

Planetary Space Missions

Cesare Barbieri

This wide-range program is divided in several projects, with the aim to:

- improve the knowledge on Mercury, comets, asteroids and minor bodies in the outer Solar System through Space missions, aided and directed by ground based observations
- promote the advancement of space technologies applied to the astronomical researches
- promote the advances of the knowledge of fundamental physical laws taking advantage of the Space environment

Project 1: The exosphere of Mercury.

Following a similar program carried out on the diffuse Sodium atmosphere of the Moon, we have started a similar investigation of the exosphere of Mercury using the Telescopio Nazionale Galileo, in collaboration with scientists from INAF, University of Boston and University of Arizona at Tucson. We intend to bring substantial new information on the behaviour of Mercury's exosphere during a full solar cycle, in order to understand the mechanism producing and replenishing these temporary gases, and provide ESA's BepiColombo with a unique data base.

Project 2: The Wide Angle Camera for the ESA ROSETTA cometary and asteroidal mission.

This advanced camera for the Rosetta Space Mission was successfully built, calibrated, delivered and launched in March 2004. This activity implied a major coordination effort with other Departments of our University, through the Center for Space Activities CISAS, with INAF researchers, with medium and small National Industries, with International partners. The WAC has surely produced an excellent return of new technologies (optical, mechanical, controls) but has also promoted the advanced formation of young researchers in Astronomy, Mechanical Engineering and Electronic Engineering. Following the launch, several images have been already obtained of comets and asteroids, which have led to very useful papers and manuals written by young PhD students and Post-Doc Fellows. The scientific and technological usefulness of the WAC will continue until the end of the mission, foreseen for Y2015.

Furthermore, the experience gained with the WAC has led to the successful proposition by our Group of the imaging camera for the BepiColombo mission. Although the optical and mechanical solution will be different, the experience, technological and managerial mentality acquired with the WAC have been of fundamental importance to achieve that goal.

We wish to underline that more recently, our proposal to observe the Rosetta targets with the NASA Spitzer Infrared Observatory has been approved for Cycle 2, and equally approved has been our proposal to observe Near Earth Asteroids that could be reached by future dedicated Space missions.

Project 3: Kuiper Belt Objects.

The interest for the minor bodies of the Solar System has been extended also to the farthest known objects in the Kuiper Belt, again in view of possible Space missions to the outer Solar System. The data have been obtained in the frame of a large International cooperation and are of unique extent and value in the literature.

Project 4: Space Quantum Communication.

This is a novel field which has been prompted by apparently diverse interests, namely the foundations of Quantum Mechanics, the interplanetary communications (even as a curiosity, extended to SETI), the detection of gravitational waves, which indeed constitute a unified body of challenging new knowledge.

Several successful steps have already been achieved, both on the theoretical and experimental side, leading at the end of 2004 to a large European Collaboration which has won an ESA contract to study Space communications (these funds will be available in Y2005, not yet accounted here). This ongoing program is named QIPS; its future evolution, named QUEST, has been rated as outstanding by an international review panel. Further activity has been started in the field of the astronomical coronagraphic application of the Photon Orbital Angular

Momentum; at moment this activity is finalized to ground based applications, but we plan to extend it to Space telescopes.

More recently, the experience we have gained for the ESA program, has been extended to Extremely Large ground telescopes of the future thanks to an ESO contract (funds available in Y2005, not accounted here). Undoubtely, this activity can lead to very stimulating results in the near future opening the way to a novel 'Quantum' Astronomy able to detect second and higher order correlation functions in the photon stream arriving from celestial sources.

Personnel:

Barbieri Cesare, Prof. Ordinario

Bianchini Antonio, Prof. Associato

Lazzarin Monica, Researcher

Fornasier Sonia, Post-Doc Yellow

Tamburini Fabrizio, Post-Doc Fellow

Bertini Ivano, PhD student

Gregnanin Alessandra, PhD student

Bernardi Fabrizio, PhD student

Musotto, Susanna, PhD student

Ubriaco Gabriele, laboratory technician

Pernechele Claudio, INAF associate astronomer

Cremonese Gabriele, INAF researcher

Claudi Riccardo, INAF Researcher

Collaborations:

CISAS

INAF

ASI

ESA

University of Paris VII (F), joint PhD program (co-tutela internazionale) and VINCI

University of Vienna (A)

University of Munich and Max-Planck Inst. Fur Quanten Optik (Munich, Germany)

DLR Berlin (D)

Max-Planck Inst fur Solar System Research (Lindau, D)

University of Boston and University of Arizona(USA)

Research Products

- a) the imaging camera WAC for the ESA ROSETTA cometary mission, and its in-flight calibration (fig. 1)
- b) the first design of the imaging system of the BepiColombo mission (approved by ESA and ASI)

15 published papers on refereed international journals, and 24 invited talks or proceedings.

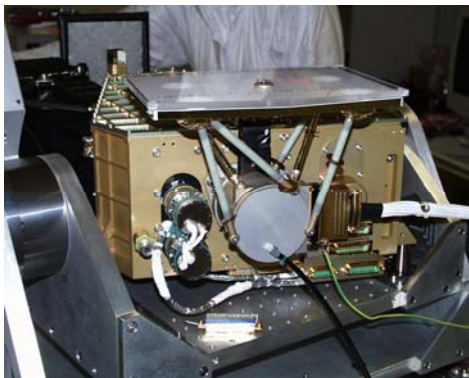


fig. 1 – left, the WAC on optical bench, right the WAC on Rosetta before launch

List of 5 most representative publications:

Barbieri C., Verani S., Cremonese G., Sprague A., Mendillo M., Cosentino R., Hunten D., 2004, *First observations of the Na exosphere of Mercury with the high resolution spectrograph of the 3.5M Telescopio Nazionale Galileo*, Planetary and Space Science, Volume 52, Issue 13, p. 1169-1175

Cremonese G., Capria M. T., Achilli V., Angrilli F., Baggio P., Barbieri C., Baumgardner J., Bistacchi N., Capaccioni F., Caporali A., Casanova I., De Bei S., Forlani G., Fornasier S., Hunten D., Ip W. H., Lazzarin M., Longhi I., Marinangeli L., Marzari F., Massironi M., Masson P., Mendillo M., Pain B., Preti G., Ragazzoni R., Raitala J., Salemi G., Sgavetti M., Sprague A., Suetta E., Tordi M., Verani S., Wilson J. K., Wilson L. (2004). *MEMORIS: a wide angle camera for the BepiColombo mission*, Advances In Space Research. vol. 33, pp. 2182-2188 ISSN: 0273-1177.

Fulle M., Barbieri C., Cremonese G., Rauer H., Weiler M., Milani G., Ligustri R. (2004). *The dust environment of comet 67P/Churyumov-Gerasimenko*. Astronomy & Astrophysics. vol. 422, pp. 357-368 ISSN: 0004-6361

Fornasier S., Barucci M.A., Binzel R.P., Birlan M., Fulchignoni M., Barbieri C., Bus S.J., Harris A.W., Rivkin A.S., Lazzarin M., Dotto E., Bertini I. (2003). *A Portrait Of 4979 Otawara, Target Of The Rosetta Space Mission*. Astronomy And Astrophysics. Vol. 398, Pp. 327-333.

Villoresi P., Tamburini F., Aspelmeyer M., Jennewein T., Ursin R., Pernechele C., Bianco G., Zeilinger A., C. Barbieri C., 2004, *Space-to-ground quantum-communication using an optical ground station: a feasibility study*, SPIE Denver Aug. 4, paper nr. 5531

Da Deppo V., Naletto G., Nicolosi P., De Cecco M., Debei S., Parzianello G., Ramous P., Zaccariotto M., Fornasier S., Verani S., Barbieri C., Et Al. (2004). *Preliminary Calibration Results for the Wide Angle Camera of the Imaging Instrument OSIRIS for the Rosetta Mission*. ICSO 2004 Fifth International Conference on Space Optics. 30 March - 2 April. Toulouse.