Call for ideas for participation in the MICROSCOPE space mission scientific data analysis

1. Introduction

MICROSCOPE is a space mission dedicated to a fundamental physics experiment, born from the conjunction of the CNES Myriade microsatellite series and the ONERA accelerometers developed for geodesy missions such as Champ, Grace and Goce. It was proposed by ONERA (DMPh) and the Observatoire de la Côte d'Azur (Géoazur) and selected by CNES in the frame of its science programme. MICROSCOPE was also selected by ESA as a contribution to a member state national project, in the frame of the space science Cosmic Vision programme. MICROSCOPE is candidate to be launched with Sentinel 1B as a passenger, from February 2016.

The scientific teams willing to participate in the data processing and exploitation of the MICROSCOPE mission are invited to express their interest by responding to the present call for ideas. The present document defines the context and conditions which will allow scientists from an institution in an ESA member state or abroad to respond. The cooperation is open on the basis of the already defined technical and scientific specifications. The Science Management Plan (SMP) defines the top-level scientific management of the Microscope mission and the respective roles of all parties involved.

The selected ideas will be presented by the applicants at the third Microscope Colloquium which will be held at ONERA Palaiseau, France, on November 3-4, 2014. The selection process is described below in this document.

2. MICROSCOPE mission

- Scientific and technical objectives

The MICROSCOPE mission aims at testing the Equivalence Principle through one of its major consequence, the Universality of Free Fall, with an accuracy better than 10^{-15} i.e. more than two orders of magnitude better than the present on-ground experiments. The violation of the Equivalence Principle would open the way to the demonstration of a new force, the existence of which is predicted by many quantum theories of gravity.

The MICROSCOPE mission will also push at their limits the technologies necessary to control the attitude and the orbit of a drag-free satellite which is shielding its payload from non-gravitational perturbations (Earth and Sun radiation pressures, atmospheric drag…). It is thus likely to acquire new information of scientific interest on the gravity field of Earth and its environment. On the other hand, information returned by the drag-free system should be very interesting for aeronomy studies.

The MICROSCOPE satellite will follow a sun-synchronous, quasi-circular orbit at an altitude of about 700 km.

- Experimental measurements

The core instrument is based on two ultra-sensitive, six-axis electrostatic differential accelerometers. These accelerometers use electrostatic levitation and minute motion and attitude sensing of solid proof masses in a precisely manufactured and thermally monitored instrument cage, at ambient temperature.

Each differential accelerometer includes two cylindrical and concentric test masses. The first differential accelerometer contains two masses made of different materials (platinum and titanium) and is dedicated to test the Equivalence Principle (EP). The second one contains two masses of the same material (platinum) and is used to assess the accuracy of the measurement and the level of systematic errors. The two differential accelerometers are separated by about 17 cm along the axis normal to the orbital plan.

The experimental procedure consists for each couple of proof masses in applying electrical potentials on electrodes surrounding them, in order to nullify their relative motion on the same orbit. The fine measurements of the applied electrical potentials provide the dissymmetry of the acceleration on both proof masses to follow the same trajectory while they are under the effect of the same Earth's gravity field.

The measurements are also used to perform the accurate control of the stability of the satellite attitude as well as of the orbit in such a way to guarantee the accuracy of the EP test. The applied non-gravitational forces on the satellite are compensated by the action of the eight cold gas micro-thrusters accommodated on two faces of the spacecraft.

This space experiment takes advantage of the undisturbed acceleration environment, on board the dedicated drag-free satellite and benefits from low fluctuations of the gravity gradients: on one hand the Earth's gravity field can be modelled with already existing static harmonic developments and on the other hand the satellite is designed to exhibit very weak mass deformations.

Thus, the success of the Microscope experiment relies first of all on performing the measurement of acceleration lower than 8. 10^{-15} ms^{-2} and on analysing very precisely the in orbit residual perturbations of the test mass motion to deduce any possible EP violation signal.

- General information on the mission can be found at:
  - P. Touboul, G. Métris, V. Lebat, and A. Robert. The MICROSCOPE experiment, ready for the in-orbit test of the equivalence principle. Class. Quantum Grav., 29 184010 (2012);
  - Microscope Science Management Plan (attached document) ;
  - Presentations at the last colloquium, available on the website http://gram.oca.eu/Workshop/2012_colloque_Microscope-2/presentations.html

- Project organisation

The project organisation can be summarized as follows:

CNES is responsible for the system development and the satellite development and participates to the performance evaluation.

ESA supplies the cold gas micro-propulsion thrusters.

ONERA is responsible for the scientific payload and the Scientific Mission Center. The PI (Pierre Touboul) chairs the Science Working Group.

The Observatoire de la Côte d'Azur (Géoazur) participates to the preparation of the mission plan and prepares the scientific processing in collaboration with ONERA.

The ZARM participates to the ground validation of the instrument performances in its free fall tower in Bremen and to the data analysis. The ZARM is part of the Science Working Group.

The German metrology laboratory PTB has provided the material (platinum and titanium), the machining, the characterization and the metrology of the proof masses.

The Steering Committee is composed of representatives of the agencies ESA, DLR, CNES, the funding science institutes and universities, the laboratory directors (ONERA/DMPh, OCA/Géoazur, ZARM), the PI et the co-PIs. It is chaired by CNES.

3. MICROSCOPE Science Working Group

The Science Working Group (SWG) acts as a focus for the interest of the scientific community in order to maximize the scientific return of the mission. It promotes the debate between the scientists interested in the MICROSCOPE data analysis, allowing exchanges with the project team and discussion with other scientific users. It coordinates the different scientific contributions.

As defined in the Science Management Plan (SMP), the SWG is responsible for:

- Supervising and approving the evaluation and the validation of the performance and of the calibration analysis of the instrument both on ground and in orbit,
- Selecting the proposals for the data processing in response to the calls,
- Selecting new Co-Is,
- Reviewing the scientific goals of the mission at regular intervals in the light of the results,
- Approving the final scientific data products to be distributed to the community,
- Reviewing the organization of the data archive,
- Promoting diffusion of information.

The SWG is presently composed of:

- The PI (ONERA) who is the Chairperson: Pierre Touboul
- The co-PI (OCA): Gilles Metris
- The ZARM co-I: Claus Lämmerzahl
- The DLR co-I: HansJörg Dittus
- Five scientific representatives of the following scientific themes:
    - General Relativity and Gravitation : Thibault Damour (co-Chairperson)

- Fundamental Interactions : Pierre Fayet
- Interdisciplinary Physics : Serge Reynaud
- Earth gravity field: Isabelle Panet
- Aeronomy : Pieter Visser

- One European scientist representative of similar space missions: Timothy Sumner

These persons will be acting in the selection of ideas in response to the present call and the preparation of the third Microscope colloquium.

4. MICROSCOPE colloquiums and calls:

MICROSCOPE colloquiums are organized on an annual basis to inform, promote and present the scientific developments of the MICROSCOPE mission.

The first colloquium took place in ONERA Palaiseau on September 19, 2011 (http://gram.oca.eu/Workshop/2011_colloque_Microscope/colloquium.html). The objective was to consider the mission scientific return with respect to the other present and envisaged accurate experiments in the fields of gravitation and metrology, and in the context of the new extended theories of gravitation.

The second colloquium took place on January 29-30, 2013 in ONERA (http://gram.oca.eu/Workshop/2012_colloque_Microscope-2/colloquium.html). The objective was to present the mission, the instrumentation and the experiment and to describe the expected data as well as the organisation of the scientific mission centre. The scientific community was invited to present their interest and their related know-how in the contribution to the data processing.

The third colloquium will take place in ONERA Palaiseau, on November 3-4, 2014. The present call for ideas is sent to the scientific community in advance so that the resulting ideas can be presented and discussed during the colloquium.

Before the fourth colloquium in 2015, a call for proposals will be issued on the basis of the outcome of the 2014 colloquium, in a more formal manner including in particular the description of duties, responsabilities and rights of the applicants. The selected proposals will be presented during the colloquium. Time will then be available in the interval between the third and the fourth colloquium to coordinate the proposed projects efficiently.

5. Application and selection procedures

- Requirements

The present call for ideas is open to qualified scientists affiliated to institutions from ESA member states or abroad, willing to participate in the scientific analysis of MICROSCOPE data.

Proposers should demonstrate their capability and interest to make a significant contribution to the scientific topics quoted in section 3 (General Relativity and Gravitation, Fundamental

Interactions, Interdisciplinary Physics, Earth gravity field, Aeronomy) or to additional proposed topics, during the remaining development time and/or the operational phases.

- Response content and procedures

The responses to this Call for ideas will be in the form of a Letter of Intent written in English, not longer than 6 pages, including the following parts:

- a 1st page cover letter, signed by the applicant(s) containing name(s), position(s), affiliation(s), full address(es) and contact information;
- the content of the foreseen activities and their objectives;
- the scientific background and expertise of the applicant(s) in the relevant areas and possibly a list of selected papers.

The responses will be submitted by email, in PDF format, to physiq@cnes.fr before September 30, 2014.

The responses will be discussed within the SWG and scientific committee of the colloquium. Selected ideas will be presented by the proposers to the scientific community during the third Microscope colloquium.

- Schedule and deadlines

• Release of the call for ideas:	July, 2014
• Deadline of the call for ideas	September 30, 2014
• Selection of the responses	October 17, 2014
• Microscope colloquium	November 3-4, 2014

Annex

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