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# Neutral molecular beam measurements with the Rosetta ROSINA-RTOF instrument

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## 1. Introduction

On the long journey to the target comet 67P/Churyumov-Gerasimenko Europe's comet chaser Rosetta performed two asteroids flybys. The first flyby took place in September 2008 at asteroid (2867) Steins, and the second one in July 2010 at asteroid (21) Lutetia. These two flybys, as well as the rehearsals for the flybys were an important opportunity for the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA), to perform measurements as a function of the location of the spacecraft, the spacecraft attitude and the other payload activity. However, the scientific goal of the ROSINA mass spectrometers was trying to detect a thin exosphere of Steins and/or Lutetia. Due to the rather large flyby velocity of 15 km/s, we performed neutral gas beam measurements at our calibration facility in the lab in order to characterize the ram pressure enhancement in the ion source of our instrument.

## 2. ROSINA

The ROSINA instrument package consists of two mass spectrometers, ROSINA-DFMS and ROSINA-RTOF, and a pressure sensor ROSINA-COPS. They are designed to measure the neutral and ionized volatile material in the coma of the comet [1]. Due to their high sensitivities, measurements of very low particle densities are possible.

### 2.1 Reflectron-type time of flight

The reflectron-type time of flight mass spectrometer (RTOF) (Fig. 1) has a large mass range from 1 to > 300 amu/e. It operates by simultaneous extraction of ions from the ionization region into the drift tube. The mass resolution is a function of the total drift time and the temporal spread of the ion packets at the location of the detector. A spectrum over the full mass range is recorded in one measurement. The mass resolution is m/Δm is ≥ 1000 at the 50% peak height. It detects particle densities of $10^2$ $cm^{-3}$ within an adjustable time (10 to 1000 s) for a complete spectrum. RTOF can be operated in either single or triple reflection mode, whereas in the later mode the mass resolution becomes larger. Although the ion sources have been designed as open sources, in the case of a fast flyby many of the incoming ions are thermalized and add to a ram pressure within the source. In order to quantify this effect RTOF has been calibrated with at neutral beam of different velocities.

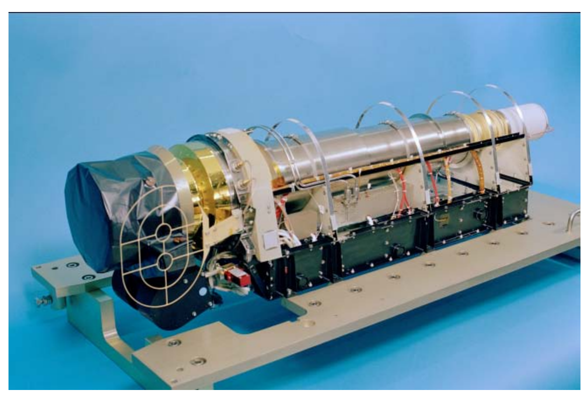

Figure 1: ROSINA-RTOF sensor in flight configuration (except base plate). The instrument is approx. 1 m long. RTOF weights 15 kg.

## 3. Calibration system and molecular beam measurements

The calibration system for the mass spectrometer instrument package ROSINA (CASYMIR) is an ultra-high vacuum system that was built to simulate the neutral gas environment around a comet nucleus. In a separate gas-mixing unit mixtures of gas can be produced that are either fed into the vacuum system by a leak valve (static mode) or through a nozzle to form a molecular beam (dynamic mode) [2]. We performed neutral molecular beam measurements with a gas mixture of $H_2$ and Krypton (4%) at different nozzle temperatures varying from T = 200 °C to T = 600 °C with $\Delta T$ = 100 °C. RTOF was operated in the same measurement mode as during the Lutetia flyby, which is the standard single reflection mode.

## 4. Summary

This paper will present the first RTOF results of the molecular beam measurements at the calibration facility in the lab. With these beam measurements at five different temperatures mirroring different beam velocities we are able to characterize the ram pressure enhancement in the RTOF ion source, which is essential to interpret the Lutetia flyby measurements.

## References

[1] Balsiger, H. et al.: ROSINA- Rosetta Orbiter Spectrometer for Ion and Neutral Analysis, Space Sci. Rev., 128, 745-801, 2007.

[2] Graf, S. et al.: A cometary neutral gas simulator for gas dynamic sensor and mass spectrometer calibration, JGR, 109, 2004.