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Castalia – A European Mission to a Main Belt Comet

H. Boehnhardt (1), **M. T. Capria** (2) and the Castalia Team
(1) MPS, Katlenburg-Lindau, Germany, (2) IAPS/INAF, Rome, Italy (mariateresa.capria@iaps.inaf.it)

Abstract

Main Belt Comets (MBCs) are a new solar system population with stable asteroid-like orbits and a comet-like appearance. It is believed that they survived the age of the solar system in a dormant state and that their activity has been triggered by a recent impact exposing buried ice.
Castalia is a science mission to an MBC with the goal to characterize this kind of bodies and study their activity.

1. Introduction

Main Belt Comets (MBCs) are a new solar system population with stable asteroid-like orbits and a comet-like appearance. It is believed that they survived the age of the solar system in a dormant state and that their activity occurred only recently. Buried water ice is the only volatile expected to survive under an insulating surface. Excavation by an impact might expose the ice and trigger the start of MBC activity.

Castalia is a science mission to an MBC with the goal to illuminate their mysteries, to decipher the messages of MBCs from the formation period of the planetary system and to explore their possible links to Earth. The specific science goals of the mission are:

(1) Characterize a new Solar System family, the MBCs, by in-situ investigation;
(2) Understand the physics of activity on MBCs;
(3) Directly sample primordial water in the asteroid belt;
(4) Test if MBCs are a viable source for Earth's water;
(5) Use MBCs as tracers of planetary system formation and evolution.

2. Mission profile

These goals can be achieved by a spacecraft designed to rendezvous with an MBC and orbit it for a time interval of some months to a year, arriving before the active period for mapping and then directly sampling the gas and dust released during the active phase. Given the low level of activity of MBCs, and the expectation that their activity comes from only a localized patch on the surface, the orbiting spacecraft will have to be able to maintain a very close orbit over extended periods – the Castalia plan envisages an orbiter capable of'hovering' autonomously at distances of only a few km from the surface of the MBC.

3. Scientific payload

The strawman instrument payload is made up of: Visible and near-infrared spectral imager; Thermal infrared imager; Radars for deep and shallow penetration depths; Radio science; Dust impact detector; Dust composition analyzer; Neutral/ion mass spectrometer; Magnetometer; Plasma package. In addition to this, the option of a surface science package is being considered.

4. Mission target

At the moment MBC 133P/Elst-Pizarro is the best-known target for such a mission. A design study for the Castalia mission has been carried out in partnership between the science team, DLR and OHB Systems in Bremen. This study looked at possible missions to 133P with launch dates around 2025, and found that this (and other MBC targets as backups) are reachable within an ESA M-class type mission.