# Observations and laboratory measurements, as tool to reveal primitive asteroids and extinct comets amongst NEA

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# Motivation

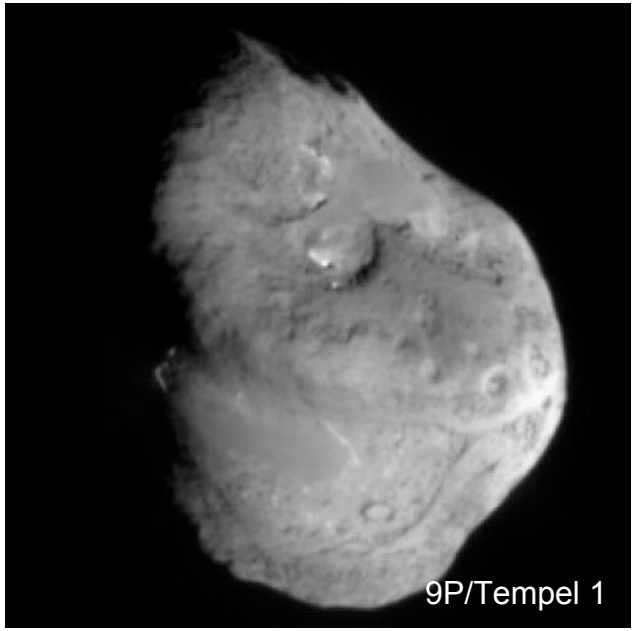
Marco Polo to lead to a better knowledge of initial conditions, early evolution and origin of life in the solar system

Best target 1999 JU3
Yet, hope for quite a few new targets in a near future

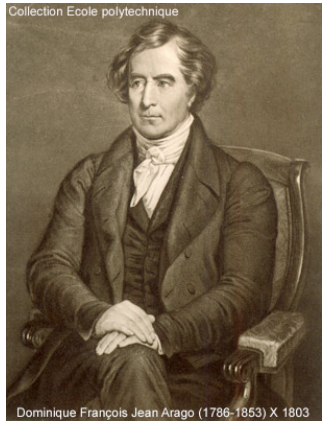
Need to recognize rapidly and accurately primitive objects,
i.e. C- or D-types
and dormant or extinct cometary nuclei

Approach
- Spectral data
- Albedo (expected to be very low)
- More generally polarimetric observations


253 Mathilda


9P/Tempel 1

# Scattered light and polarization



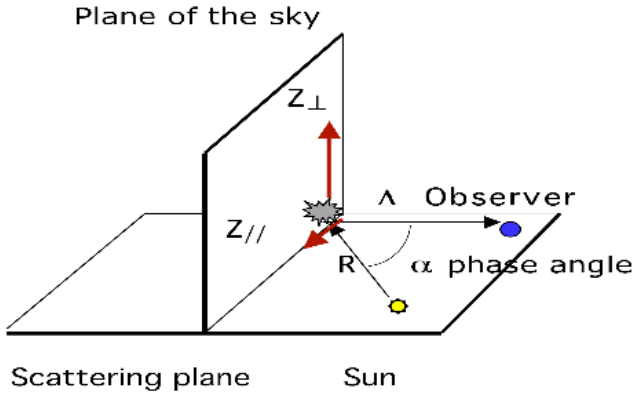

Solar light scattered by dust
partially linearly polarised, as used by
- arthropods (honeybees) to navigate
- Arago to establish the presence of dust in comets

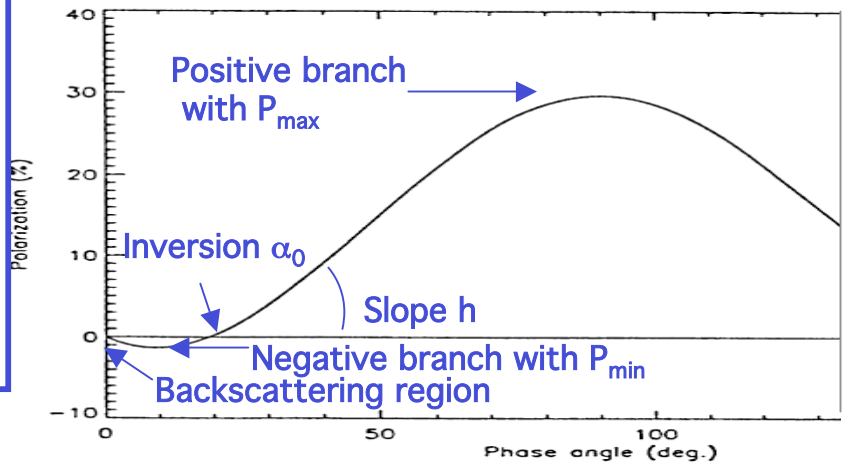
Linear polarisation P, dimensionless ratio, allowing comparisons

P varying only with
- phase angle $\alpha$ (or scattering angle $\theta = \pi - \alpha$)
- wavelength $\lambda$
- properties of the scattering medium

For numerous solar system objects, "smooth" polarization phase curves, typical of scattering by irregular particles with sizes greater than the wavelength

$$P = (I_{\perp} - I_{//}) / (I_{\perp} + I_{//}) = -Q/I$$



# Observations of asteroids
# $\alpha$ dependence

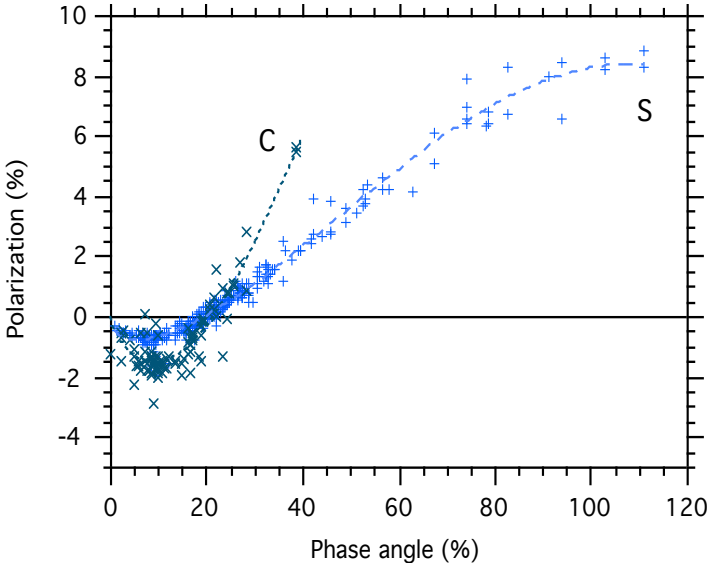
Mostly observations of S-type and C-type

Observations small $\alpha$, but for NEA

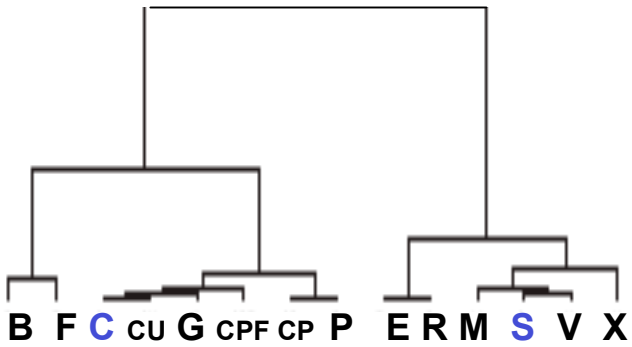
Slope at inversion increasing
when the albedo decreases,
with 'empirical law' between h and albedo

Trend of the positive branch providing
information about the taxonomic type, as
illustrated by a principal component analysis

Trends in $P_\lambda(\alpha)$ [e.g. $\alpha_{min}$, $P_{min}$, $\alpha_0$, h, $\alpha_{max}$]
to be interpreted in terms of
physical properties, i.e. albedo, porosity,
size distribution of the dust particles




Levasseur-Regourd & Hadamcik, JQSRT2003




Pentillä et al., A&A 2005

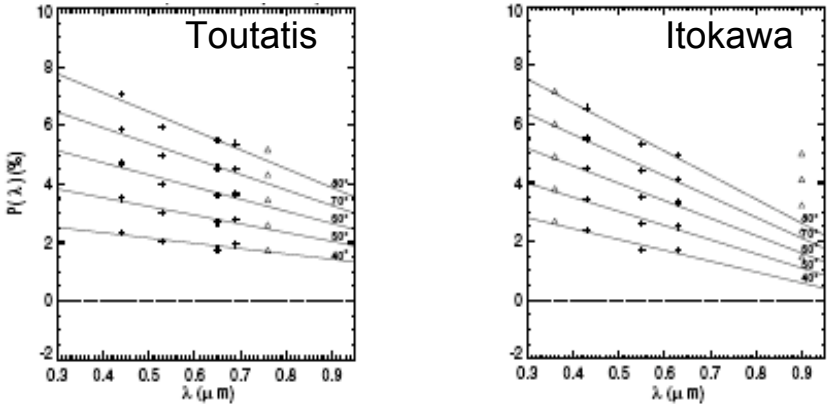
# Asteroids λ dependence, S type objects

Well documented on the positive branch for a few NEA, e.g. 4179 Toutatis and 25143 Itokawa

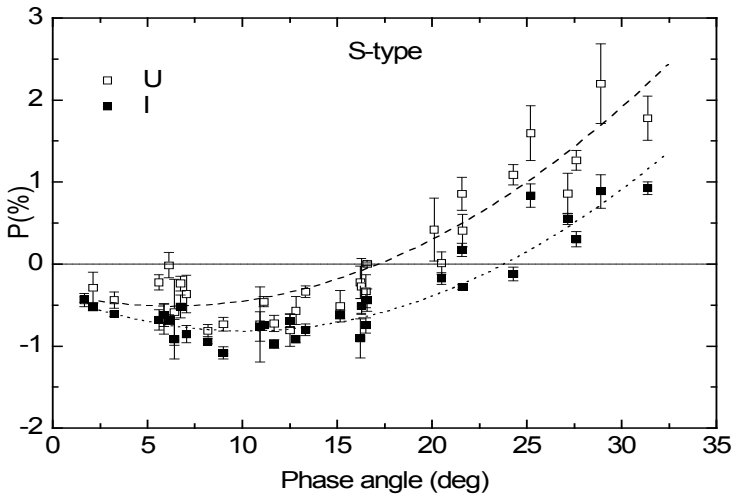
Negative branch also well documented for MBA

Above ≈ 25°, polarisation significantly decreasing with increasing λ
(as opposed to cometary dust)

See also poster by I. Beskaya



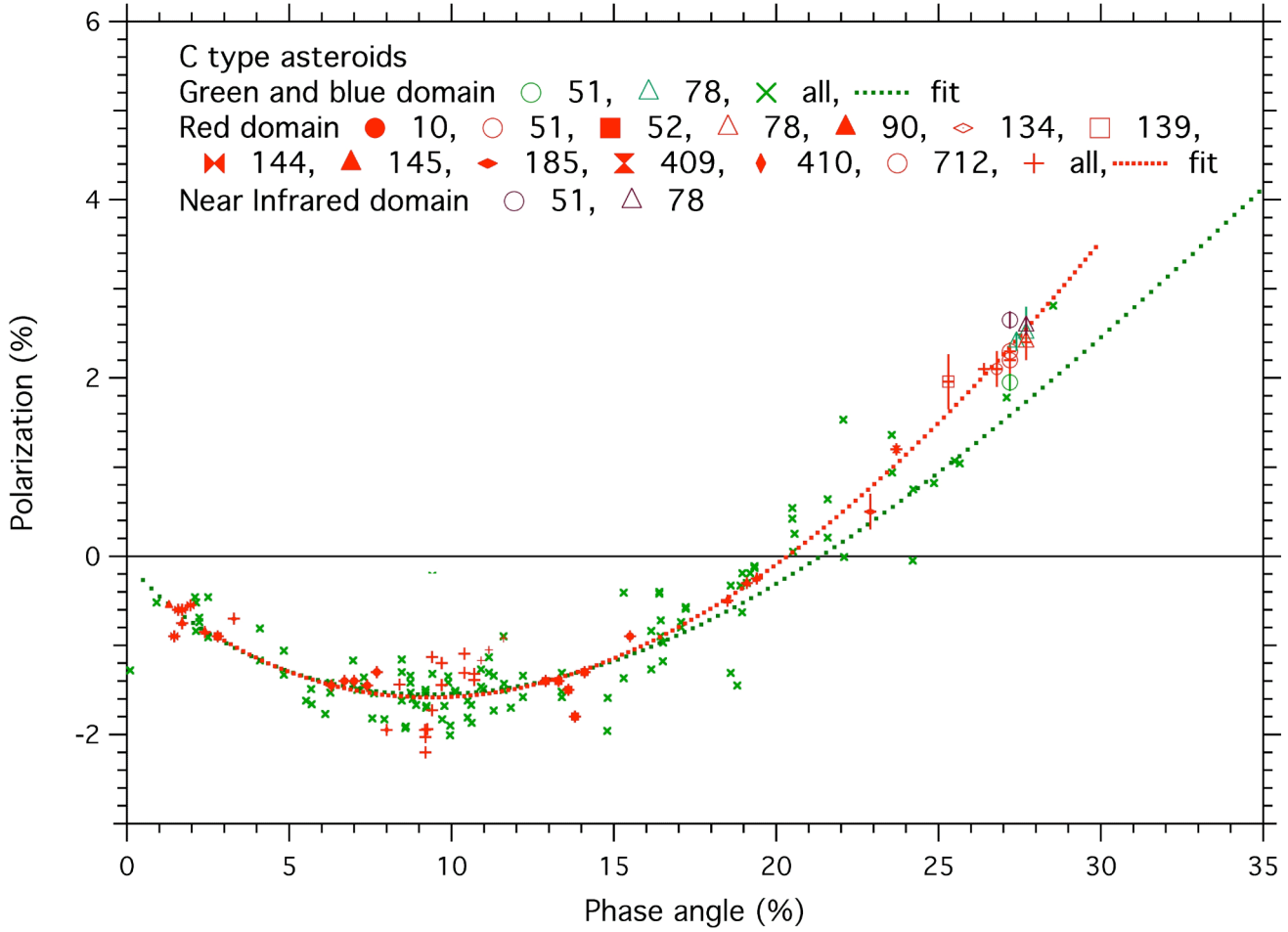

Levasseur-Regourd et al., JQSRT 2003




Belskaya et al., Icarus 2009

# Asteroids λ dependence, C type objects

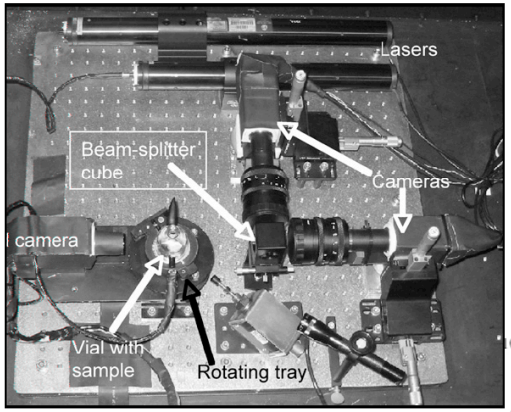
From ongoing observations at Haute-Provence Observatory, trend to a slight increase of polarisation with increasing λ



# Interpretation through simulations

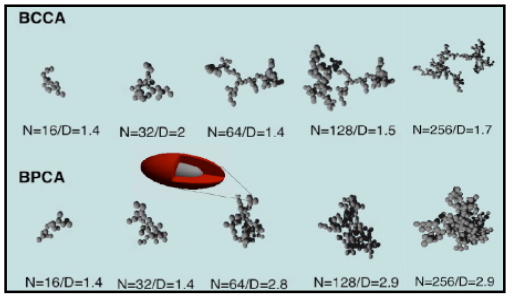
Need to interpret the changes in $P_\lambda(\alpha)$ and in $P_\alpha(\lambda)$ in terms of physical properties through experimental and numerical simulations, as successfully done for cometary dust

Excellent match with porous aggregates
of subμm (MgSiO + FeSiO + C) grains and compact Mg-silicates

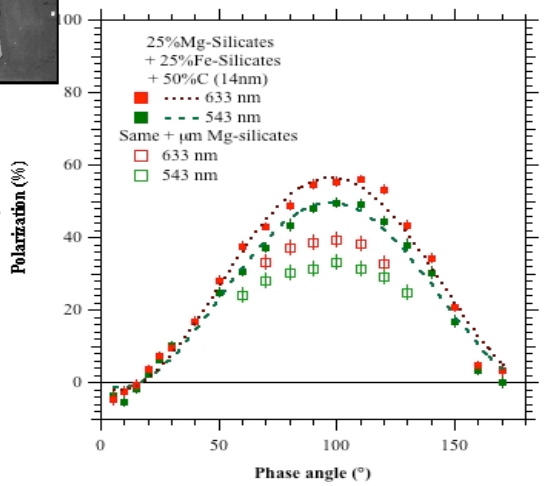


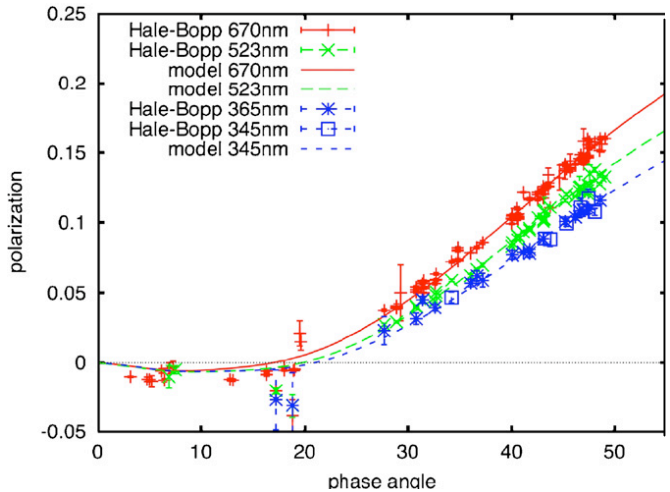

Experimental setup and results

Hadamcik et al., Icarus 2007




Numerical models and results

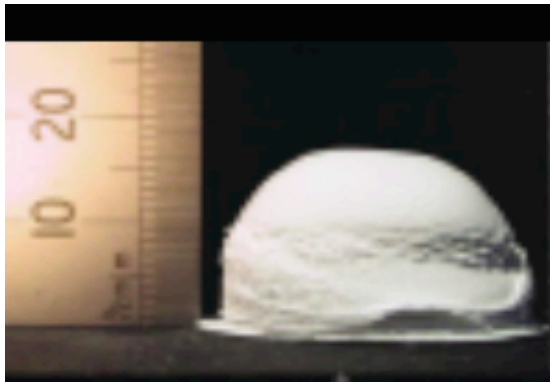


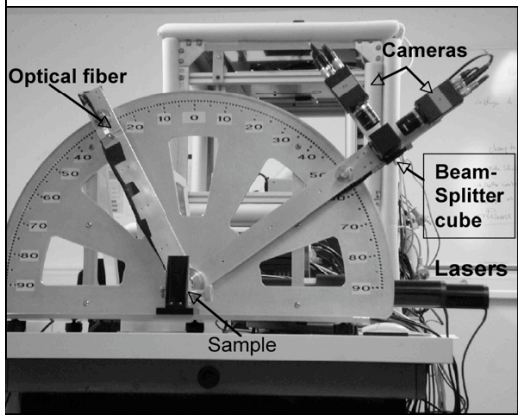

A.Ch. Levasseur-Regourd

Levasseur-Regourd & Zolensky., PSS 2008

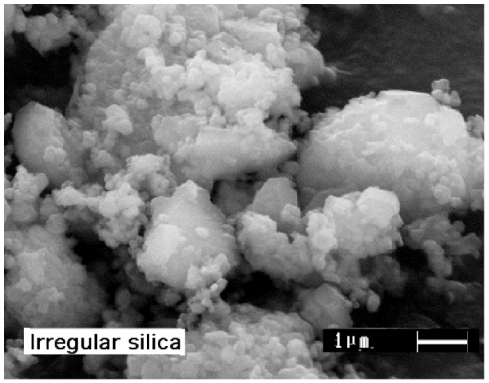
# New laboratory measurements on dust agglomerates

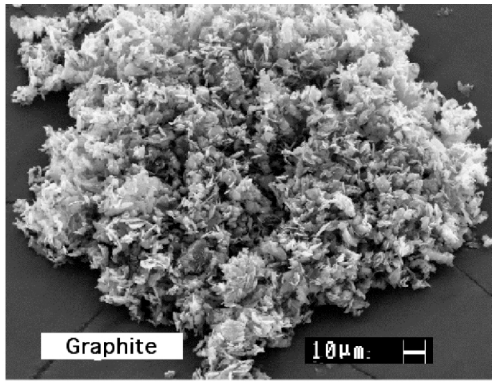


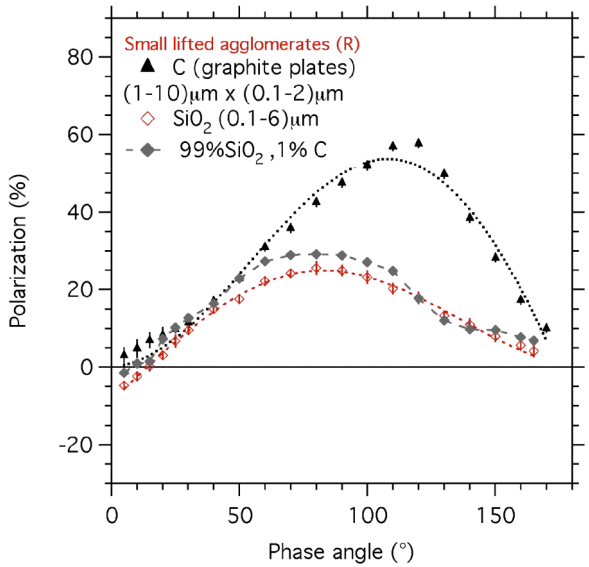
Huge agglomerates
U. of Braunschweig

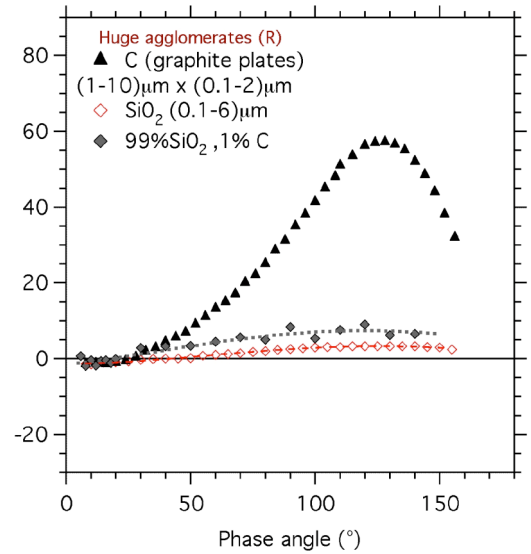



Experimental setup
Hadamcik et al., JQSRT 2009




h and $P_{max}$ decreasing when albedo increases higher (less absorbing)
$P_{max}$ smaller for deposited transparent particles (multiple scattering)

# In fine…

Polarization is a powerful tool to derive physical properties
(e.g. different coma regions and comets, as far as their dust is concerned)

It has been known for long that the slope of polarization phase curves at inversion provides a value of the bulk albedo of the surface of asteroids

Besides, wavelength dependence is now beginning to be monitored

Such results provide constraints for experimental (and numerical) simulations of the properties of surface layers on low gravity bodies

Assuming numerous small NEO are to be discovered in a near future…
- Systematic polarimetric observations would provide indications on the type
- Systematic observations on a couple of wavelengths could provide indications on the surface layer porosity

However…
Such observations require rather large axially symmetric telescopes, operating on quite a regular basis (to monitor different phase angles)