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The DFMS sensor of ROSINA onboard Rosetta: A computer-assisted approach to resolve mass calibration, flux calibration, and fragmentation issues

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Rosetta will rendezvous with comet 67P/Churyumov-Gerasimenko in May 2014. The Rosetta Orbiter Spectrometer for Ion and Neutral Analysis (ROSINA) instrument comprises three sensors: the pressure sensor (COPS) and two mass spectrometers (RTOF and DFMS). The double focusing mass spectrometer DFMS is optimized for mass resolution and consists of an ion source, a mass analyser and a detector package operated in analogue mode. The magnetic sector of the analyser provides the mass dispersion needed for use with the position-sensitive microchannel plate (MCP) detector. Ions that hit the MCP release electrons that are recorded digitally using a linear electron detector array with 512 pixels. Raw data for a given commanded mass are obtained as ADC counts as a function of pixel number. We have developed a computer-assisted approach to address the problem of calibrating such raw data.

Mass calibration: Ion identification is based on their mass-over-charge (m/Z) ratio and requires an accurate correlation of pixel number and m/Z. The m/Z scale depends on the commanded mass and the magnetic field and can be described by an offset of the pixel associated with the commanded mass from the centre of the detector array and a scaling factor. Mass calibration is aided by the built-in gas calibration unit (GCU), which allows one to inject a known gas mixture into the instrument. In a first, fully automatic step of the mass calibration procedure, the calibration uses all GCU spectra and extracts information about the mass peak closest to the centre pixel, since those peaks can be identified unambiguously. This preliminary mass-calibration relation can then be applied to all spectra. Human-assisted identification of additional mass peaks further improves the mass calibration.

Ion flux calibration: ADC counts per pixel are converted to ion counts per second using the overall gain, the individual pixel gain, and the total data accumulation time. DFMS can perform an internal scan to determine the pixel gain and related detector aging. The software automatically corrects for these effects to calibrate the fluxes. The COPS sensor can be used for an a posteriori calibration of the fluxes.

Neutral gas number densities: Neutrals are ionized in the ion source before they are transferred to the mass analyser, but during this process fragmentation may occur. Our software allows one to identify which neutrals entered the instrument, given the ion fragments that are detected. First, multiple spectra with a limited mass range are combined to provide an overview of as many ion fragments as possible. We then exploit a fragmentation database to assist in figuring out the relation between entering species and recorded fragments. Finally, using experimentally determined sensitivities, gas number densities are obtained.

The instrument characterisation (experimental determination of sensitivities, fragmentation patterns for the most common neutral species, etc.) has been conducted by the consortium using an instrument copy in the University of Bern test facilities during the cruise phase of the mission.