Changes in dust properties in inner comae, as detected by polarimetry: Open questions

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1. Background, Giotto polarimetric observations of cometary dust
2. Earth-based observations, more evidence for changes within comae
3. Possible differences between dust in periodic and new comets
4. Implications: EnVisS and Comet Interceptor?

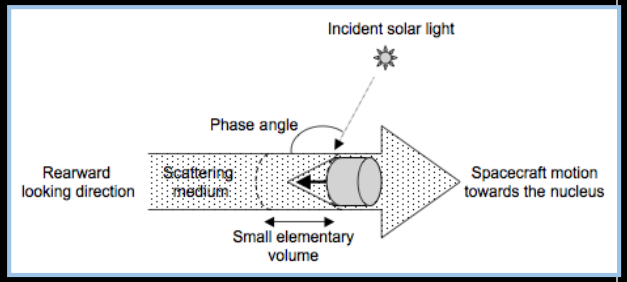
1. Background
Giotto polarimetric observations of cometary dust

Giotto OPE photo-polarimeter at 1P/Halley

- Spinning spacecraft, mosaic of interference filters
- Rearward-looking along trajectory, α = 73°, thus local $P_{\alpha,\lambda}$

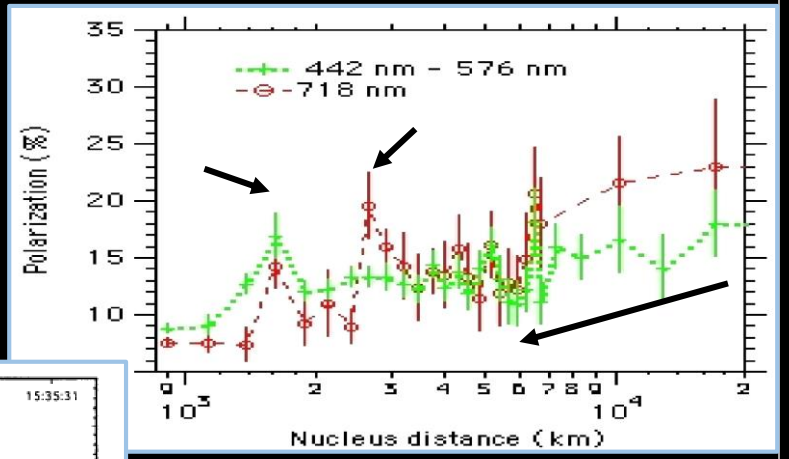
→ Increase within jets and decrease towards the nucleus

→ Theoretical model suggesting low density
≈ 100 kgm^{-3} and albedo ≈ 4% *(Fulle+ AJ 2000).*

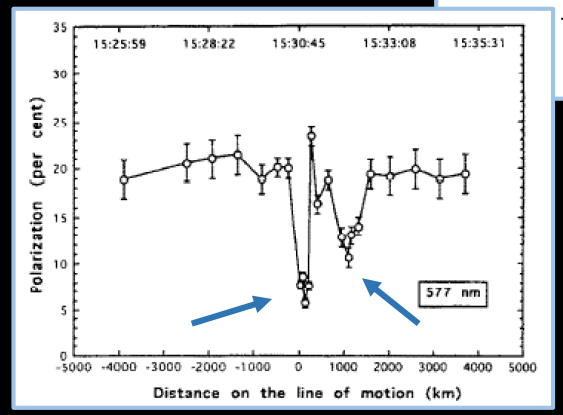


Extended Mission, OPE at 27P/Grigg-Skjellerup

- Line of sight no more parallel to the trajectory with α = 90.4°
- Two decreases in polarization, together with increases in brightness, attributed to the release of dust fragments (peebles or chunks).



Adapted from ACLR+ 2005



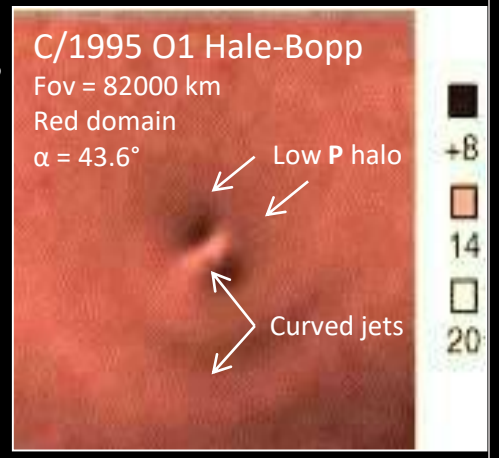
ACLR+ PSS 1993

2. More evidence for changes within inner comae Earth-based remote observations…

Polarimetric imaging at a given phase angle

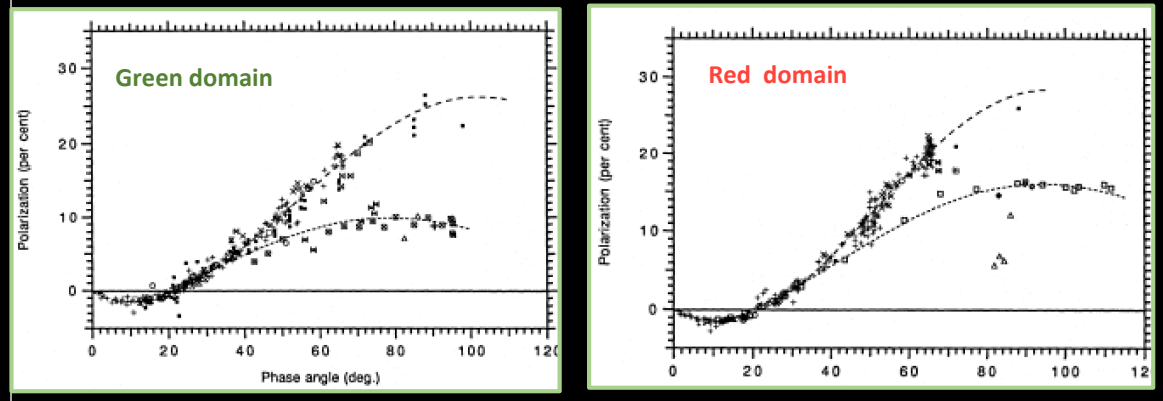
Changes in dust properties : evidence within curved jets and possibly near-nucleus halo.

Hadamcik+ A&A 2003



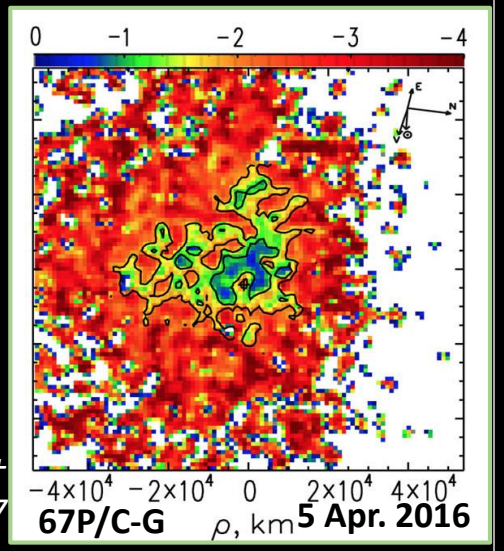
Polarimetric phase curves

- Smooth curves, typical of irregular dust particles
- P_{max} higher whenever high IR silicate emission features
- Slight increase on positive branch with increasing □



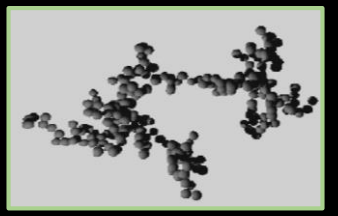
Levasseur-Regourd+ A&A 1996

Rosenbush+ MNRAS 2017

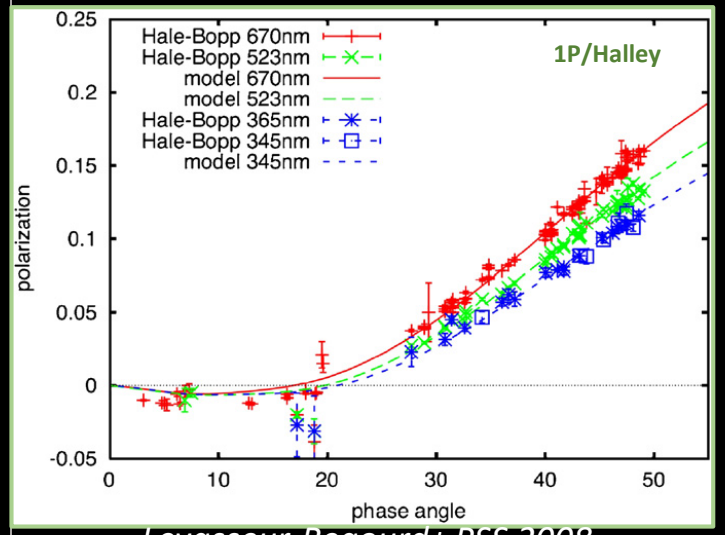


2. More evidence for changes within inner comae
Earth-based remote observations

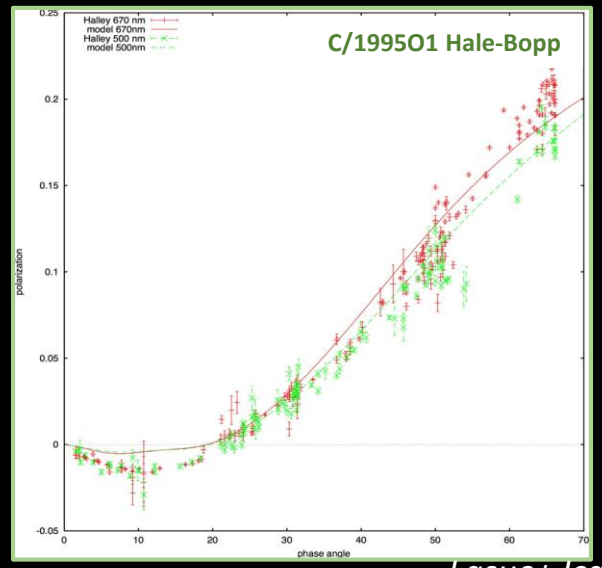
Interpretation of polarimetric phase curves through simulations

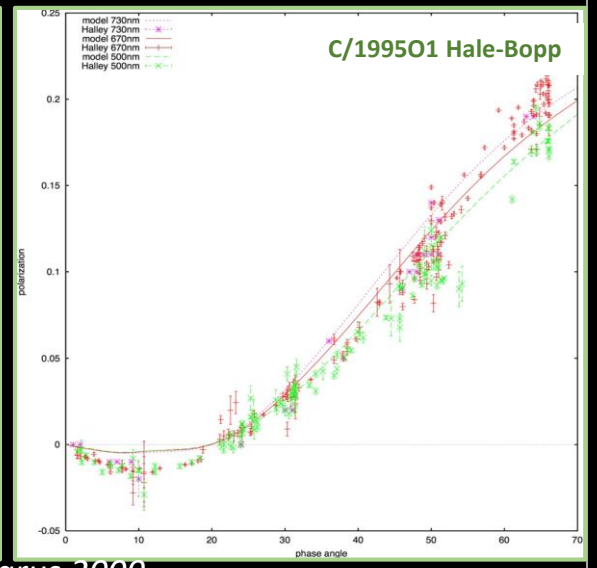


- From all published polarimetric observations of the two extensively observed comets (1P/Halley & C/1995 O1 Hale-Bopp), satisfactory fits (green & red observations) for fractal porous aggregates and more compact spheroids, built of silicates & absorbing organics with sizes ≈ 0.20-40 µm
- Simulated phase curves in other colors (blue & IR) fitting nicely the observations.



Levasseur-Regourd+ PSS 2008



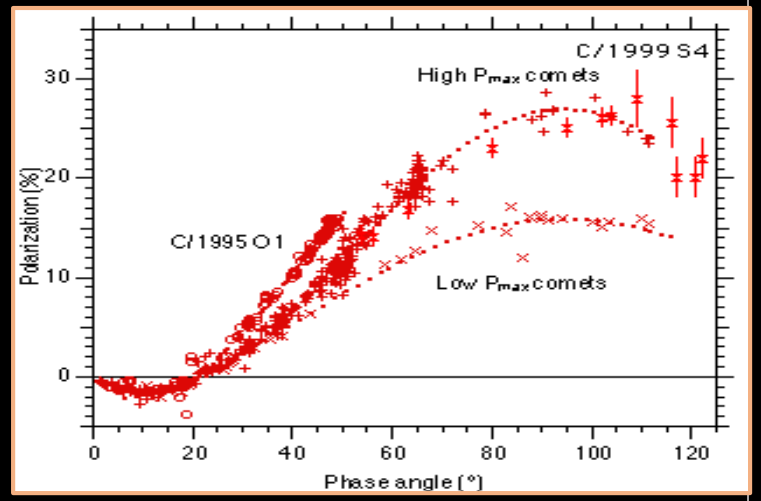


Lasue+ Icarus 2009

3. Possible differences between dust in periodic and new comets

Delicate polarimetric observations of dust in comets

- To be done through narrow interference filters, to avoid contamination from gaseous emission bands
- Most observations on “short” period comets, i.e. Jupiter-family comets and Halley-type comets.



C/1995 O1 Hale-Bopp…

- Extensively observed Hale-Bopp Hale-Bopp with phase curves above those of periodic comets
- Also the case for C/1999 S4 LINEAR, while it was fragmenting

→ Somehow different dust properties?

→ Consistent with fresh dust particles ejected from the nucleus, instead of particles coming from relatively dense sub-surfaces induced by dust falling back?

4. Implications: EnVisS & Comet Interceptor?

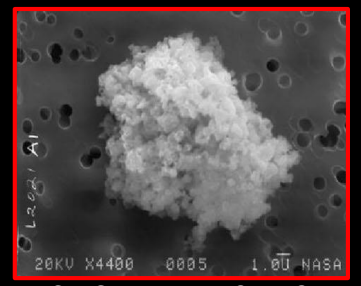
Ground-truth on short period comets from Rosetta at 67P/C-G

Composition and physical properties, e.g. structure, sizes, and albedo, of “short” period comets in agreement with trends suggested by polarimetric observations, and established during Rosetta rendezvous with 67P/Churyumov-Gerasimenko.

Fascinating new results expected by Comet Interceptor with EnVisS

- **Indeed,** observations at one wavelength only, in the near IR without local inversion
- Nevertheless fascinating, for a new comet or a fragmenting one, not to mention an interstellar comet

→ Better understanding of Solar System formation-evolution, and the origins of cometary dust particles collected in our troposphere



NASA CP-IDP ≈ 10 x 13 µm

More information from recent reviews
Kiselev+, Comets, Polarimetry of stars and planetary systems, CUP 2015
Levasseur-Regourd+, Cometary Dust, SSR 2018