Icy Bodies of the Solar System
Proceedings IAU Symposium No. 263, 2009
J.A. Fernández, D. Lazzaro, D. Prialnik & R. Schulz, eds.

doi:10.1017/S1743921310001778

Are the main belt comets, comets?

Javier Licandro[1,2] and Humberto Campins[3]

[1]Instituto de Astrofísica de Canarias,
c/Vía Láctea s/n, 38200 La Laguna, Tenerife, Spain.
email: `jlicandr@iac.es`

[2]Departamento de Astrofísica, Universidad de La Laguna,
E-38205 La Laguna, Tenerife, Spain

[3]Physics Department, University of Central Florida,
Orlando, FL, 32816, USA.
email: `campins@physics.ucf.edu`

Abstract. We present the visible spectrum of asteroid-comet transition object 133P/Elst-Pizarro (7968), the first member of the new population of objects called Main Belt Comets (Hsieh & Jewitt 2006). The spectrum was obtained with the 4.2m William Herschel Telescope at the "Roque de los Muchachos" observatory. The orbital elements of 133P place it within the Themis collisional family, but the observed cometary activity during it last 3 perihelion passages also suggest a possible origin in the trans-Neptunian belt or the Oort Cloud, the known sources of comets. We found a clear similarity between our spectrum of 133P and those of other members of the Themis family such as 62 Erato, and a strong contrast with those of cometary nuclei, such as 162P/Siding-Spring. This spectral comparison leads us to conclude that 133P is unlikely to have a cometary origin. This conclusion is strengthened by spectral similarities with activated near-Earth asteroid 3200 Phaethon, and suggest that there are activated asteroids in the near-Earth asteroid and main belt populations with similar surface properties.

Keywords. asteroid, comet, spectroscopy

1. Introduction

Icy minor bodies are known to originate in the trans-neptunian Belt (TNB) and the Oort Cloud. Recently, a third class of objects has been discovered: the Main Belt Comets (MBCs) (Hsieh & Jewitt 2006). Currently, only 4 MBCs are known, two of them, 133P/Elst-Pizarro (7968) and 176P/LINEAR (118401), are within the Themis collisional family of asteroids, a third one, P/2005 U1 (Read) is almost within it, and P/2008 R1 (Garradd) is near the 8:3 mean motion resonance with Jupiter. All of them have Tisserand parameter $T_J > 3.15$, this suggests they have an unlikely cometary origin. 133P is the best characterized having been seen active at 3 perihelion passages, which supports the hypothesis that the activity is driven by sublimation of water ice (Hsieh & Jewitt 2006).

Understanding the asteroidal or cometary nature of these bodies is crucial. If they are formed in situ and, in particular if they are members of a collisional family and their activity is due to water ice sublimation, there should be water ice in many asteroids. If they are captured TNB or Oort cloud comets the mechanisms that drove them to their present orbits needs to be understood.

2. Observations

The spectrum of 133P in the visible spectral region was obtained on July 9, 2007, with the 4.2m William Herschel Telescope (WHT) at the "Roque de los Muchachos"

Observatorio (ORM, Canary Islands, Spain), using the double arm ISIS spectrograph. Spectra in the red and blue arm where obtained simultaneously, using the R300B grating in the blue arm, with a dispersion of 0.86Å/pixel, and the R158R gratting in the red arm, with a dispersion of 1.81Å/pixel. A 5" slit width was used, oriented at the parallactic angle to minimize the spectral effects of atmospheric dispersion. Two spectra of 1800s exposure time where obtained in both arms. The tracking was at the asteroid proper motion. Images were over-scan corrected, and flat-field corrected using lamp flats. The two-dimensional spectra were extracted, sky background subtracted, and collapsed to one dimension. The wavelength calibration was done using the Neon and Argon lamps.

To correct for telluric absorption and to obtain the relative reflectance, the G star Landolt (SA) 115-271, (Landolt 1992) was observed at different airmasses (similar to those of the object) before and after the 133P's observations, and used as a solar analogue star. The spectrum of 133P object was divided by those of the solar analogue star, and then normalized to unity around 0.55μm thus obtaining the normalized reflectance. The obtained spectrum, rebined to a dispersion of 100Å/pixel is shown in Fig. 1.

In order to compare with other Themis family objects, the spectra of Themis family asteroids 62 Erato, 379 Huenna and 383 Janina were observed on April 1, 2006 using the same instrument and configuration. Landolt (SA) 107-689 and the solar analogue star BS4486 were observed to obtain the relative reflectance of the asteroids. The three asteroids present very similar spectral characteristics. The relative reflectance of 62 Erato is shown in Fig. 1. Notice that it is very similar to the spectrum of 133P.

3. Discussion and conclusions

The spectrum of 133P (Fig. 1) present a slightly blue slope at wavelenghts larger than 5000Å, and a drop in the UV region. Notice that 133P & 62 Erato spectra are very similar, supporting that both are likely fragments of the collision that formed the Themis family. So, we conclude that 133P belongs to the Themis family as suggested also by its orbital elements. Notice also that the large majority of Themis family asteroids do not present any cometary like activity, suggesting that "activated asteroids" (or MBCs) in the family are scarce.

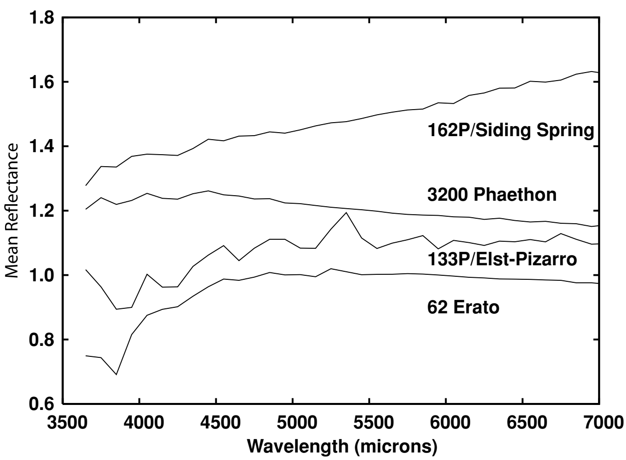

Figure 1. From top to bottom, visible spectrum of 162P/Siding Spring (Campins *et al.* 2006), 3200 Phaethon (Licandro *et al.* 2007), 133P/Elst-Pizarro and Themis family asteroid 62 Erato, shifted in reflectance axis for clarity.

Also in Fig. 1 it is evident that 133P's spectrum has similarities with that of the Near Earth Asteroid (NEA) 3200 Phaethon taken from Licandro *et al.* (2007). The shape of Phaethon's spectrum is similar, even though it is slightly bluer in the red and the UV drop is not as deep as in the 133P's spectrum. Phaethon is an asteroid-comet transition object that probably had past activity . Phaethon's surface contains hydrated silicates and this does not support its possible cometary nature (Licandro *et al.* 2007). The similarity between Phaethon's spectrum and that of 133P also suggests an asteroidal nature for the MBCs.

In Fig. 1 we also plot the spectrum of 162P/Siding-Spring from Campins *et al.* (2006), one of the best S/N spectrum of a comet nucleus, rebined to the same spectral resolution as the other objects, with the aim to explore the possible cometary origin of 133P. Notice that 162P's spectrum is very different to that of the Themis family asteroids and 3200 Phaethon. The large majority of comet nuclei with observed spectra, have an spectrum similar to that of 162P and compatible with that of P- or D-type asteroids (Jewitt 2002, Licandro *et al.* 2002, Campins *et al.* 2006, Snodgrass *et al.* 2008). P- and D-type spectra are featureless with a slightly red to red slope, and it is assumed they are composed of very primitive material. Finally, the asteroids in cometary orbits that more likely have a cometary origin (those with $T_J < 2.7$) are also P- and D-type (Licandro *et al.* 2008).

So, we conclude that 133P's spectrum and its dynamical properties show that this asteroid is a member of the Themis family of asteroids and is unlikely to have a cometary origin. If the activity is water-ice driven, these results suggest that there are some activated asteroids in the NEA and main belt population that were able to retain some water ice that sublimates under certain circumstances.

Exploring the volatile content of icy minor bodies is critical for understanding the physical conditions and the mechanisms of planetary formation, and also addresses the question of the origin of Earth's water. If the outer main belt has a large population of asteroids with ice, they could have contributed to the water on Earth. Additionally, this indicates the extent and origin of volatiles in asteroids that could be used as resources for space exploration.

Acknowledgements

JL gratefully acknowledges support from the spanish "Ministerio de Ciencia e Innovación" project AYA2008-06202-C03-02. HC acknowledges the support of NASA's Planetary Astronomy Program and of the National Science Foundation.

References

Campins, H., Ziffer, J., Licandro, J. Pinilla-Alonso, N., Fernandez, Y., de Leon, J., Mothé-Diniz, T., & Binzel, R. 2006, *AJ*, 132, 1346

Hsieh, H. & Jewitt, D. 2006, *Science*, 312, 561

Jewitt, D. 2002, *A.J*, 123, 1039

Landolt A. 1992, *AJ*, 104, 340

Licandro, J., Campins, H., Hergenrother, C., & Lara, L. M. 2002, *A&A*, 398, L45

Licandro, J., Campins, H., Mothé-Diniz, T., Pinilla-Alonso, N., & de León, J. 2007, *A&A*, 461, 751

Licandro, J., Alvarez-Candal, A., de León, J., Pinilla-Alonso, N., Lazzaro, D., & Campins, H., 2008, *A&A*, 481, 861

Snodgrass, C., Lowry, S. C., & Fitzsimmons, A. 2008, *MNRAS*, 385, 737