ESA Call for M4, GG ("Galileo Galilei") mission proposal and the role of INRIM.

Workshop at INRIM, Torino, 24 October 2014

Summary

M. Pisani welcomed the participants and introduced the meeting.

A. Nobili summarized the terms and conditions of the ESA call and the status of the GG project. The fourth call for a medium-sized mission of ESA's science programme was published on August 19th. Letters of intent from parties intending to submit a proposal were due on September 19th; one such letter was sent by A. Nobili on behalf of the GG collaboration (read GG letter of intent). The deadline for submission of the complete proposal is January 15th, 2015. ESA will select three proposals for in-depth study; the shortlist of selected proposals will be made known in March 2015. Subsequently, following the customary sequence of studies and deliberations by ESA's advisory bodies, one proposal will be selected around 2018 for implementation and launch in 2025. The GG proposal addresses all of the themes in ESA's "Cosmic Visions" to various degrees, its main thrust being Theme 3, the fundamental physical laws of the Universe. The significance of a test of the Weak Equivalence Principle / Universality of Free Fall for the future of physics is undisputed and the WEP has been the focus of ESA studies since at least the mid-nineties. GG targets a test to 1 part in 10^{17} after 1 day integration time, characteristics which no other WEP experiment proposal can match. The GG concept is also unique in that a laboratory experiment, GGG, is up and running, matching the space experiment in all details but those that depend on strength of the sources field and weightlessness, which cannot be replicated on Earth but can be extrapolated reliably.

A. Anselmi recapitulated the industrial work performed in recent years by Thales Alenia Space Italia (TASI) in support of the GG proposal. Major Phase A studies were made for ASI in 1998-2000 and again in 2008-2009. The latter study, in particular, included detailed design of the drag-free control system and the development of a sophisticated software simulator which was meticulously validated and used to produce a detailed error budget. The technology needs are covered for the most part by state-of-the-art equipment; the 2009 study included manufacturing and test (at INRIM) of the spin rate sensor, the one spacecraft element which could not claim TRL 5. GG proves that very high objectives can be attained with small resources (500 kg, 500W), a short mission (9 months), and at low cost.

A. Nobili then went into some details of the instrument. The clever mechanical design of GG is integrally tested by the ongoing ground experiment, with the exception of the tiny flexures intended for coupling of the test masses with the balance arms and the PBG shaft. There, the space experiment allows springs more than seven orders of magnitude weaker than those that would be required to suspend the same masses in Earth gravity. A significant novelty introduced in recent years is the laser gauge readout. The idea was proposed by JPL in 2010 during a Workshop in Pisa and further investigated during a 2.5-month study at JPL when GG was considered as a candidate for NASA's Explorer program as an ASI/NASA project (2011). The concept is being developed in collaboration with M. Shao of JPL. Capacitance bridges will continue to be implemented as sensors/actuators for controlling the unstable part of the "whirl" orbital motion of the test masses and as sensors for the input signal of the drag-free control.

M. Pisani gave an overview of the expertise at INRIM relevant for GG and the associated research projects. Fundamental physics experiments, such as measurement of fundamental constants, are an integral part of INRIM's remit. There already exists at INRIM considerable experience with space applications, mostly developed in collaboration with TASI. Precision manufacturing of the test masses, the laser metrology and the capacitance sensing and readout are all areas to which INRIM can make outstanding contributions.

At the beginning of the discussion session, questions were answered and clarifications given. Then, the discussion focused on the more immediate tasks at hand. A. Nobili will circulate a table of the contents of the proposal with an indication of the sections to be provided by the various contributors. The deadline for drafts is the end of November, to give some time to revisions. INRIM will be asked in particular to check and give advise on the section dedicated to the payload and to contribute a section about the laser gauge (conceptual design, implementation aspects, development and test roadmap). A teleconference involving Pisa, INRIM and M. Shao will be convened by mid November to establish the boundaries of the collaboration.

Another opportunity on laser gauge interferometry has recently arisen in the framework of the ESA Innovation Triangle Initiative (ITI). ITI supports identification, validation and development of new ideas for space equipment, giving preference to innovations coming from non-space industry or the research sector. Informal talks have already taken place about a proposal on the subject of a Laser Interferometer Gauge (LIG) and the reaction was encouraging. Pisa and INRIM will jointly submit a proposal for a 50 k€ grant targeting an initial 9-month study of the LIG, dedicated to producing a draft design and the plans for a breadboard to be financed with a later, more substantial grant.