Our Solar System with LSST
The Italian interest

Elena Mazzotta Epifani – INAF OAR (Roma)

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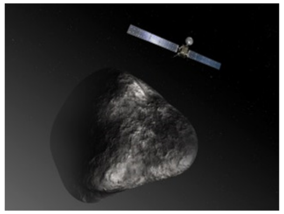
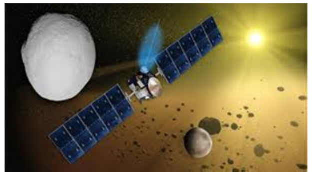
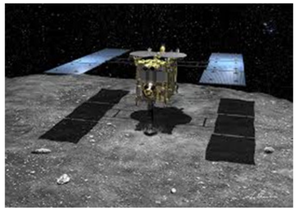
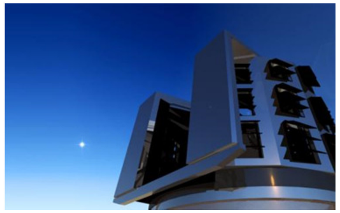
   

Many individual bodies have been, are being, or will be explored with in situ, ad hoc space missions, which have revealed exciting new insights on a few targets (asteroids or comets) and helped in defining more reliable constraints on the general and fundamental questions on **formation and evolution of a planetary system around a standard star**.

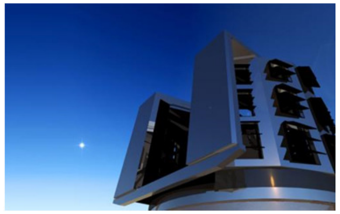


Why observing with LSST?

Conversely, ground-based observations allow us to investigate **<u>a large number of small bodies</u>** and therefore assess a number of scientific aims and goals, impossible to be achieved from space, spanning e.g. from investigation of time-critical and/or transient events to repeated monitoring of several phenomena. Such measurements are needed to obtain the necessary **general overview of the planetary complex**.

In a nutshell: **ground-based observations of many small bodies are essential to provide characterizing information on a very large sample of members of many families and groups. It has to be underlined that this deals with bodies that are usually considered to be "closest" to the formation era of the planetary system.**

The Solar System: potential interest for LSST data in Italy



NEAs and Potential Hazardous Asteroids: characterization and risks assessment; synergy with results from OSIRIS-REx mission to Bennu (primitive asteroid)

Recovery of close Near Earth Asteroids and potential impactors, and removing of hazard list

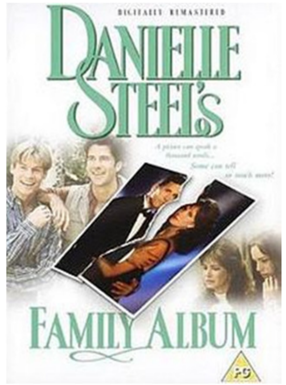
Asteroids and other close Minor Bodies: dynamics in the Main Belt, Mars Trojans, Barbarians, synergy with GAIA mission

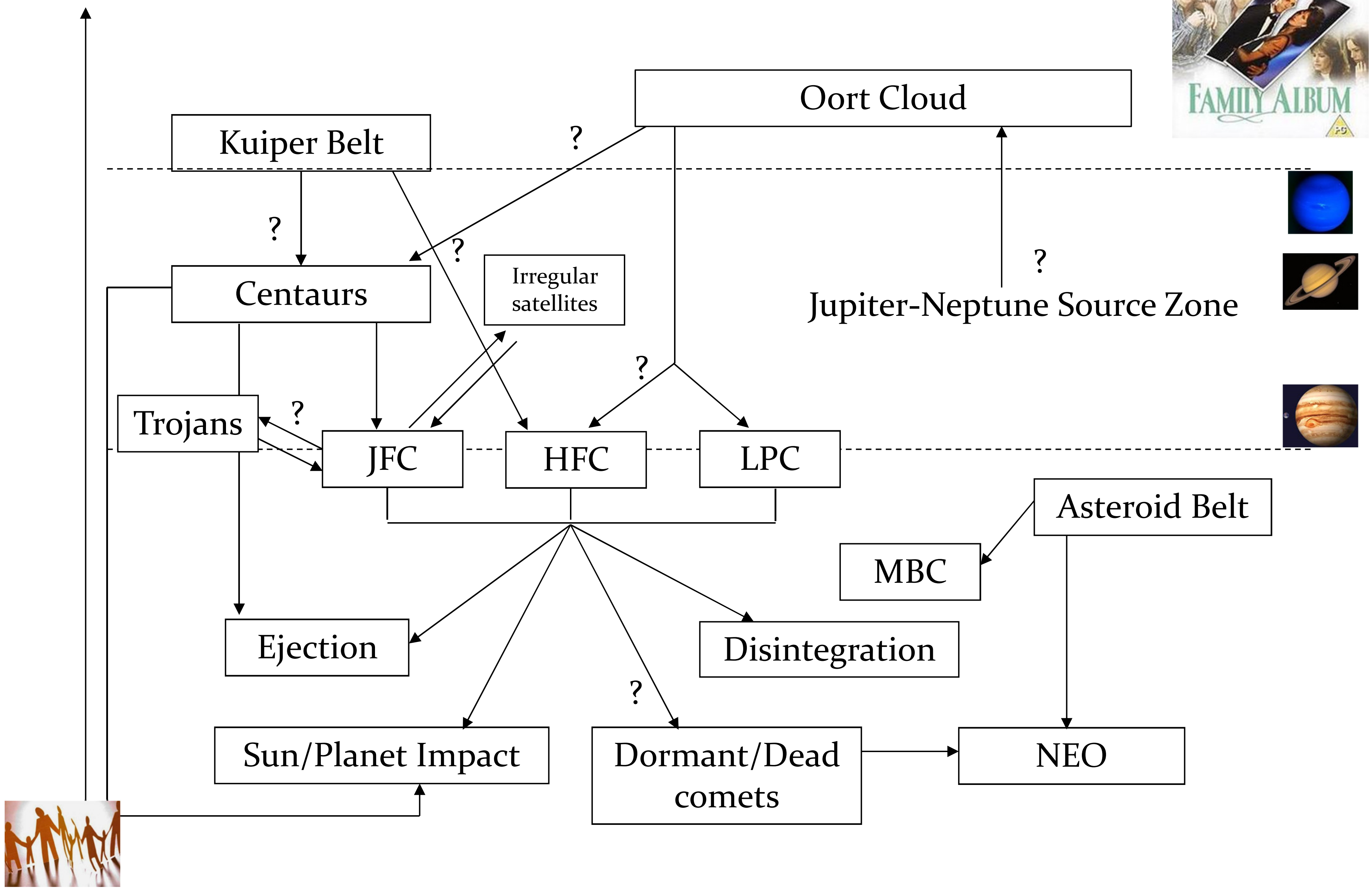
Monitoring of Main Belt Comets; Jupiter Family Comets as primitive bodies (surface properties); synergy with results from ROSETTA mission to 67P

Distant MBs (Centaurs, Jupiter Trojans): monitoring of comet-like activity, surface properties, laboratory studies

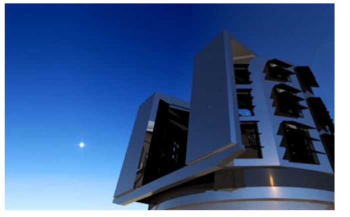
Numerical modelling of comet-like activity in members of many groups/classes of MBs

Family album

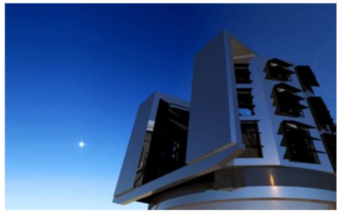




The Solar System: potential interest for LSST data in Italy

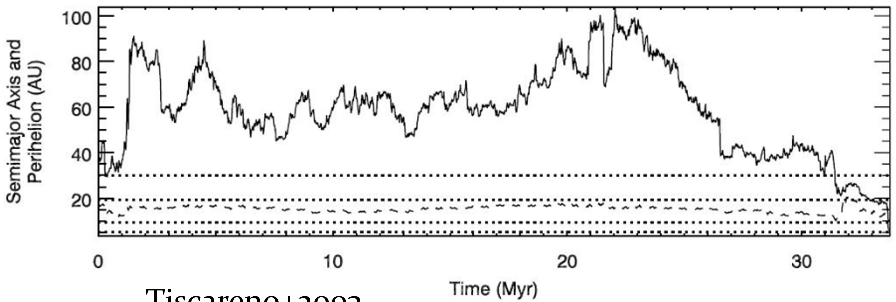


Two possible scientific cases

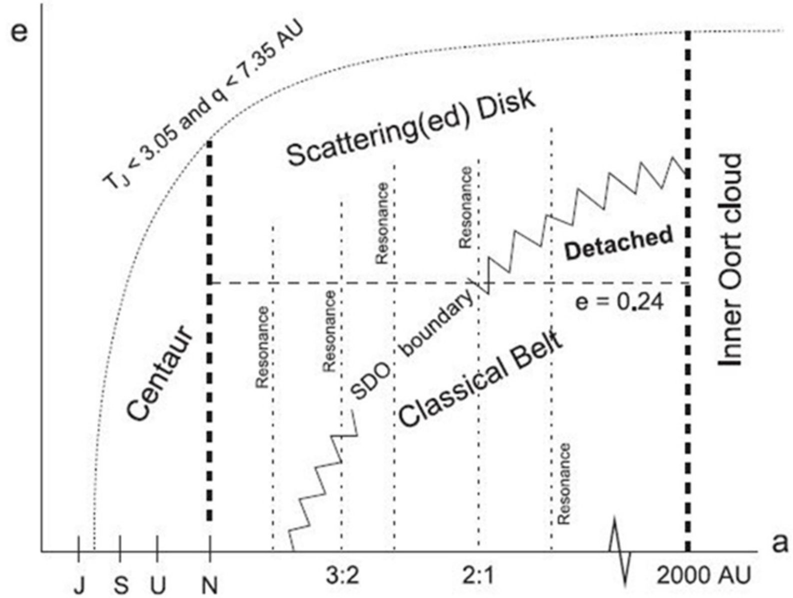


Scientific case: the elusive, puzzling case of **the Centaurs among the giants**

Centaurs move on <u>unstable</u> and <u>cahotic</u> orbits with typical lifetimes of 10^6 - 10^7 years, spending most of their dynamical lifetimes in orbits of eccentricity 0.2–0.6 and perihelion distance 12–30 AU



Tiscareno+2003



The quintessentially "transition" Objects

Numerical simulations show that a Centaur can:

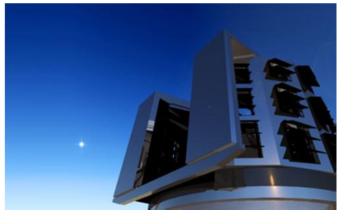
→ Slow back-drift, towards the SD of the KB

→ be captured by a giant planet in a temporary satellite orbit

→ be expelled from SS due to a close encounter with a giant planet

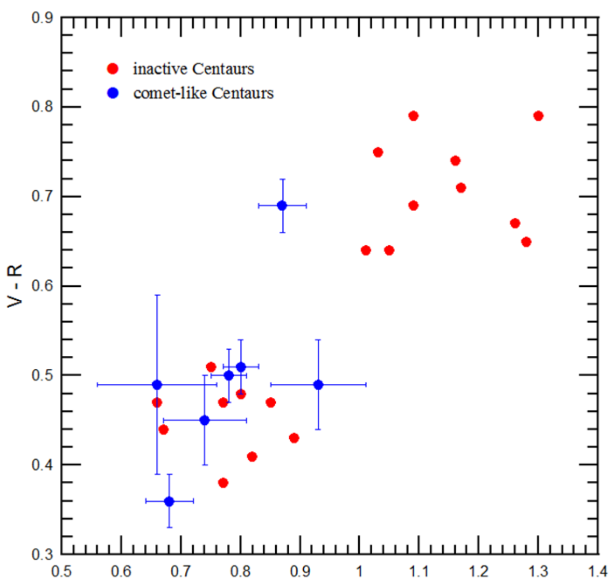
→ evolve in the inner SS as SPCs

→ impact on a planet

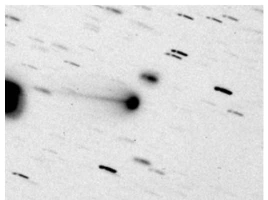


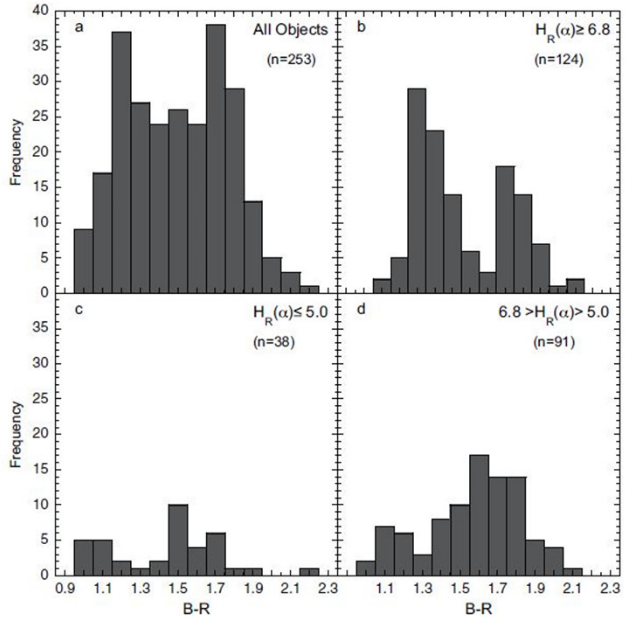
Scientific case: the elusive, puzzling case of **the Centaurs among the giants**

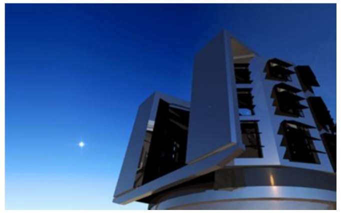
- Still very few members of the class have been discovered (~150, biased towards large and close members: estimated population for r > 1 km ~ 45000)
- Even less (~ 40) have been characterised (colours, taxonomy, surface composition, shape, light curves…), many only with snapshot observations
- A handful (~ 15) shows comet-like activity, in very few cases studied and monitored
- Puzzling bi-modal colour behaviour (unique in the Solar System), with possible different origin, possible link with physical properties (size, shape…), evidences of relations with other SM families/groups (JTs, JFCs…)



Mazzotta Epifani et al. 2016, in prep.

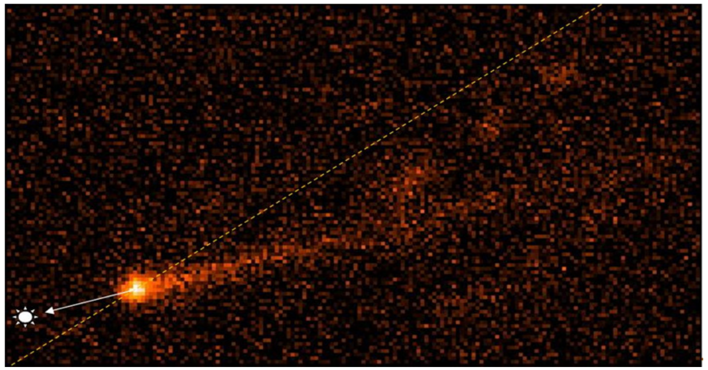

P/2004 A1 LONEOS
Mazzotta Epifani et al. 2011.



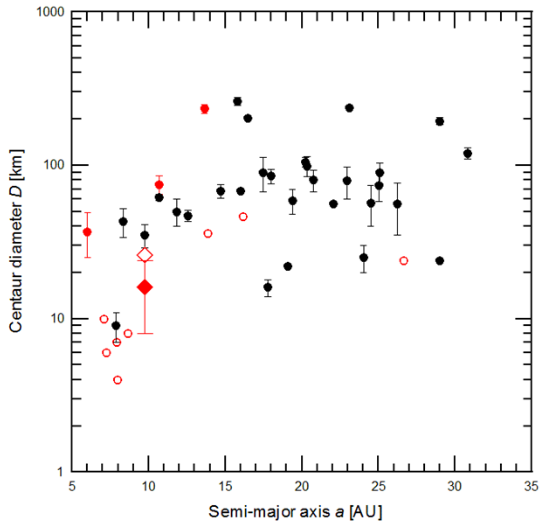


Scientific case: the elusive, puzzling case of **the Centaurs among the giants**

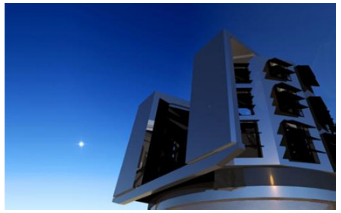
- Long-lasting experience in <u>**search for**</u> and eventually <u>**characterisation of**</u> distant comet-like activity in several groups and families of MBs: JFCs, Centaurs
- Present on-going Long Term Program of analysis of physical properties, colours and taxonomy in the class: up to know, we almost doubled the number of Centaurs observed in the BVRI range (mid-class telescopes: TNG, CAHA, NOT)
- Preparation for a deep search and characterization of comet-like activity in blue targets with large telescopes
- Preparation for spectroscopic surface characterisation with large telescopes and comparison with laboratory results



Mazzotta Epifani et al. 2014: The active Centaur P/2010 C1 (Scotti)



Mazzotta Epifani et al. 2016 (submitted): The nucleus of the active Centaur C/2011 P2 (PANSTARSS)



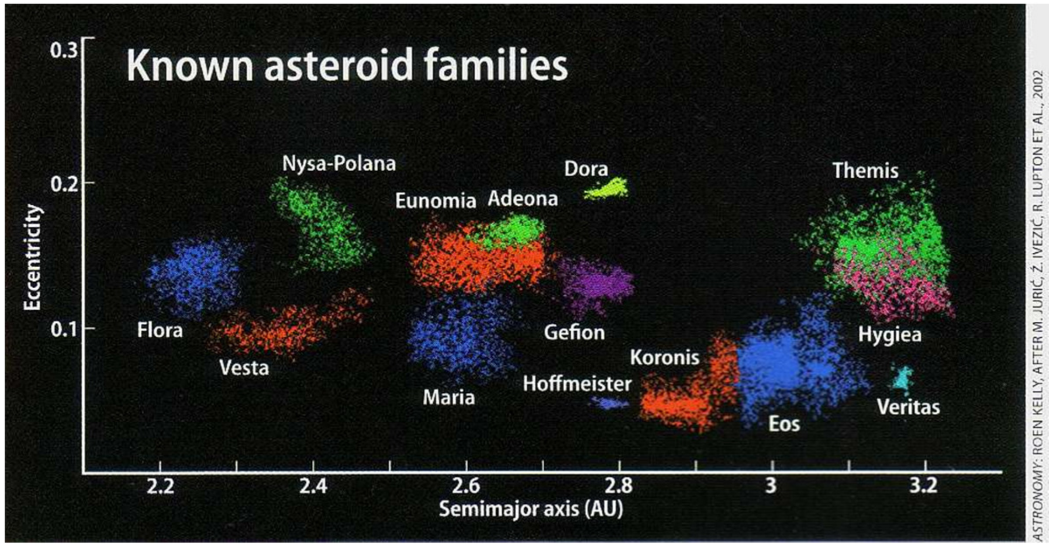
Scientific case: open problems on **the close Small Bodies (SMs)**

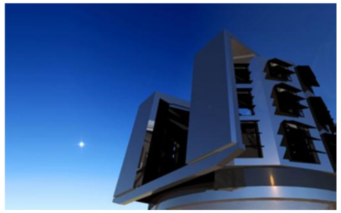
- DYNAMICAL FAMILIES

(1) SD of faint objects: extension down to size of ~ 100 m needed to confirm or disprove the subtle structure of dynamical families and sub-families (Milani et al. 2014, 2015, 2016 submitted). The age of families as tracer of the early and late evolution of the SS will be deeply investigated

(2) Families of the Jupiter Trojans: case study for collisional events and ejection velocity, modelling the velocity fields and discriminate between co-formation and capture

(3)Photometric analysis will be useful to distinguish family members and field interlopers, in order to reconstruct the cynematic properties of families and to derive their age.





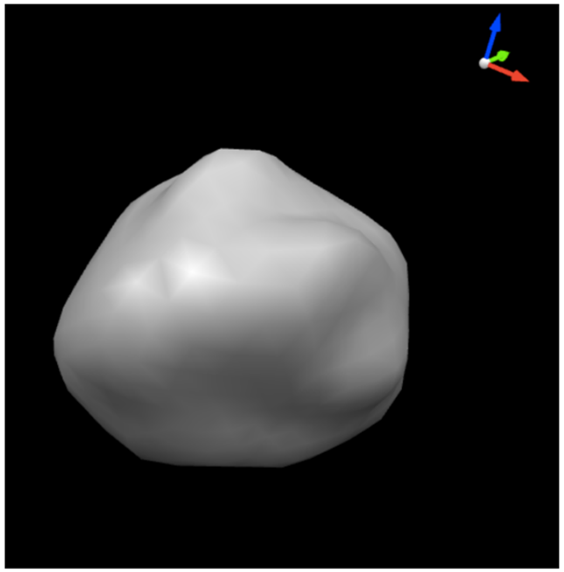
Scientific case: open problems on **the close Small Bodies (SMs)**

- MARS TROJANS

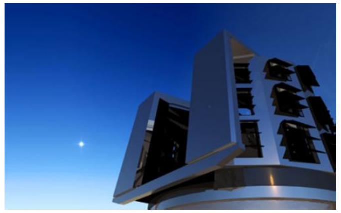
Very new and fastly evolving issue: Mars Trojans have been only recently identified (the first one, 5261 Eureka, in 1990), and the class is very scarcely populated (7 + 1 candidate, up to 2015). There is still ambiguity on their origin, and it is not clear if they can be considered remnants of the very first generation of planetesimals formed in the inner Solar System. Later capture would be puzzling, due to the low mass of Mars, but statistics is still too poor. Their taxa (photometric analysis) indicate that they are different among each other, and very rare and peculiar (Christou et al., 2013, 2016). E.g. Eureka is a rare (only 15 discovered up to now) A-type asteroid, with a strong 1 μm olivine band – from a completely differentiated mantle?

- BARBARIANS (Cellino et al., 2006, 2014)

A very recent italian discovery: very primitive asteroids in the MB. (234) Barbara is the main representative of this population. Relatively rare (L taxa, less than 17% of the MBAs), scarcely populated class (~ 15 members), with anomalous polarimetry and rare spectroscopic features (spinel and refractory minerals on the surface). Some evidence of the possible origin of several (but not all) Barbarians from the disruption of a single parent body at the epoch of the Heavy Late Bombardment



The reconstructed shape of the asteroid (234) Barbara (Tanga et al. 2012).



Scientific case: open problems on **the close Small Bodies (SMs)**

- MBCs: detection and monitoring of faint and transient /sustained comet-like comae

- Photometric analysis of NEOs (dormant/dead comets, re-activated target, collisional events, potential impactors…)

- Synergy with GAIA: extension of astrometric ground-based mesurements for asteroids in mutual close encounter events. This will allow a more accurate measurement of the mass for the ~100 largets asteroids by GAIA (need to obtain many accurate astrometric measurements before and after the encounter). Extension of GAIA up to 2020?