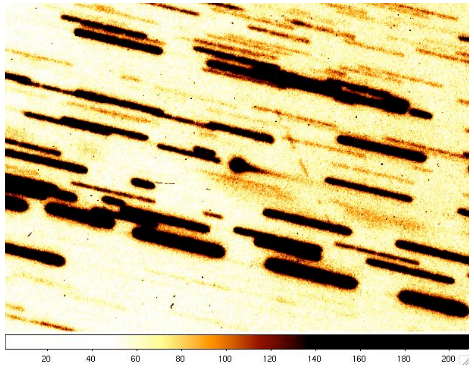
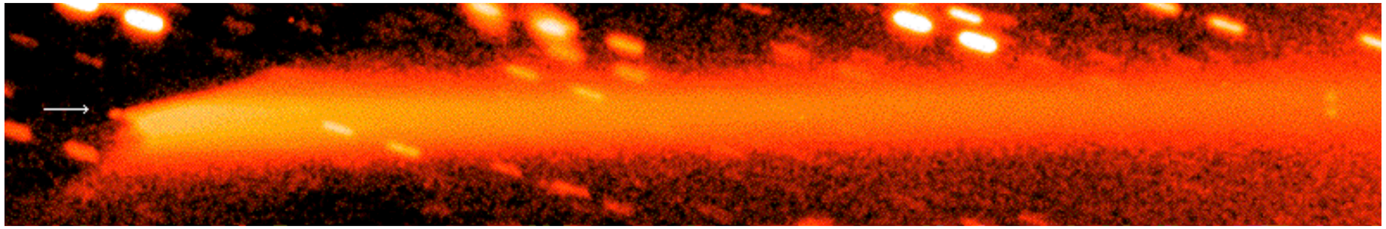




Activated Asteroids

Javier Licandro
Instituto de Astrofísica de Canarias, Spain

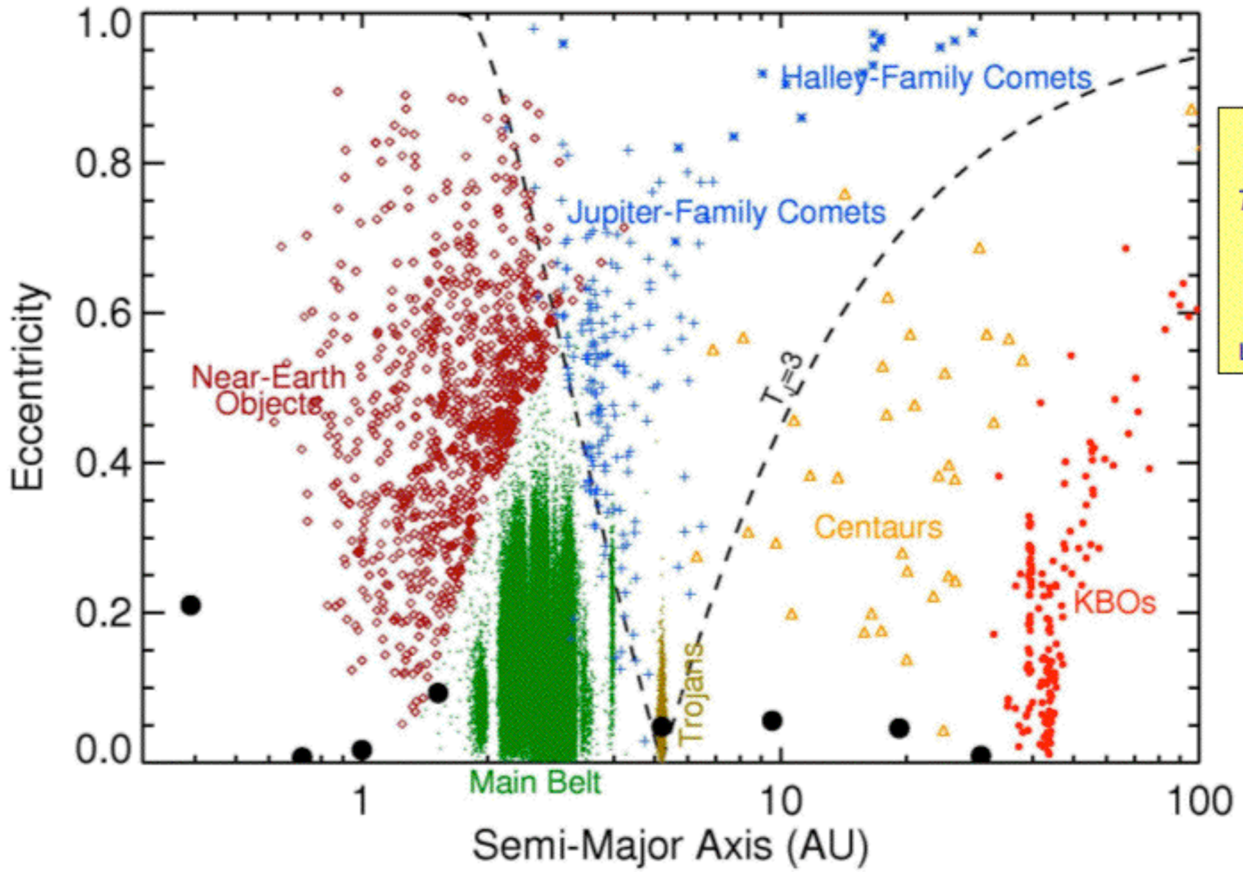
The Activated Asteroids (AAs)

"Objects in orbits with an unlikely cometary origin that were observed active or there is evidence that have been active in the past."

Orbits with an unlikely cometary origin: "*objects unlikely scattered from the known cometary reservoirs, the Oort Cloud or the trans-neptunian belt."*

Activity: "*ejection of a significant amount of dust by any mechanism."*

Asteroids & Icy Objects: Dynamical differences



Tisserand Parameter

$T_J = a_J/a + 2[(1-e)^2 a/a_J]^{1/2} \cos(i)$

a, e, i of the object
a_J of Jupiter

Los cometas tienen casi todos $T_J<3$

KBOs = TNOs, viene de Kuiper Belt Objects

Asteroids and icy bodies are in different regions

- Comets come from two reservoirs: the trans-neptunian belt and the Oort Cloud

Most Asteroids $T_J>3$

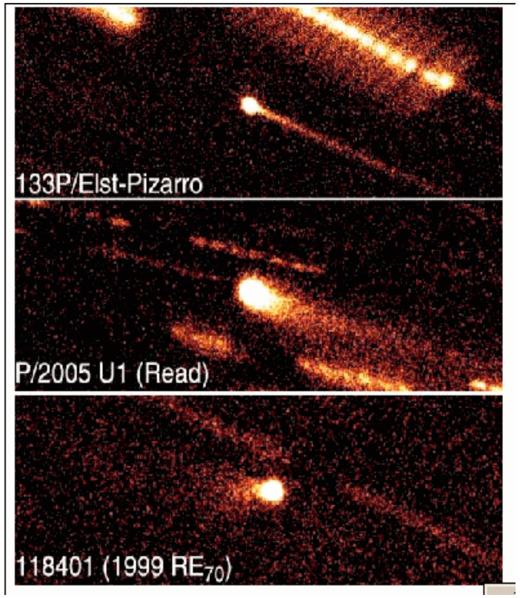
Almost all comets $T_J<3$

JFC in the 2-3 range

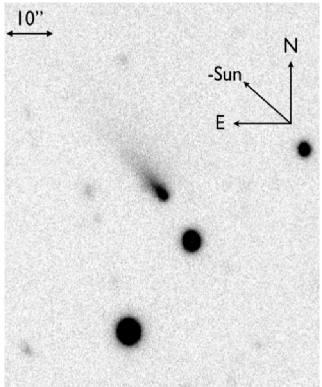
Halley Type and LP $T_J<2$

Activated Asteroids in the Main Belt: Main Belt Comets? (Hsieh et al. 2006)

- Objects with cometary like coma and tails
- in main belt asteroidal orbits with an unlikely cometary origin

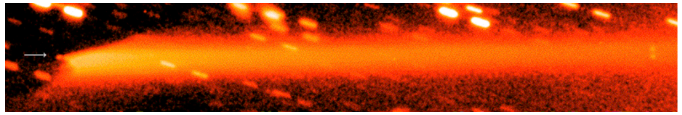


(Hsieh & Jewitt 2006)



P/2008 R1 (Garrad)

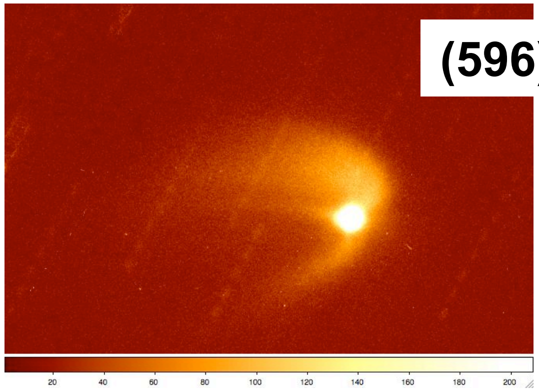
(Jewitt et al. 2009)



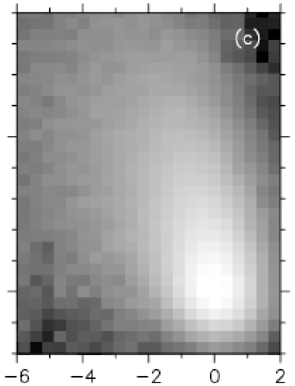
P/2010 A2 (LINEAR)

(Moreno et al. 2010)

(596) Scheila



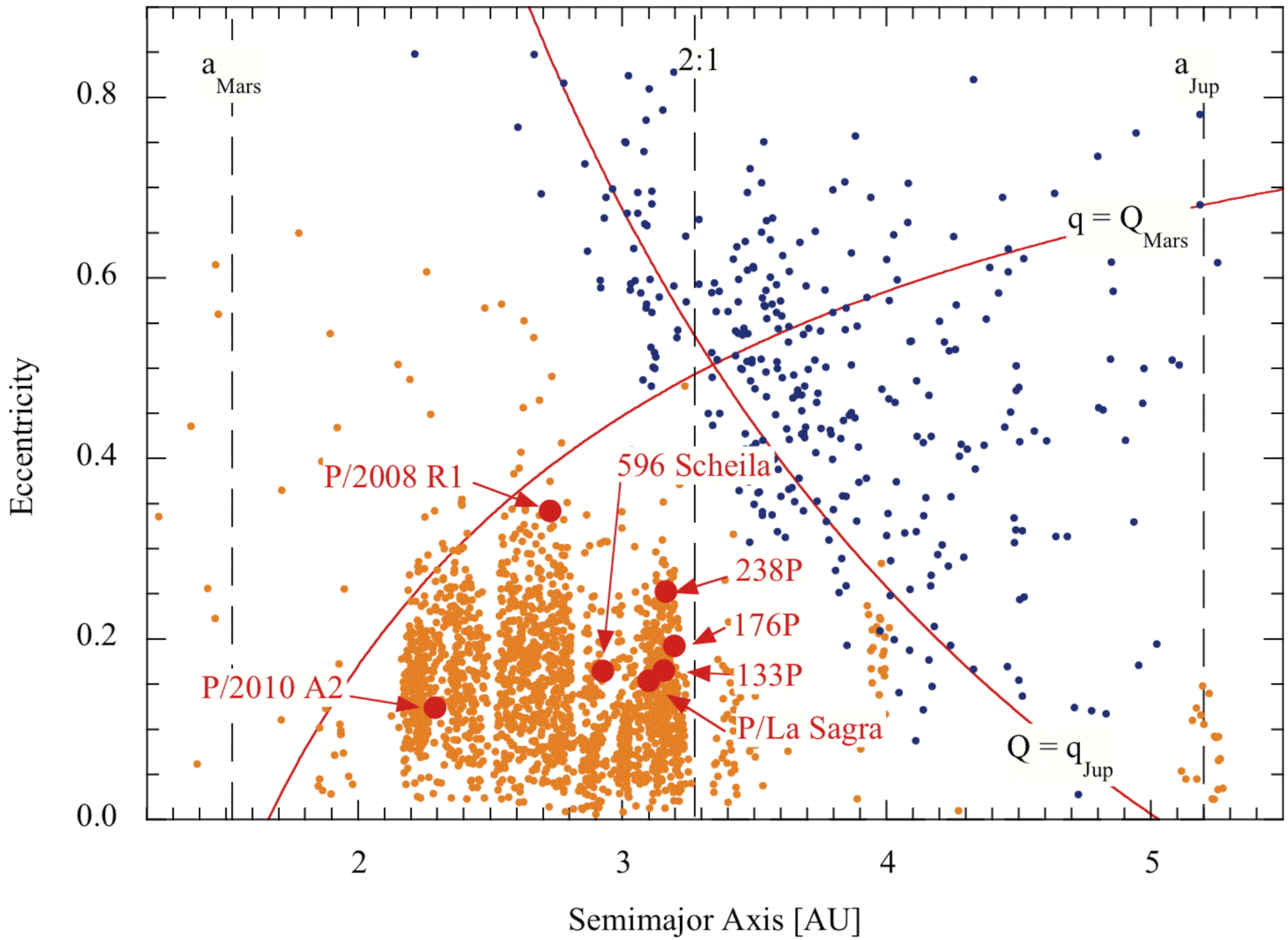
(Moreno et al. 2011)



P/2010 R2 (La Sagra)

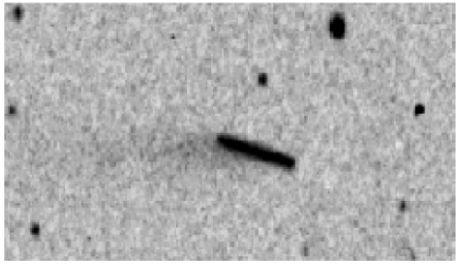
(Moreno et al. 2011)

Activated Asteroids in the Main Belt



The Activated Asteroids (AAs) in the NEO population (q<1.3 AU)

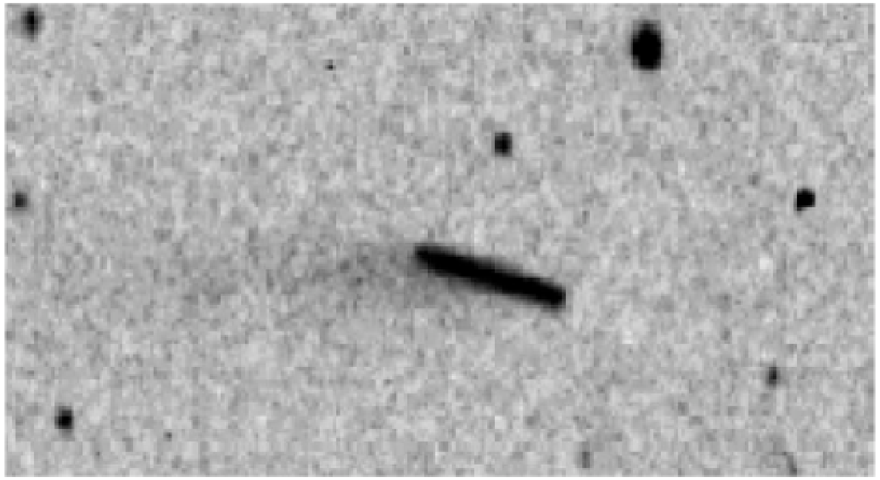
NEOs with sporadic observed activity: 107P/1949 W1 (Wilson-Harrington)



NEOs with associated meteor showers: e.g. (3200) Phaethon & 1999 YC (Geminids), 2005 UD (Sextantids), 2003 EH1 (Quadrantids), 2001 YB5 (no name)

Phaethon reported active in 2009 (Jewitt & Ling 2010)

Activity of 107P/Wilson-Harrington



- Observed active only when discovered in 1949
- Only seen in the blue band plate (suggesting gas emission Fernandez et al. 1997)
- Different search for activity failed (e.g. Ishiguro et al. 2011, Chamberlin et al. 1996)
- Dynamically unlikely have a cometary origin (4% chance of a JF origin, 65% of an outer belt origin (Bottke et al. 2002
- Activity mechanism unknown

(3200) Phaethon activity

- Parent body of the Geminids (Whipple 1983)
- Models favor long-lasted (cometary-like) activity as the ejection mechanism of the dust (Gustafson 1989, Williams and Wu 1993)
- Possible detection of activity in NASA STEREO-A images (Jewitt & Li 2010), never detected before.
- 0% probability of a dynamical cometary origin (Bottke et al. 2002)

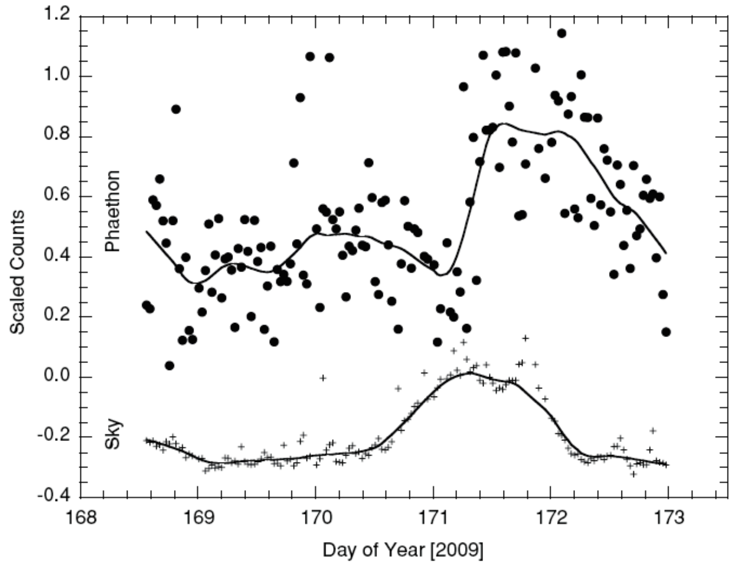


Figure 3. Sky-subtracted Phaethon photometry (upper) and the associated sky (lower), vs. Day of year in 2009. The Phaethon signal is the sum of the 9 pixels within a 3 × 3 pixel box, with the sky level subtracted from each. The sky is the median of the 16 pixels contained within nested squares of width 3 pixels and 5 pixels. To avoid overlap in the plot, 0.35 counts have been subtracted from the sky signal data.

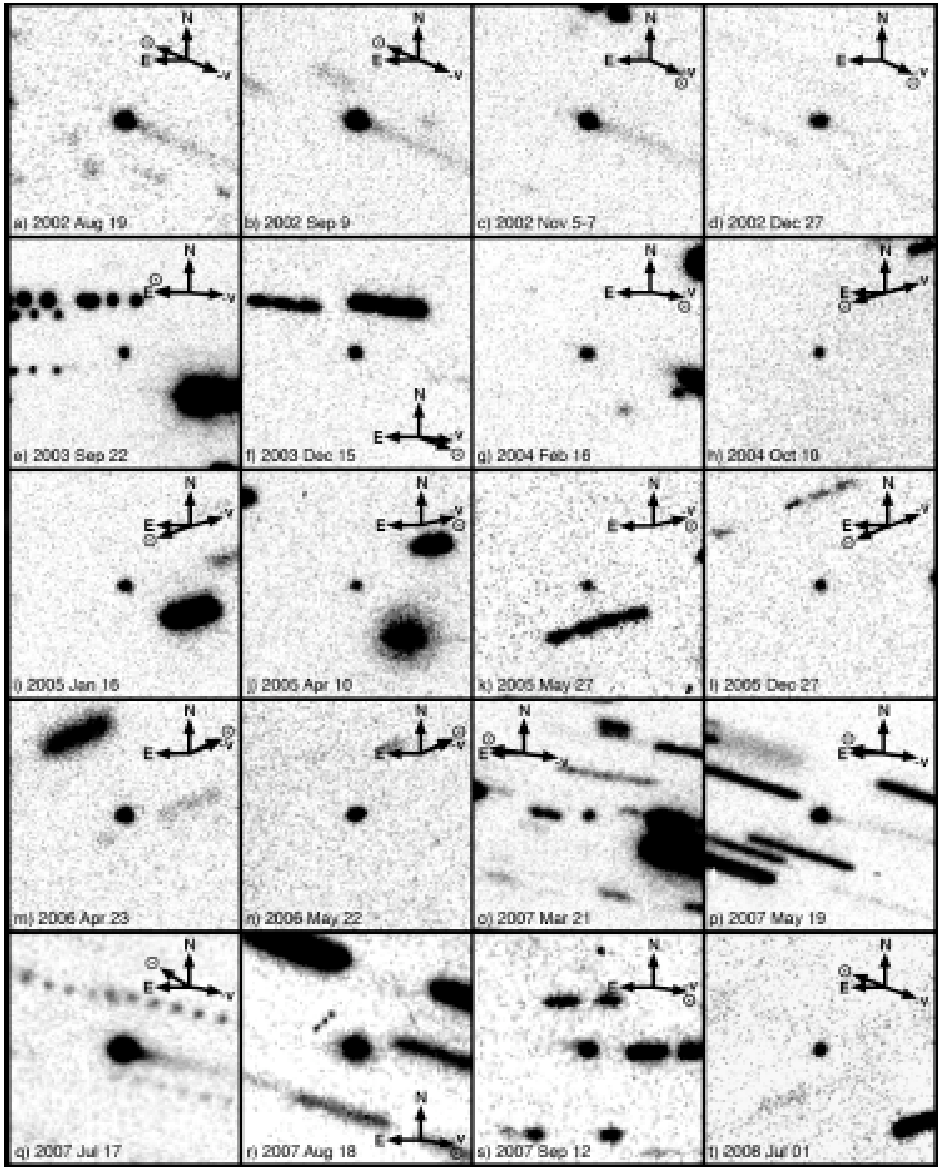
Jewitt & Li (2010)

Element	Value
e	.8900592737612761
a	1.271252093519295
q	.1397623783940094
i	22.21023338962487
node	265.3205455800504
peri	322.0805184648304
M	188.5645804112991
t_p	2456049.812470642624 (2012-May-02.31247064)
period	523.5352743713881 1.43
n	.687632749163376
Q	2.402741808644581

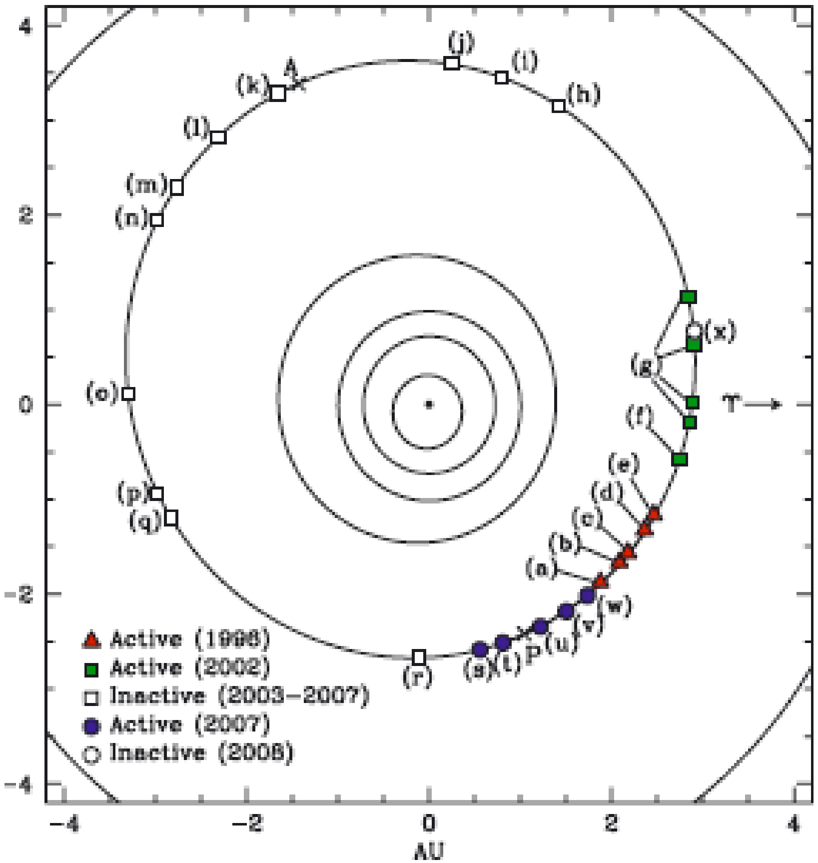
- *Jewitt & Li (2010) suggest thermal fracture and decomposition cracking of hydrated minerals as the dust production mechanism*

Activity of 133P/Elst-Pizarro

Hsieh et al. (2010)

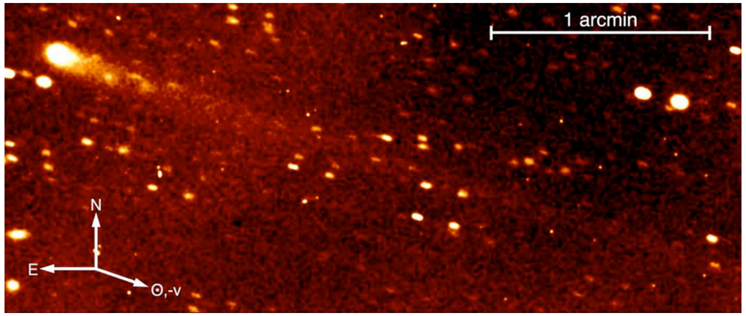


- Active in 1996, 2002, & 2007
- Dust models favor long-lasted (cometary-like) activity
- Seasonally modulated sublimation?



Activity of 238P/READ

Hsieh et al. 2009



Hsieh et al. 2011

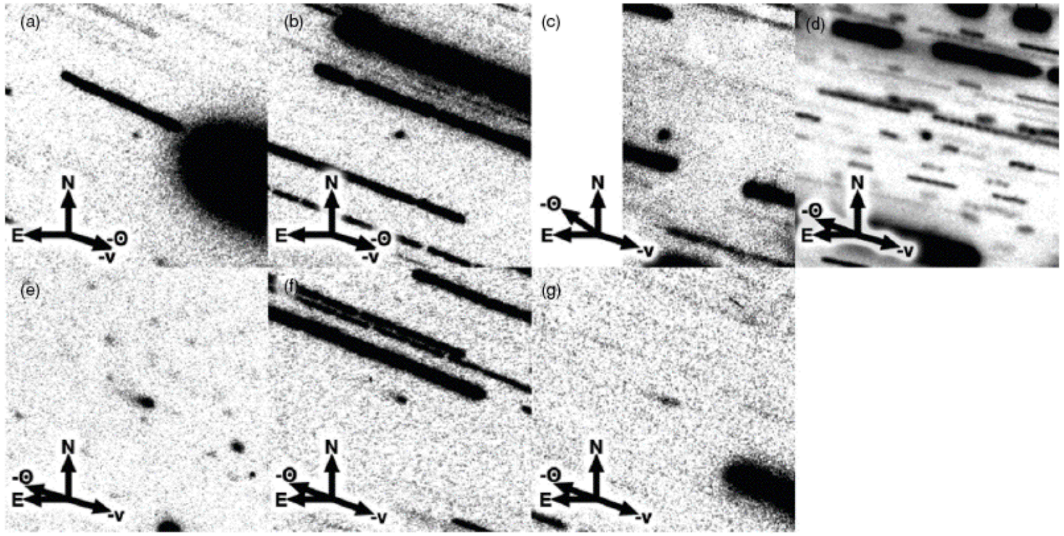
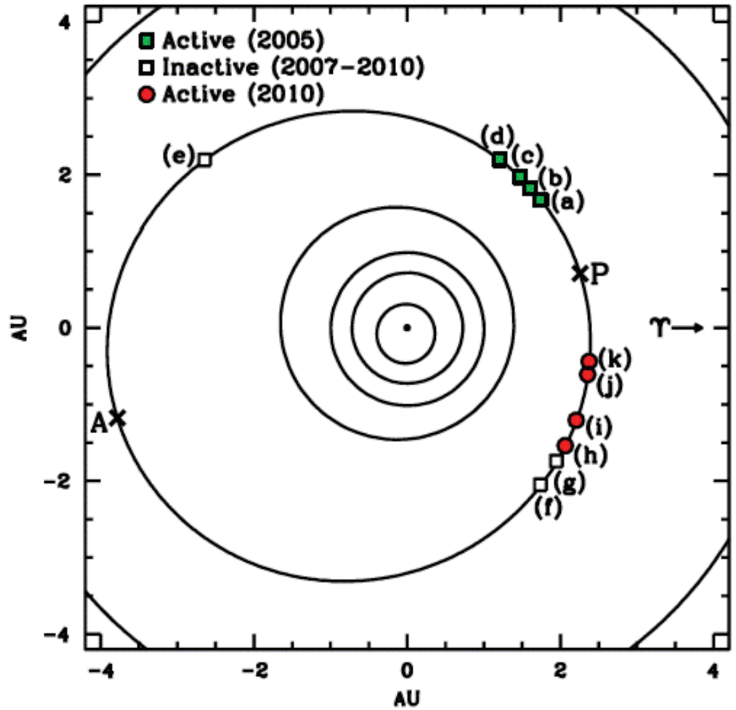


Figure 1. Composite *R*-band images of 238P (at the center of each panel) constructed from data obtained on (a) UT 2010 July 7 (8100 s of effective exposure time on the UH 2.2 m), (b) UT 2010 July 20 (19530 s on the UH 2.2 m), (c) UT 2010 August 14 (4050 s on SOAR), (d) UT 2010 September 3 and 4 (23100 s on the NTT), (e) UT 2010 October 5 (840 s on Keck), (f) UT 2010 November 25 (4800 s on the UH 2.2 m), and (g) UT 2010 December 9 (4500 s on the UH 2.2 m). All panels are $60''.0 \times 60''.0$ in size, with north (N), east (E), the antisolar direction ($-\odot$), and the negative heliocentric velocity vector ($-v$), as projected on the sky, marked.



- Active in 2005 and 2010
- Dust models favor long-lasted (cometary-like) activity
- Seasonally modulated sublimation?

Activity of 176P/READ

Hsieh et al. 2011

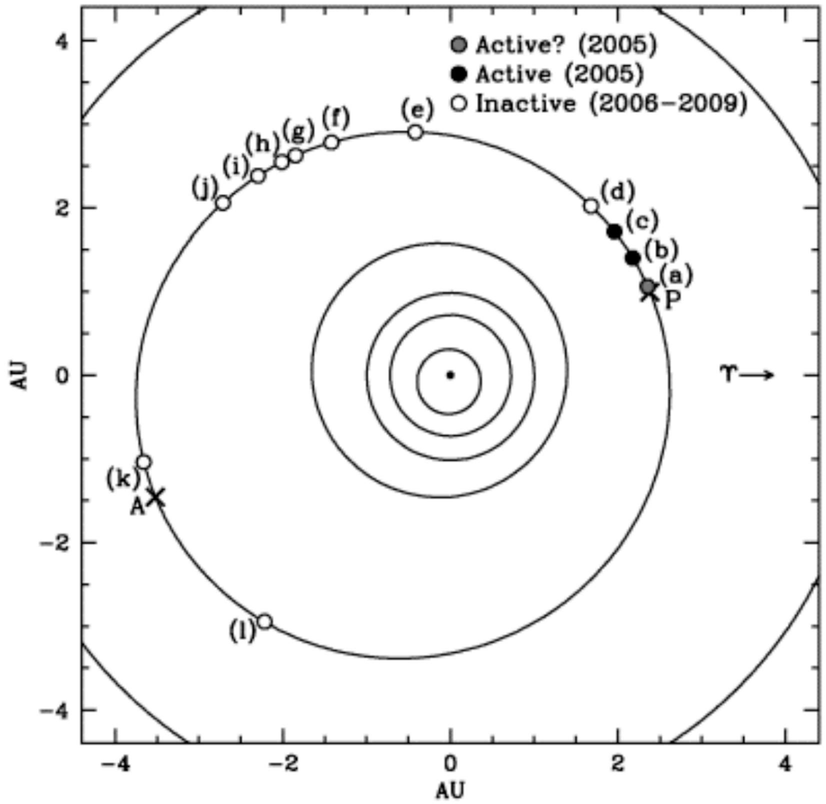


Figure 2. Orbital position plot of active and inactive phases of 176P detailed in Table 1. The Sun is shown at the center as a solid dot, with the orbits of Mercury, Venus, Earth, Mars, 176P, and Jupiter (from the center of the plot outward) are shown as black lines. Solid circles mark positions where 176P was observed to be active, while open circles mark positions where 176P was observed to be inactive. Perihelion (P) and aphelion (A) positions are also marked with crosses. References: (a) 2005 October 24 (Hsieh 2009), (b) 2005 November 26 (Hsieh & Jewitt 2006), (c) 2005 December 22–29 (Hsieh & Jewitt 2006), (d) 2006 February 3–8, (e) 2006 August 31–September 2, (f) 2006 December 11–18, (g) 2007 January 27, (h) 2007 February 15–16, (i) 2007 March 21–22, (j) 2007 May 19, (k) 2008 June 29–July 1, (l) 2009 May 3, where (d)–(l) are from this work.

- Active only in 2005
- Dust models favor long-lasted (cometary-like) activity

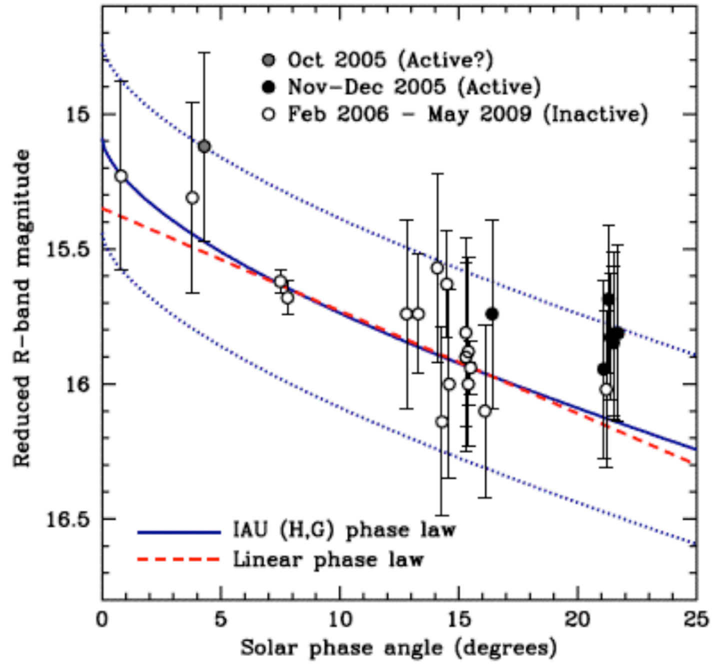
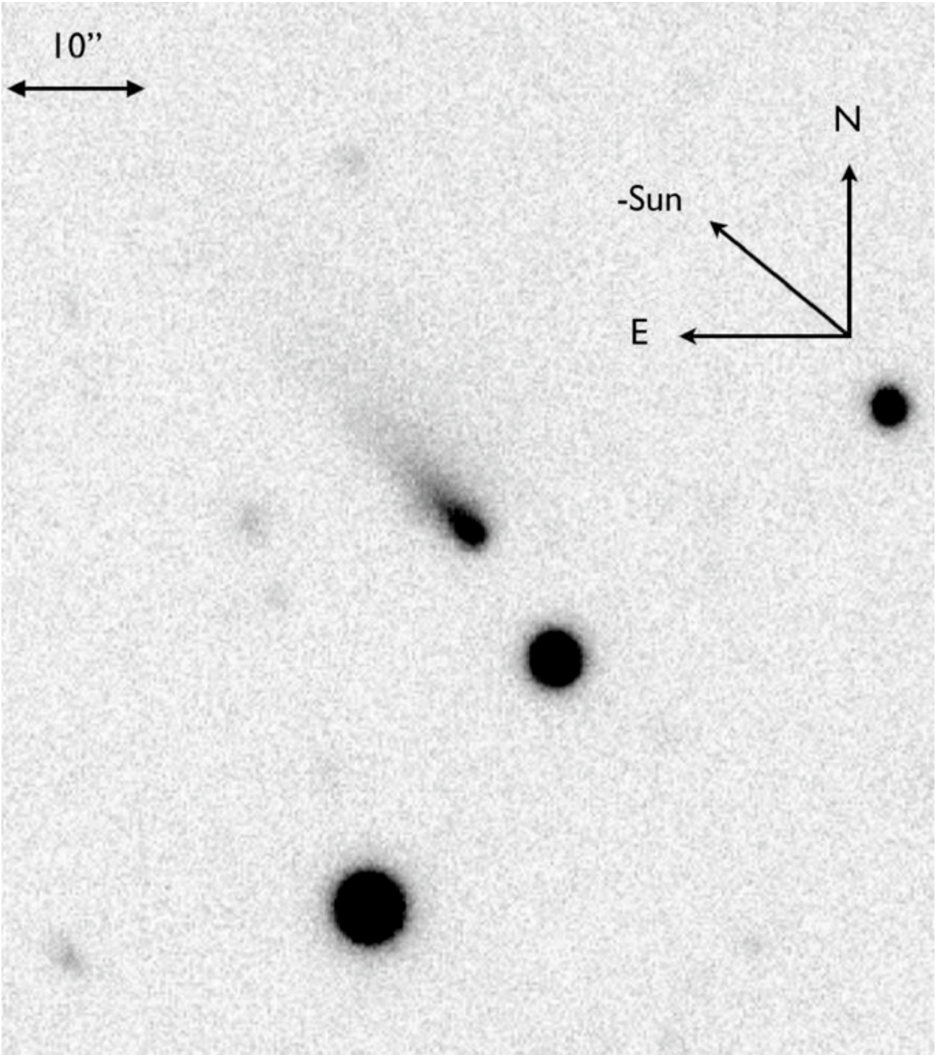


Figure 3. Phase functions for 176P. Points are estimated R-band magnitudes (normalized to heliocentric and geocentric distances of 1 AU; tabulated in Table 1) at the midpoint of the full photometric range of the nucleus's rotational light curve. Solid circles denote photometry obtained while 176P was visibly active, while open circles denote photometry obtained while 176P appeared to be inactive. The dashed line represents a least-squares fit (excluding photometry points for which $\alpha < 5°$ where an opposition surge effect is expected) to a linear phase function where $m_R(1,1,0) = 15.35 \pm 0.08$ mag and $\beta = 0.038 \pm 0.008$ mag deg^{-1}. The solid line represents an IAU (H, G) phase function fit where $H_R = 15.09 \pm 0.05$ mag and $G_R = 0.15 \pm 0.10$, while the dotted lines indicate the expected range of possible magnitude variations (~0.35 mag) due to the object's rotation.

Activity of P/2008 R1 (Garrad)

Jewitt et al. 2009



- Active only in 2008
- Dust models favor long-lasted (cometary-like) activity

Activity of P/2010 R2 (La Sagra)

- Active in 2010-2011
- Dust models favor long-lasted (cometary-

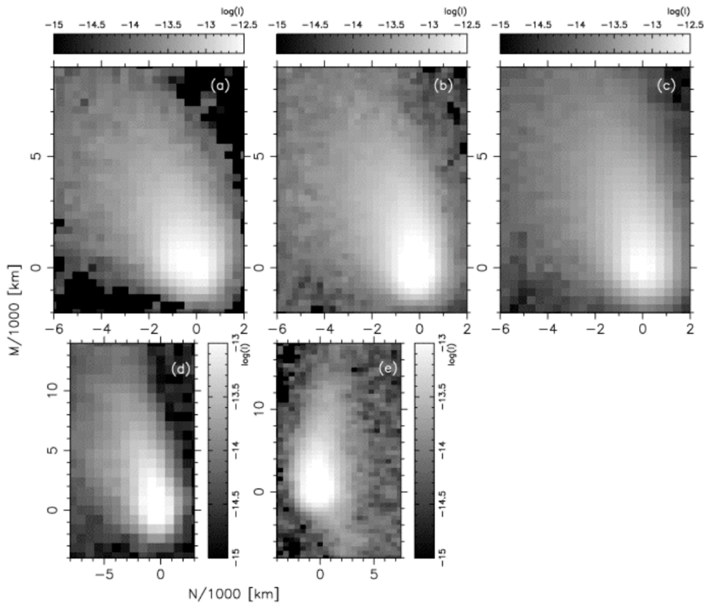


Figure 1. Images of P/La Sagra corresponding to 2010 October 10.9 (a), 2010 October 16.0 (b), 2010 October 26.9 (c), 2010 November 4.8 (d), and 2011 January 9.8 (e). Brightness is displayed in logarithmic scale, in solar disk intensity units. The images are oriented to the (N, M) coordinate system, with the scale in thousands of kilometers.

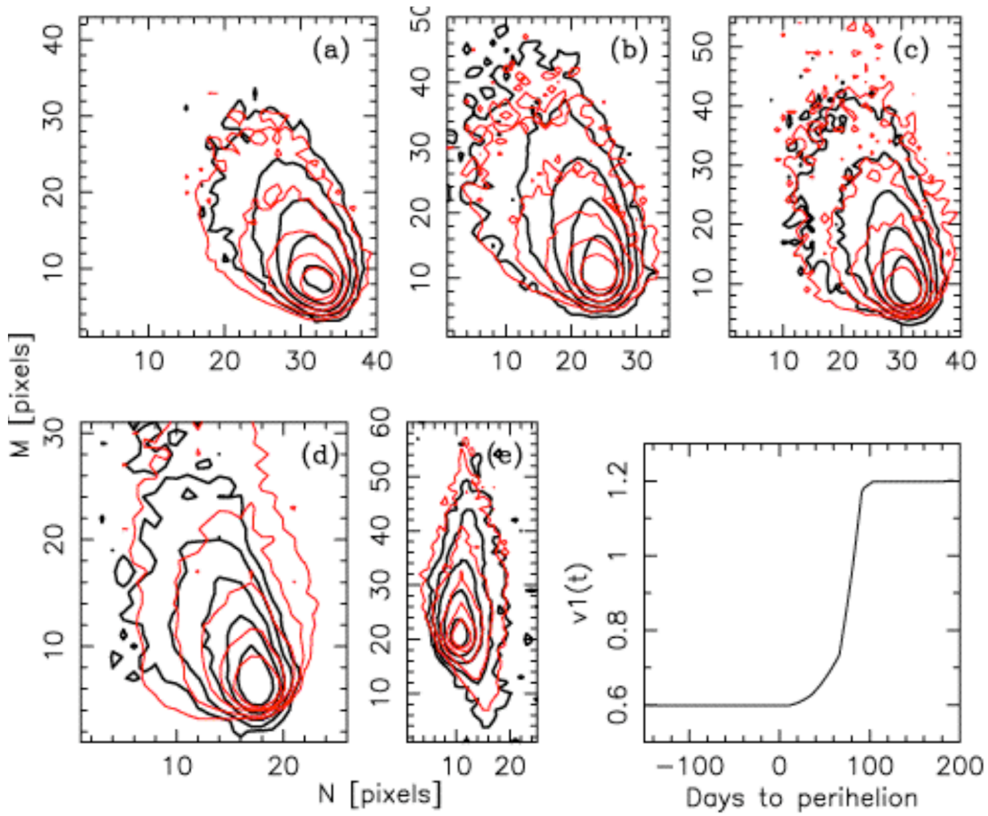
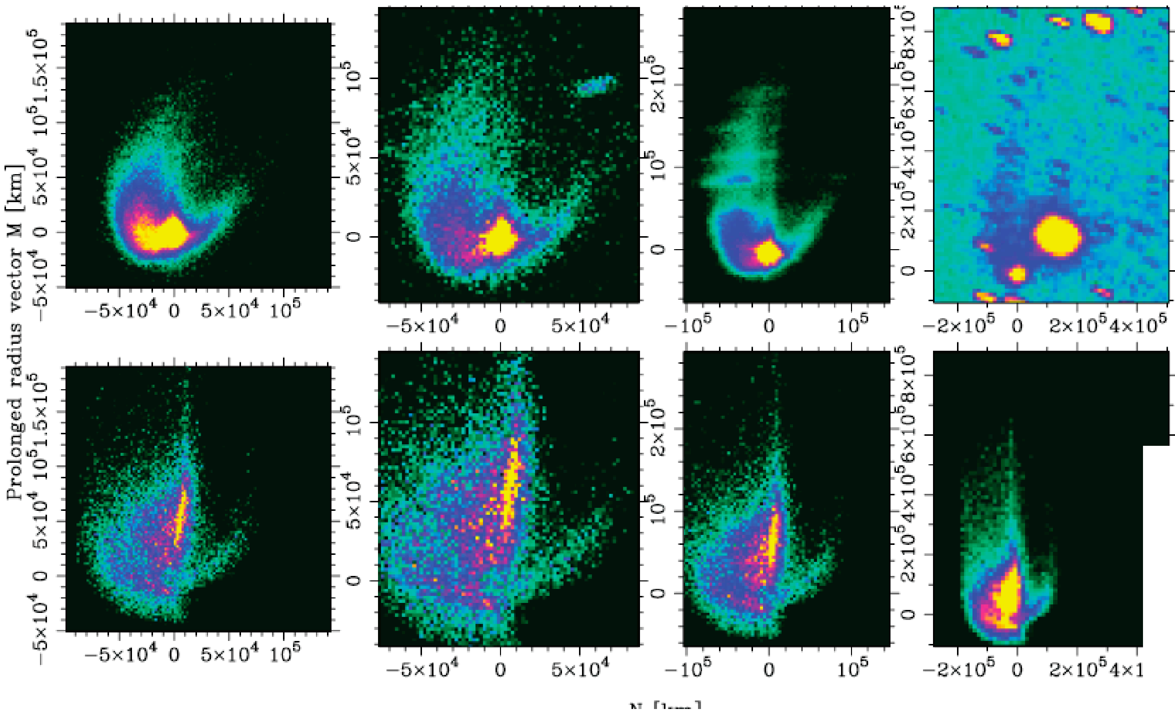


Figure 2. (a)–(e) In black thick solid lines contour plots corresponding to the observations, and in thin red lines to the isotropic model, for the following dates (UT): (a) 2010 October 10.9; (b) 2010 October 16.0; (c) 2010 October 26.9; (d) 2010 November 4.8; (e) 2011 January 9.8. Isophotes vary in factors of two, being the innermost contour of 2×10^{-14} for panels (a) and (b), 10^{-14} for panel (c), 5×10^{-15} for panel (d), and 10^{-14} for panel (e), all expressed in solar disk intensity units. The rightmost lower panel shows the variation of the dust loss mass rate with time relative to perihelion.

Activity of (596) Scheila



Moreno et al. 2011

- Active in 2010
- Rapid fading of the coma
- Different papers support an **impact cratering event** (Moreno et al. 2011, Hsieh et al. 2011, Bodewits et al. 2011, Jewitt et al. 2011)

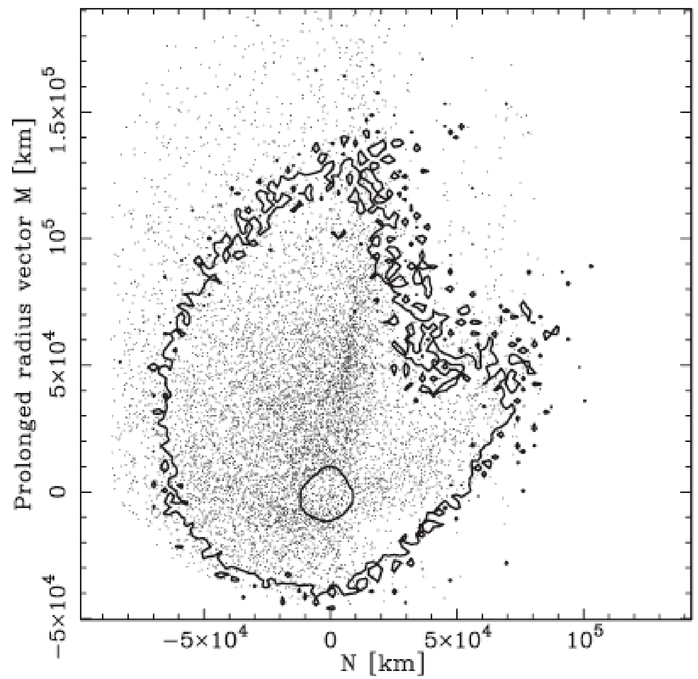
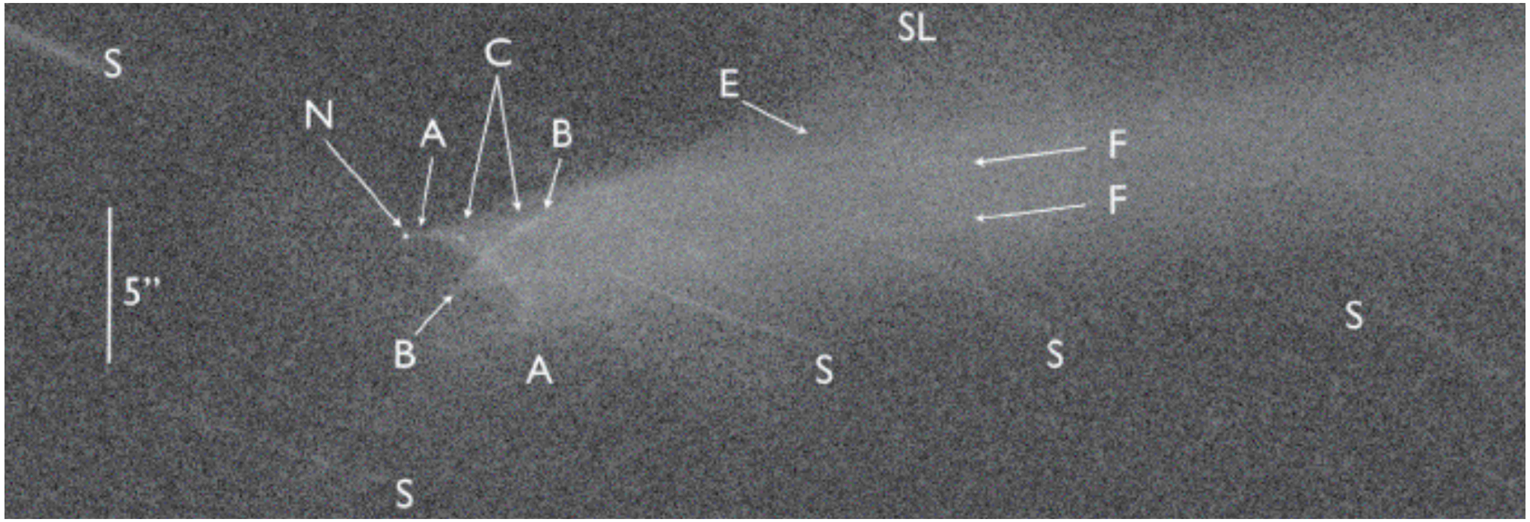


Figure 4. Black thick solid lines: contour plots at 10^{-14} and 7×10^{-14} solar disk intensity units for Scheila's December 13 image. The dots represent the position on the (N, M) plane of particles ejected for the best-fit model parameters, but with some ejection restrictions along the z asterocentric axis (see the text).

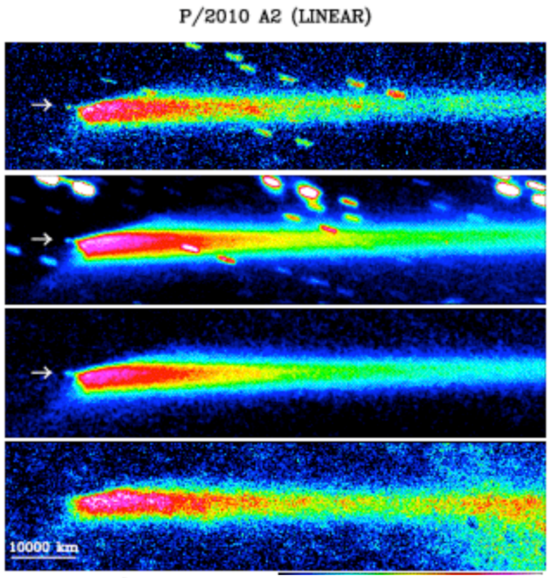
Activity of P/2010 A2 (LINEAR)

Jewitt et al. 2010



- Active in 2010
- Asteroid separated from a dust cloud full of “structures”
- Different papers support an **impact cratering event** (Snodgrass et al. 2010, Jewitt et al. 2010, Hainaut et al. 2011)
- **But** Monte Carlos dust models from Moreno et al. 2010 support a **long-lasted ejection event**

Activity of P/2010 A2 (LINEAR)



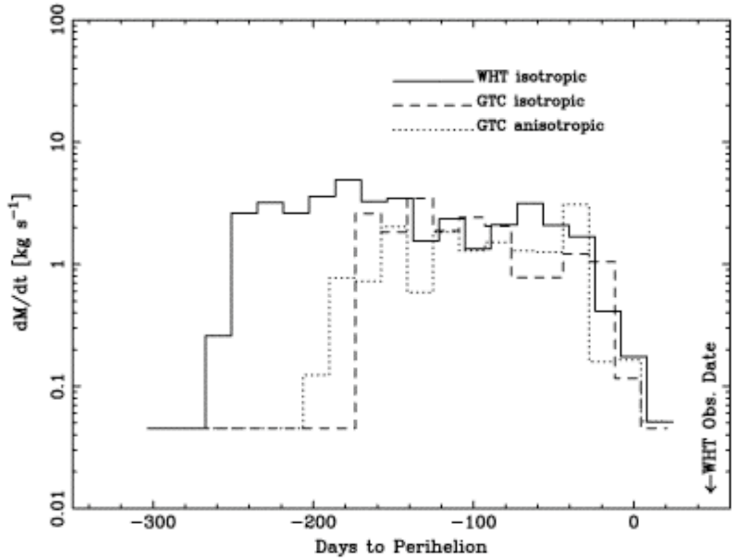


Figure 4. Derived dust mass-loss rates vs. time from the WHT and GTC images using isotropic and anisotropic dust ejection models as indicated. The arrow marks the date of the observation of the WHT image.

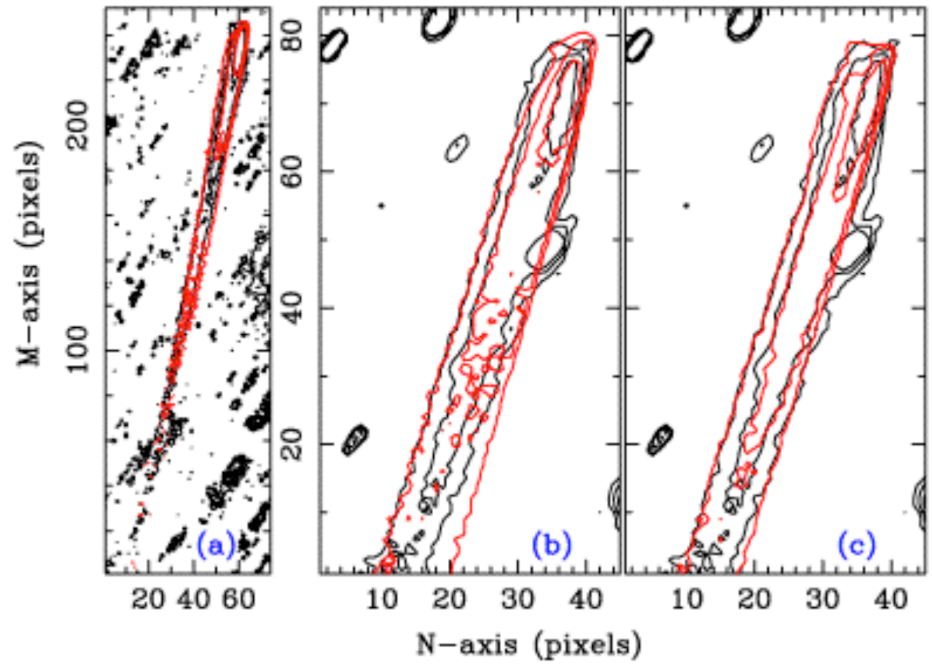


Figure 3. Results of the dust model applied to the WHT and GTC images. Coordinate axes correspond to the (N, M) system (see the text). Black contours, with isophote levels of 5×10^{-15}, 10^{-14}, and 2×10^{-14} solar disk intensity units, correspond to the observations. Red contours correspond to the model. Panel (a): the isotropic model applied to the WHT image. The physical dimensions of the images are 57,154 km × 19,4632 km. Panel (b): the isotropic model applied to the GTC image. The physical dimensions of the images are 25932 km × 48407 km. Panel (c): the anisotropic model applied to the GTC image, with same physical dimensions as those of panel (b).

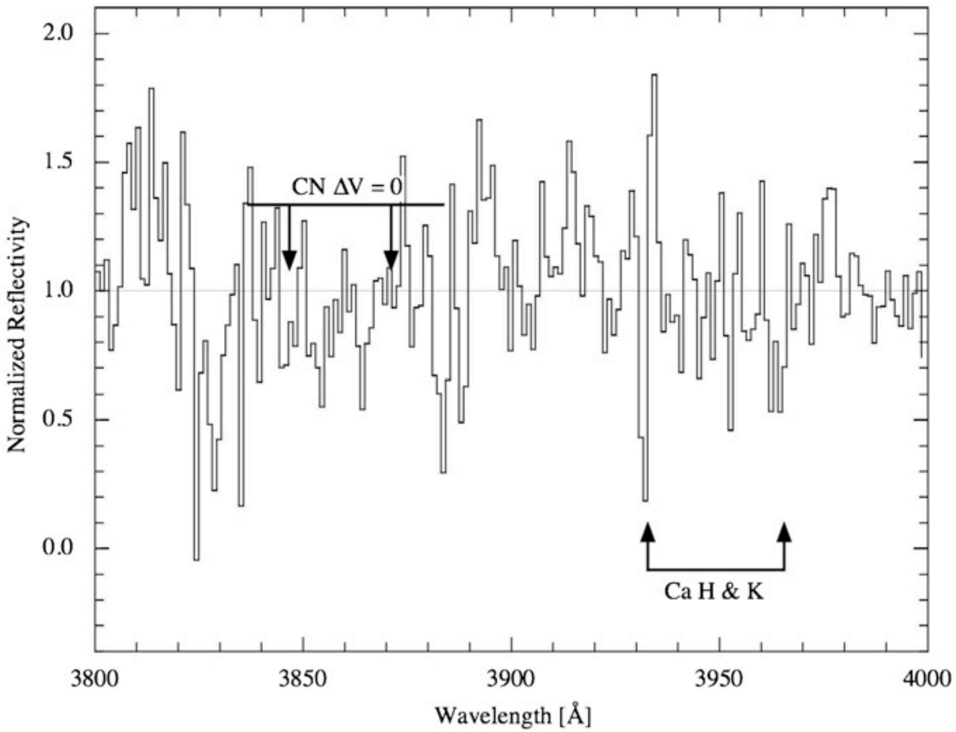
Moreno et al. 2010

Activated Asteroids observed activity

- 133P/E-P & 238P/Read observed active on each perihelion pasage
- Dust models of the observed activity of 133P, 176P, 238P, P/2008 R1, P/2010 R2 suggest a **dust emission along several months and compatible with comet-like activity**
- Dust models of the observed activity of (596) Scheila suggest **a collisional event**
- The case of P/2010 A2 (LINEAR) is still **controversial**
- (3200) Phaethon dust cloud suggest **long lasted cometary activity**
- 107P/Wilson-Harrington observed active only once.

- WATER ICE on several asteroids?
- Collisions, rotational disruption, others?

Search for gas emission



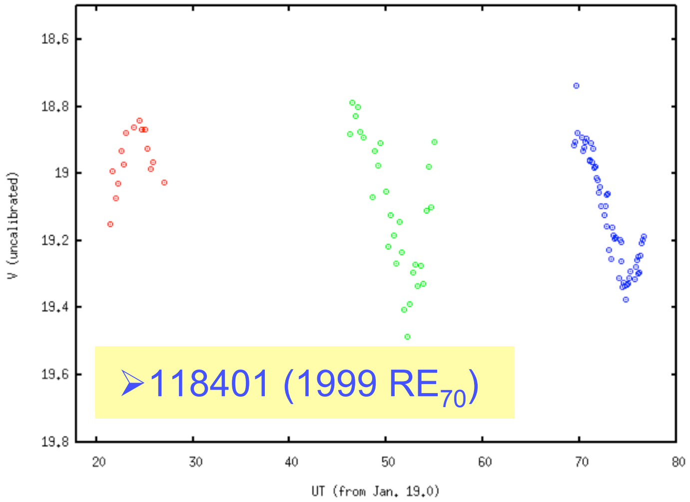
Several attempts failed to detect gas emission, in particular CN band at 380nm (Chamberlin et al. 1996, Licandro et al. 2011, Hsieh et al. 2011, Bodewitz et al. 2011, Ishiguro et al. 2011 …)

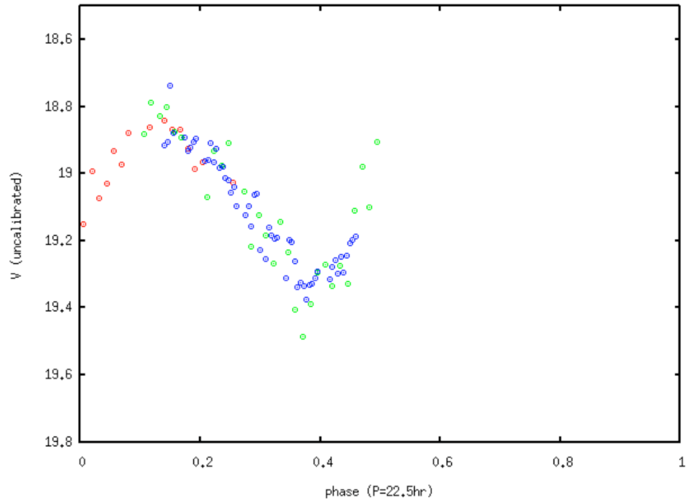
- too faint and/or too far to detect CN emission?

- Do objects formed closer to the Sun than "normal" comet accreted similar amounts of volatiles, eg. HCN?

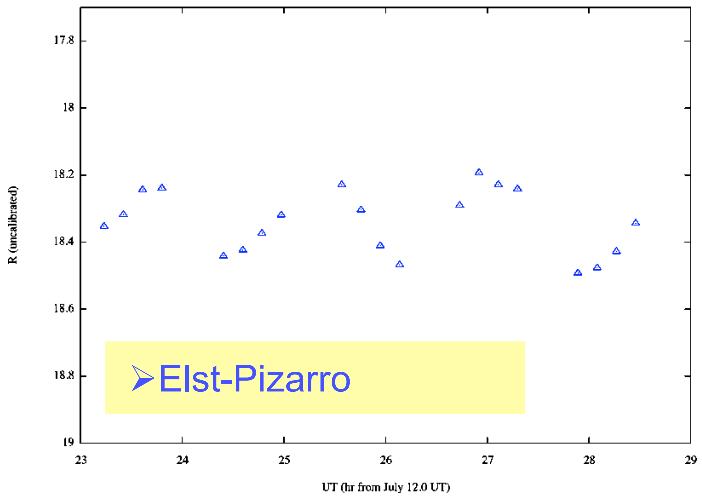
Rotational light-curves

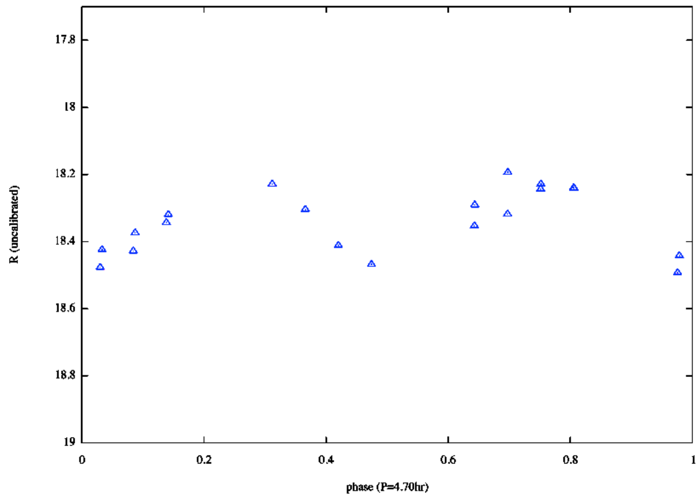
Studying the internal structure





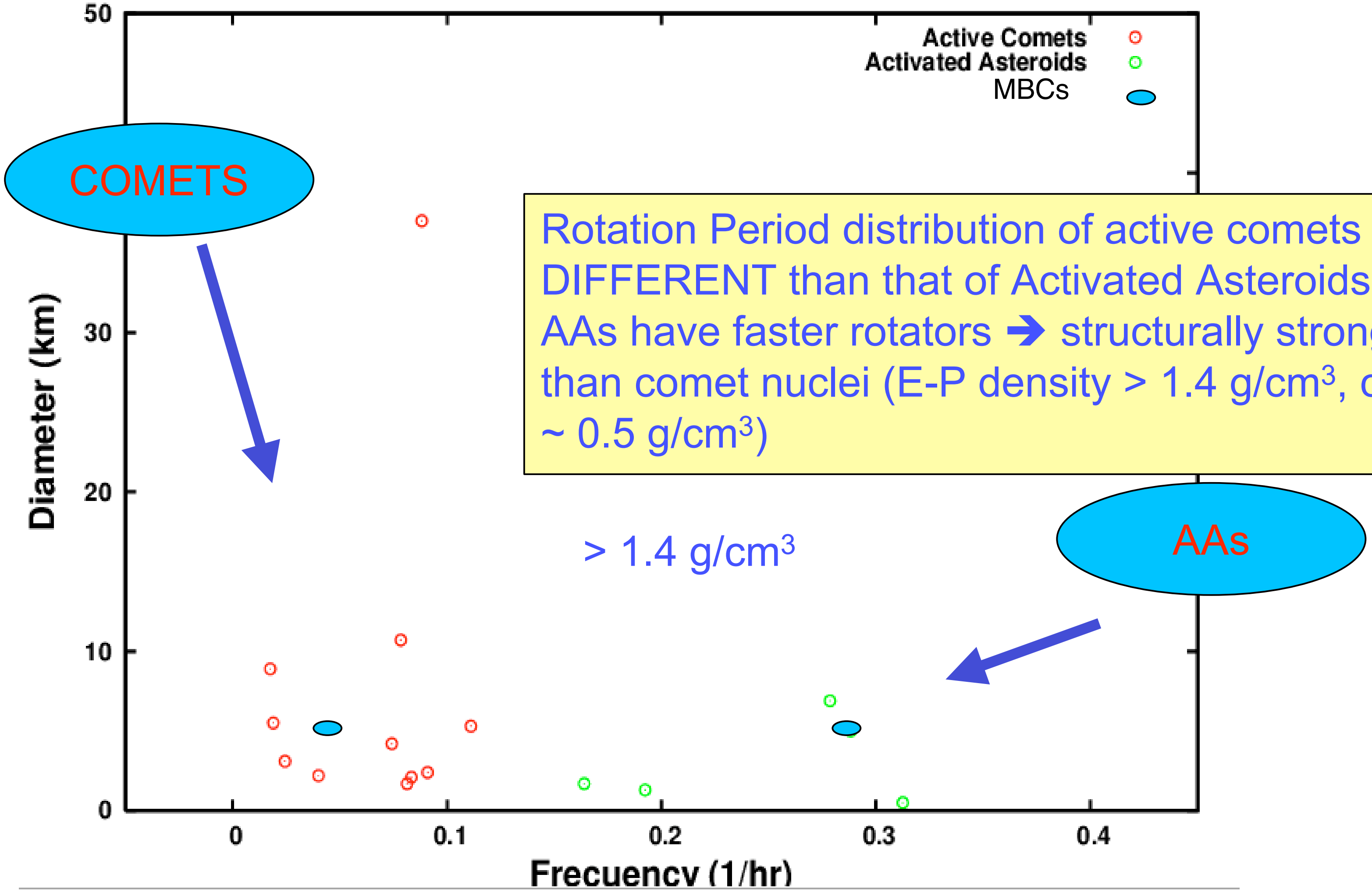
- Time-series CCD images obtained Jan. 19-21 2007 with the 2.5m NOT telescope
- **P=22.5±0.2hr.**
- Amplitude A_V=0.6





- Time-series CCD images obtained July. 12, 2007 with the 2.5m NOT telescope
- **P=3.47±0.05hr.**
- Amplitude A_R=0.3

Rotational properties: comets and AAs



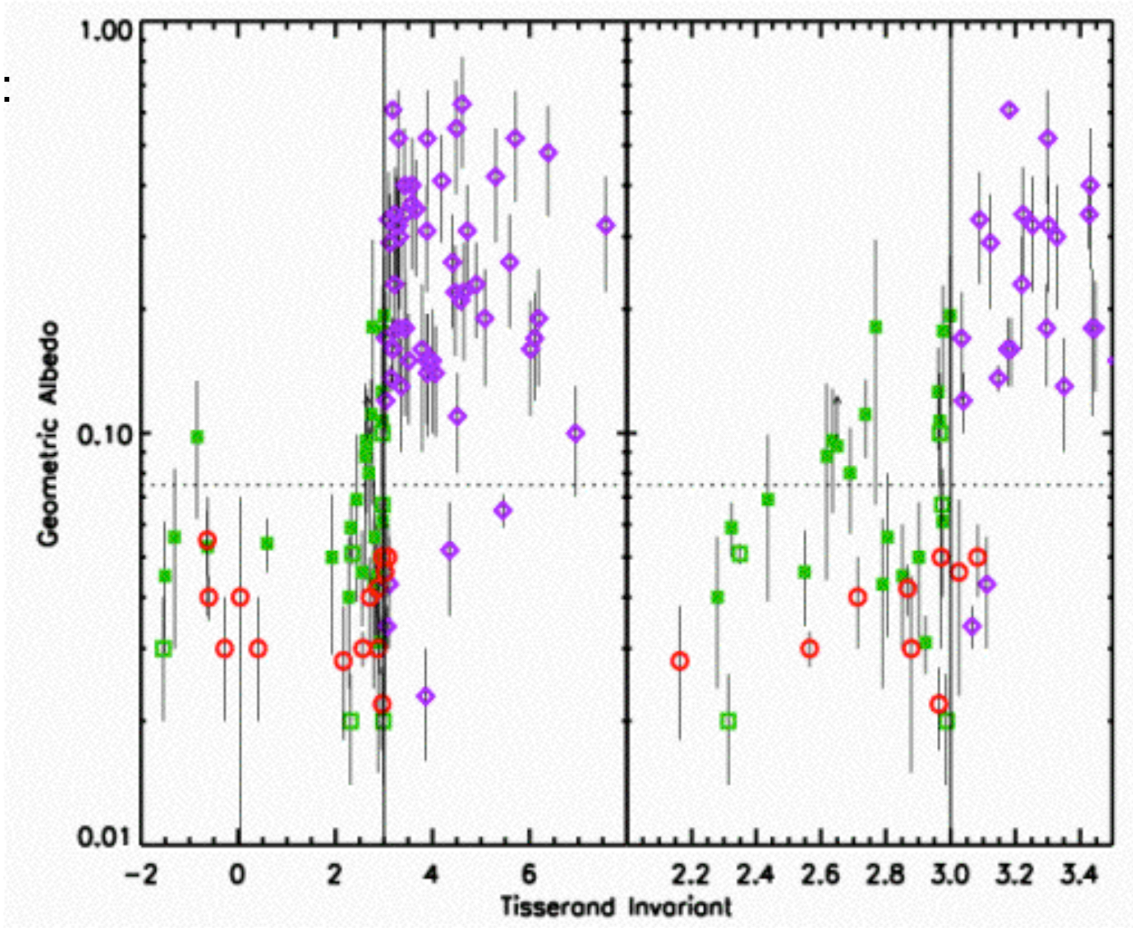
Rotation Period distribution of active comets is DIFFERENT than that of Activated Asteroids, AAs have faster rotators ➔ structurally stronger than comet nuclei (E-P density > 1.4 g/cm^3, comets ~ 0.5 g/cm^3)

Albedo of comets and ACOs

COMETS:
- albedo p_V between 0.02-0.06 (Campins et al. 2000)
- cometary-like albedo $p_V < 0.075$ (Fernández et al. 2008)

ACOs (Fernández et al. 2008) :
- 65±5% cometary-like albedo
- if $T_J < 2.8$ almost 100% (no scattered asteroids)

Other primitive asteroids:
C, P, D, B-type asteroids present also low albedo



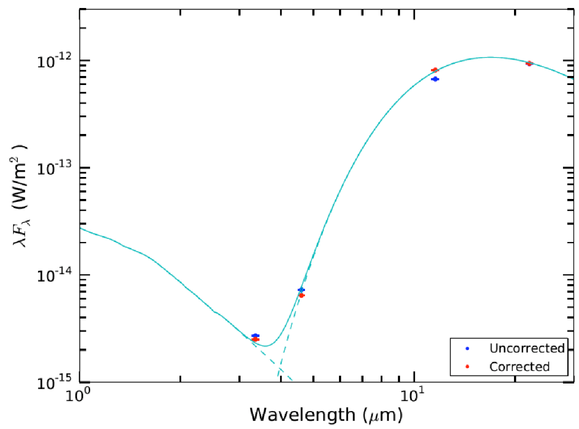
Fernández et al. (2008)

Albedo of Activated Asteroids

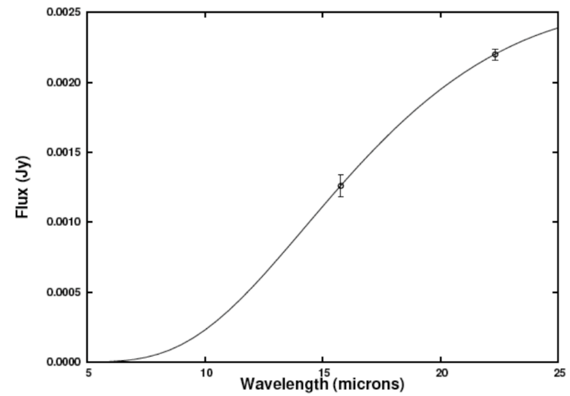
ALBEDO

- 133P pR=0.039-0.054 (Hsieh et al. 2009)
- 176P pR=0.050-0.068 (Hsieh et al. 2009)
- Phaethon ~ 0.11 (Tholen et al. 2002)
- Wilson-Harrington pV=0.06±0.01 (Campins et al. 1995, Licandro et al. 2009)

¬ Compatible with primitive asteroids



J. Licandro et al.: Spitzer Observations of 4015 Wilson-Harrington



Spectra of Asteroids with associated meteorite shower

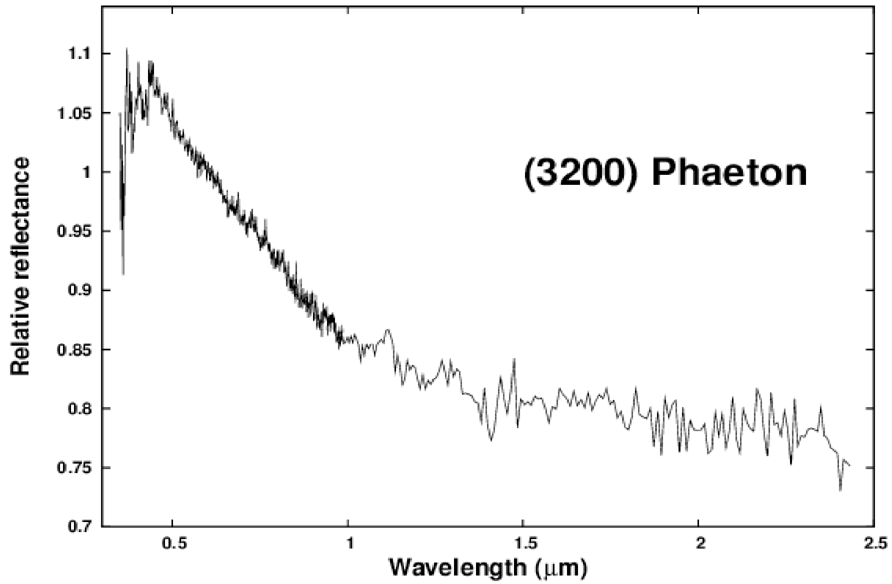
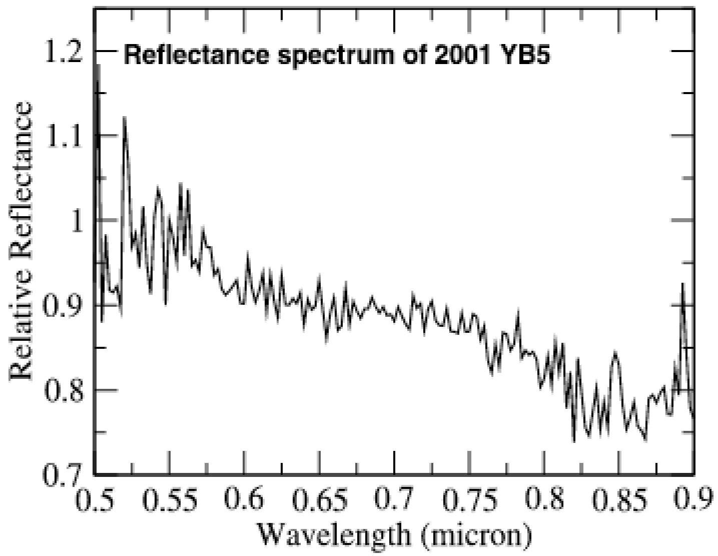
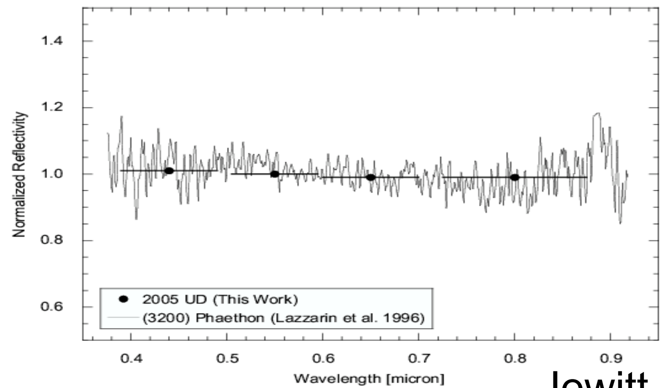


Fig. 2. The combined visible and near-infrared reflectance spectrum of (3200) Phaethon normalized to unity at 0.55 μm.



Yang et al 2003
Meng et al. 2004

- ➢Three asteroids with associated meteor showers, are B-type (3200 Phaeton and 2001 YB5)
- ➢Spectra different from comet nuclei



Jewitt & Hsieh (2006)

Fig. 4.— Normalized reflectivity as a function of wavelength, for 2005 UD (filled circles) and (3200) Phaethon (line, from Lazzarin et al. 1996). Error bars on the 2005 UD data are about the size of the symbols. Horizontal bars mark the FWHM of the B, V, R and I filters.

3200 Phaethon

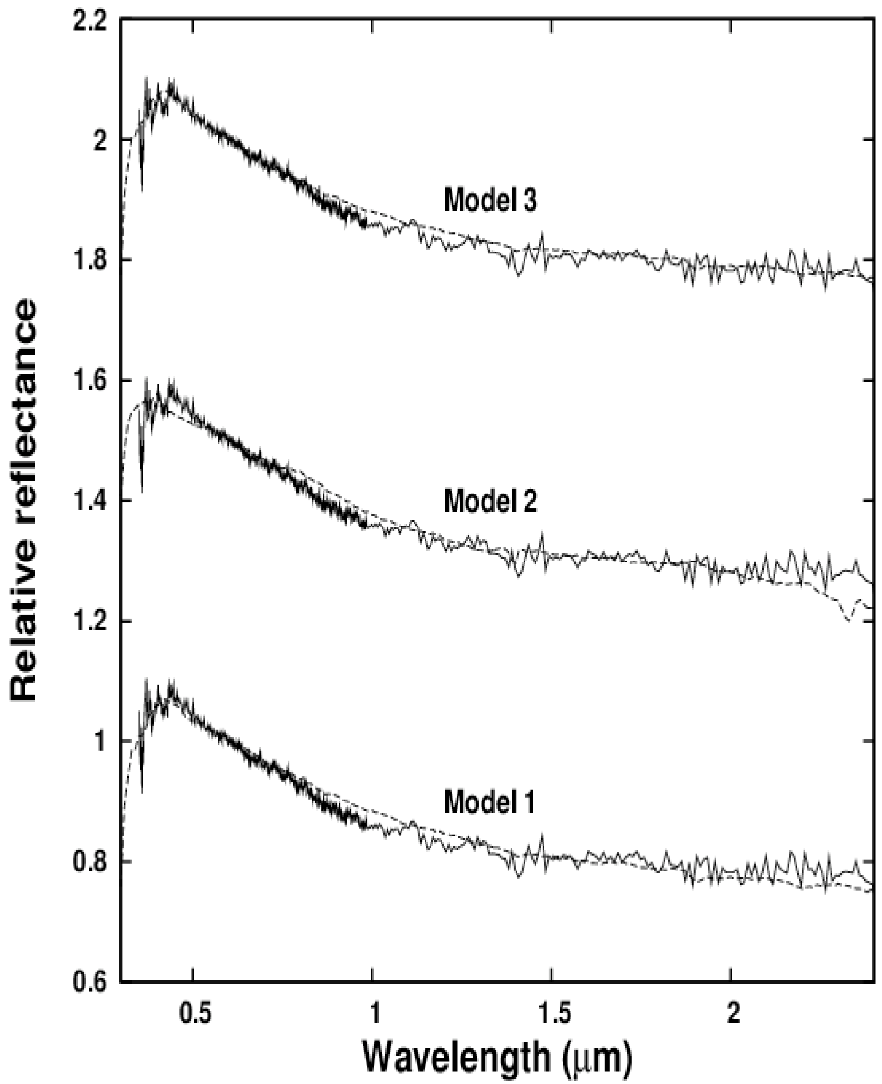


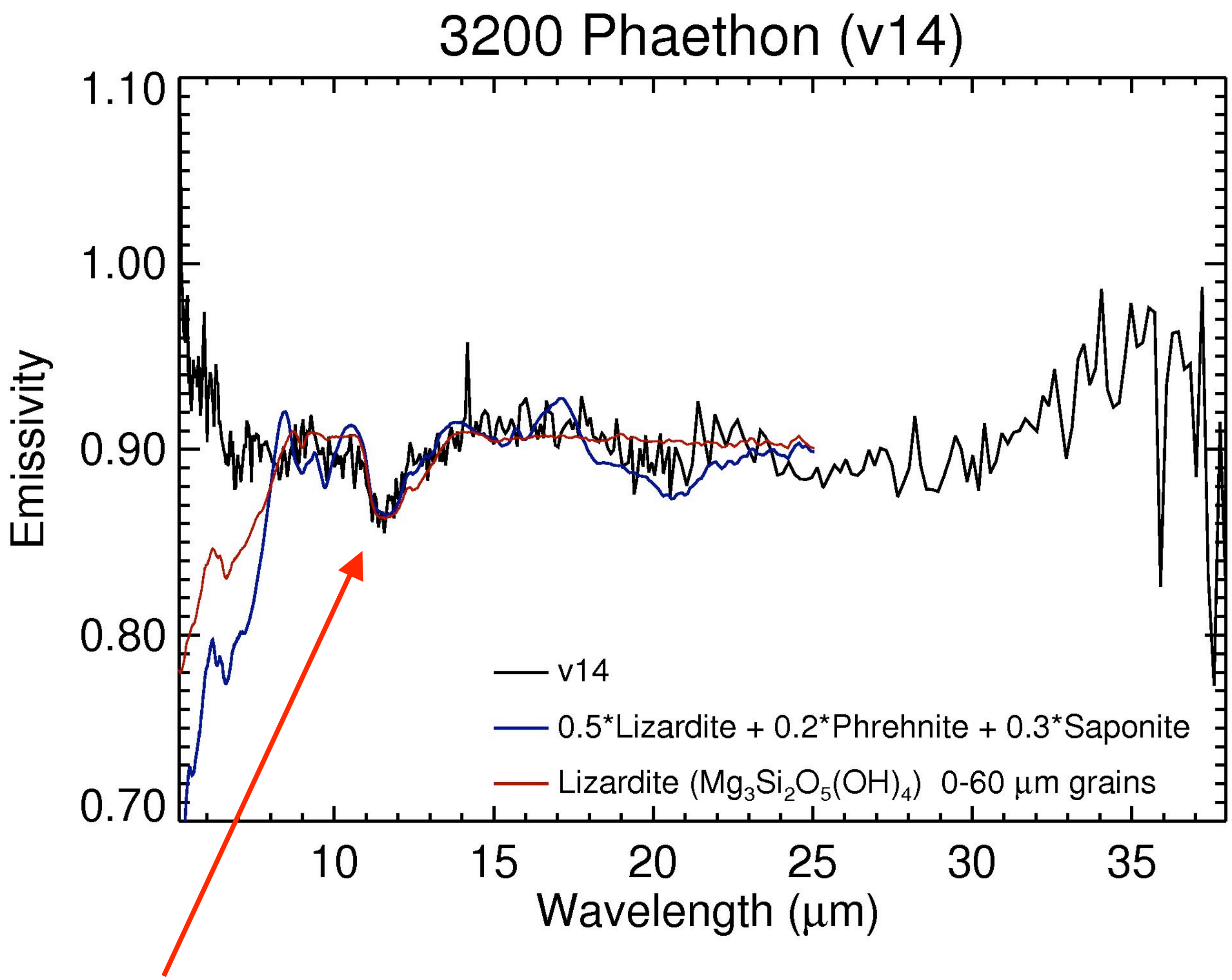
Fig. 7. Phaethon's spectrum with the three modeled spectra from Table 2 overplotted (dashed lines).

Licandro et al. (2007)

Phaethon is NOT a dormant comet, Its surface is likely composed of hydrated minerals (Licandro et al. 2007)

Geminid meteorites have larger densities than comet meteor showers (3.0 g/cm^3 Bellot-Rubio et al. 2002), consistent with hydrated silicates

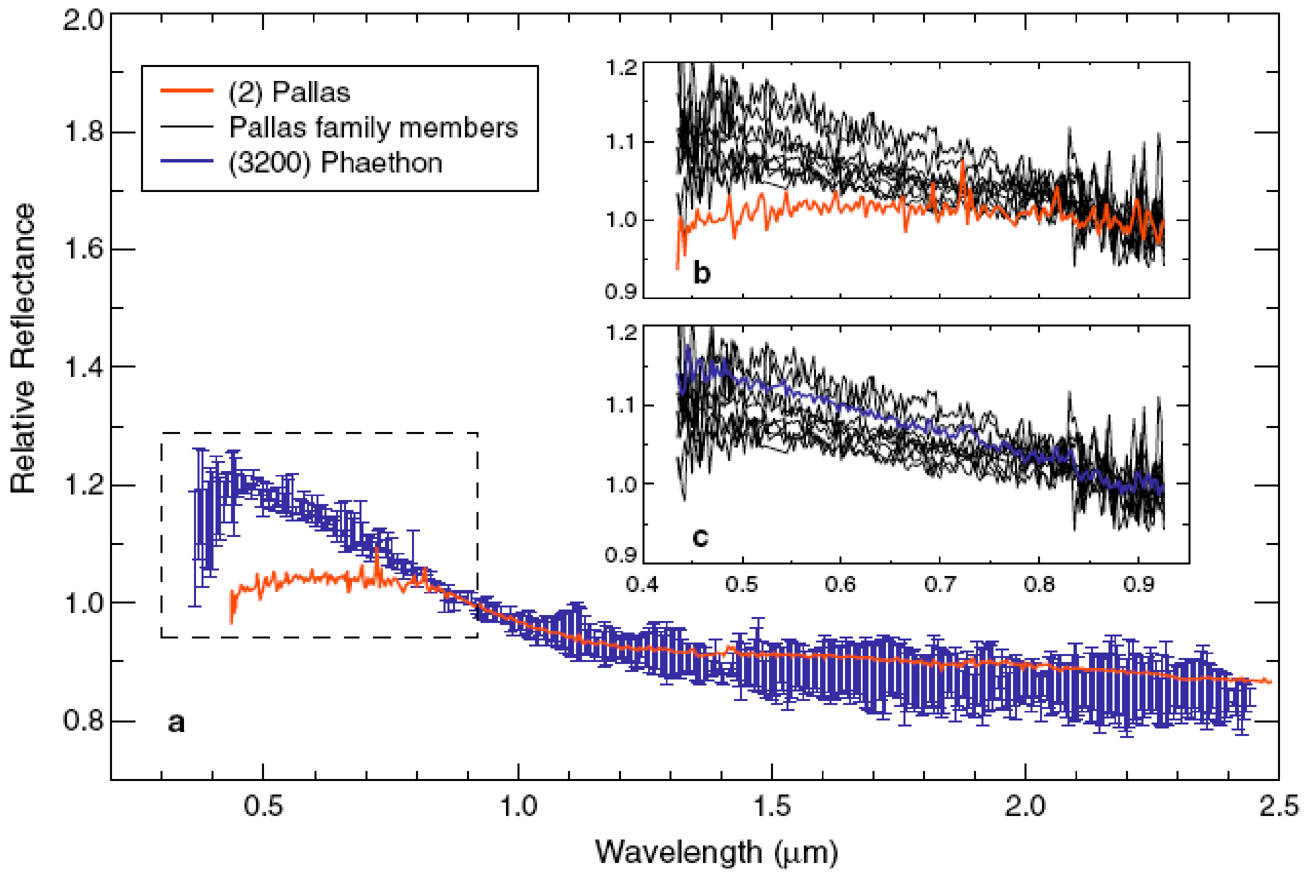
3200 Phaethon



Hydrated silicate signature (Emery. 2010)

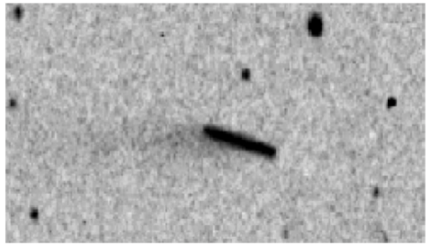
3200 Phaethon & the Pallas family

J. de León et al.: Connection between Phaethon and Pallas

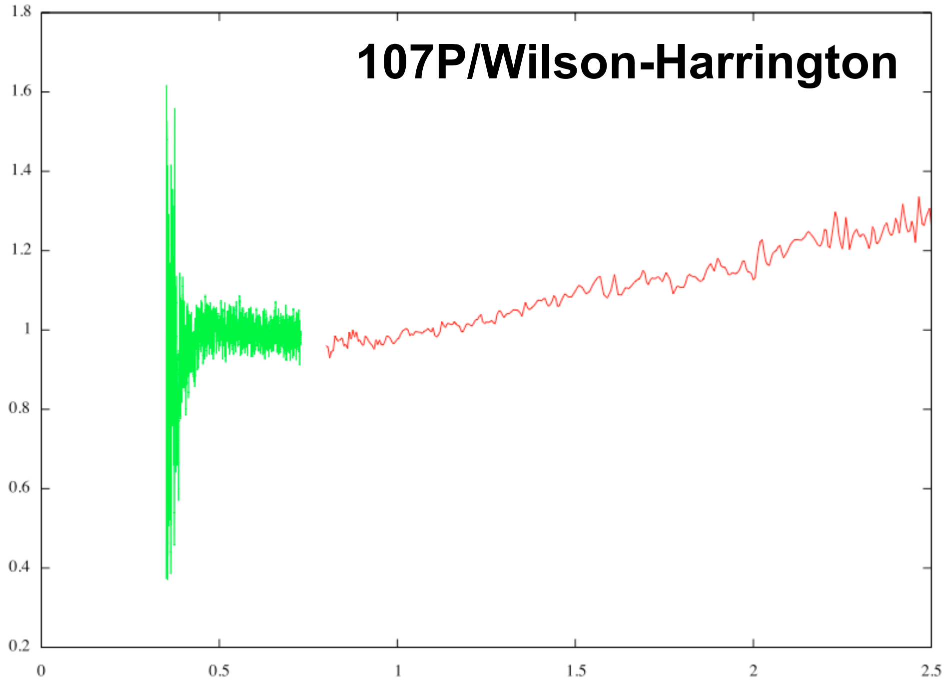


Phaethon is probably an scattered Pallas family asteroid (de León et al. 2010)

4015 Wilson-Harrington



Licandro et al. In prep.



Also a B-type

possible origin in the Themis family

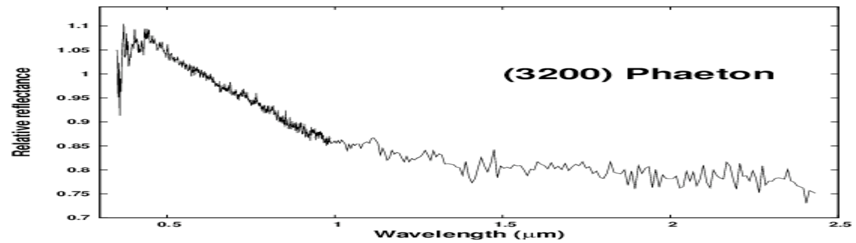
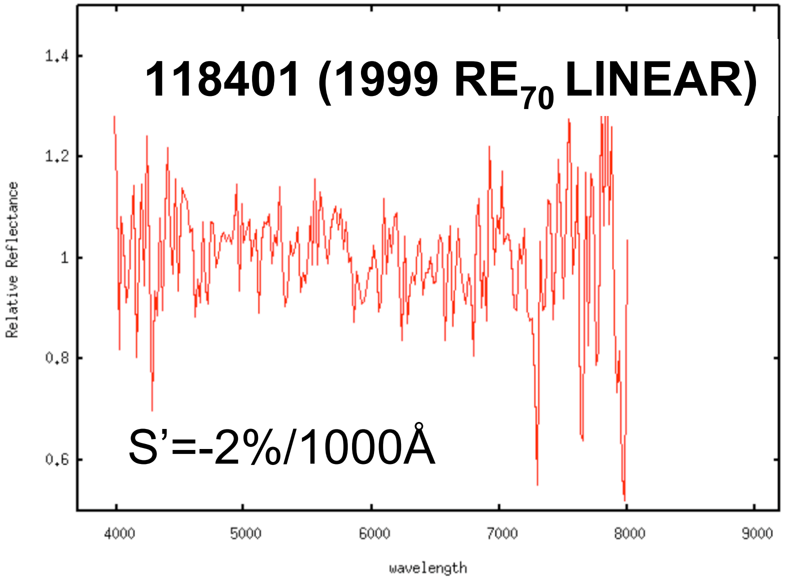


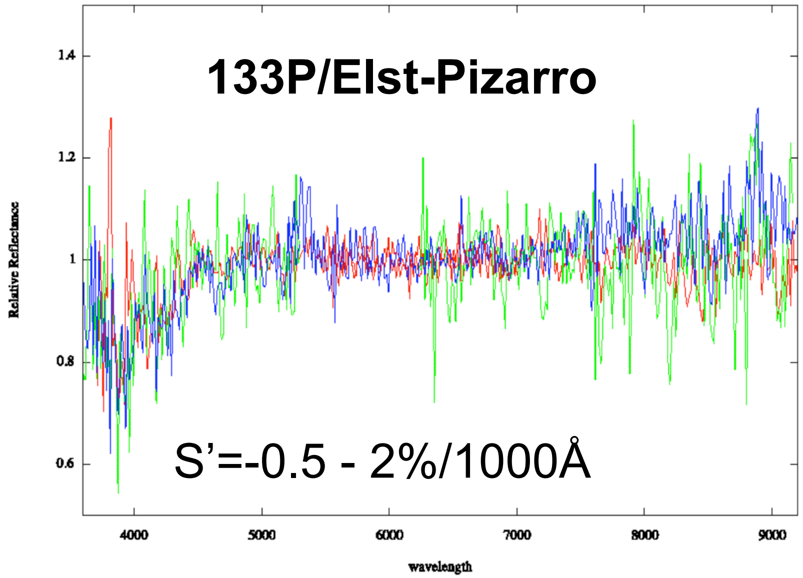
Fig. 2. The combined visible and near-infrared reflectance spectrum of (3200) Phaethon normalized to unity at 0.55 μm.

Spectra of Activated Asteroids

Licandro et al. 2011



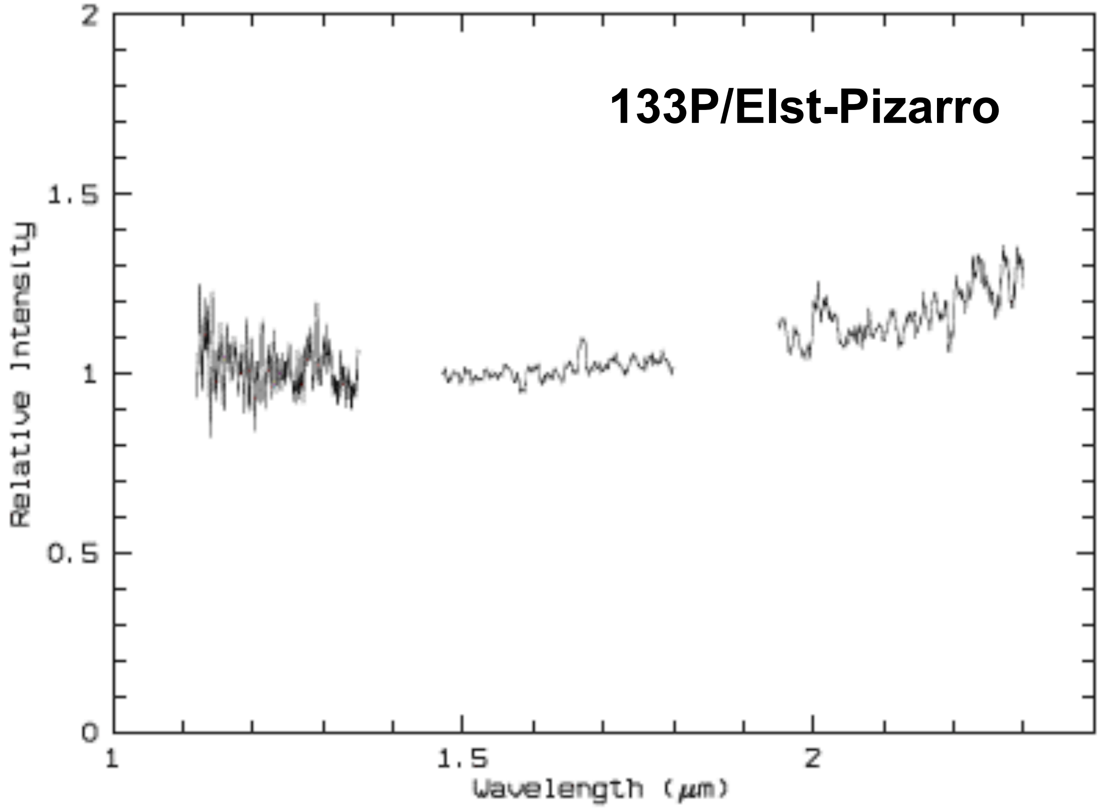
NOT telescope, Jan. 19, 2007



WHT and TNG telescopes, Jan. 19, 2007

- Neutral to blue slope,
- absorption below 4500Å (B-, Cb-type)

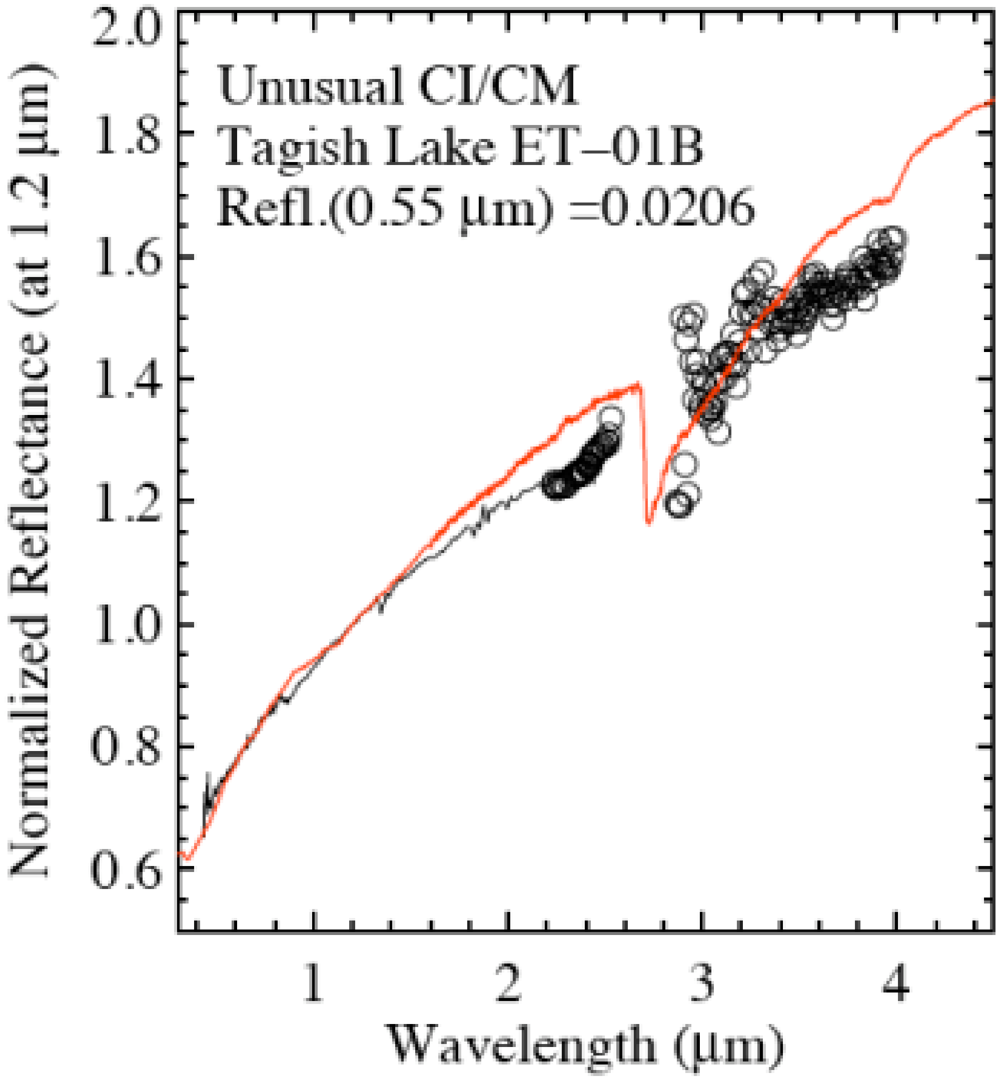
Spectra of Activated Asteroids



Rousselot et al. 2011

(596) Scheila

Licandro et al. 2011



- D-type
- homogeneous surface
- match with a unusual CI/CM meteorite
- but no sign of hydration at 3 microns within the SNR

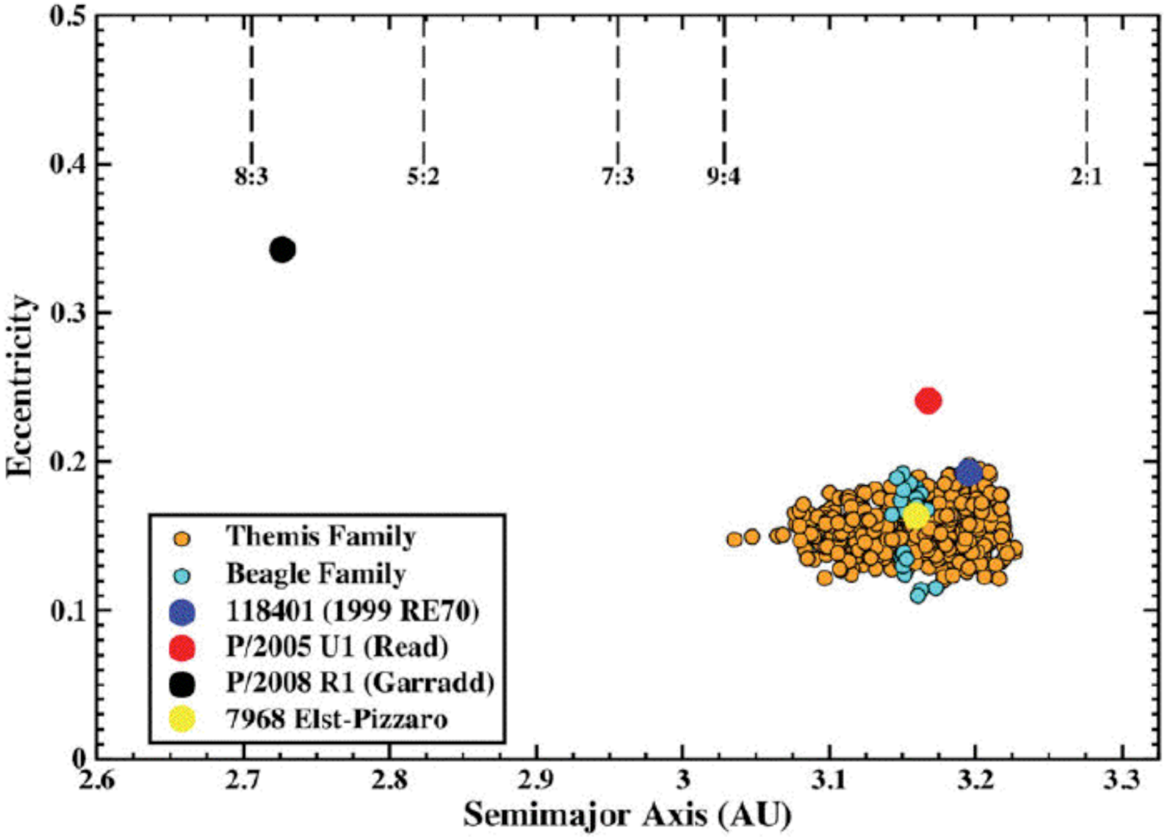
A scatterd TNO? (Levison et al. 2009)

Similar results by Yang & Hsieh 2011

Spectra of activated asteroids

- All primitive C-, B-, P- or D-type?
- All but P/2010 A2 (LINEAR), likely and S-type as it belongs to the Flora family (anyone is able to obtain an spectrum of a 23-25 mag. Asteroid?)
- Activated Asteroids are very similar bodies, with an unlikely cometary origin

Activated Asteroids & the Themis family

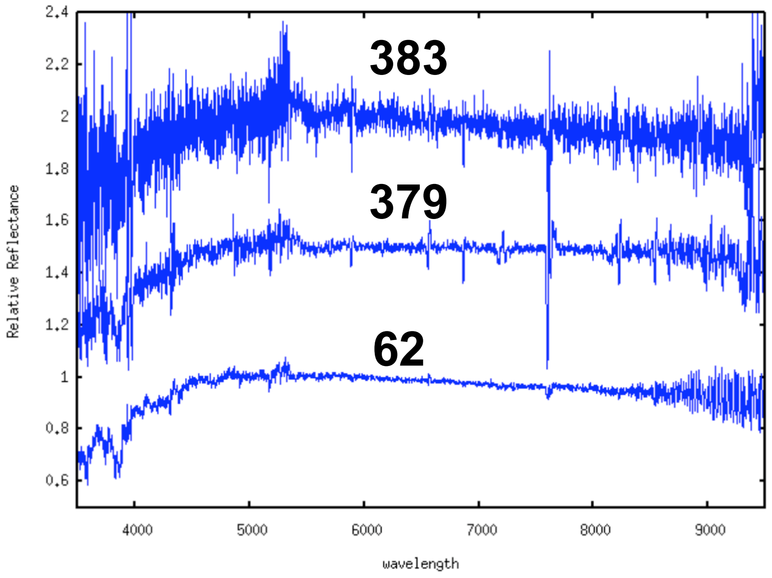


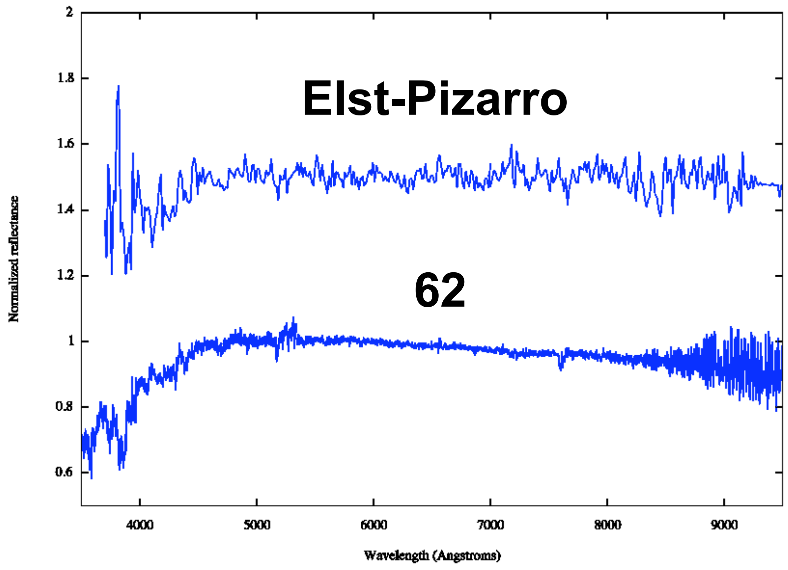
Haghighipour (2010)

- Old and large collisional family
- (24) Themis is the largest remnant of the parent body
- primitive asteroids (C-complex)
- 50% of them present hydrated surfaces (Florczac et al 1999)

Spectra of MBCs & Themis asteroids

Themis family asteroids





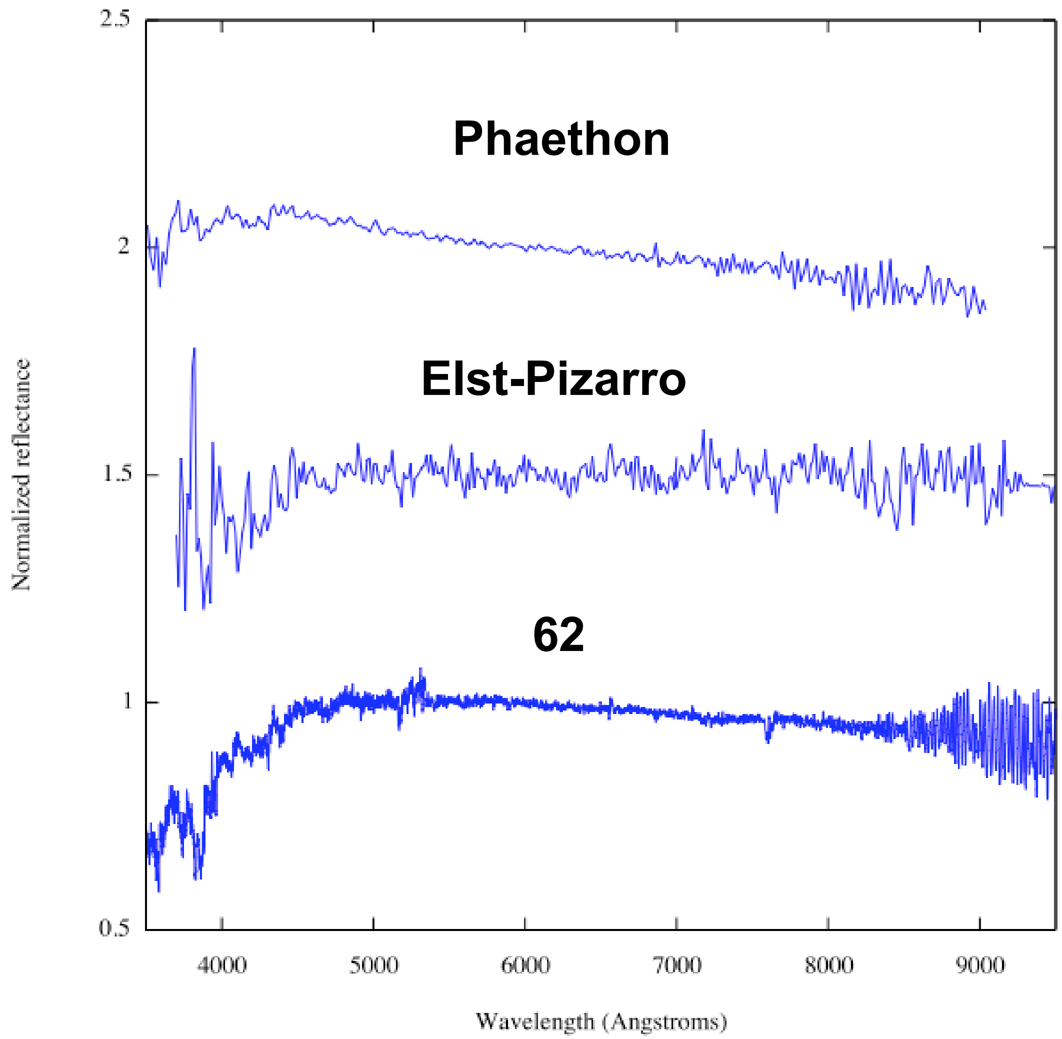
Obtained with the WHT telescope

- Most B-, Cb-type asteroids
- 50% of them present hydrated surfaces (Florczac et al 1999)

- **spectra of 133P & 176P support that they are Themis family members**

Licandro et al. 2011

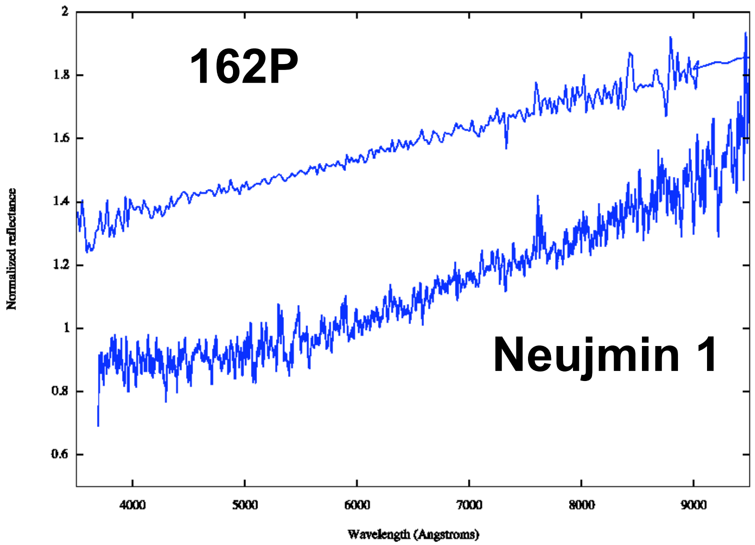
Spectra of MBCs & NEO Activated Asteroids

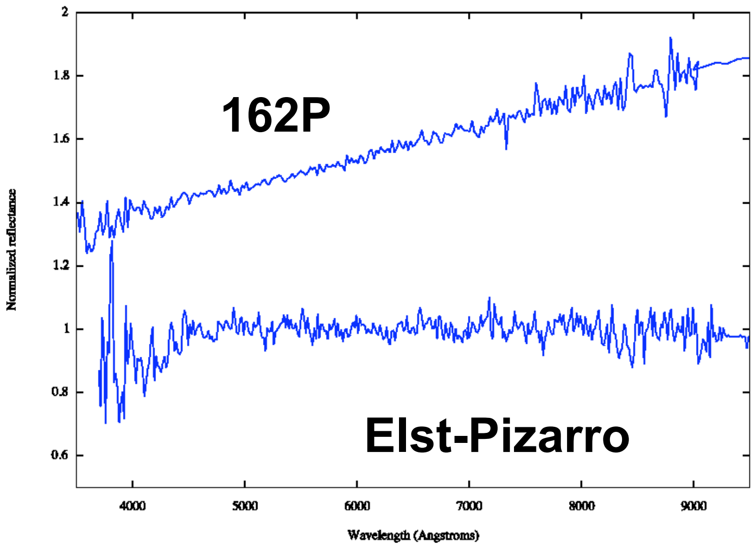


- spectra of MBCs are very similar to those of NEO AAs which suggest a **common origin and/or surface composition**
- against a cometary origin of the MBCs

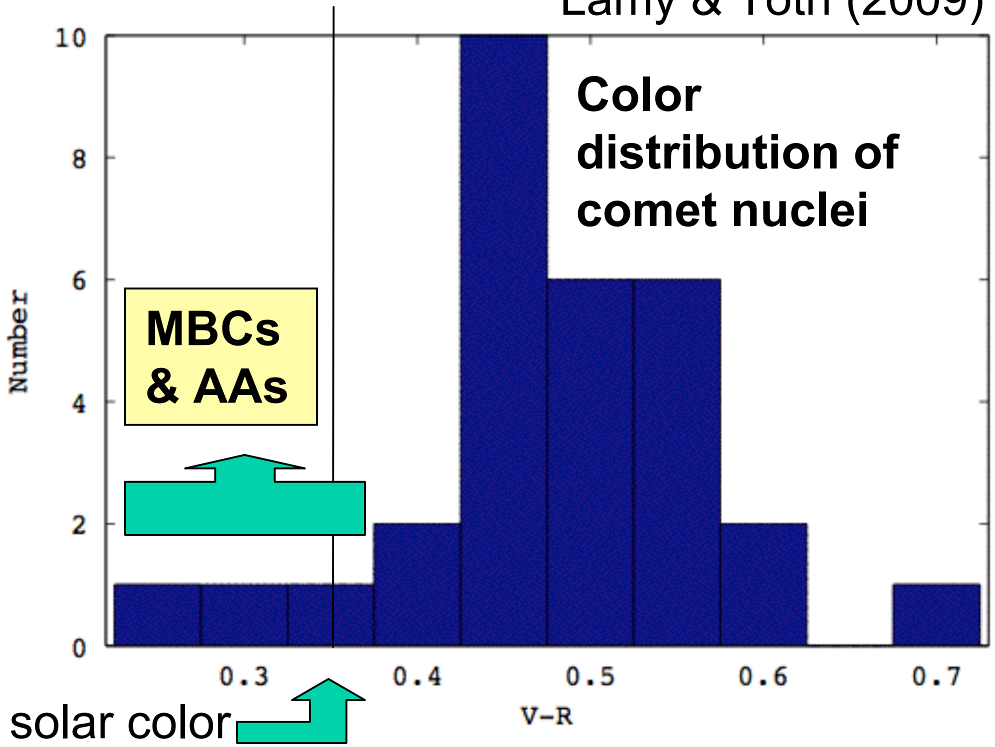
Spectra of MBCs & comet nuclei

Comet nuclei





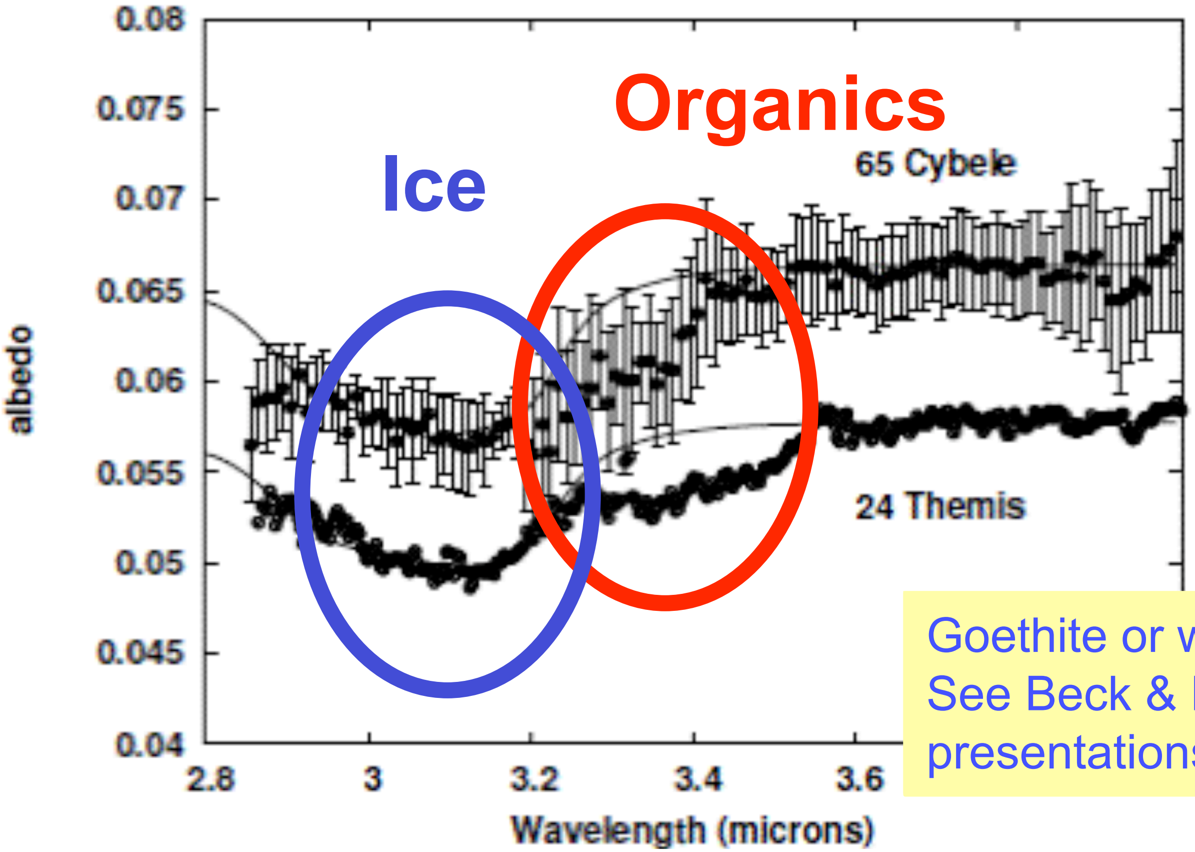
Lamy & Toth (2009)



- Most comets are D-, P-type
- also other comet candidates like Damocloids and ACOs are mostly D-, P-type

- **spectra of MBCs supports that they are different than normal comets**

Water Ice and organics on (24) Themis & (65) Cybele



Goethite or water ice feature? See Beck & Pinilla-Alonso presentations this meeting

➢Campins et al. (2010) & Emery et al. (2010) detect water ice and organics on the surface of 24 Themis,

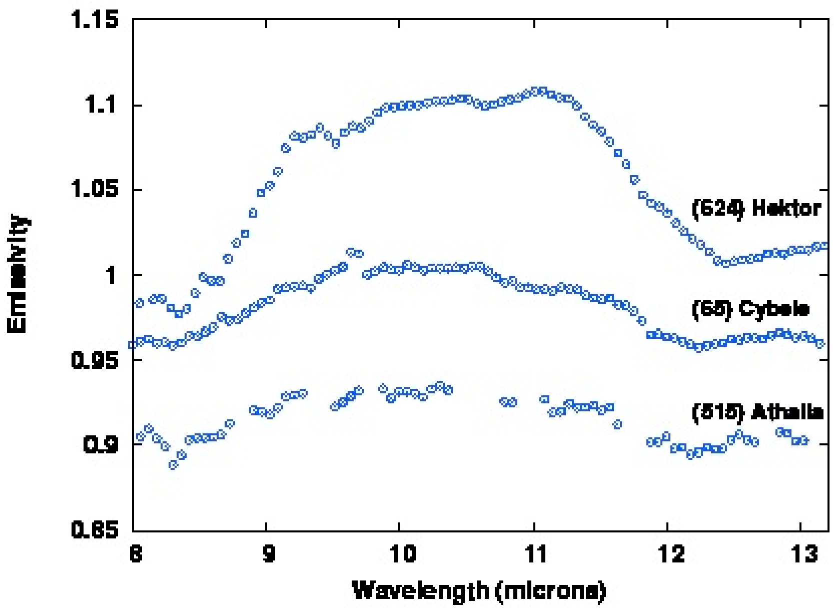
➢**Particles of pyroxene, carbon, Covered by a thin layer of water ice (< 0.01µm)**

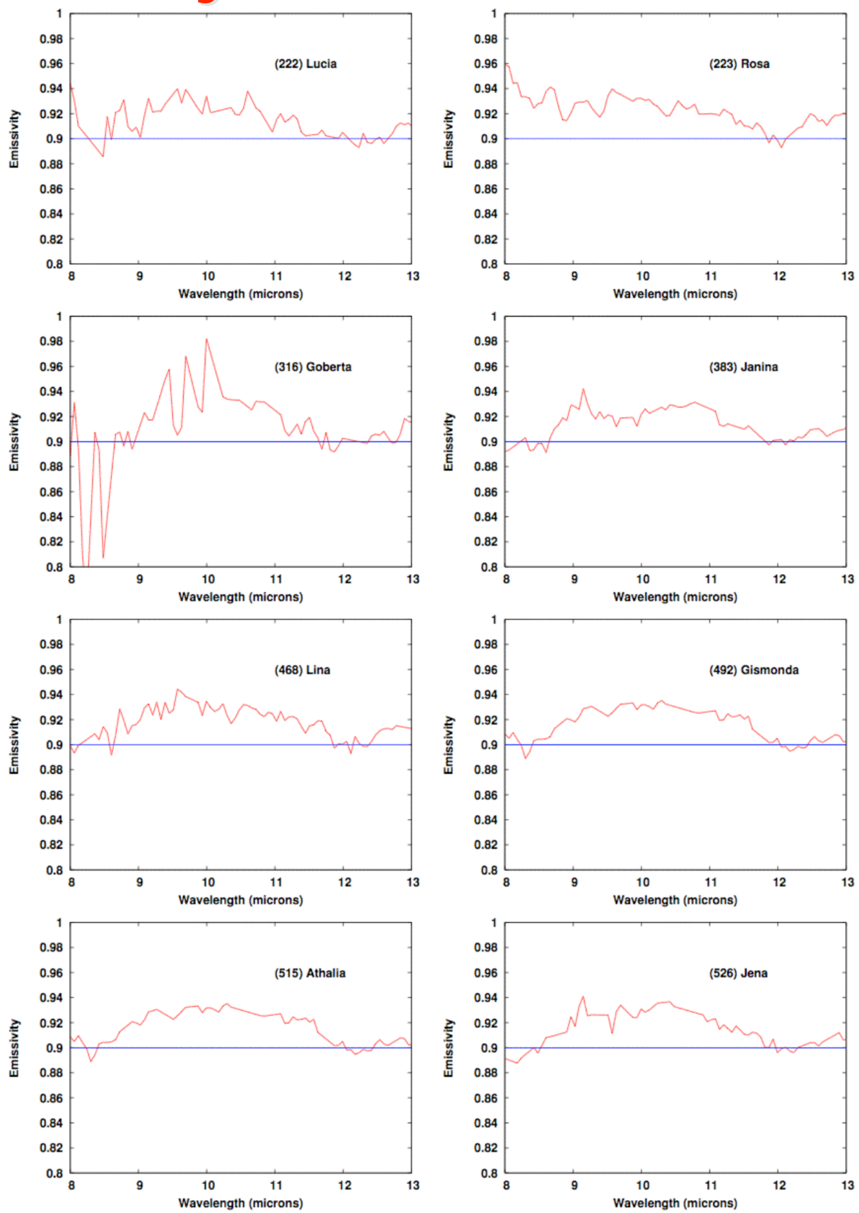
➢Licandro et al. (2010) also on 65 Cybele (the largest member of the Cybeles)

Dust mantle on Themis family asteroids?

object	D(km)	p_V	η	H_V
(222) Lucia	59.8±0.8	0.110	1.03±0.02	9.13
(223) Rosa	61.2±0.3	0.063	0.85±0.01	9.68
(316) Goberta	46.8±1.2	0.097	1.15±0.04	9.80
(383) Janina	48.4±0.3	0.082	1.12±0.01	9.91
(468) Lina	59.7±0.5	0.058	0.95±0.01	9.83
(492) Gismonda	50.3±1.1	0.084	1.12±0.03	9.80
(515) Athalia	43.0±0.2	0.031	1.07±0.01	11.23
(526) Jena	52.3±0.5	0.055	1.10±0.02	10.17

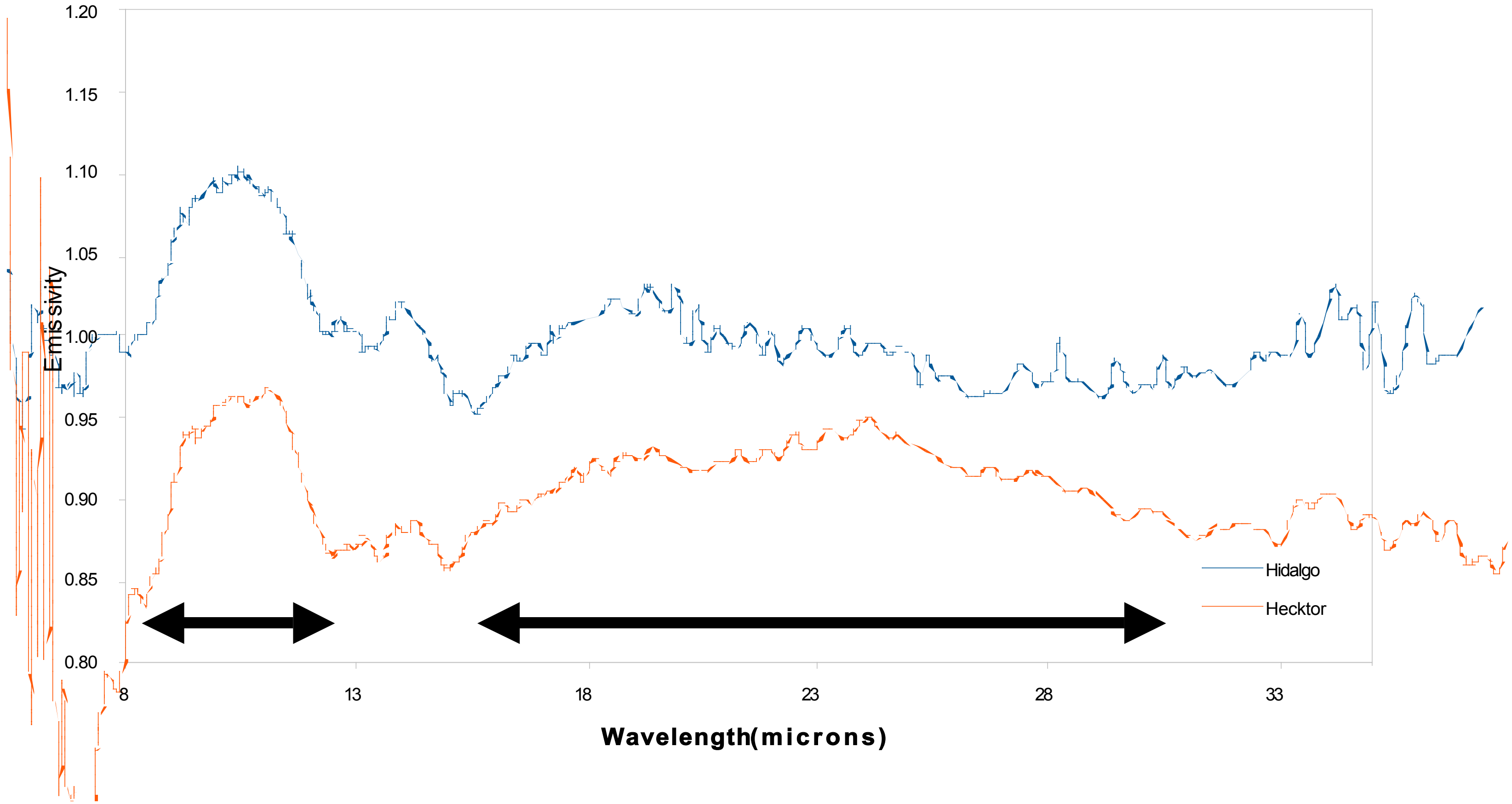
Mean pV=0.07, eta=1.05





Licandro et al. 2011; Alí Lagoa et al. EPSC/DPS

944 Hidalgo and Hecktor (Trojan D-Type)



2011 CR42, a new AA in the Cybele population?

Electronic Telegram No. 2823

Central Bureau for Astronomical Telegrams
INTERNATIONAL ASTRONOMICAL UNION
CBAT Director: Daniel W. E. Green; Hoffman Lab 209; Harvard University;
20 Oxford St.; Cambridge, MA 02138; U.S.A.
e-mail: cbatiau@eps.harvard.edu (alternate cbat@iau.org)
URL http://www.cbat.eps.harvard.edu/index.html
Prepared using the Tamkin Foundation Computer Network

2011 CR42

A. Waszczak, California Institute of Technology; and E. O. Ofek and D. Polishook, Weizmann Institute of Science, report that CCD images (1".01/pixel) of 2011 CR42, taken by the "Palomar Transient Factory" (PTF; cf. Law et al. 2009, PASP 121, 1395; Rau et al. 2009, PASP 121, 1334) on Mar. 5 and 6 with the 1.2-m f/2.44 Oschin Schmidt telescope, suggest that this minor-planet-designated object may have episodic cometary activity. The object consistently had a FWHM nearly twice that of all similar-magnitude SDSS-referenced stars (York et al. 2000, A.J. 120, 1579), thus suggestive of a cometary coma. This could not be caused by trailing, as the object's motion was < 1"/min. No sign of a cometary tail was visible before or after stacking the images. Six g-band 60-s astrometric observations are tabulated below in MPC format.

```
    K11C42R  C2011 03  5.47755 11 25 21.43 +17 05 13.2          17.8 g I41
    K11C42R  C2011 03  6.14243 11 24 51.10 +17 08 12.8          17.9 g I41
    K11C42R  C2011 03  6.19523 11 24 48.60 +17 08 27.1          17.8 g I41
    K11C42R  C2011 03  6.23933 11 24 46.50 +17 08 39.1          18.0 g I41
    K11C42R  C2011 03  6.43924 11 24 36.90 +17 09 32.7          17.6 g I41
    K11C42R  C2011 03  6.48991 11 24 34.48 +17 09 46.0          17.7 g I41
```

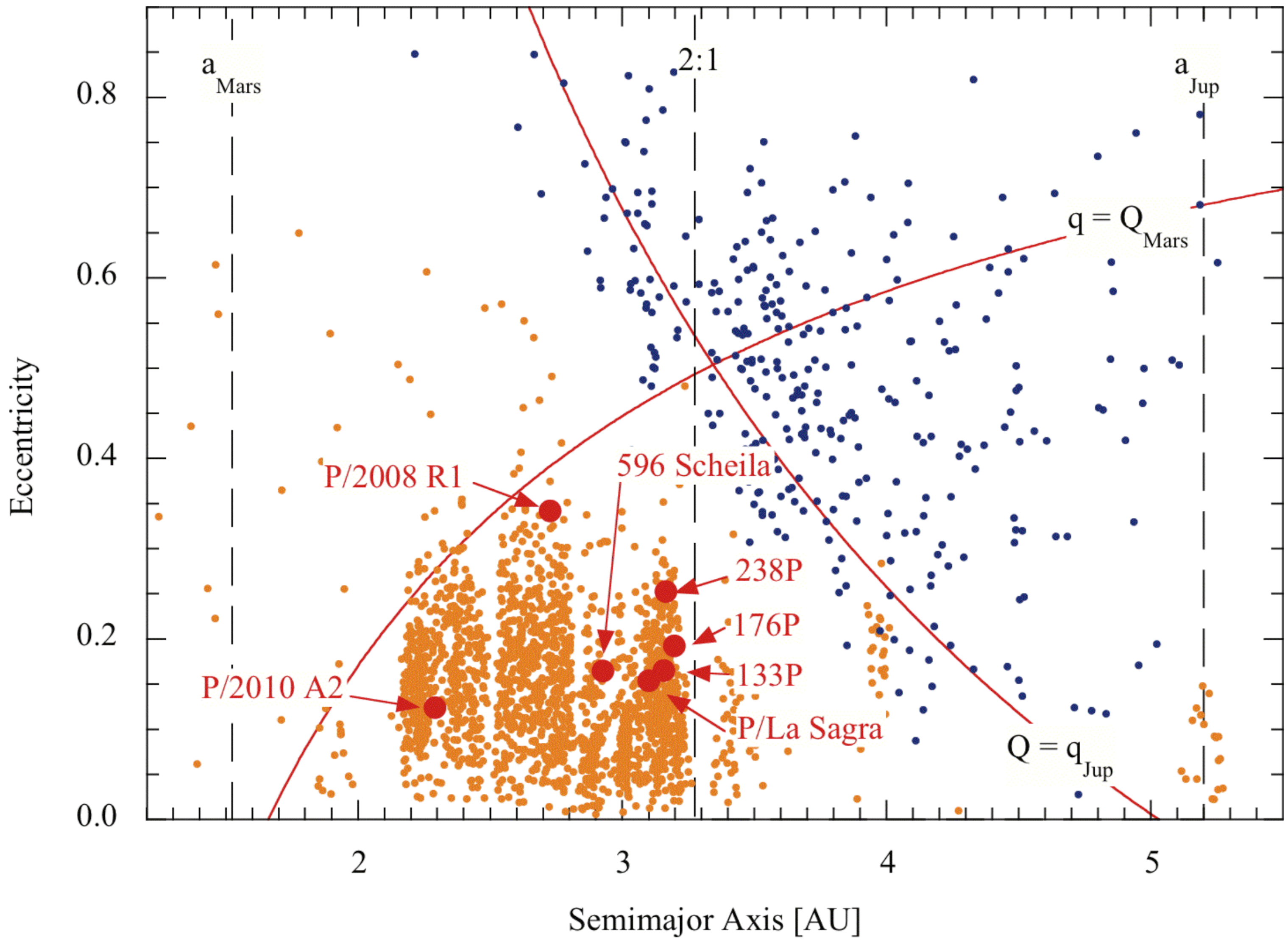
The object was 2.92 AU from the sun and approaching perihelion (q = 2.53 AU on 2011 Nov. 30.0 TT). The object is currently on the earth's day side and will not be observable until after perihelion. Based on its current 86-day orbital solution (MPO 198577) and photometric parameters (H = 13.0, G = 0.15), the PTF survey should have acquired pre-discovery observations of 2011 CR42 in 2010 Feb. and Dec., at predicted magnitudes 19.2 and 18.8, when the object was at 3.8 and 3.1 AU from the sun, respectively. Upon inspection of these earlier images, no source was found within 200" of the predicted position brighter than mag 20.5. These null detections may be indicative of recent and relatively abrupt cometary activity.

FWHM consistently twice that of field stars

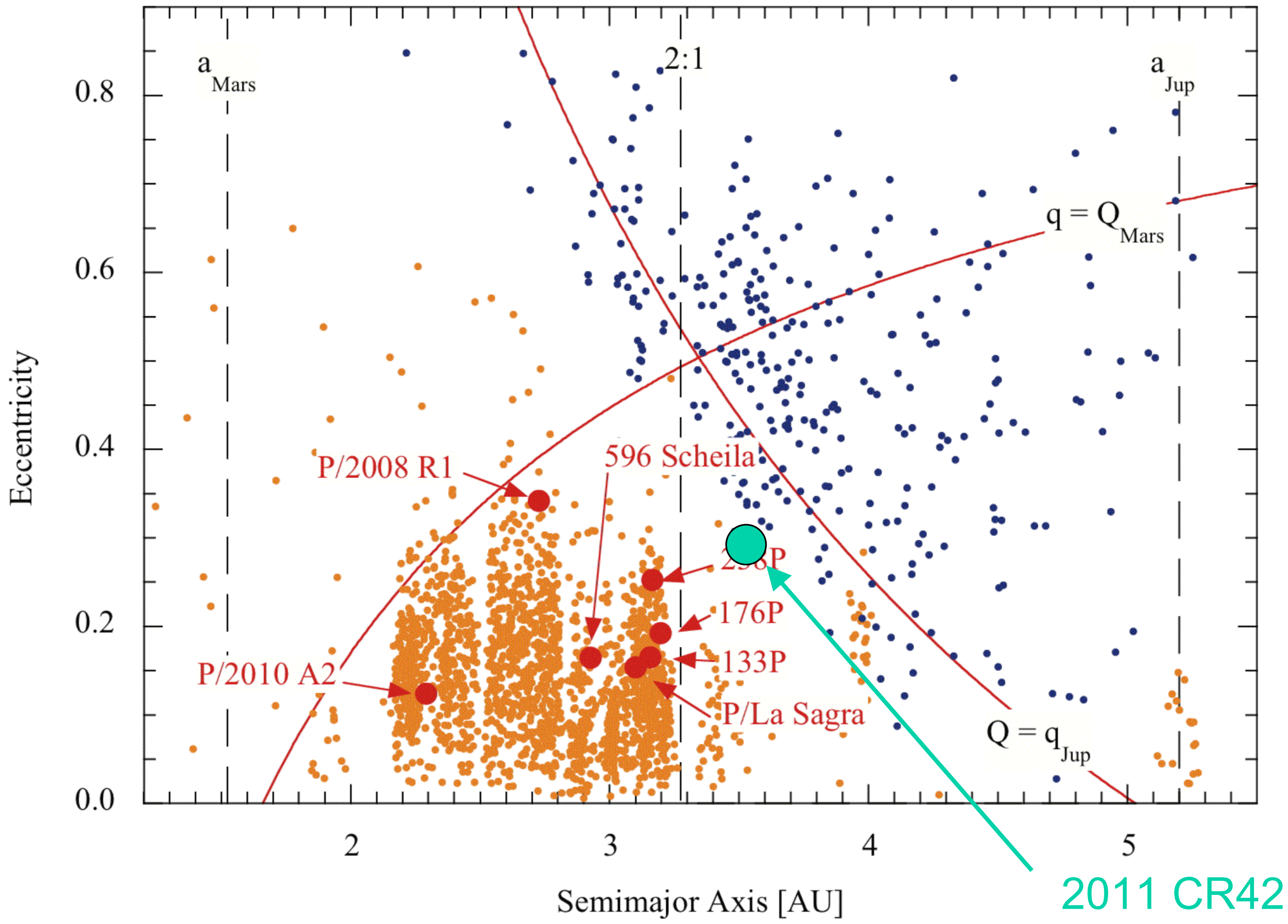
Element	Value	Uncertainty (1-sigma)	Units
e	0.2798747	n/a	
a	3.5114529	n/a	AU
q	2.5286861	n/a	AU
i	8.45937	n/a	deg
node	58.74584	n/a	deg
peri	173.50064	n/a	deg
M	345.77319	n/a	deg
t_p	2455895.4803417 (2011-Nov-29.98034170)	n/a	JED
period	2403.4146113	n/a	d
	6.58	n/a	yr
n	0.14978689	n/a	deg/d
Q	4.4942197	n/a	AU

H_V= 13
D~15km if p_V=0.05

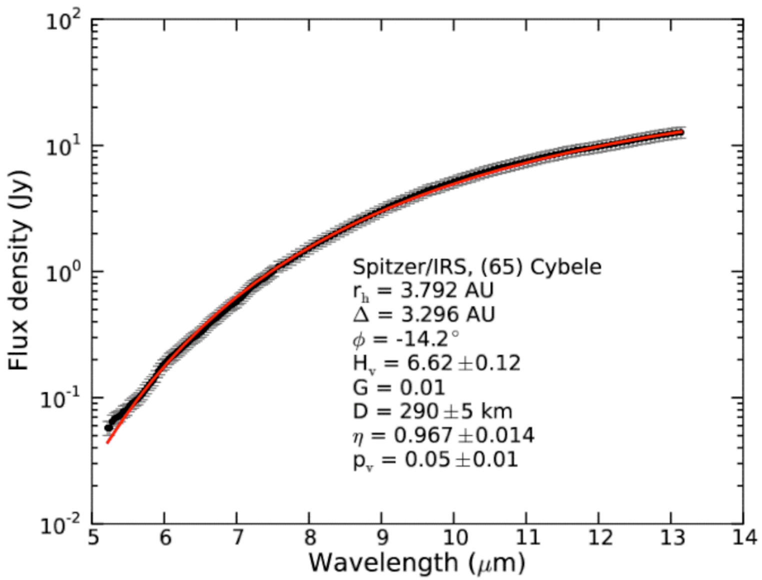
Activated Asteroids in the Main Belt

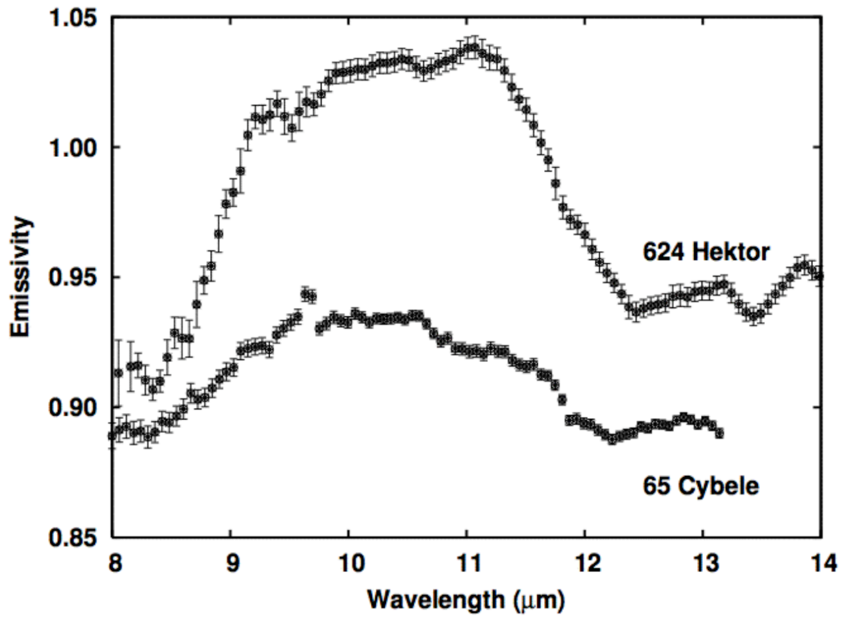


Activated Asteroids in the Main Belt



Spectroscopy at mid-infrared wavelengths, the thermal emission: 65 Cybele





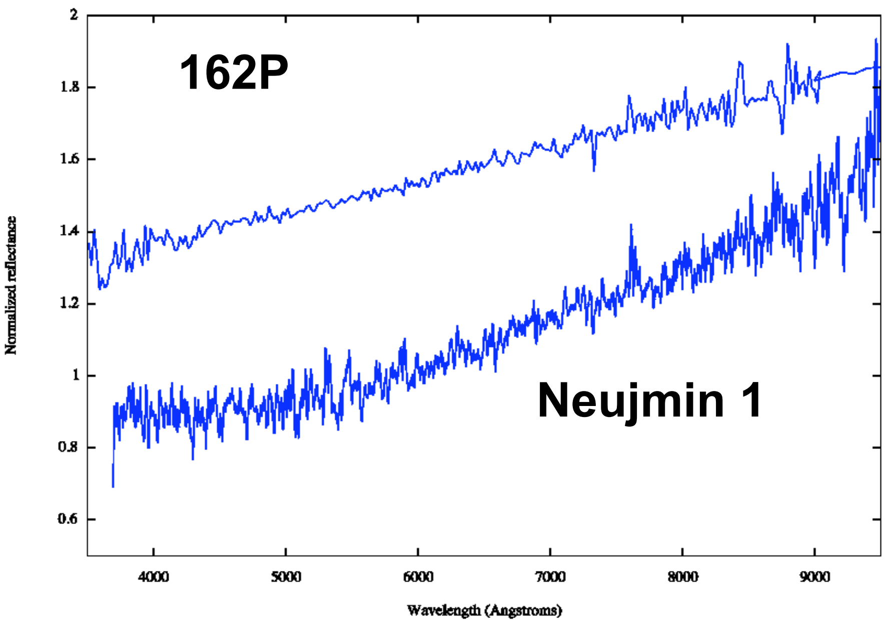
Fine dust in the surface similar to the case of Trojan asteroids and comets ==> 65 Cybele could be covered by a “cometary like” dust mantle

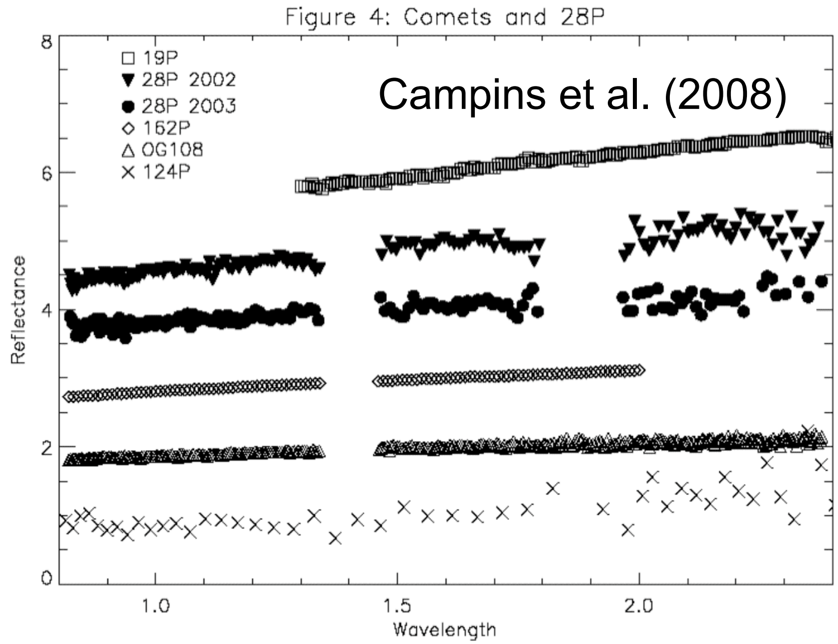
Conclusion/s

A lot still has to be done (observations, models) to understand these key small bodies, their nature and the mechanisms of activation

Spectra of comet nuclei

Comet nuclei: important because we almost know their nature and origin

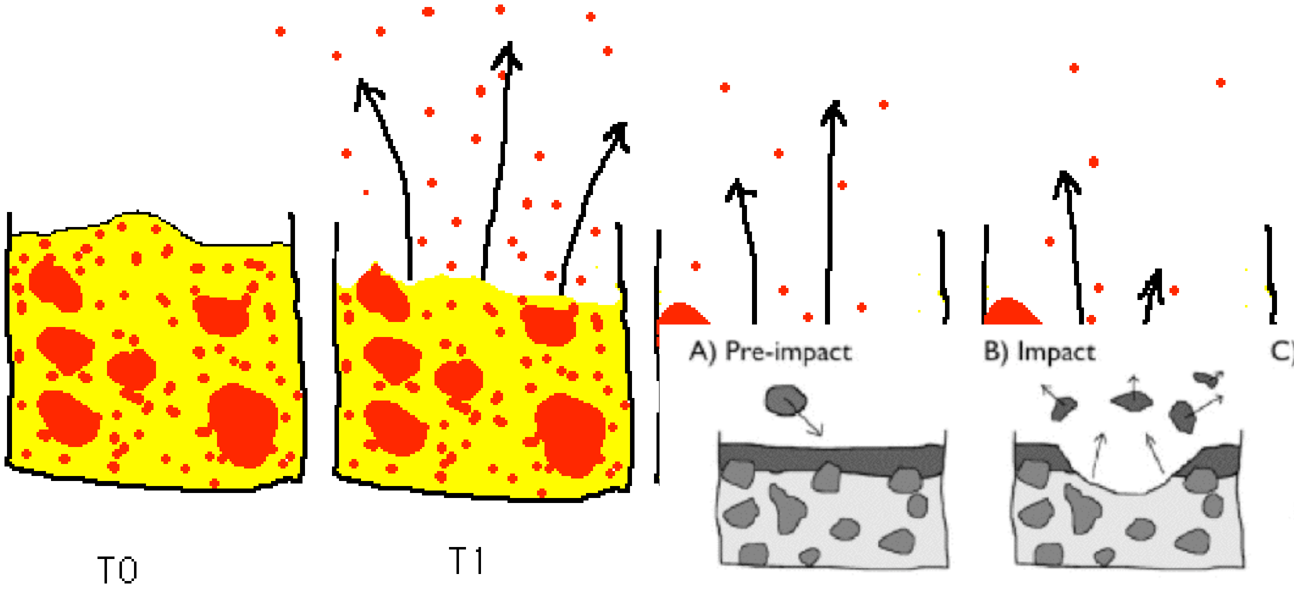


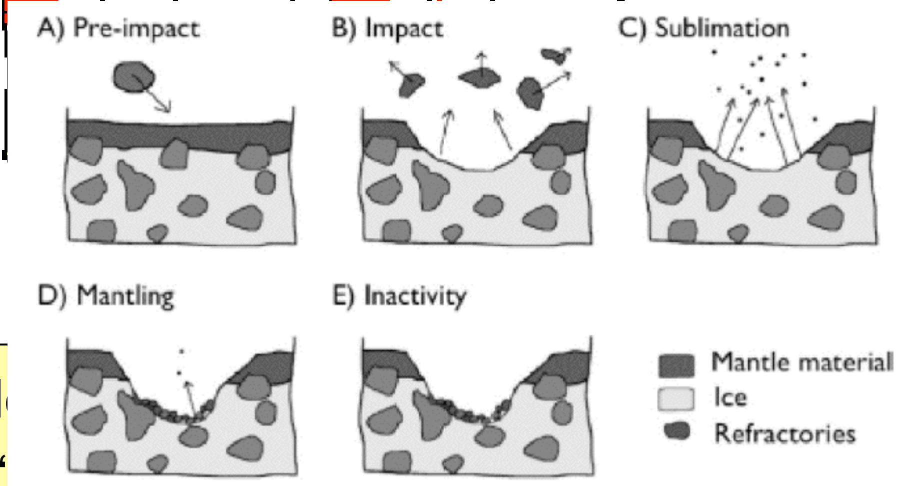


- Visible spectra like D-,P-type asteroids
- Near-ir spectra also featureless
- very few comet nuclei observed

Almost inactive comets
➔ is this the spectrum of a dust mantle?

Formation of cometary dust mantles



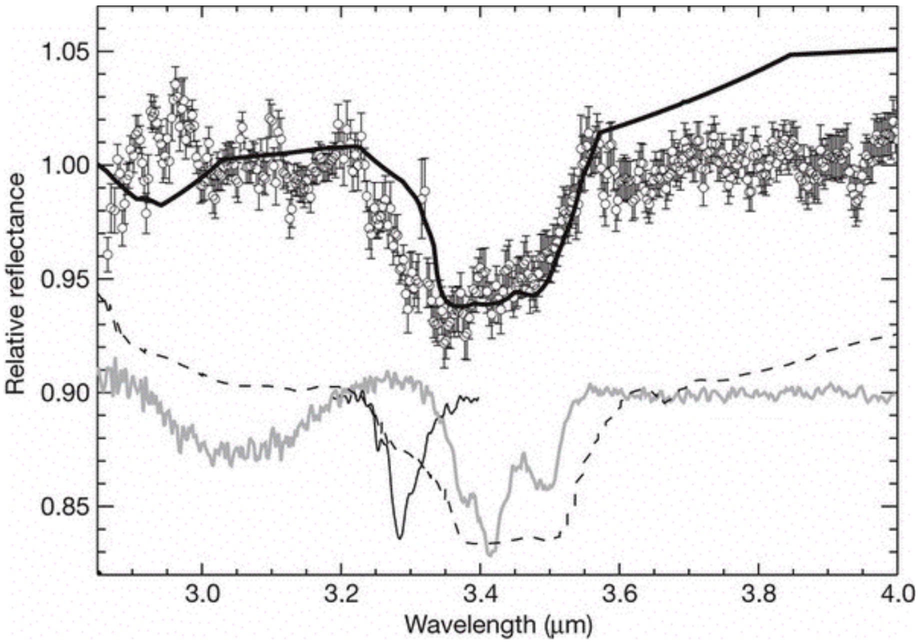


➢Developed an insulating dust mantl
volatiles below it (become inactive o ‘

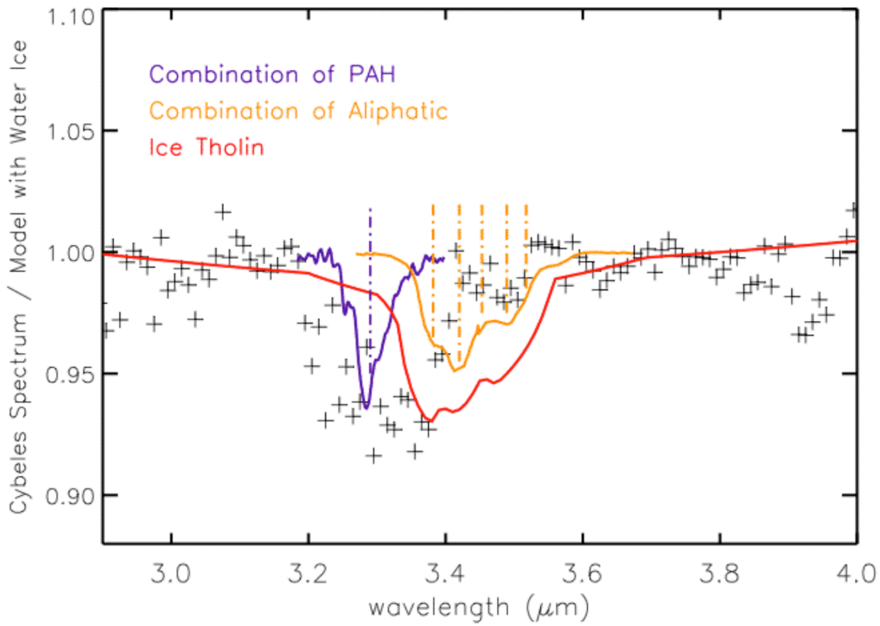
➢This is probably also the case of primitive asteroids scattered from the TNB during the LHB

Organics on 24 Themis and 65 Cybele

24 Themis (Rivkin & emery 2010)

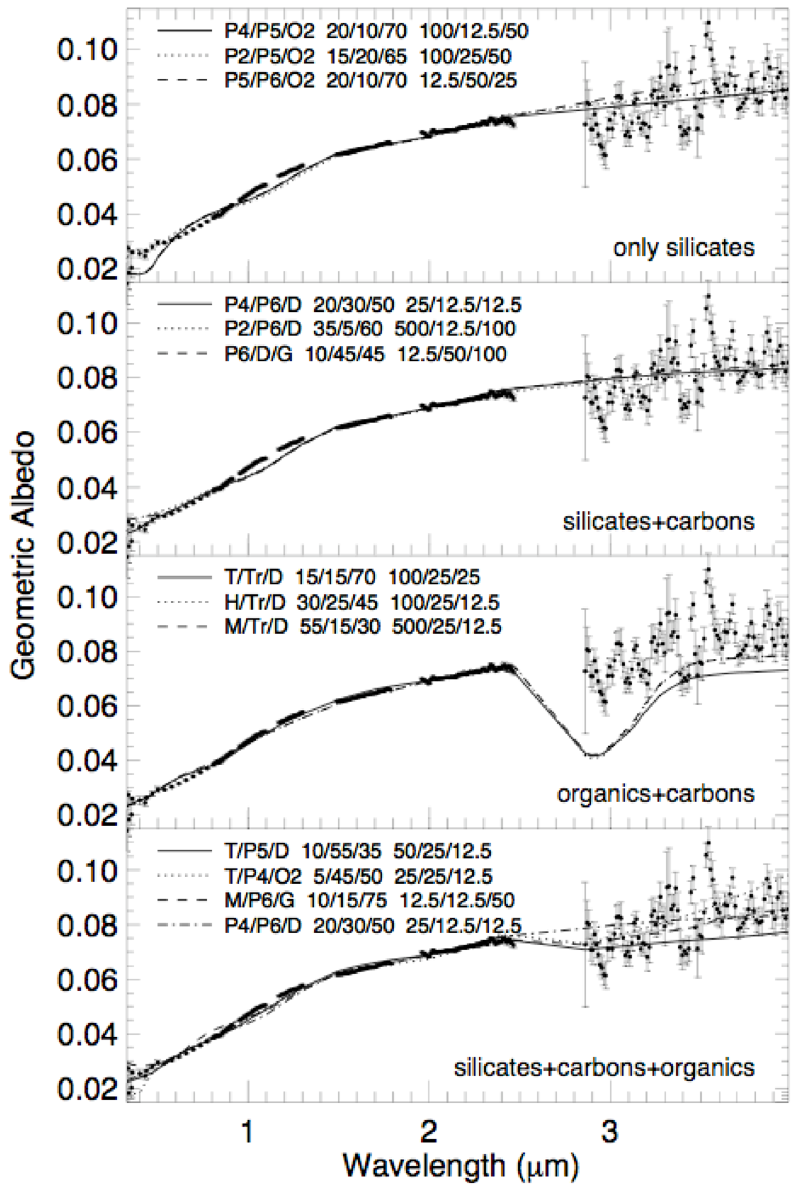


65 Cybele (Campins et al. 2010)



Spectra of 24 Themis and 65 Cybele divided by the water ice model, together with spectra of organic materials and organic-rich meteorite Cold Bokkeveld

Spectroscopy at 3μm: The Trojans



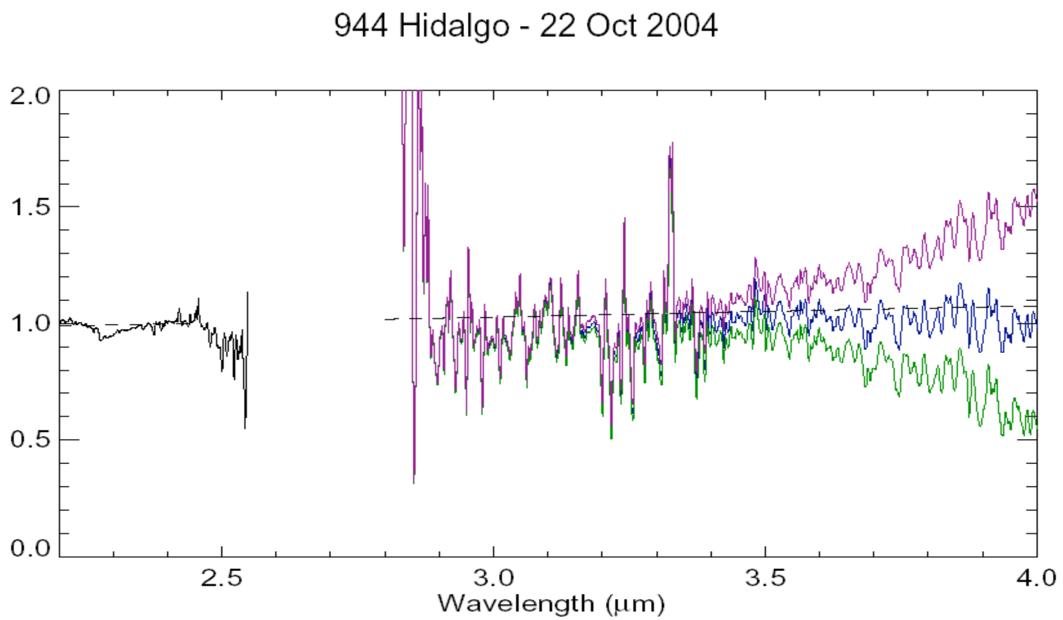
No absorption features ==>
Trojan surfaces are composed of anhydrous silicates and some carbonaceous, may be a few organics.
Unlikely the red spectral slope is due to organics.
No water ice detected.

Emery & Brown (2004).

Spectroscopy at 3μm of a paradigmatic ACO: (944) Hidalgo

Campins et al. (2005, ACM meeting)

II. b) 2-4 μm spectra

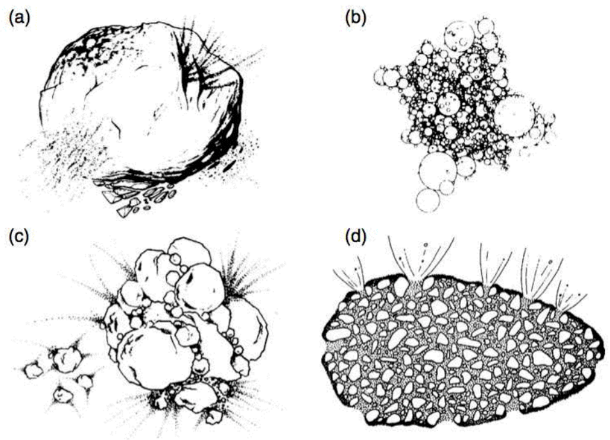


Hidalgo is one of the best candidates to be a dormant comet
IRTF spectrum do not show any spectral structure (no water, no organics, no hidrated minerals) ➔ ANHYDROUS SILICATE COMPOSITION? ➔ DUST MANTLE

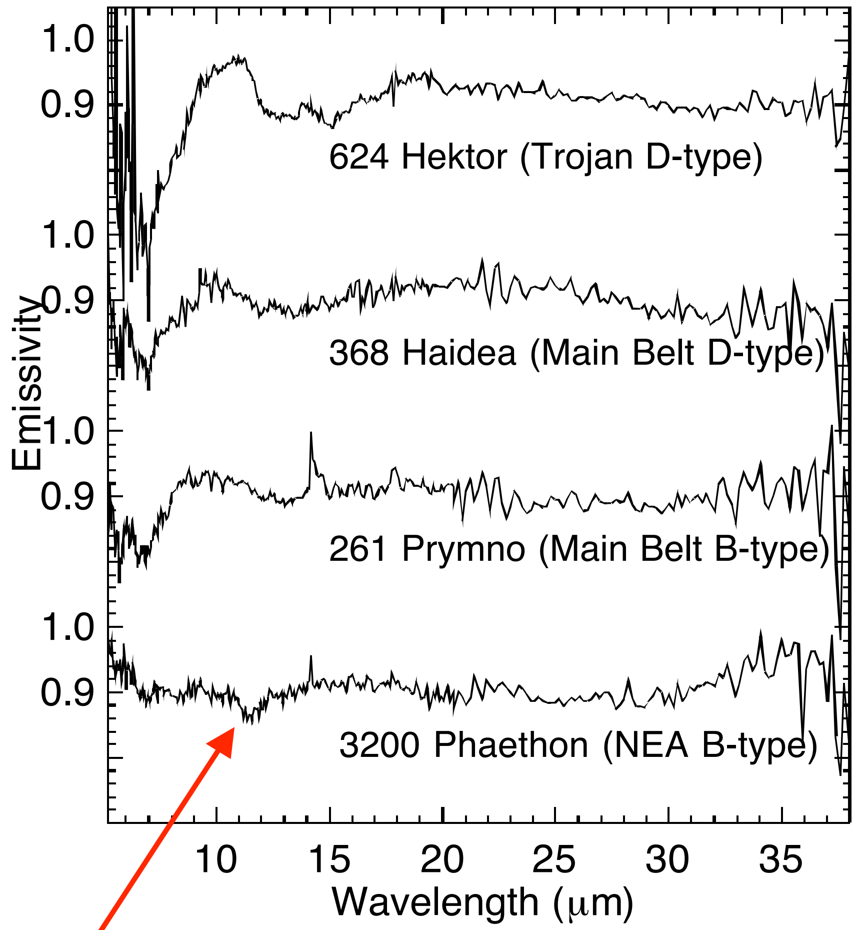
So, are the Main Belt Comets, comets?

May be, it's up to you … but

Its seems that they are not as our lovely "dirty ice objects"

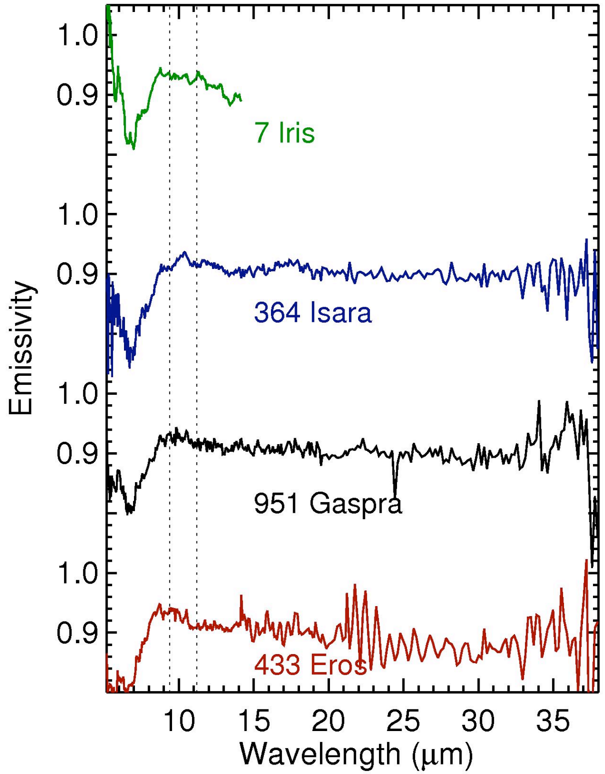


Primitive asteroids in the mid-ir



Hydrated silicate signature (Emery. 2010)

Main Belt: S-type Asteroids



The asteroid-comet transition problem

PHYSICAL NATURE:
- ACOs: Asteroids scattered from the main-belt or Inactive comets?
- AAs: Do some asteroids keep a small fraction of ices or there is another activation mechanism?
- Are all the primitive D-type asteroids scattered TNOs?

IMPORTANT TO:
- the problem of water in the early Solar System & formation of Earth oceans
- test for dynamical models
- understand end states of comets (deactivation-disruption)
- determine the population of JF comets
- determine contribution of comets to NEA population

INFORMATION FROM:
- spectral properties
- albedo
- rotational properties
- size distribution
- dynamical studies
- models

What do we actually know?

Conclusions

- Activity on some Activated Asteroids support that some primitive asteroids retained water ice
- Activated Asteroids have spectra of primitive asteroids of the C-complex (most are B-type) ➔ unlikely comets due also to dynamical arguments
- MBCs Elst-Pizarro and LINEAR & Themis family asteroids have very similar spectra ➔ belongs to the Themis family
- Themis & Cybele, primitive asteroids in the outer belt, have water ice & organics in their surface ➔ asteroids in this region (including MBCs)can also have ice & organics
- The recurrent activity of Elst-Pizarro and the presence of ice on the surface of Themis favour an activation mechanism based on water ice sublimation
- The detection of Ice & organics in asteroids is very relevant for cosmogonical and astrobiological theories.