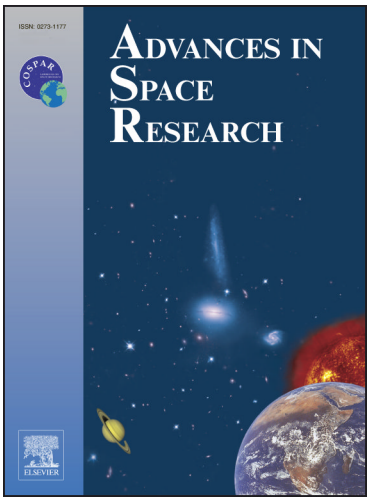

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The proposed Caroline ESA M3 mission to a Main Belt Comet

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Abstract

We describe *Caroline*, a mission proposal submitted to the European Space Agency in 2010 in response to the Cosmic Visions M3 call for medium-sized missions. *Caroline* would have travelled to a Main Belt Comet (MBC), characterizing the object during a flyby, and capturing dust from its tenuous coma for return to Earth. MBCs are suspected to be transition objects straddling the traditional boundary between volatile–poor rocky asteroids and volatile–rich comets. The weak cometary activity exhibited by these objects indicates the presence of water ice, and may represent the primary type of object that delivered water to the early Earth. The *Caroline* mission would have employed aerogel as a medium for the capture of dust grains, as successfully used by the NASA *Stardust* mission to Comet 81P/Wild 2. We describe the proposed mission design, primary elements of the spacecraft, and provide an overview of the science instruments and their measurement goals. *Caroline* was ultimately not selected by the European Space Agency during the M3 call; we briefly reflect on the pros and cons of the mission as proposed, and how current and future mission MBC mission proposals such as *Castalia* could best be approached.

Keywords: Asteroids, Comets, Interplanetary dust and gas

1. Introduction

Where does Earth's water come from? There are few questions about our planet's history that are more fundamental. Here, we describe a mission proposed to the European Space Agency that aimed to address this question, and many others, by visiting for the first time a member of a newly-discovered family of objects in our Solar System: Main Belt Comets (MBCs). These perplexing objects have stable orbits within the asteroid belt, but during certain seasons behave like comets, possessing a dust coma and tail. This strongly suggests that volatiles at their surfaces are sublimating, driving off the dust. This volatile material is likely to be water ice. Dynamical models suggest that bodies from this region brought water to Earth. The remaining MBCs are therefore believed to hold a frozen record of the source of Earth's water. The proposed mission's name — *Caroline* — was in honour of Caroline Lucretia Herschel (1750–1848), arguably the first great female astronomer, and discoverer or co-discoverer of at least six comets.

This highly focused small mission would have travelled to the MBC 133P/Elst-Pizarro to capture material from its dust coma/tail, bringing it back to Earth for highly detailed laboratory analysis. The capture of the dust would be achieved through the use of aerogel — an extremely low density material whose application to the collection of cosmic dust was very successfully demonstrated by NASA's *Stardust* mission to Comet 81P/Wild 2.

While capturing the dust from Elst-Pizarro, *Caroline* would scrutinize the nucleus with a visible camera and thermal infrared mapping spectrometer, searching for the source of the dust and mapping the body's surface morphology and mineralogy. A separate instrument would detect dust impacts on the spacecraft's protective shield.

MBCs are of particular interest to the planetary science community as they represent the "missing link" between rocky asteroids and icy comets. The population was only recognized in 2006, and has since been the subject of detailed scrutiny by planetary astronomers. They are dynamically stable now, but the may have formed beyond

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