cnes presse

Communiqué

PARIS, 25 June 2004
CP 038/2004

THE MICROSCOPE PROJECT BEGINS
Will new physics ultimately replace the current model?

The CNES Board of Administration decided on 24 June 2004 to start the B, C, D and E phases of the MICROSCOPE project, undertaken jointly with the European Space Agency and ONERA.
MICROSCOPE is a fundamental physics mission proposed by ONERA and the Côte d'Azur Observatory. The principal scientific objective is to test the Equivalence Principle, which postulates the equality between gravitational mass and inertial mass.

This mission will also provide an opportunity to qualify the technology required for making a drag compensated satellite, which is indispensable for the scientific experiment. The scientific payload will be carried on a CNES microsatellite from the MYRIADE product line.

The Equivalence Principle identifies two conceptually different physical properties: inertia and gravity. It is a key postulate in the characterization of space-time and the theoretical formulation of gravitation. It is thus vitally important to determine to what extent it can be validated experimentally. Recent progress in space instrumentation and space flights in general now offer new possibilities for experiments to enable us to increase the accuracy or sensitivity of measurements by several orders of magnitude.

Will MICROSCOPE topple Einstein's theory?

The MICROSCOPE experiment is an attempt to test the Equivalence principle with a resolution of 10^{-15}, in other words almost three orders of magnitude more than the best tests so far performed on Earth. The idea is to measure the relative acceleration of two masses of different composition in free motion in a drag compensated satellite, in orbit in the Earth's gravitational field.

The main advantage of a space experiment is that it will eliminate random vibrations of seismic origin, which limit laboratory experiments. In addition, it is possible to compare the relative motion of two masses for much longer times, longer than the satellite's orbital period around the Earth.

Any violation of the Equivalence principle would be of vital importance because it would bring into question the very basis of General Relativity and, more generally speaking our understanding of the space-time environment . It would be the first sign of new physical phenomena, the signatures of new interactions or new forces, which are not explained by our standard physics model. It would thus bring into question our knowledge at the interface between the field quantum theory and relativity theories of gravitation as well as the application of these theories to astrophysics and cosmology.

Inversely, if the principle were to be confirmed to an accuracy of 10^{-15} this would be extremely interesting, as it would place new constraints on unified models of fundamental interactions.

Le Service de Presse du CNES
Tél 01 44 76 76 87 - Fax 01 44 76 78 16 – cnes-presse@cnes.fr – www.cnes.fr
cnes
CENTRE NATIONAL D'ETUDES SPATIALES

European cooperation, a great technological breakthrough, optimised industrial organization

The ONERA Department of Physical Measurements has defined its scientific objectives and mission specifications. It has also validated the choice of instrumentation and scientific programme for the payload. ONERA is Prime Contractor for the payload (which consists of electrostatic accelerometers and related electronics) and of the Scientific Mission Centre.

The GEMINI Department of the Côte d'Azur Observatory at Grasse is helping ONERA and CNES analyse the mission and process measurements.

The ZARM (*Zentrum für Angewandte Raumfahrttechnologie und Mikrogravitation*) at the University of Bremen in Germany) has contributed to qualification tests for the accelerometers by making its free fall tower available to ONERA.

ESA is providing the Field Emission Electric Propulsion (FEEP) microthrusters, developed by ALTA at Pisa in Italy.

The mission will also offer an opportunity to qualify technology for making a drag compensated, Earth orbit satellite. This type of satellite uses the coupling of an ultra-sensitive, accelerometer sensor and a very precise, electric propulsion system to compensate for non-gravitational perturbations (drag, solar radiation pressure). This objective is an indispensable prior condition for testing the Equivalence Principle as well as for future fundamental physics missions, or missions for geodesy, interferometry and satellite formation flying.

The satellite mainly consists of :

- two differential, electrostatic accelerometers (each with two concentric, cylindrical test masses),
- an attitude control and drag compensation system,
- a set of field effect, electric micro-thrusters with variable thrust as well as their command and power supply electronics. .

This experiment requires measuring accelerations less than a femto-g (in other words a millionth of a billionth of Earth gravity), a particularly stable on-board environment and an extremely thorough analysis of perturbations in orbit.

CNES is prime contractor for the project and the system as well as for the satellite, which is one of its Myriade product line. It has in particular developed the satellite platform and conducted integration and tests. It is also in charge of the Mission Control and Launch Centre.

MICROSCOPE is due to be launched in March 2008 on a circular, quasi-polar, Sun-synchronous orbit (at an altitude of 700 km with ascending and descending nodes at 6:00 and 18:00 respectively) for a nominal duration of one year.

The industrial organisation will draw on the experience acquired with the Myriade line of microsatellites, first inaugurated with Demeter and then with Parasol. This involves sharing ground integration or control facilities with other CNES satellites in the line and pooled procurement for recurrent flight equipment. It also means limiting new developments to what is strictly necessary in order to achieve maximum synergy with the other satellites in the line as well as acting as internal prime contractor at both system and satellite level.

MICROSCOPE is a good example of space technology pushed to its extreme limits, in which scientific challenges are matched by technological challenges. MICROSCOPE has received funding from ESA's obligatory scientific programme. The total consolidated cost of the project (phases A, B, C, D and E) for all of the partners is 70.4 Meuros of which CNES has provided 90%.

Memorandum

The Equivalence principle

The inert mass of a body measures the effort needed to change the state of motion of this body whereas the gravitational mass measures the coupling of this body with gravity. The following conclusion may be derived from the equality of these two masses: the trajectory of a body in free fall (in other words a body which is not subject to any interaction, for instance electromagnetic) does not depend either on its internal structure or its composition. This is the universal free fall phenomenon..

The generally accepted theory for describing gravitation is the General Relativity theory, which is based on the Equivalence Principle. Einstein in fact promoted this principle, which has been considered to be empirical since Galileo and Newton, as a postulate on which to build his theory.

Another reason for testing the principle is that gravitation, which is the first of the known fundamental interactions, has until now resisted all efforts to unify it with other fundamental interactions, electromagnetic, weak nuclear and strong nuclear forces.

The latter are described by a field quantum theory model, the standard model for particle physics, whereas gravitation is described by a classic theory (as opposed to quantum theory), that of General Relativity, which links space-time geometry to the density of the matter-energy that it contains.

The most recent unified theories such as string theory have also tried to give a coherent description of gravitation and other interactions.

All of these theories predict the existence of a new interaction depending on the composition of bodies. No matter what its origin, a new force, which would combine with gravitation, might be detected and this would be a violation of the Equivalence Principle.

It is thus necessary to test the Equivalence Principle, and in particular the universality of free fall, in order to search for and characterize this new interaction.

Background to the MICROSCOPE microsatellite project

The project was suggested by ONERA and the Côte d'Azur Observatory in response to a CNES Call for ideas for scientific missions on microsatellites in July 1997.

As of 1993, the idea of testing the Equivalence Principle was considered to be a major priority for fundamental physics.

CNES then undertook a preliminary mission study, which led to the definition of GEOSTEP, a mini-satellite to be carried on a Proteus platform at a cryogenic temperature, but this was found to be too ambitious.

At the same time ONERA had participated in studies with the University of Stanford to propose STEP, another minisatellite project, to NASA.

Following these GEOSTEP and STEP proposals, R&T work has been financed by CNES since 1994 on ONERA's electrostatic accelerometers and ONERA has obtained results during space geodesy missions (the STAR accelerometer integrated on the CHAMP satellite in 2000 and the super-STAR accelerometer carried on the GRACE mission in 2001). It then appeared possible to make an instrument which could satisfy microsatellite constraints and which would nevertheless allow for significant progress to be made in testing the Equivalence Principle at ambient temperature.

The high priority put on testing the Equivalence Principle was emphasized again in 1998 with the proposal for the MICROSCOPE microsatellite. This became even more relevant in that NASA had suspended the STEP minisatellite project.

Likewise, the GREX research group (on Experimental Gravitation) set up by the CNRS had included the MICROSCOPE project as a leading priority of its research programme.