Mem. S.A.It. Vol. 74, 831

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Experimental activity in Palermo related to Solar-B and CALOS satellites

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Abstract. We report on the experimental activities related to the calibration of the XRT telescope on board the Solar-B satellite and on the design and studies related to the X-ray-calorimeters-based satellite CALOS (Calorimetri per Osservazioni Solari).

Key words. X-Ray – coronae – spectroscopy

1. Introduction

The experimental activity of the solar group at INAF-Osservatorio di Palermo (OAPA) and at Dip. di Scienze Fisiche ed Astronomiche - Univ di Palermo (UNIPA) presently is mostly focused on the X-Ray Telescope (XRT) whose P.I. is L. Golub at Center for Astrophysics, Cambridge - Mass., to be flown in 2005 on the Solar-B Japanese satellite, and on the study and design of the CALorimetri per Osservazioni Solari (CALOS) satellite (P.I. G. Peres) for X-ray spectroscopy of the solar corona.
The X-Ray Astronomy Calibration and Testing (XACT) facility, at OAPA is fundamental for all the related work.

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2. The XACT facility

The experimental activity at OAPA was established in 1990 with the design and set up of the XACT facility. The XACT facility has been designed to perform a large variety of measurements in the UV and in X-rays: measuring transmission and reflection of sample materials, transmission mapping of relatively wide area filters ($\approx$ 10×10 cm^2), quantum efficiency measurements of detectors, calibration of small (max diameter $\approx$ 50 cm), moderate angular resolution ($\approx$ 20 arcsec FWHM), telescopes. The XACT facility has already been used successfully in the framework of some X-ray Astronomy missions, most notably the NASA Chandra X-ray Observatory, the ESA X-Ray Multi Mirror (XMM) and the Joint European X-

Fig. 1. The X-ray beam line of XACT. The X-ray source is in the forefront, on the right, the conical pipe is at the center of the image running, roughly, from right to left, with its supports, ports and all the technical equipments attaches. The test chamber with the clean room is in background, on the left.

ray Telescope (JET-X). It is presently used, among other projects, for the calibration of the X-Ray Telescope (XRT) experiment on board the Japanese Solar-B mission and in the design of the new experiment CALOS, to perform spatially resolved high spectral resolution spectroscopy of the solar corona with low temperature X-ray microcalorimeter. The main component of the XACT facility is a 17 meter long stainless-steel vacuum beam line that follows the divergence of the X-ray beam from the X-ray "point source" (an electron impact multianode) to a 65 cm aperture at the entrance of a test chamber. The cylindrical test chamber (1 meter long and 1 meter diameter) opens to a class 1000 clean-room. The present configuration of the X-ray beam-line allows full illumination tests of X-ray optics with outer diameters less than about 45 cm, focal length less than 4.5 meters and angular resolution of the order of 20 arcsec depending on the specific optic design. The XACT facility includes also various X-ray, UV, and visible sources, detectors and monochromators covering the energy range $\sim$ 2 - 10000 eV (wavelength range $\sim$ $1 - 7000$ Å). An adiabatic demagnetization refrigerator has recently been set-up to test X-ray microcalorimeter detectors at temperature below 100 mK.

3. XRT/Solar-B

The solar group in Palermo is involved in the calibration of XRT of the Solar-B mission (Golub, 1999). More specifically, since October 2002, and probably across the entire year 2003, the XACT facility of the OAPA is used, in collaboration with the PI team at SAO (Cambridge, MA), to calibrate the flight focal plane filters and front filters of the XRT experiment as well as for the measurement of reflectivity versus energy and vs. angle of incidence of flat samples of the grazing incidence X-ray otpics. The filter calibration program includes X-ray shadographs of the six 50 mm diameter flight filters to determine the uniformity of spatial thickness, and trasmission measurements at various photon energies to determine the transmission curve with

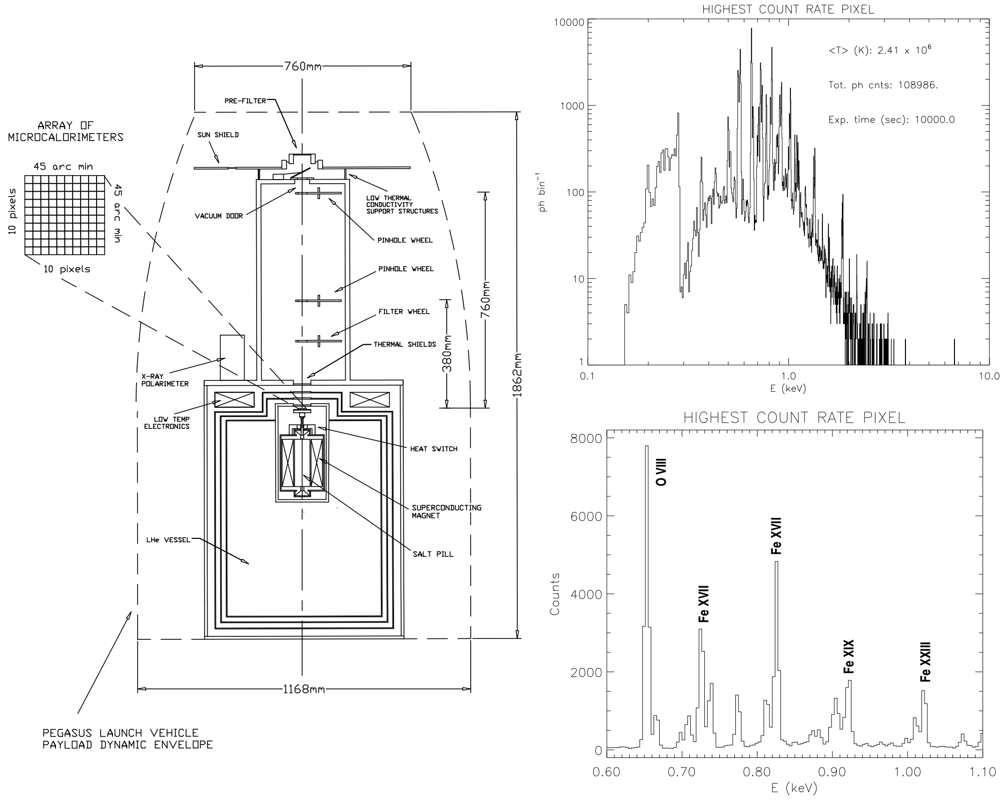

Fig. 2. The three panels of this image illustrate a few aspects of the CALOS satellite. Left - Scheme of CALOS, in the configuration for launch with Pegasus, with the Pegasus dynamic envelope. A zoom on the left illustrates the focal plane array of calorimeters. – Upper right: simulated example of the entire spectrum from 0.1 to 10 keV, collected in the course of an observation, in the pixel with the highest count rate, with an integration time of 10^4 s. – Lower right: a fraction of the simulated nhe same spectrum in the 0.8 - 1.1 keV range.

an accuracy of better than 5% in the energy band 0.1-6 keV. The flat mirror sample reflection measurements will take advantage of the long X-ray beam-line (see Fig. 1) to perform reflection measurements versus angle at various energies with 1 arcmin angular resolution. XRT/Solar-B will have a spatial resolution twice better than that of Yohkoh/SXT and a broader temperature response, allowing a deeper and more detailed study of the whole corona and of its fine structure, so important to understand its heating and dynamics. It will provide diagnostics of temperature and emission measure, with high angular resolution, of the highly dynamic confined coronal plasma in the EUV and X-ray bands.

These characteristics are important in the framework of the research activities carried out in Palermo. In particular, the XRT data will be important to study the distribution of emission measure vs. temperature in the transition region and corona of isolated coronal structures and of the whole solar corona and to understand the structuring of the plasma along and across the magnetic field. In addition, the Palermo team will take advantage of the database which XRT will produce to tune up a tool of pattern recognition to identify automatically coronal structures on X-ray images. The XRT data will be useful also for the solar-stellar connection studies carried out in Palermo, in particular for the detailed determination of the distribution of emission measure vs. temperature.

4. The CALOS Observatory

CALOS is a solar observatory that will perform X-ray spectroscopy of the solar corona with $\Delta E \approx 6$ eV, over the 0.1 - 10 keV band, at moderate angular resolution ($\Delta\theta \approx 2 - 4$ $arcmin$), using an array of 10×10 Neutron Transmutation Doped germanium microcalorimeters in photon counting mode to achieve non-dispersive wide-angular-field spectroscopy (Peres et al. 2001; Barbera et al. 2002). The group in Palermo has proposed to build and operate the observatory in collaboration with the group of E. Silver and H. Schnopper at the Harvard-Smithsonian Center for Astrophysics (CfA). The proposed instrument would allow a scientific quantum leap of coronal physics: the spatially resolved coronal spectrum over the whole soft X-ray band, in a very cost-effective way with a 10×10 array of microcalorimeters of advanced design developed by the research team at CfA. The capability of measuring simultaneously lines and continuum over a large range (Fig. 2) allows a careful characterization of the continuum, line complexes, line ratios in very different parts of the X-ray spectrum without any problem of cross calibration among different detectors. In order to keep costs low and photon count rates at a level acceptable for microcalorimeters (not more than 100 photons per pixels) we have adopted a pin-hole optics (Fig. 2). An important technical challenge will be to develop and use for astrophysical observations a microcalorimeter array with an adiabatic demagnetization cooler and a liquid He cryostat. The observatory will include an hard-X-ray polarimeter ($E = 4 - 12$ keV) of radically new design developed by Bellazzini at INFN-Pisa and by Costa at IASF-CNR: it will serve as a flare alarm and will study the hard X-ray initial part and the related polarized emission. Three possible launch configurations are being examined: with the Pegasus rocket, as one of the external payloads on the International Space Station and as short-time mission in the Shuttle cargo bay.

Acknowledgements. Part of this work was supported by the funds from Agenzia Spaziale Italiana.

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