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The organic content of comets: how to get prepared for the COSIMA TOF-SIMS measurements onboard the ROSETTA spacecraft.

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Abstract

COSIMA is a time of flight mass spectrometer onboard the ESA ROSETTA spacecraft. It is meant to collect and analyze dust grains ejected from the comet 67P/Churyumov–Gerasimenko. In this presentation we will focus on the extent to which the organic content of the comet can be characterized with this instrument.

1. Introduction

The Rosetta mission launched by ESA in March 2004 will reach the comet 67P/Churyumov-Gerasimenko in 2014 to perform the most exhaustive study ever achieved on comets [1]. A time-of-flight secondary ion mass spectrometer (TOF-SIMS), named COSIMA (COmetary Secondary Ion Mass Analyser), is onboard the orbiter Rosetta spacecraft [2]. It has been built for chemical analysis of solid cometary grains collected *in situ*. COSIMA is one of the most promising instruments in the payload of Rosetta to identify the refractory organic molecules present on comet.

2 The COSIMA Instrument

The COSIMA instrument is a secondary ion mass spectrometer equipped with a dust collector, an ion gun, and an optical microscope for target characterization. Dust from the near comet environment will be collected on a target. The target can be moved to a microscope imager where the positions of the collected grains can be determined. The cometary grains will be bombarded with a liquid indium ion gun. The resulting secondary ions will be extracted into a time-of-flight mass spectrometer and the secondary mass spectra will be recorded for science analysis (Figure 1).

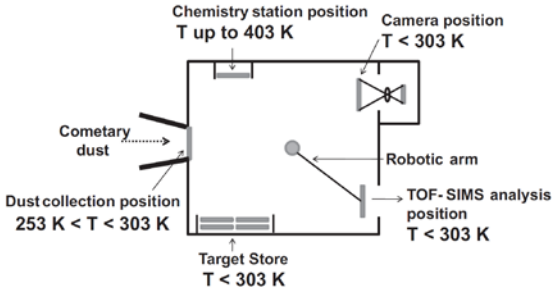

Figure 1: Schematic view of COSIMA based on Kissel et al. (2007). The temperatures that cometary dust could encounter in COSIMA are shown.

COSIMA is expected to measure the molecular, elemental and isotopic composition of the cometary grains. It will study the mineralogy and chemistry of the cometary grains in the framework of the solar system chemistry and asses the relevance of the cometary organic matter as potential precursor material for more complex organic matter in the frame of the study of the origin of life.

3. COSIMA and the study of the organic content of comets.

COSIMA will analyze the bulk composition of grains. Thanks to the resolving power of the instrument (about 1400 at 100 AMU) and mass defect properties, the organic content should be discriminated from the mineral phase. However, several thousands (and probably even more) of organic molecules could built up the organic component of the grains [3]. Moreover, after ejection from the nucleus, grains will be submitted to photons and heat, both in the coma and in the instrument. Timing between collection of the grain and analysis could be critical as shown in the case of the search for polyoxymethylene [4].

The COSIMA team members are getting prepared to face those challenges and decipher the organic content of cometary grains within the limits of analytical capabilities of the instrument. During the last few years, a library of standardized spectra (including hydrocarbons, nitrogenated bases, polycyclic aromatic hydrocarbons, amino acids…) has been prepared on ground instruments similar to the space COSIMA instrument. We also tested the analytical capabilities of COSIMA on laboratory analogs of cometary organic matter synthesized from heating and/or photolysis of icy mixtures (inspired from the classical Greenberg yellow stuff experiments [5]), as well as on natural proxy such as insoluble organic matter from carbonaceous chondrites (Murchison & Orgueil) and kerogen.

This talk will show the hopes and limitations in term of analytical capabilities of the COSIMA instrument, and the expected science return for our understanding of the origin of comets and their astrobiological relevance.

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