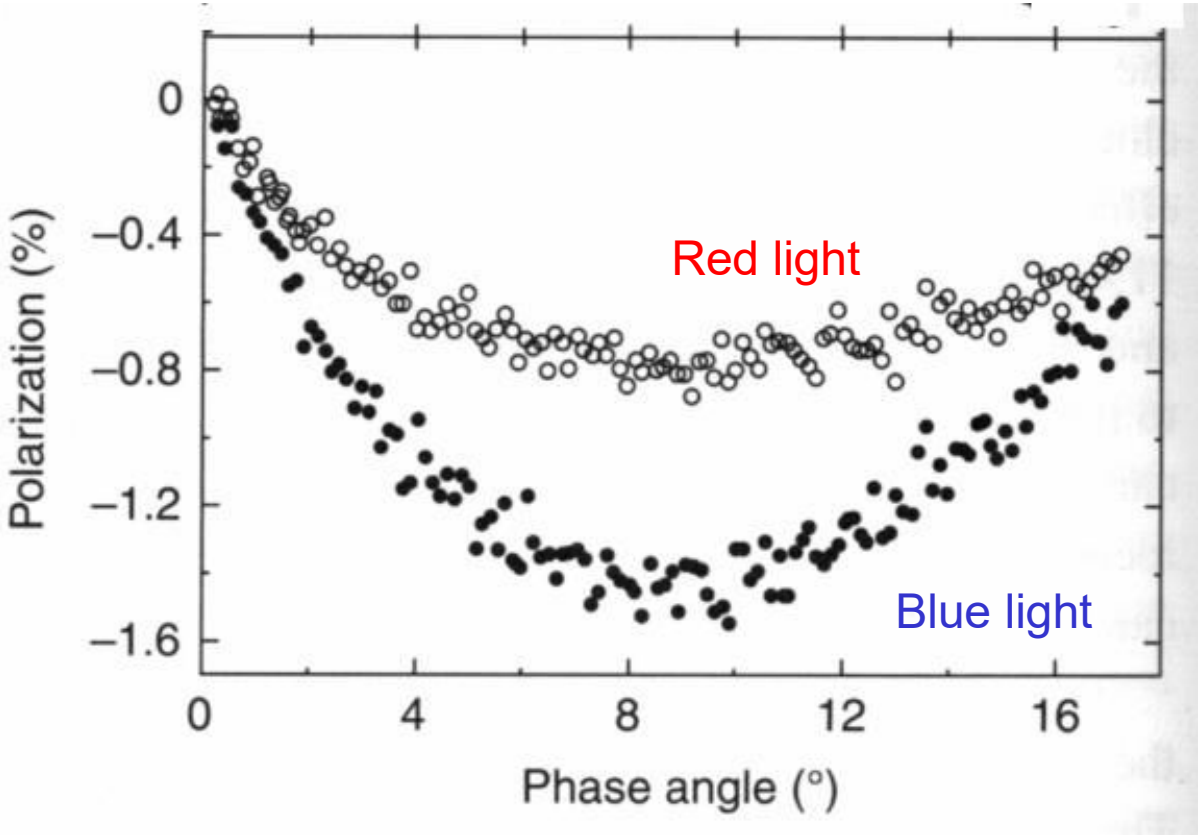
surface + atmosphere

Clouds with ice (white) or dust (yellow)

Negative branch varies because the atmospheric haze

Lee et al. (1990)
Ebisawa & Dollfus (1993)

Polarimetry of terrestrial planets



Mars

strong dependence of negative branch on wavelength

change in α_0 and albedo

Schkuratov et al. (2002)
Ovcharenko et al. (2002)

Polarimetry of giant planets

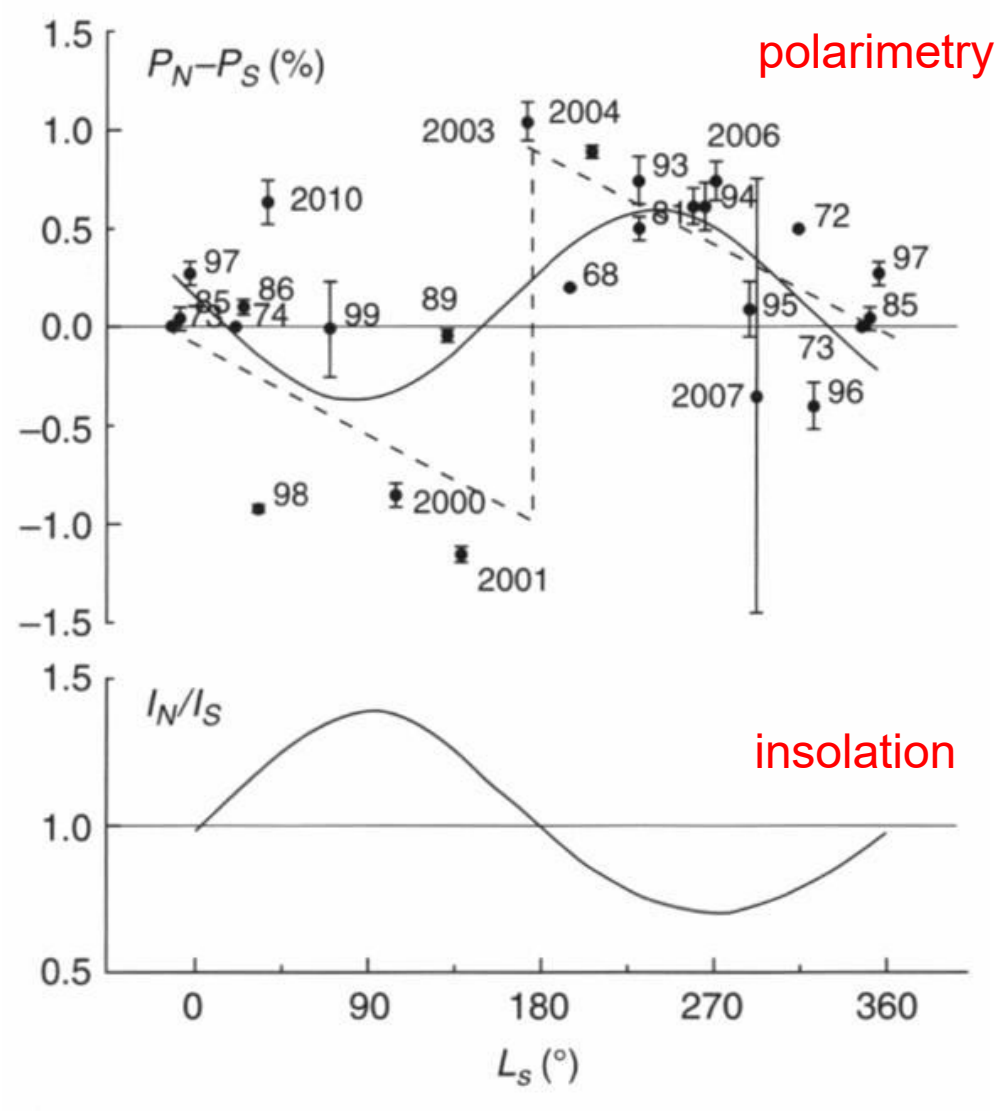
- Polarization is produced by scattering due to particles in the atmosphere.

- It is used as a tool to study the properties of the particles and their dinamics in the atmosphere.

- With a few exceptions, it concern linear polarization.

- The giant planets can be observed over a small range of phase angles (less than 11.7, 6.4, 3.2 and 2.0 degrees for Jupiter, Saturn, Uranus and Neptune, respectively).

Polarimetry of giant planets



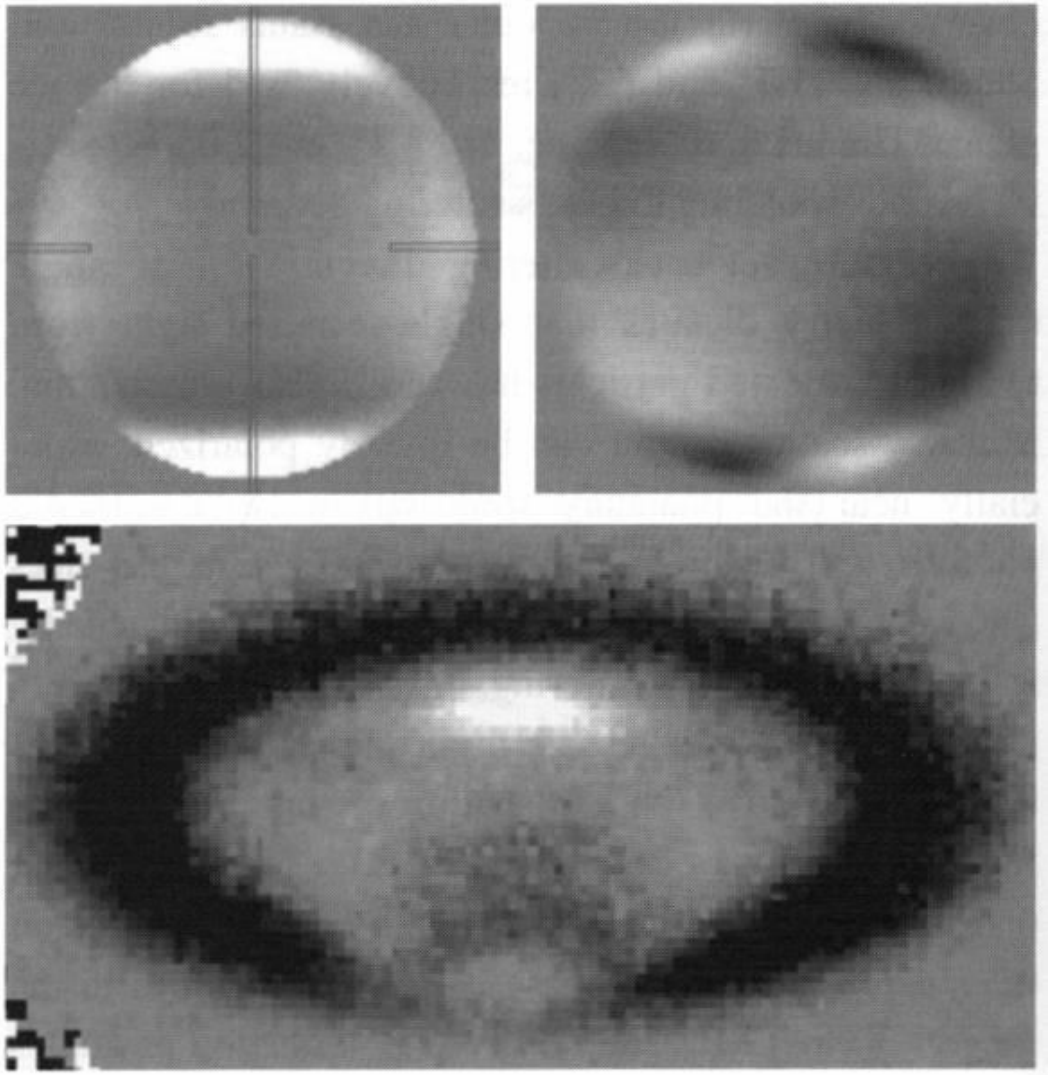
Jupiter

north-south assymetry
P% at $|\varphi| > 60^o$

It follows a clear sinusoidal trend

Starodubtseva et al. (2002)

Polarimetry of giant planets



Jupiter

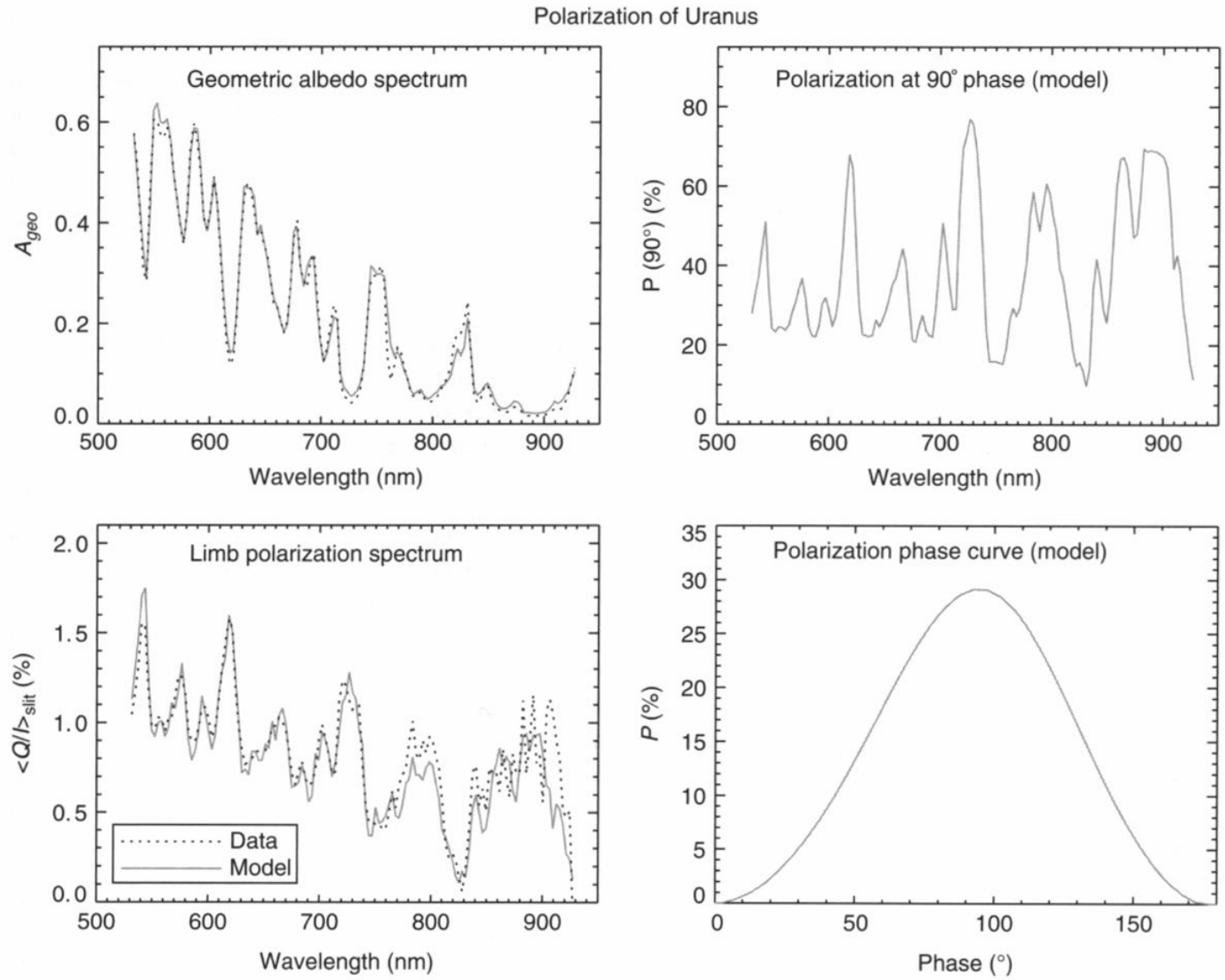
Q and U maps indicating differences between the poles and equatorial zone

Saturn

Q image at l = 730 nm (methane absorption band)

Schmid et al. (2011)

Polarimetry of giant planets



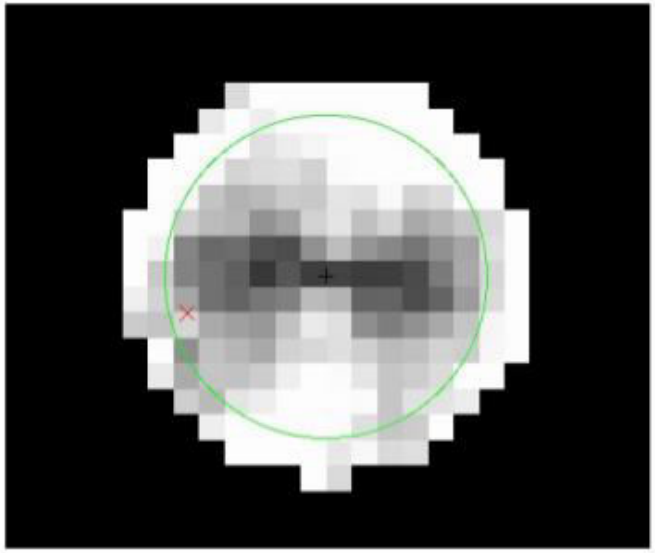
Uranus

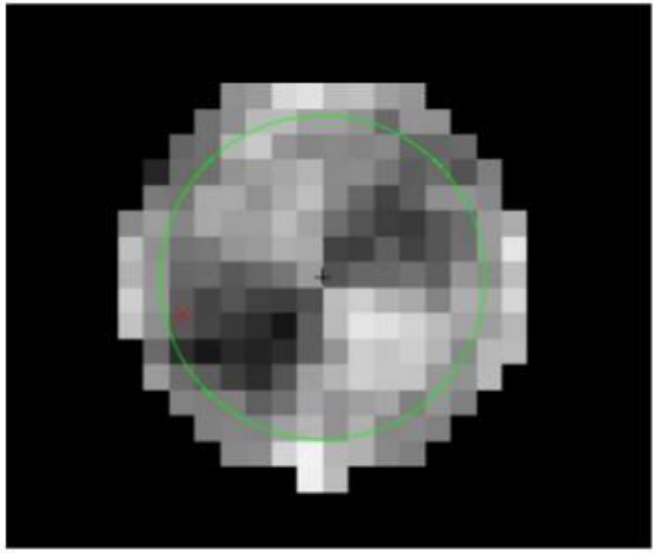
Strong limb polarization for Uranus and Neptune

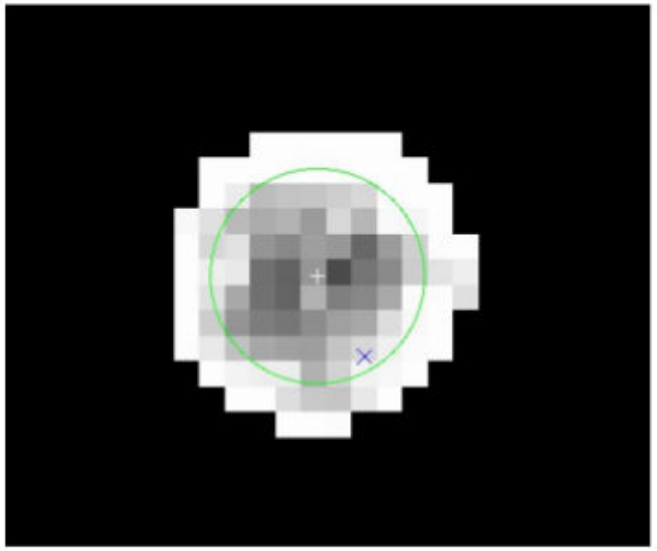
Rayleigh scattering and absorption by gas

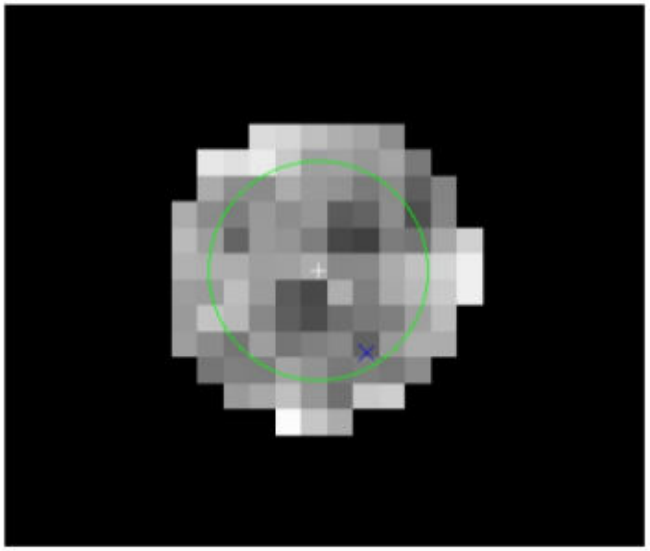
Joos & Schmid (2007)
Buenzli & Schmid (2009)

Polarimetry of giant planets







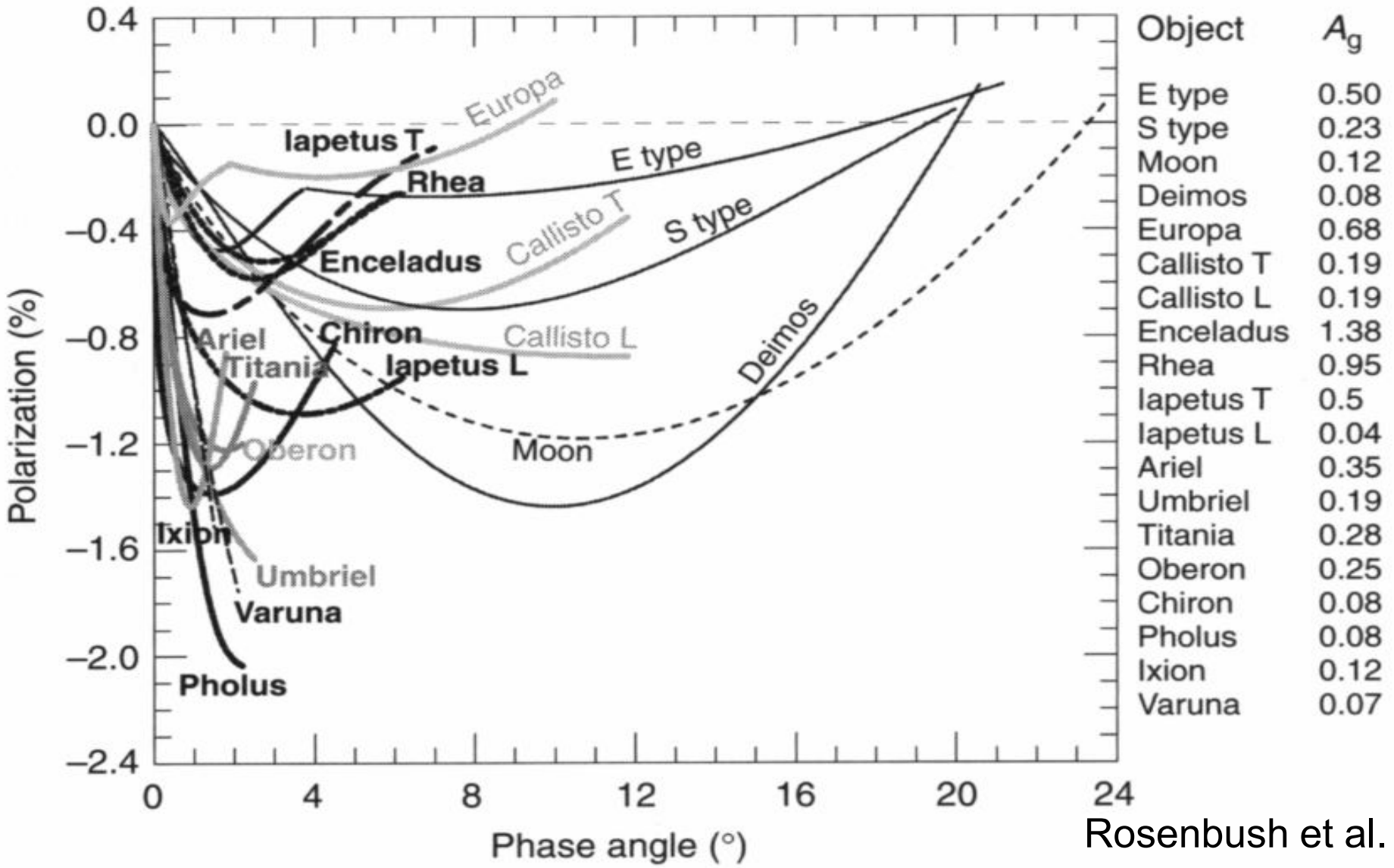


Uranus and Neptune

Radial Q and U

López-Sisterna (2014)

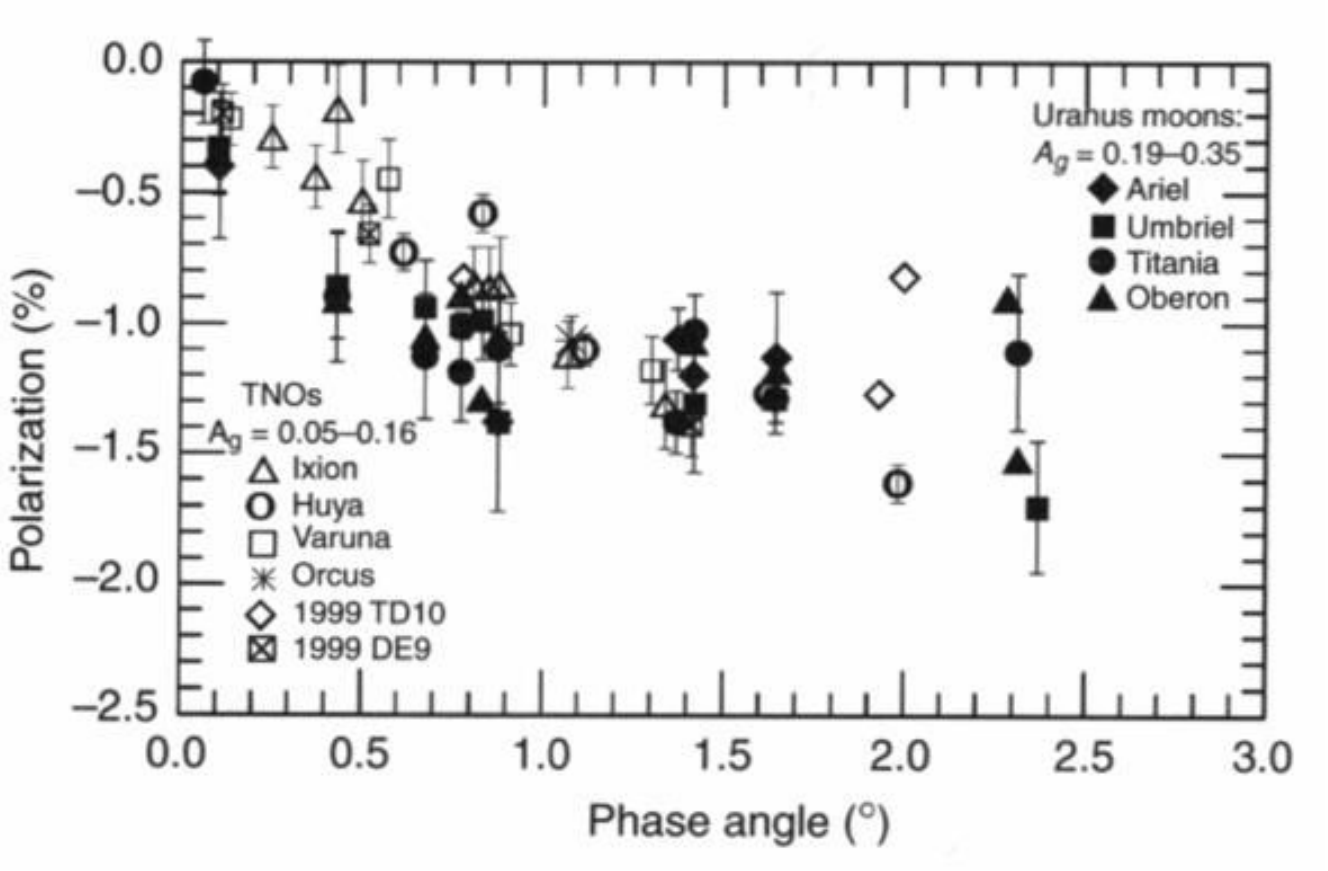
Polarimetry of icy moons



Object	A_g
E type	0.50
S type	0.23
Moon	0.12
Deimos	0.08
Europa	0.68
Callisto T	0.19
Callisto L	0.19
Enceladus	1.38
Rhea	0.95
Iapetus T	0.5
Iapetus L	0.04
Ariel	0.35
Umbriel	0.19
Titania	0.28
Oberon	0.25
Chiron	0.08
Pholus	0.08
Ixion	0.12
Varuna	0.07

Rosenbush et al. (2015)

Polarimetry of icy moons

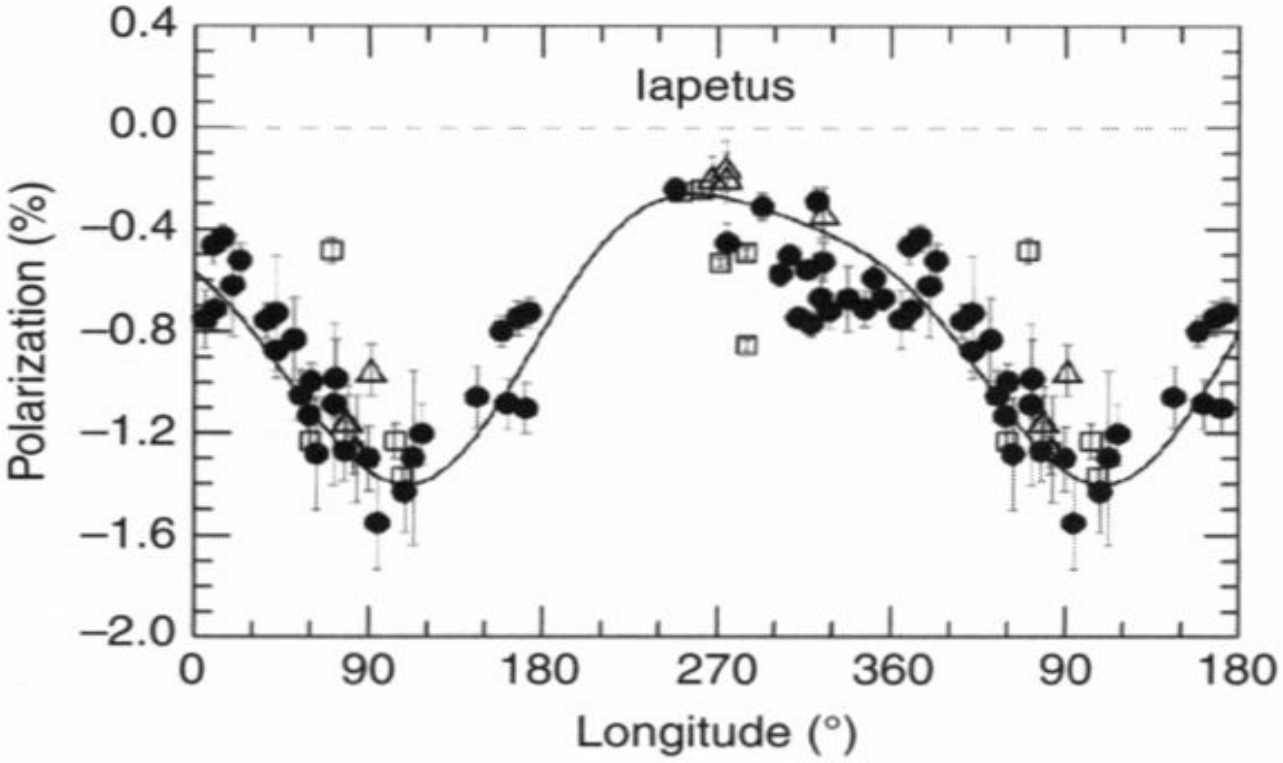


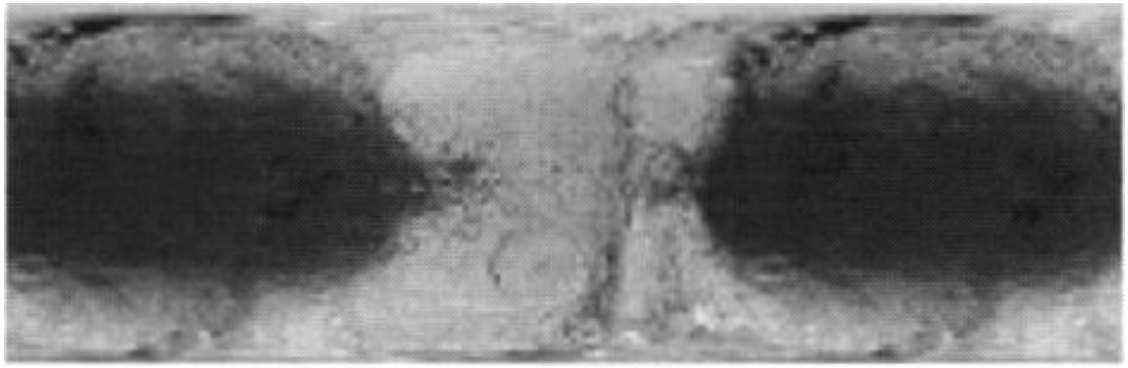
Uranian moons

Comparison with TNOs

Rosenbush et al. (2015)

Polarimetry of icy moons





Iapetus

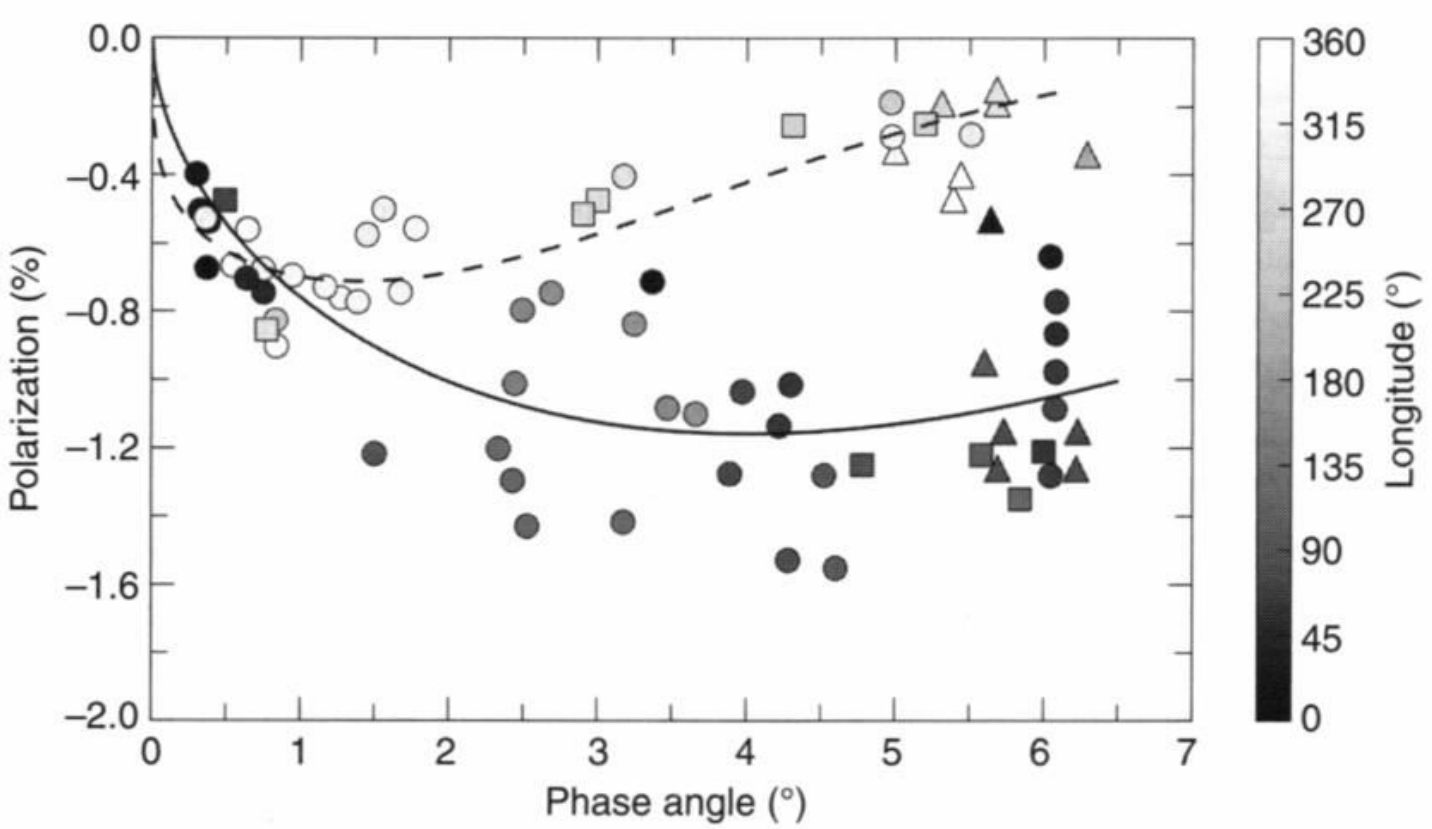
Longitudinal dependence of polarization

and

albedo map

Rosenbush et al. (2015)

Polarimetry of icy moons



Iapetus

R filter vs. Phase angle

Rosenbush et al. (2015)

Polarimetry of icy moons