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Overview of the Science implementation on Rosetta

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Abstract

The ESA/NASA Rosetta mission arrives at proximity of the comet 67P/Churyumov-Gerasimenko in Summer 2014 [1]. The complementarity of the 11 scientific instruments on board the Orbiter, together with the 10 scientific instruments carried by the Lander Philae, constitutes the most complete space laboratory ever flown to study a comet in its greatest details and understand how it works.
All previous mission encounters with a comet provided a snapshot analysis of the cometary activity at a given heliocentric distance. In contrast, the large range of cometo-centric and heliocentric distances (down to ~10km and from ~3.5 down to 1.5 AU resp.), the low relative velocity of the spacecraft (down to ~0.5m/s) and the extended stay in the vicinity of the nucleus (>15 months) will provide exceptional and unprecedented observing conditions to study, analyse and monitor 67P while it approaches the Sun.
In this presentation, we give an overview of the science to be performed during the various phases of the mission including multi-instrumental campaigns, and considering the complementarity of the different instruments, the environmental conditions and the associated spacecraft navigability constraints.

1. Introduction

The science planning approach on Rosetta can be divided in two distinct phases: before and after Philae has been delivered. Before landing, high emphasis is given to the characterization of the nucleus and to the cometary activity, to support the selection of a landing site as well as to ensure a safe descent and landing of Philae (section 2). After landing, the Orbiter trajectory is driven by the science requirements. To design the trajectory, the science team has identified four main disciplines and associated groups. Each group is responsible for designing some segments of the overall trajectory, to try and best serve its scientific measurements. The four Disciplinary Groups are described in section 3.

2. Beyond 3 A.U: (relatively) inactive nucleus

During this phase the trajectory was designed such as to provide the best conditions (given the largely unknown environment) to identify candidate landing site(s) for Philae and ensure a safe landing. Several science measurements will contribute to this goal. The detailed characterization of the inactive nucleus, its dynamical (rotation period, spin axis orientation…) and physical properties (shape, surface temperature and composition, gravity field…), as well as measurements related to comet activity (gas/dust production rate, gas velocity, onset of water activity…) will be performed.
This phase will also provide a unique opportunity for additional science measurements. Amongst others, the global gas composition of the early coma (CO/CO_2 oxygen isotopes, N_2 measurement before its peak gets overlapped by CO, noble gases…), and the direct (unshielded) nucleus-solar wind interaction will be measured. All measurements performed during this phase will be repeated as the heliocentric distance decreases to monitor their temporal evolution. The last days before Lander delivery will also provide a unique opportunity to go down to ~10km for an extended period of time. This may provide favorable conditions to measure the dust dynamics, size distribution and composition [Fig 1].

3. Below 3 A.U: Activity development and monitoring

Once Philae has been released and has completed its First Science Sequence [1], the trajectory will be designed based on the inputs provided by each of the four Disciplinary Groups. Trajectory parameters will need to be adapted to the encountered activity level of the comet.

3.1. Discipline 1: Nucleus characterization

The Nucleus characterization includes surface morphology and composition measurements but also nucleus interior investigation and remnant magnetic field measurements. Early in the escort phase, when flying through zero phase angle (>2.1AU), a trajectory segment will be designed as a close flyby going through the sub-solar point to allow measurements related to the surface (e.g. surface roughness, surface color map, surface composition). During the first weeks of the mission, when bound orbit are feasible, the CONSERT experiment will perform regular sounding of the nucleus interior, when the emitter of the signal (on-board the Rosetta Spacecraft), and the receiver (on-board the Philae lander) are located on opposite sides of the nucleus [1].

3.2. Discipline 2: Chemical, mineralogical and isotopic composition of volatiles and refractories in a cometary nucleus

Several of the Rosetta instruments can provide measurements that address this topic. However, with different, and often conflicting operational requirements, a high level of coordination of the campaigns is needed to get the most complementary science out of a given trajectory segment. One example is the Volatile Abundance Campaigns designed to: i) Correlate the column densities measured by the remote sensing instruments with the densities measured by in-situ mass spectrometers during a flyby. ii) be able to separate compositional variations due to diurnal (thermal) and spatial (nucleus heterogeneity) effects.

3.3. Discipline 3: Physical properties and interrelation of volatiles and refractories in a cometary nucleus

This topic is mainly addressed by the dust and gas in-situ instruments (together with Philae). For the first time, during the closest approach to the comet, Rosetta will provide measurements of dust and gas dynamics before the dust grains decouple from the accelerating gas and sublimation processes will be observed. First 3D imaging of fresh dust grains (MIDAS experiment [1]) will be acquired and the optical surface properties of the grains will be related to their dynamics and chemical composition. The best collecting conditions for the gas/dust in-situ instruments is obtained by pointing the spacecraft at the nucleus while getting as close as possible at a relatively low velocity. This will drive the design of the Discipline 3 close flybys.

3.4. Discipline 4: Study the development of cometary activity

The overarching objective of this discipline is to understand how the onset and evolution of cometary activity works. It will be addressed all along the mission through monitoring observations, involving most of the Rosetta payload. Additionally, some specific trajectory segments are foreseen to conduct dedicated campaigns, e.g. flyby over an identified active region (jet) or partially co-rotational flybys to study the diurnal activity evolution of a given point on the nucleus.

3. Figures

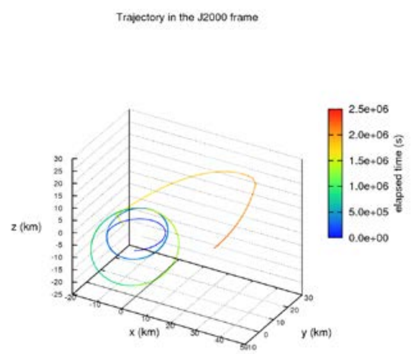

Figure 1: 3D vizualisation of the Close Approach Observations phase trajectory (before Lander delivery).

4. Summary and Conclusions

Measurements of Rosetta and its lander Philae will provide many ‘First Time Achievements’ in understanding comets and the physical processes driving their activity. We will provide a synthetic view of these achievements and discuss them in the broader context of past and present research on comets.

References

[1] Rosetta: Mission to Comet 67P/Churyumov-Gerasimenko, Space Science Reviews, Vol. 128, Issue 1-4, 2007.

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