Cometary dust - exploration with photo-polarimetric measurements at optical wavelengths

Joshi, U.C.,

Ganesh, S. and Baliyan K. S.

Physical Research Laboratory, Ahmedabad

IDMC2011 November 24 , 2011

Outline:

- Cometary dust
- Phase curve of comets at low phase angle:

i) Enhancement of brightness near opposition and

ii) Negative branch of polarization (NBP)

Cases of the comets 17/P Holmes, C/2007 N3 (Lulin) etc are discussed.

Joshi et al. MNRAS 2010

Joshi et al. MNRAS 2011

Scattering of Sun light by Comet dust makes them the most fascinating objects in the sky

Hale-Bopp

Comet McNaught

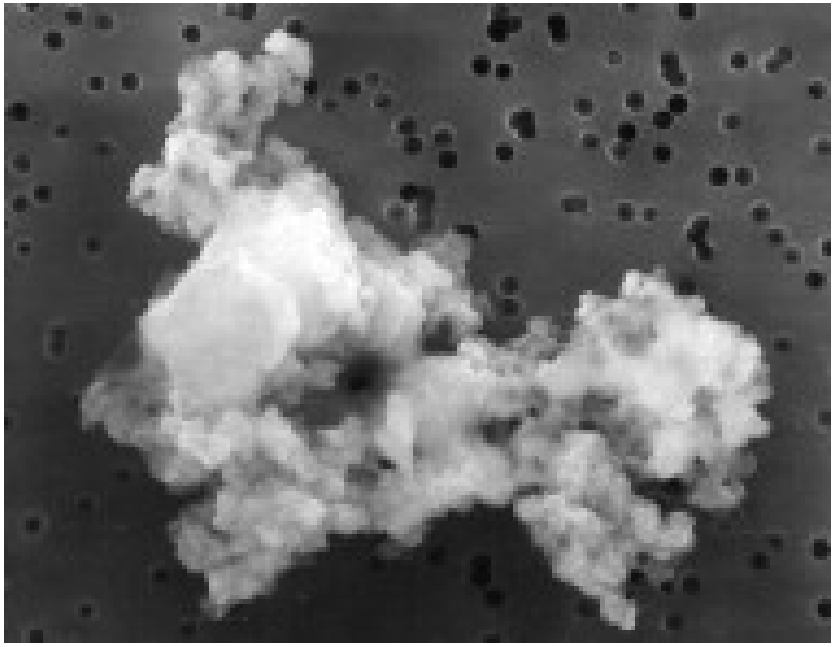
Why study dust in comets?

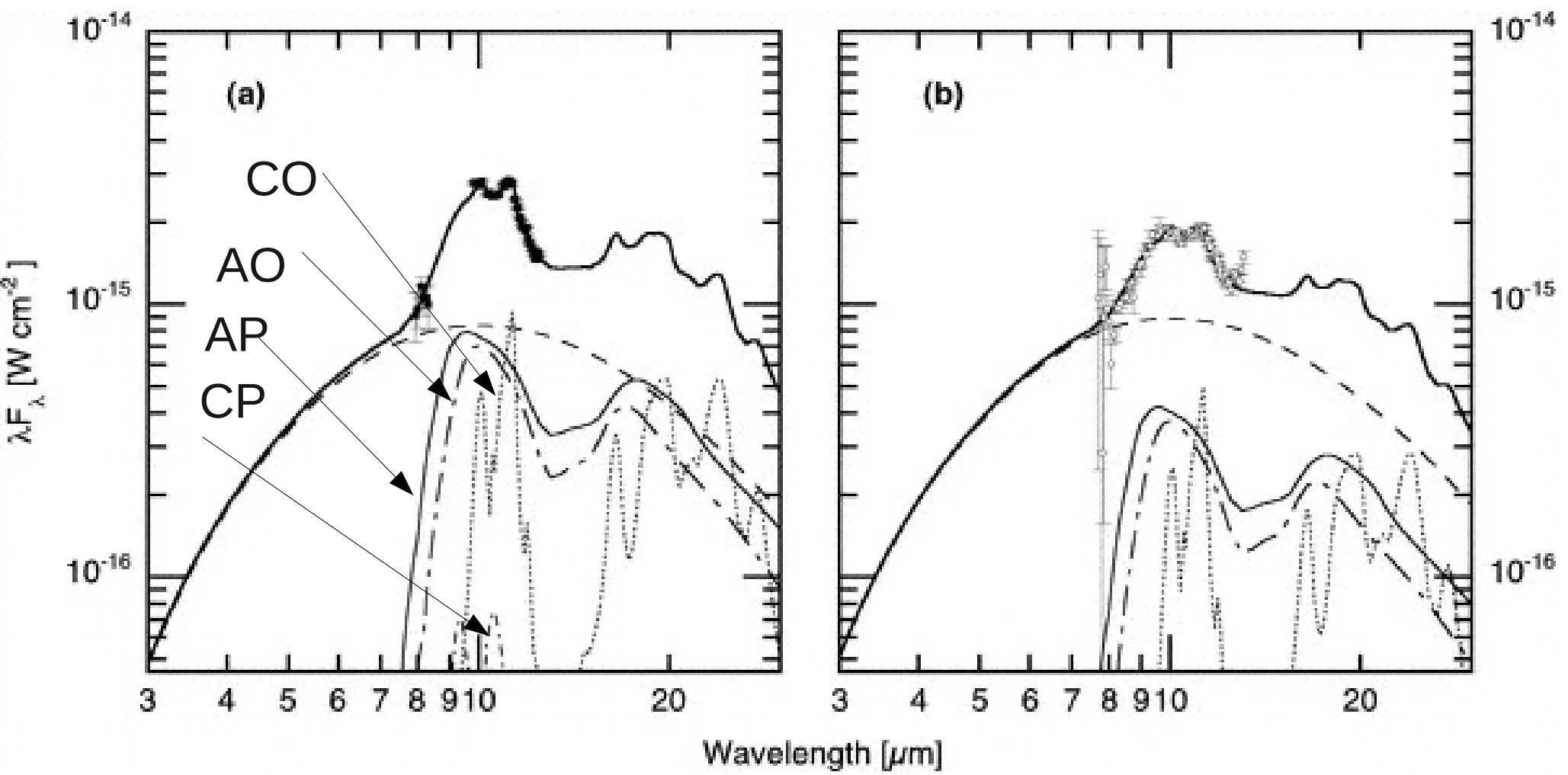
Cometary dust contain pristine matter with signatures of formative stage of Solar System

Spend most of their time away from Sun- less weathering

Dust characterization:

- Polarization;
- Thermal emission;
- Dust particle trajectories;
- in situ measurements;

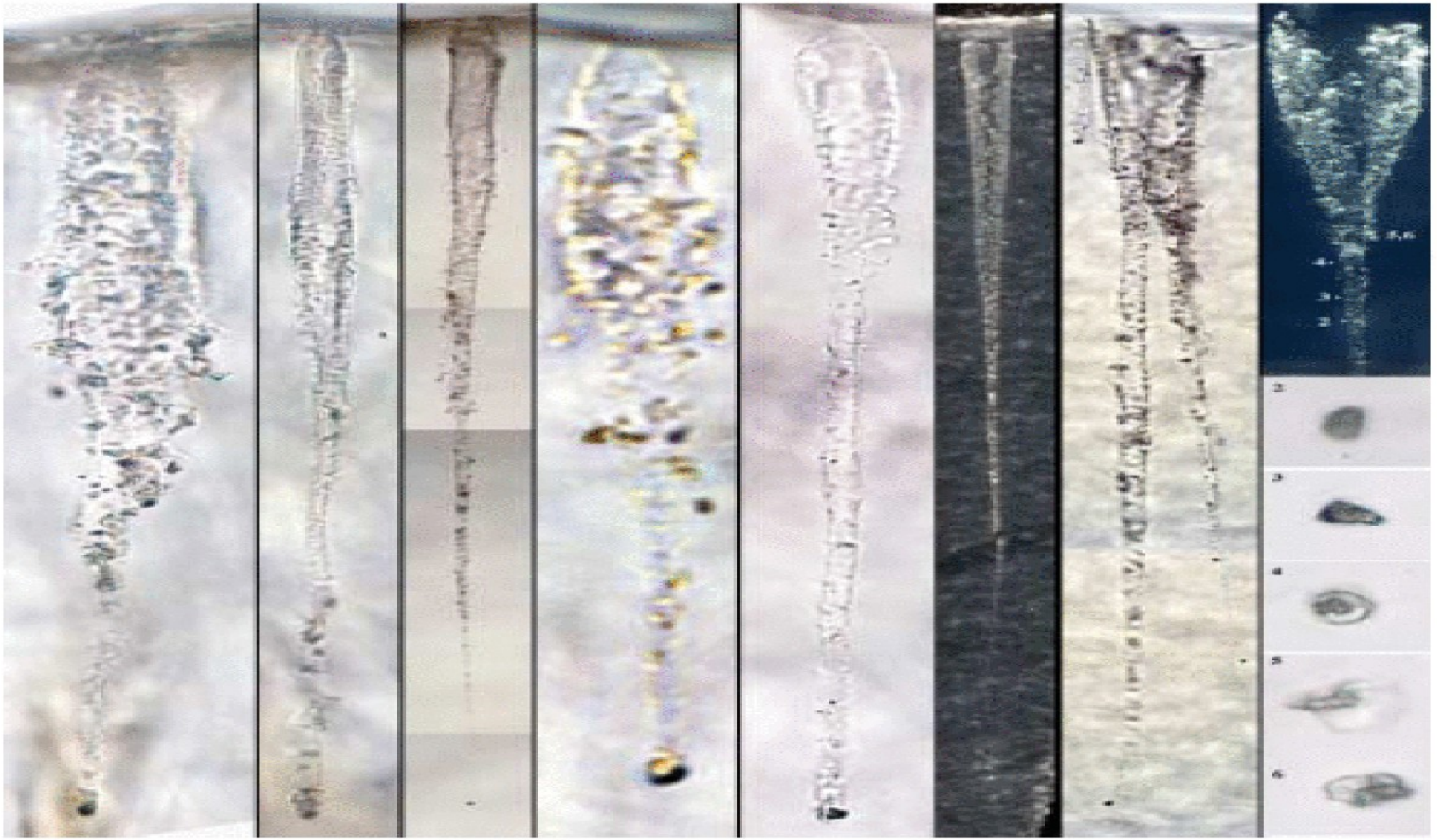




Thermal emission model SEDs compared with the observed HIFOGS SEDs of comet C/2001 Q4 (NEAT) on (a) 2004 May 11.25 UT (chi^2 = 5.7) and (b) 2004 May 11.30 UT (chi^2 = 3.7). Model parameters for the grain size distribution are N = 3.7, ap = 0.3 micron, and D = 3 for solid grains. For model a (thick solid line), the number of peak grain size grains Np(x10^19), i.e., scaling factor, for five minerals are amorphous carbon (8.50; dashed line), amorphous pyroxene (7.00; thin solid line), amorphous olivine (3.55; long-dashed-- dotted line), crystalline olivine (24.2; dotted line), and crystalline orthopyroxene (0.77; dash-dotted line). For model b, all Np are multiplied by a factor of 0.53, except Np for amorphous carbon is multiplied by a factor of 1.06. For model a, the mass ratio to the total of submicron-radii grains is amorphous carbon : amorphous pyroxene : amorphous olivine : crystalline olivine : crystalline orthopyroxene = 0.15 : 0.17 : 0.08 : 0.58 : 0.02. This yields a silicate-to-amorphous carbon ratio of 5.7 and a silicate crystalline-to-amorphous ratio of 2.4. For comparison with C/1995 O1 (Hale-Bopp), from Harker et al. (2002, Fig. 7) or Harker et al. (2004, Table 4).

Thermal emission

Results from Stardust mission

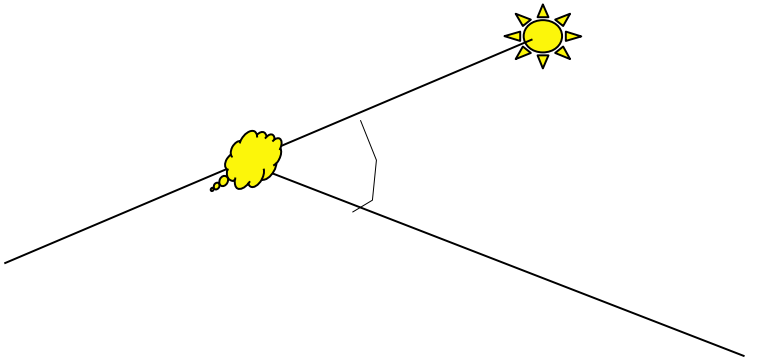


Cometary dust- Polarisation Studies

Interaction of light with matter- Scattering

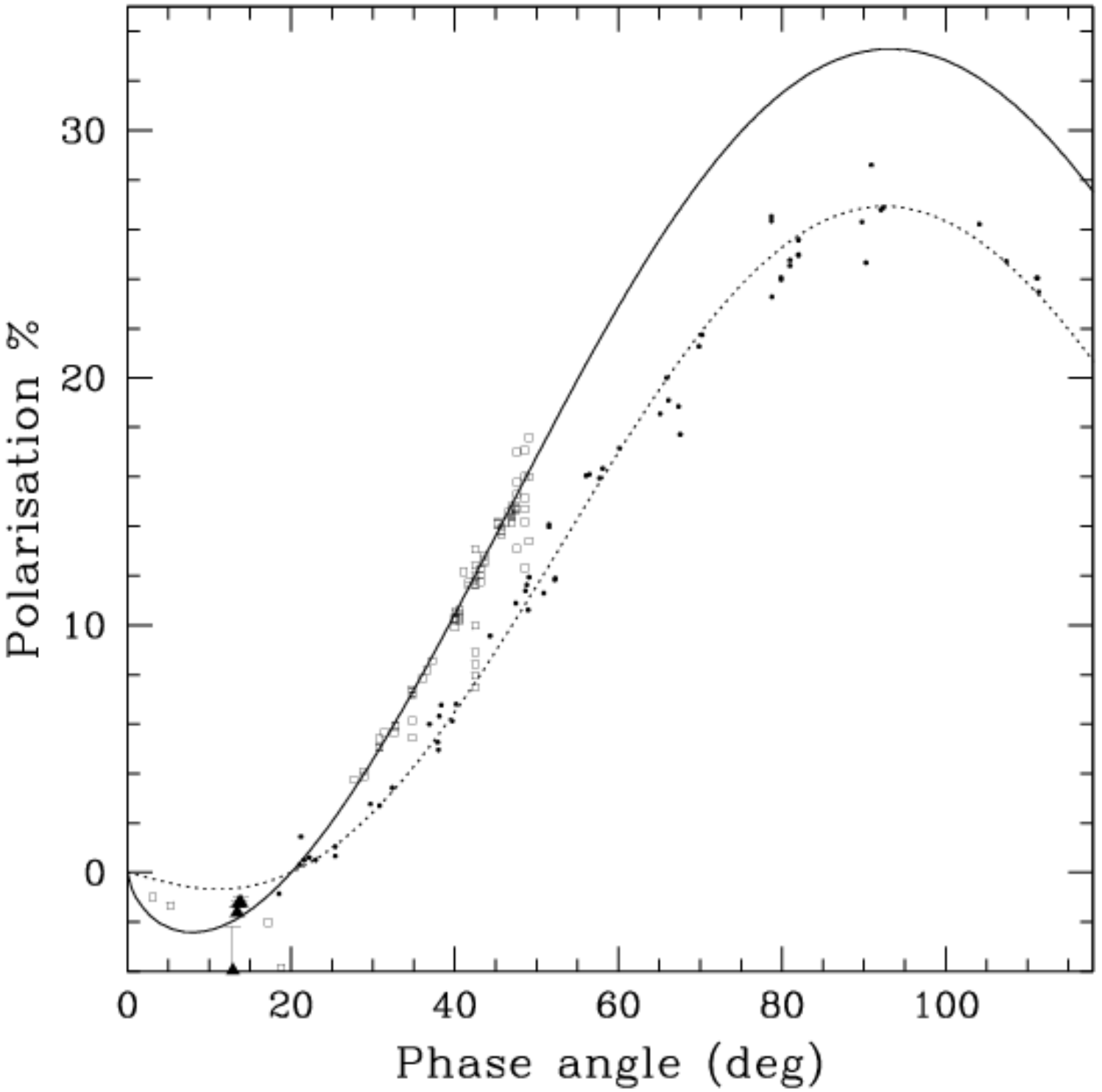
Polarization of Solar radiation by Comet Coma depends upon

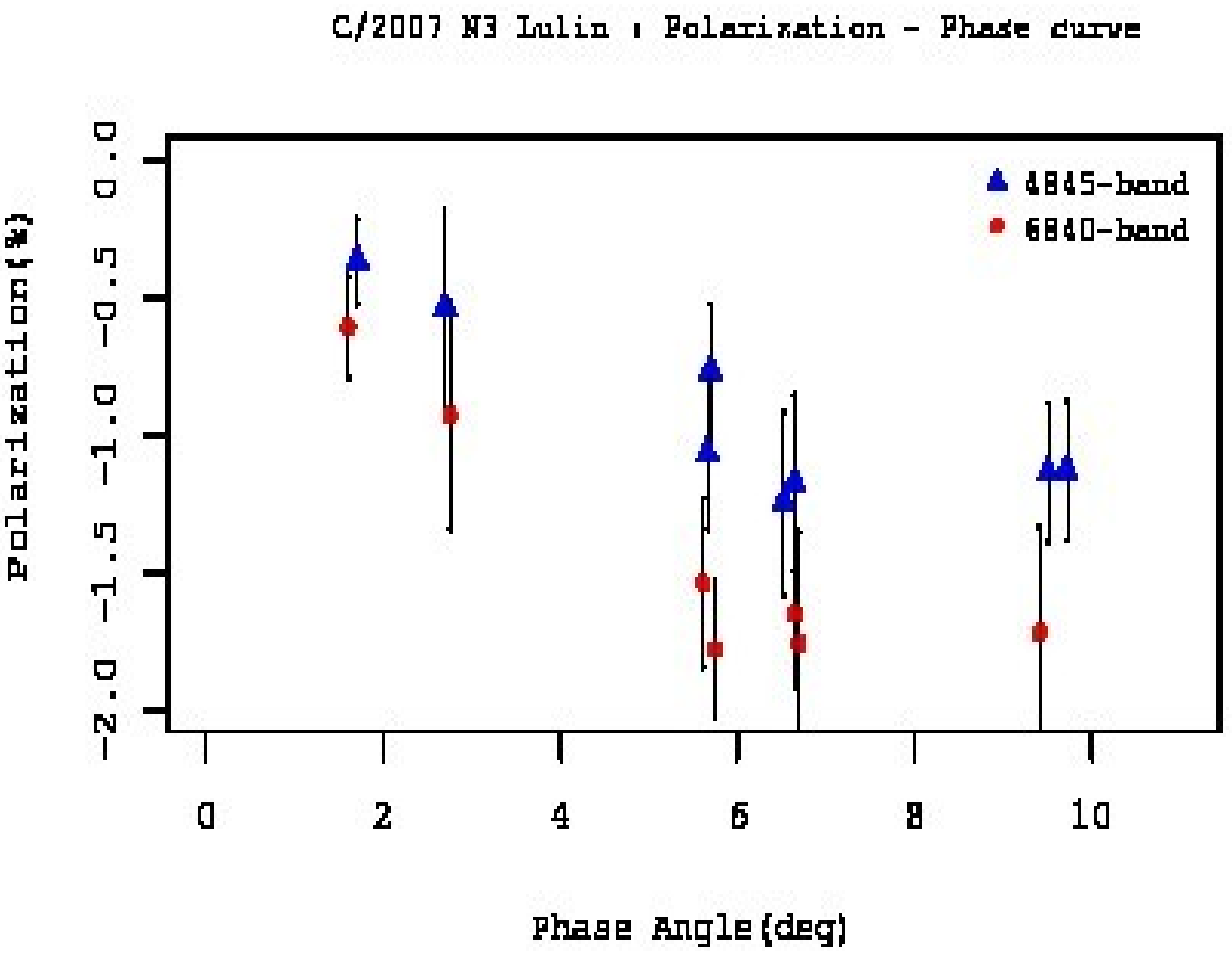
- Incident wavelength
- Phase angle
- Refractive index of grains
- Grain size distribution

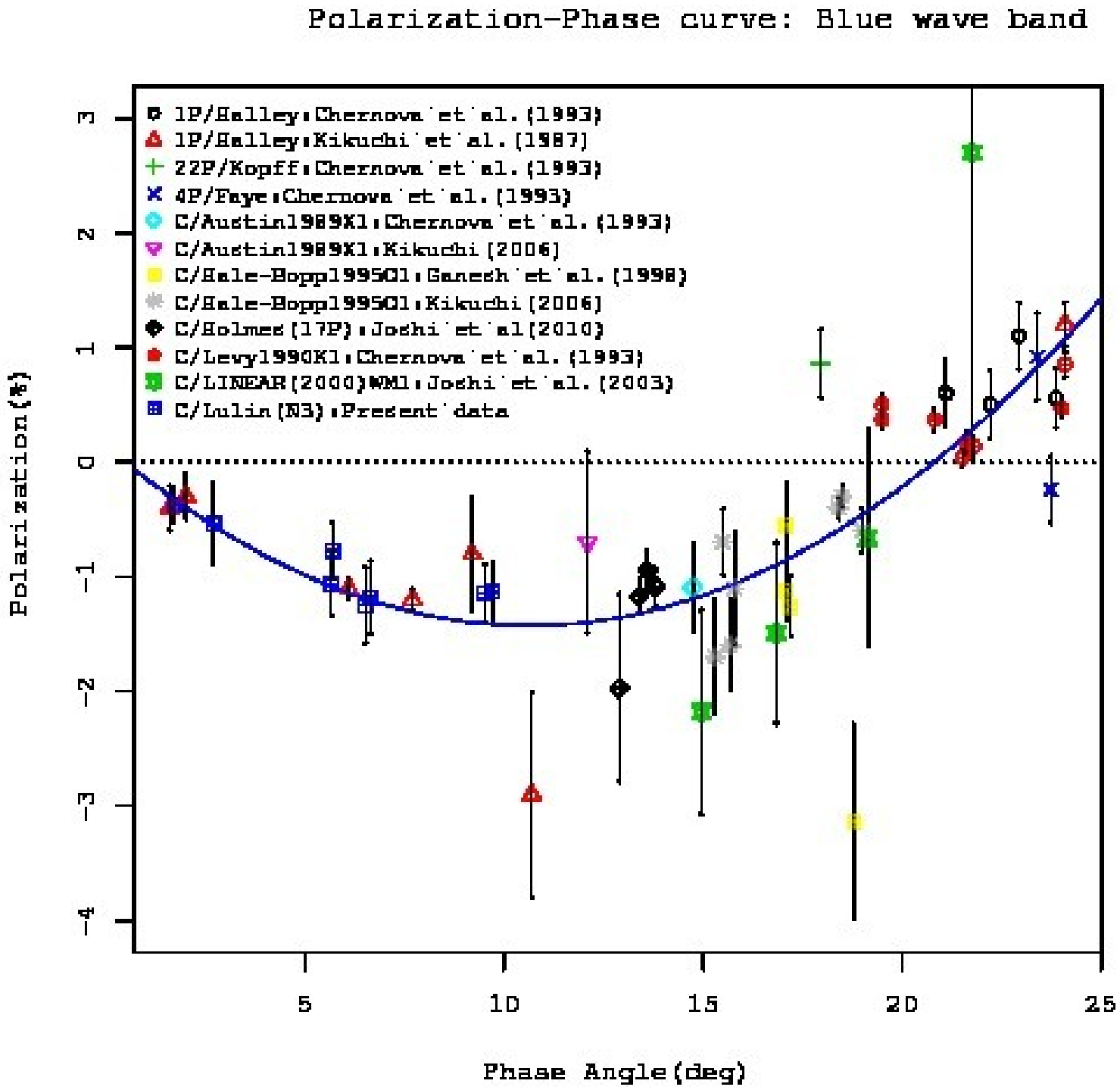


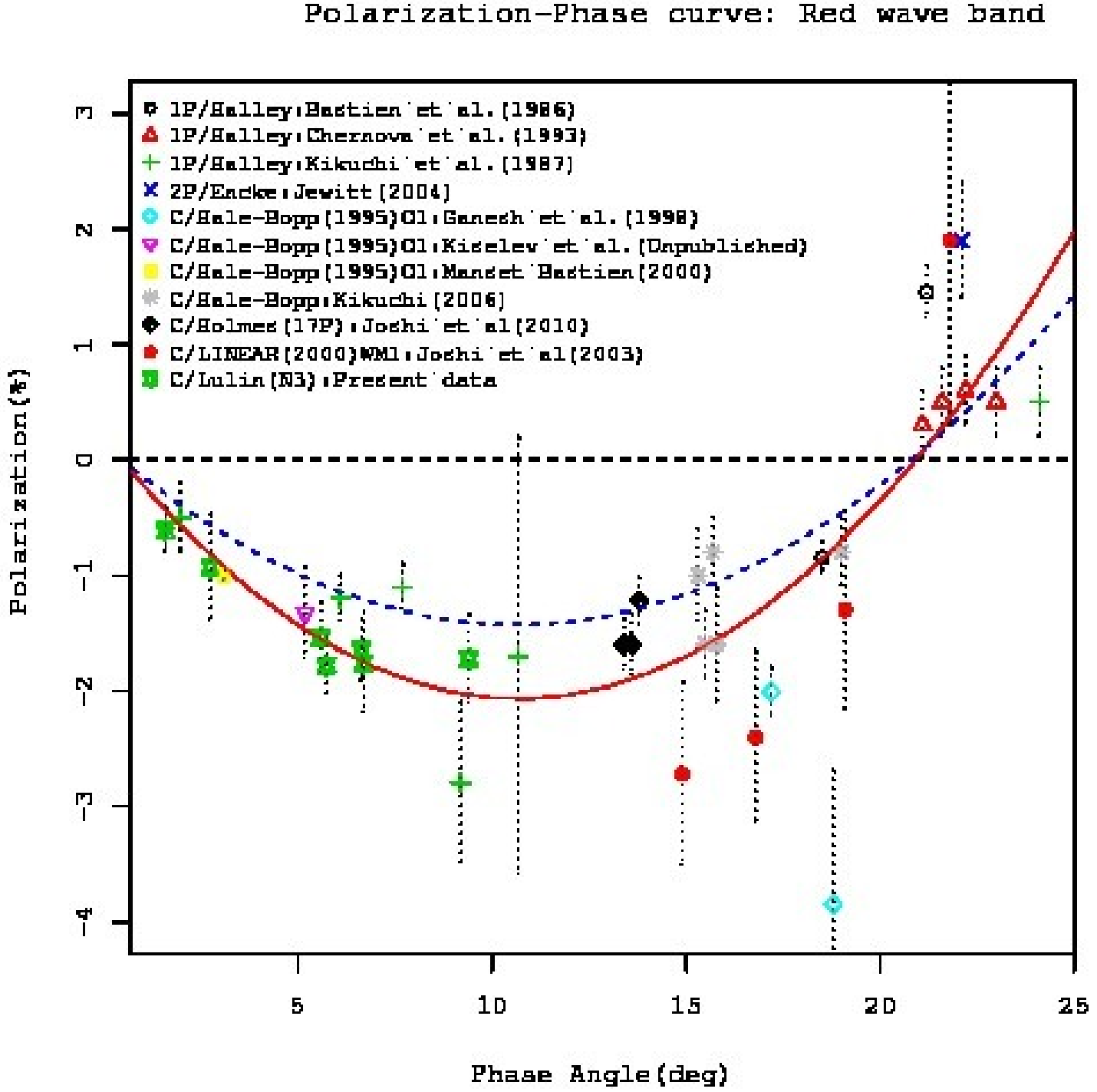
$$P = f(\lambda\ ,\ n\text{-}ik,\ \alpha\ ,\ n(a))$$

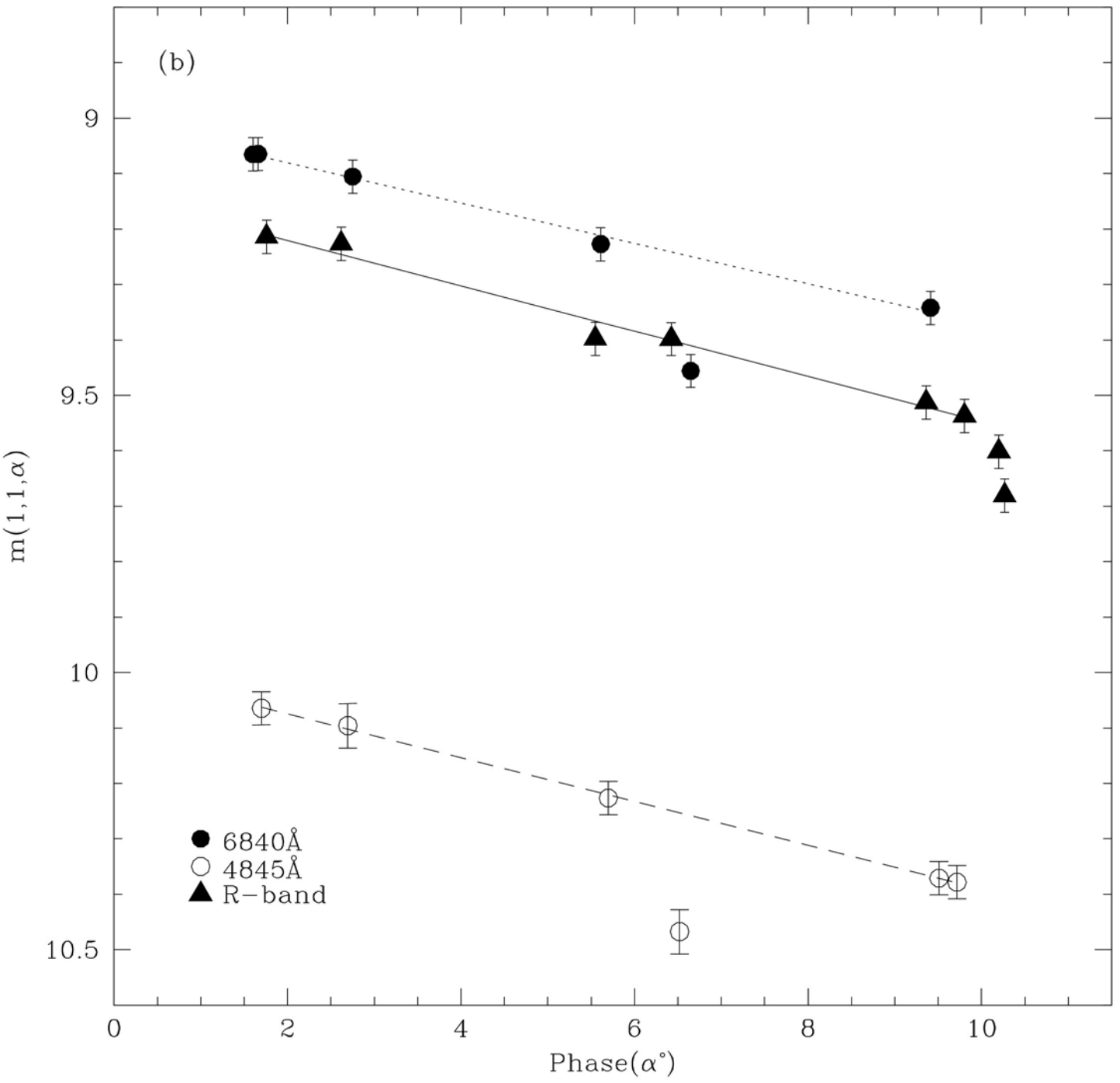
Polarization measurements on a large phase angle range are crucial to model cometary grain characteristics


Polarisation %
30
20
10
0
0
20
40
60
80
100
Phase angle (deg)


C/2007 N3 Lulin : Polarization - Phase curve
4845-band
6840-band
Polarization(%)
-2.0
-1.5
-1.0
-0.5
0.0
0
2
4
6
8
10
Phase Angle(deg)


Polarization-Phase curve: Blue wave band
1P/Halley:Chernova et al.(1993)
1P/Halley:Kikuchi et al.(1987)
22P/Kopff:Chernova et al.(1993)
4P/Faye:Chernova et al.(1993)
C/Austin1989X1:Chernova et al.(1993)
C/Austin1989X1:Kikuchi(2006)
C/Hale-Bopp1995O1:Ganesh et al.(1998)
C/Hale-Bopp1995O1:Kikuchi(2006)
C/Holmes(17P):Joshi et al(2010)
C/Levy1990K1:Chernova et al.(1993)
C/LINEAR(2000)WM1:Joshi et al.(2003)
C/Lulin(N3):Present data
Polarization(%)
3
2
1
0
-1
-2
-3
-4
5
10
15
20
25
Phase Angle(deg)


Polarization-Phase curve: Red wave band
1P/Halley:Bastien et al.(1986)
1P/Halley:Chernova et al.(1993)
1P/Halley:Kikuchi et al.(1987)
2P/Encke:Jewitt(2004)
C/Hale-Bopp(1995)O1:Ganesh et al.(1998)
C/Hale-Bopp(1995)O1:Kiselev et al.(Unpublished)
C/Hale-Bopp(1995)O1:Manset Bastien(2000)
C/Hale-Bopp:Kikuchi(2006)
C/Holmes(17P):Joshi et al(2010)
C/LINEAR(2000)WM1:Joshi et al(2003)
C/Lulin(N3):Present data
Polarization(%)
3
2
1
0
-1
-2
-3
-4
5
10
15
20
25
Phase Angle(deg)


Phase curve of comet C/2007 N3 (Lulin)
(b)
9
9.5
10
10.5
m(1,1,α)
0
2
4
6
8
10
Phase(α°)
6840Å
4845Å
R−band

Conclusions:

i) Polarizationin in NBP is found to be Wavelength dependent; maximum amplitude is more in red waveband compared to blue wavelength;

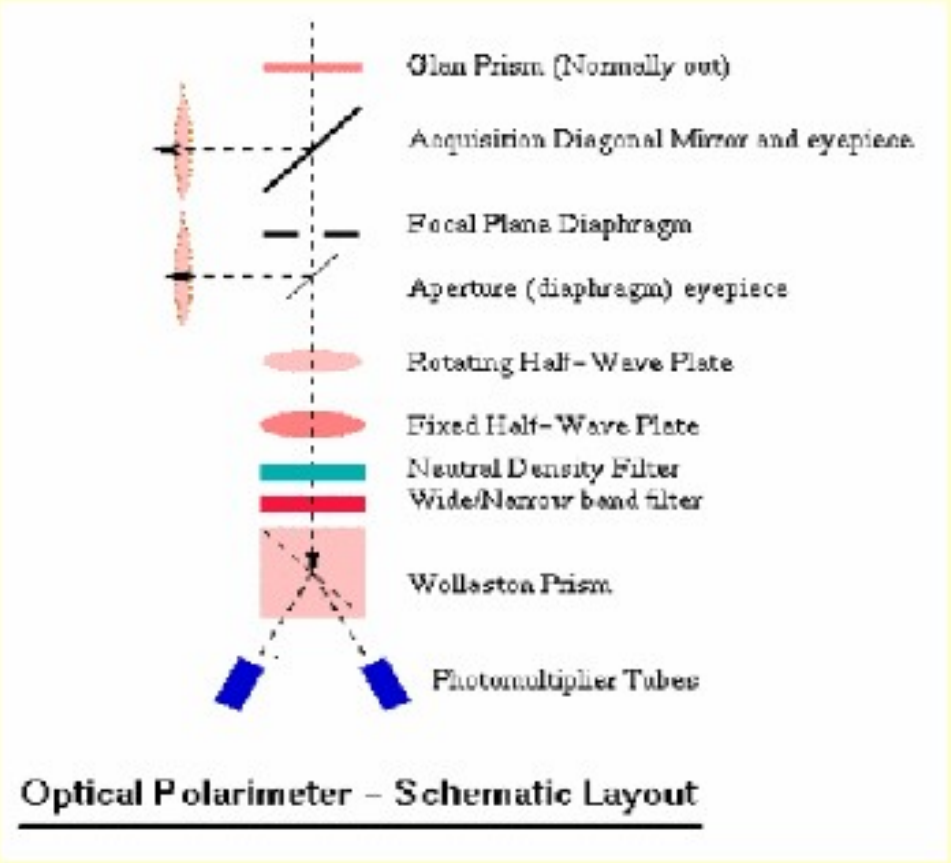
The finding refutes the present belief that In NBP P% is not wavelength dependent.

ii) No non-linear increase in brightness is detected; only a mild linear increase 0.041+-0.001 mag/deg, in phase angle range 1.7-11deg, is detected, which can be be explained with shadow hiding model.

Study of Comets

Polarimetric Observations of Comets from Mt Abu

Optical Photopolarimeter



Optical Polarimeter – Schematic Layout

Mt Abu Observatory

Thanks for the Attention