The Langmuir probe instrument for Rosetta:

A Nordic collaboration

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ESA's comet chaser Rosetta is set for launch in February-March 2004, to reach its target comet ten years later. While the prime aim of the mission thus is far ahead in time, the instrument with the strongest Nordic participation, the Langmuir probe LAP with Swedish, Finnish and Norwegian contributions, will provide scientifc measurements just a few weeks after launch.

Figure 1. *Left:* comet Hale-Bopp as seen from Svalöv in southern Sweden on the night of April 6, 1997 (courtesy of Bengt Ask, bengt@df.lth.se). *Centre*: The nucleus of comet Wild-2, as seen from 240 km distance by the Stardust spacecraft on January 2, 2004 (courtesy of NASA). *Right:* Rosetta, ESA's comet chaser, during integration with the Ariane launcher, February 17, 2004 (courtesy of ESA). In the left photo, the two tails of the comet can be clearly seen, with the smooth dust tail extending to the lower right, and the thinner, more structured and bluish plasma tail extending to the upper right.

Most Nordic children get acquaintaned to comets at an early age, through Emil in Lönneberga crashing through a window at the passage of Halley´s comet in 1910 or by the ominous appearance of the comet over the Moomin valley. One can discuss if the picture of comets thus provided to the growing generation is appropriate, but this early acquaintance with comets may at the very least promote some curiosity, perhaps stimulating some a more scientific interest later in life. May this be a reason for the strong Nordic participation in the science payload on ESA's Rosetta mission to comet Churyomov-Gerasimenko? At least five instruments on the Rosetta orbiter and one on the lander have signficant contributions from Nordic research teams. This representation is particularly strong in the Rosetta Plasma Consortium, RPC, whose main target is the ionized environment of the comet and its interaction with the solar wind.

Anders Eriksson at the the Swedish Institute of Space Physics in Uppsala works with probe instruments, data analysis and space plasma physics, mainly using the Viking, Freja and Cluster satellites. He now looks forward to reaching further away with Rosetta, though he is very happy that what goes to the comet is the LAP instrument, for which he is Principal Investigator, rather than his own mortal body

Comets are of course fascinating by their own real merits, without need for literary inventions to promote interest. Consider the beautiful appearance of a fully developed comet in the sky, like comet Hale-Bopp in 1997, a spectacular sight in the night sky by any measure (Figure 1, left). Among the wonders of comets is the variety in size one immediately encounters when starting to study them. A comet tail can extend for millions of kilometers and over a wide range of the night sky. But this dramatic and apparently immense object is just a very tenuous cloud of vapour and dust, emanating from a tiny kilometer-size nucleus (Figure 1, centre) embedded deep in the coma, the region of gas and dust that forms the head of the comet. Solid as the coma may look, it is but a good vacuum on the standards of any Earth-bound laboratory. Nevertheless, it is the arena for a lot of interesting physics, for Rosetta to explore.

The primary aim for Rosetta is to investigate the comet nucleus and its environment in detail. To achieve this, Rosetta will catch up with its target comet at around 5 astronomical units (AU) distance from the sun, and follow it in its orbit in toward closest approach to sun (at around 1 AU). There have been spacecraft missions to comets before, but only brief flybys. Best known is ESA's Giotto spacecraft, which passed at some 600 km from Halley's comet during a few minutes in March 1986, at a relative speed of nearly 70 km/s. More recently, on January 2, 2004, NASA's Stardust spacecraft passed within 240 km from comet Wild-2 at a more gentle pace of 6 km/s. However, Rosetta will follow the comet nucleus at distances down to just a few kilometers for more than a year, at a relative speed often well below a meter per second! It will even place a small lander, with a comprehensive set of instruments, onto the nucleus of comet Churyomov-Gerasimenko, to do on-the-spot investigations.

The instruments of the Rosetta Plasma Consortium (RPC) will study the plasma in the coma. This consortium includes two Nordic instruments, the Ion Composition Analyzer (ICA, see article by Hans Nilsson in this issue) and the dual Langmuir probe instrument (LAP). The LAP is built around a technology established on the Swedish satellites Viking, Freja and Astrid-2 by the Swedish Institute of Space Physics in Uppsala and partner institutes (Table 1). The basic quantities to be studied with a Langmuir probe are the plasma density and temperature. By using two probes to observe the plasma density at two different points (Figure 2) and comparing the variations seen in the two measurments, we can derive the plasma flow speed. We can also use the two probes either floating or with a bias current to measure the electric field and its variations up to 8 kHz. Interplanetary dust grains may also be observed through the electrical discharge they generate at impact on the spacecraft. Hence, LAP is a very versatile and comprehensive plasma instrument, capable of establishing several key parameters of the cometary plasma environment. As can be seen from Table 1, LAP is also a truly Nordic effort, involving four institutes in three Nordic countries. Together, the five RPC sensors (LAP, ICA, the flux gate magnetometer MAG, the mutual impedance probe MIP, the ion and electron sensor IES) will provide a comprehensive picture of outgassing and plasma processes in the cometary environment.

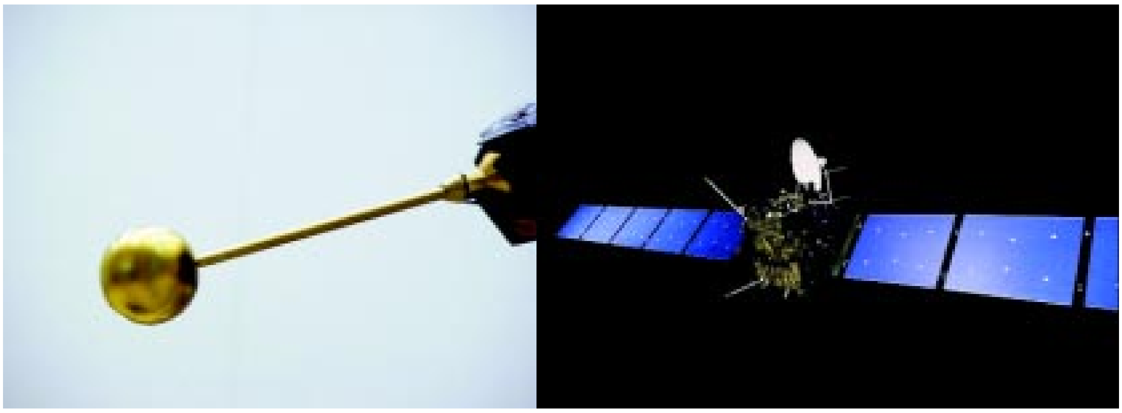

Figure 2. Rosetta in space (at right), with solar panels and booms deployed. The two booms, extending to the upper and lower left from the spacecraft, hosts some of the sensors of the RPC, a package of plasma instruments. At the boom tips, the Langmuir probes of the LAP instrument, one of which is shown in detail in the left panel, will provide the density, temperature and flow speed of the plasma environment. Unlike most instruments onboard, the RPC can gather useful science data immediately soon after launch, by measuring the properties of the solar wind and the environments of Earth and Mars when Rosetta passes these planets.

The long time Rosetta stays around the comet opens new perspectives for science investigations. The cometary features visible from Earth, the coma and the tail, are due to sunlight reflected from dust and gas expelled from the comet when it gets heated by the sun. Consequently, no such features, or very weak variants of them, can be seen when comets are far from the sun. Rosetta will follow the comet from a distance of about 5 astronomical units from the sun, when the comet activity is low, to its closest solar approach (perihelion) around 1 AU where the outgassing rate is high, and the coma and the tail are fully developed. The onset and evolution of the outgassing determines the brightness of the comet as well as its development with time, and are prime targets for RPC research.

A nice feature with LAP and the other plasma instruments in RPC is that we will not have to wait until Rosetta reaches comet Churyomov-Gerasimenko in 2014 to get scientific results. RPC is turned on just three weeks after launch, and the instruments can then start doing measurements in the solar wind. Though the comet is the prime target, the

Figure 3. **The LAP electronics boards mounted in their frame, ready for intergration with the RPC main unit. The frames from four RPC instruments together form the main RPC electronics box. The board seen contains the analog electronics, with the digital board invisible beneath.**

data from RPC in the solar wind can provide an extraterrestrial measurement point for parameters like solar wind density and flow speed and interplanetary magnetic field strength at any time during the ten year cruise, valuable for space weather studies and solar wind research. We also plan to do measurements during the planetary swing-by maneouvres. On its way to the comet, Rosetta will pass by Earth no less than three times and Mars once. The Mars flyby is particularly interesting from a science point of view, as it can give us an opportunity to study the Martian plasma environment all the way down to the ionosphere, the distance of closest approach being only 200 km. An additional opportunity is the asteroid flybys planned for Rosetta.

But of course the riddles of the comet that are the main target for our instruments. Missions like Giotto have provided a snapshot of what the environment of a fully active comet looks like. Exploring the unknown details and mechanisms of this picture will certainly be interesting, as will following the onset of comet activity and its development as tit approaches preihelion. This is what we have designed our instruments for. However, what we really look forward to are the surprises nature may have in stock for us. Rosetta will give us better measurments closer to a comet during a longer time than any mission before, and it would be strange if there were no new discoveries to be made.

Institute	Role
Swedish Institute of Space Physics, Uppsala	Principal investigator, overall design, sensors, analog electronics, flight software, operations
Geophysical Research, Finnish Meteorological Institute, Helsinki	Digital electronics
Department of Physics, University of Oslo	Ground support equipment, test support, data handling
Alfvén Laboratory, Royal Institute of Technology, Stockholm	DC-DC converter, soldering

Table 1. The LAP instrument on Rosetta is a joint effort by several Nordic space plasma research groups providing hardware and support. Additional co-investigating institutes will provide scientific support in the data analysis phase of the mission.