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Ptolemy operations as part of the Rosetta mission up to and including the targeted flyby of asteroid 21 Lutetia.

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Abstract

Rosetta is the European Space Agency 'planetary cornerstone' mission intended to solve many of the unanswered questions surrounding the small bodies of the Solar System. Launched in March 2004 it is now over halfway through its decade long cruise, leading up to entering orbit around the nucleus of comet 67P/Churyumov-Gerasimenko in mid-2014. To date, this cruise has included three gravitational assist manoeuvres using Earth, one such manoeuvre past Mars, and a 800 km distant targeted scientific flyby of the 5 km diameter E-type asteroid 2867 Šteins. The latter returned a plethora of data to be compared with the comet observations to come. It is anticipated that Rosetta will have passed within 3,100 km of the 100 km diameter M-type asteroid 21 Lutetia during a targeted flyby taking place on July 10th 2010.

Ptolemy is a miniature chemical analysis laboratory aboard the Philae lander and is intended to determine the chemical and isotopic composition of cometary material sourced from beneath, on and above the surface of the target comet. Samples are taken from the Sampler, Drill and Distribution system (SD2) and are then processed in a chemical preparation suite before delivery to a three channel gas chromatograph (GC). Elution products from the GC are passed to a quadrupole ion trap mass spectrometer for detection [3]. As well as analysing solid samples, Ptolemy can passively adsorb coma material onto Carbosphere™ molecular sieve contained within one of the 26 SD2 sample ovens for later thermal release and analysis. Ptolemy can also make simple 'sniff' detections of the current spacecraft environment bypassing the sample inlet and GC system and instead directly analysing the inside of the mass spectrometer, itself connected to space via a vent pipe.

During the cruise to date Ptolemy has undergone five active checkout periods where in-flight testing was undertaken under 'real time' control from the ground, confirming that Ptolemy had survived launch and allowing the instrument team to prepare for science operations. The detection limit for a typical gas was measured to be 10^{-11} mbar, using an on board supply of argon doped at a 100 ppm level into the grade 6.5 helium gas chromatography carrier gas.

Recent observations of the main belt asteroid 24 Themis have shown this body to have an organic-rich surface with exposed water ice [4]. It is also known that there at least four main belt comets – comets residing within the main asteroid belt, the prototype being 133P/Elst-Pizarro – and there are likely to be many more such bodies undergoing lower levels of cometary activity yet to be discovered [2]. The once clear-cut differentiation between volatile rich comets and volatile depleted asteroids has been somewhat eroded by these findings.

Using the demonstrated instrument performance, and knowing that the state of knowledge concerning the volatile composition and outgassing nature of main belt asteroids is only loosely constrained, it was decided to attempt to detect the plausible exosphere surrounding asteroid 21 Lutetia during the 2010 flyby opportunity. This body is thought to have on its surface both carbonaceous material and hydrated minerals – potential sources of outgassing – and is therefore worthwhile of study in this manner [1].

The flight demonstrated mass range of the Ptolemy mass spectrometer (10-140 Da) is particularly suited for detecting volatiles such as water, SO_2 and organics during the flyby. Ptolemy will make 'sniff' measurements both several hours either side of 'close approach' to provide background data, and near to close approach whilst over the sub-solar point of the asteroid's surface. The following work will describe Ptolemy's record in space to date, including post-launch testing and science operations hopefully leading to the detection of any tenuous exosphere surrounding asteroid 21 Lutetia.

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