A Chinese / European Exploration Mission to a Binary Near-Earth Asteroid

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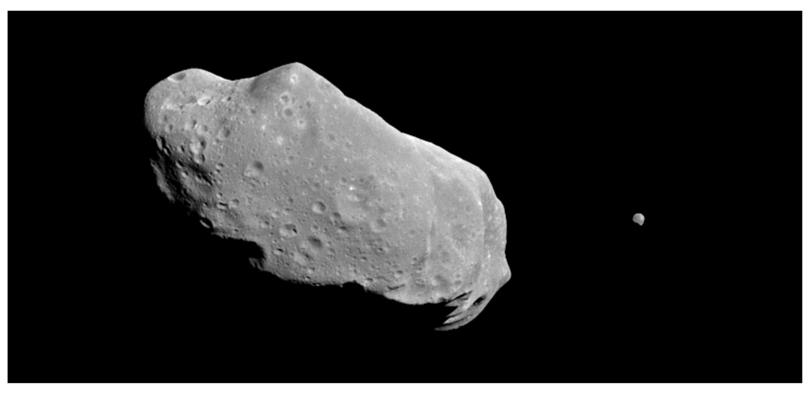
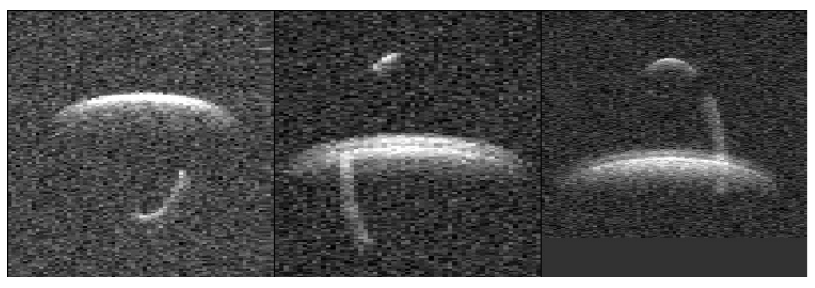
Overview

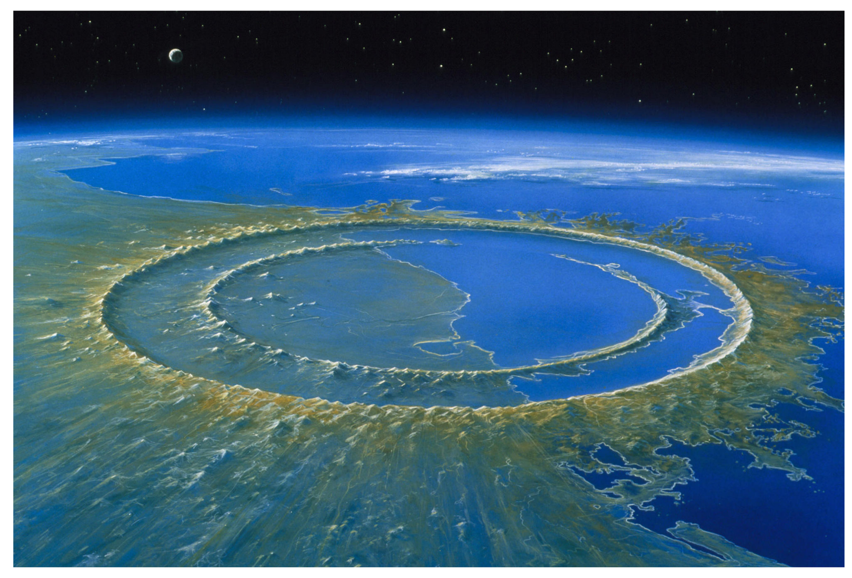


Binary asteroid (243) Ida and its moon Dactyl observed by Galileo spacecraft. (credit: NASA/JPL)



Radar images of Near-Earth binary asteroid (66391)1999 KW4 and the trails of its moon. (credit: Ostro et al.)

Asteroids in near-Earth space represent messengers from distant parent bodies, and may provide records on the origin and evolution of our planetary system. While most NEOs (Near-Earth Objects) are believed to originate from the asteroid main belt, some of them may represent extinct cometary nuclei. NEOs are also of interest, as they are on potential collision courses with Earth and may pose a threat to civilization and life. There is much interest in studying compositions and structures of the NEOs for understanding of the hazards and for possibly mitigating the collision effects. Binary asteroids are abundant among the NEOs, making up approximately 15% of all Near-Earth asteroids (Pravec et al., 2006). Recent work suggests that most of them have a significant macro-porosity and represent so-called "rubble-piles". Their origin might be closely presented by interaction with terrestial planets. Hence investigations of binary asteroids bare strongly on the origin and evolution of the NEO population as well as the solar system.



Artwork of the Chicxulub crater off the Yucatán Peninsula, Mexico, which is suggested in a recent research as result of an impact by binray asteroid (Miljkovic, et al., 2013). The impact is believed by many scientitst to have caused the demise of the dinosaurs. (credit: Detlev van Ravenswaay)

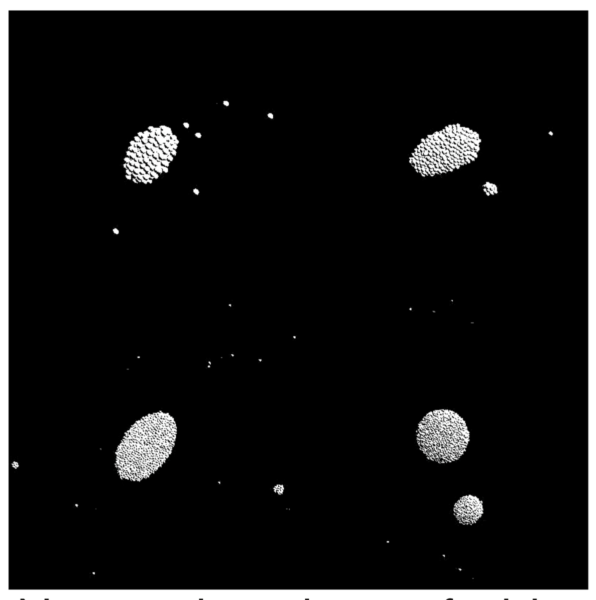
Scientific Objectives

Evaluate scenarios for the origin of binary systems
- Tidal disruption (Walsh & Richardson, 2006)
- Rotational breakup due to YORP effects (Walsh et al., 2008)

Determine the dynamical characters of the system
- How do the primary and secondary interact with each other?
- How does the YORP effect influence?

Determine the composition of both bodies
- Does compositional heterogeneity exist in the system?
- Is there any meteorite resemblance?

Constrain the model of internal structure
- Macroprosity or microporosity?



Numerical simulation of tidal disruption of an Earth-crossing asteroid. (credit: Richardson et al., 1998)

Payloads and Measurements

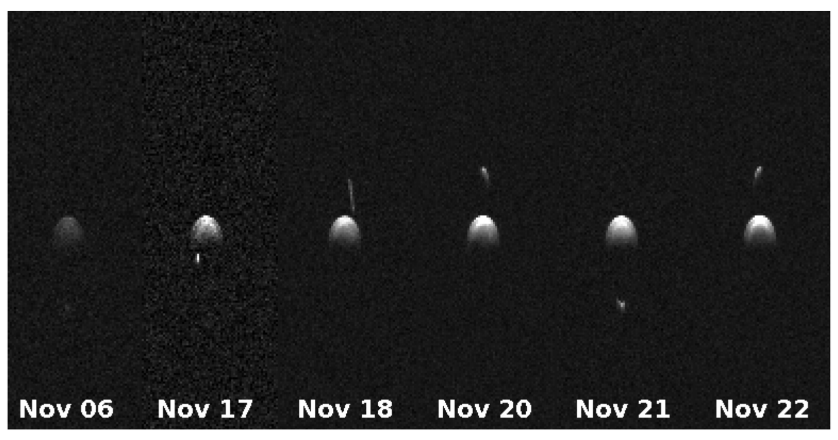
Optical remote sensing
- Shape
- Multispectral mapping
- Morphology and Geological features

Laser ranging
- Topography
- Rotational parameters
- Ephemeris

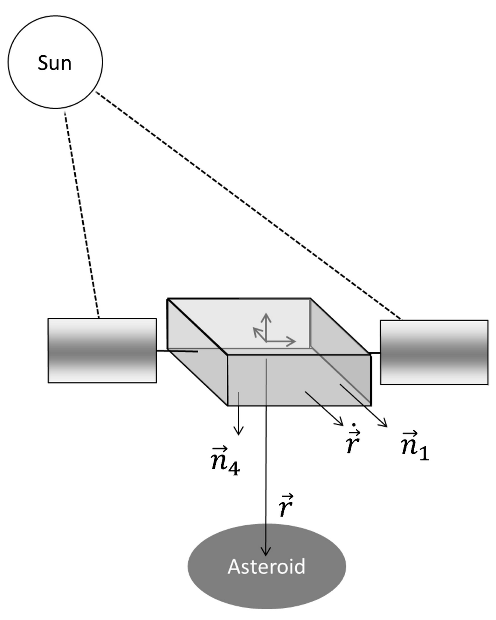
Radio science
- Gravity field
- Ephemeris

Mission Concept

Sample target: (175706) 1996 FG3
Launch: 2022-2024
Rendezvous & Mapping
Impact on primary or secondary

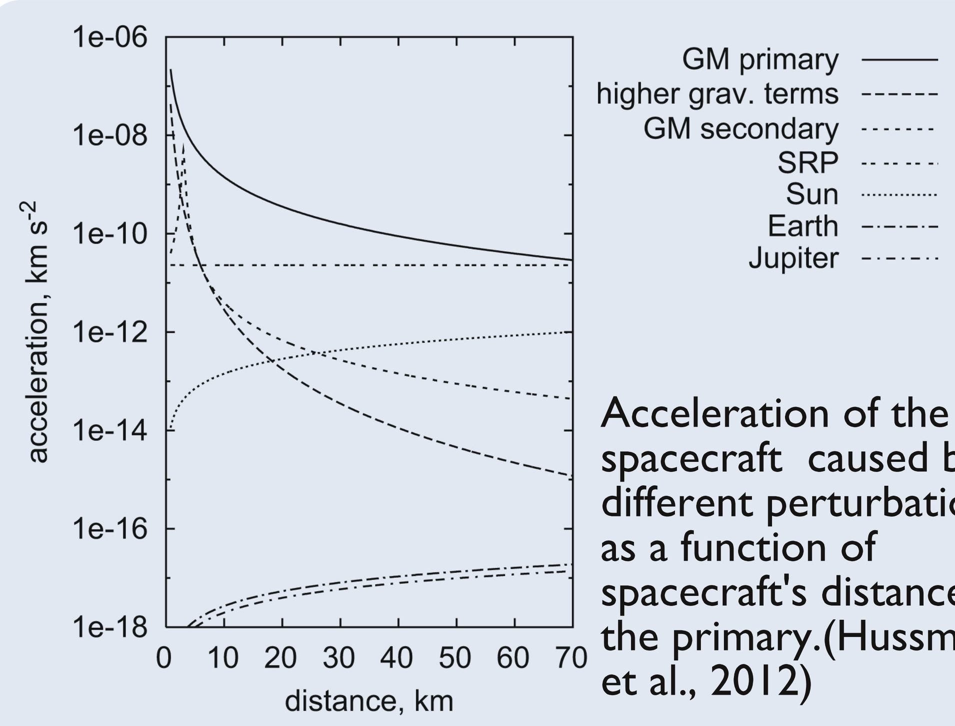


Arecibo radar observations of (175706) 1996 FG3 (credit: NASA/JPL)



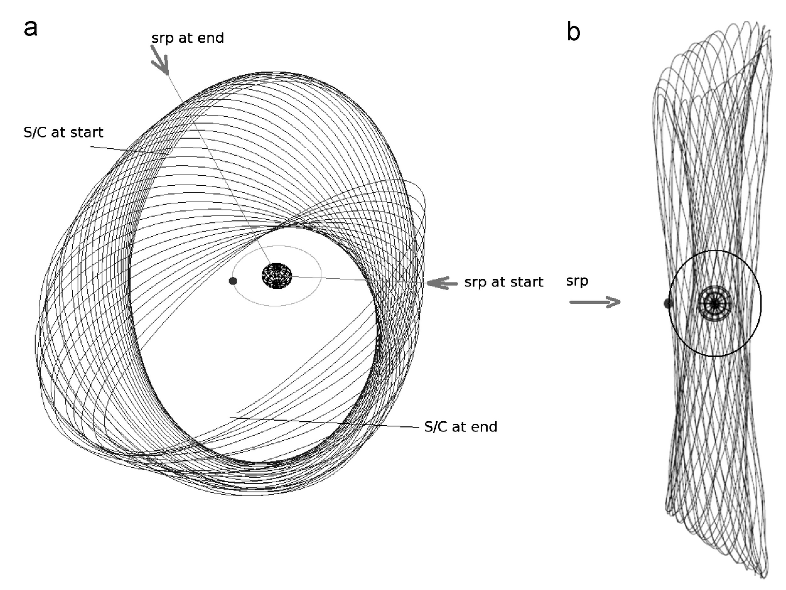
Model of the Spacecraft (Hussmann et al., 2012)
Mass: 1275 kg
Reflectivity: 0.8(platform), 0.21(solar panel)
Size of solar panel: 10 m^2

Orbital Stability



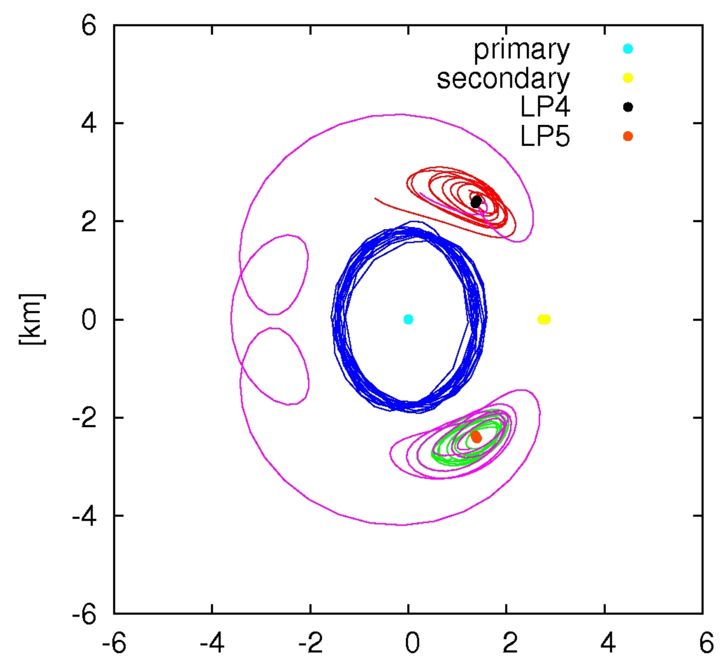
Acceleration of the spacecraft caused by different perturbations as a function of spacecraft's distance to the primary.(Hussmann et al., 2012)

Orbiting around the binary system

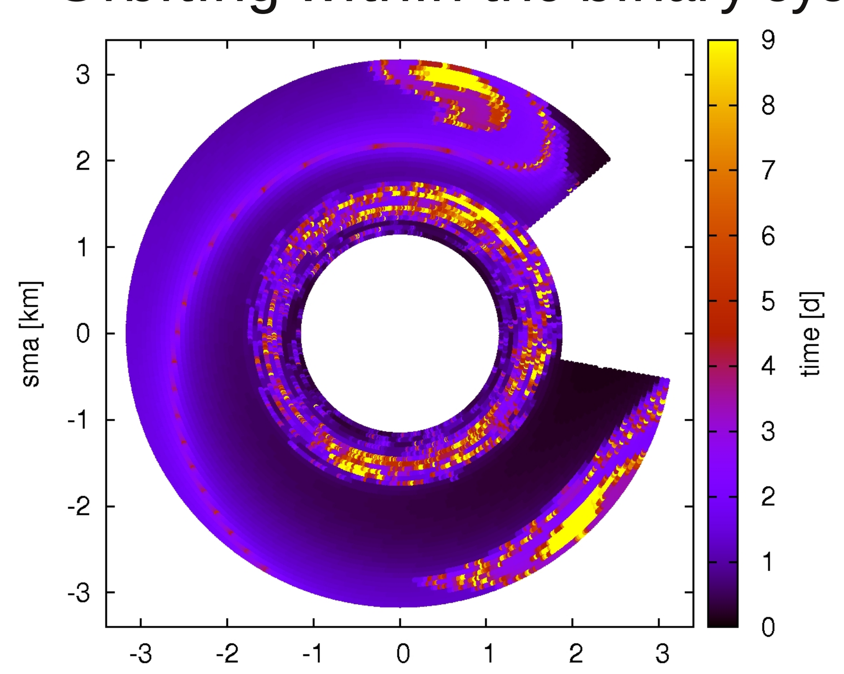


Spacecraft's motion over six months viewed in a) inertial frame; b) Sun-terminator frame. (Hussmann et al., 2012)

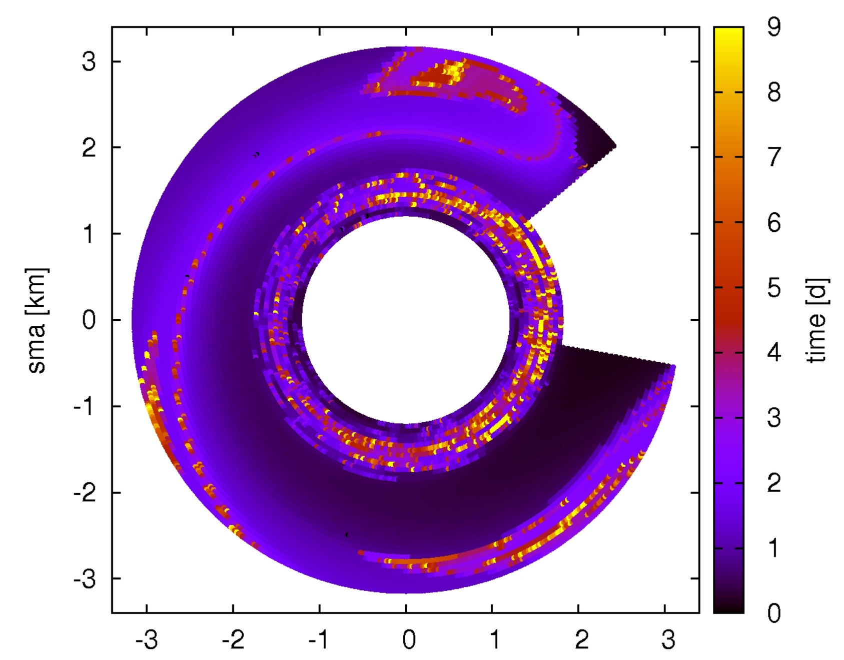
Orbiting within the binary system



Examples of relatively stable orbits around L4 point (red); around L5 point (green), in resonnance (blue), and transfering orbit from L5 to L4 (pink)



Stability analysis of different initial conditions (semi-major axis and mean anomaly), without considering solar radiation pressure. Colors indicate the length of time of stable orbiting.



Stability analysis of different initial conditions (semi-major axis and mean anomaly), considering solar radiation pressure. Colors indicate the length of time of stable orbiting.

References
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