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NEUTRON IMAGING STUDIES WITHIN THE »neu_ART« CULTURAL HERITAGE PROJECT

The importance of neutron radiography in archaeology and in cultural heritage is assessed by now considering that the first radiographies with neutrons were already performed in the seventies (Hilling 1975). However, the recent development of new methods, detectors and instruments and the availability of neutron radiography at smaller reactors has allowed researchers to obtain more and more interesting results. The aim of the this work, car ied on within the neu_ART project, has been to determine the imaging potentials of neutron radiography and tomography of artistic objects, in particular those containing metallic artefacts performing several measurements at two laboratories, the NECTAR facility at the FRM II reactor of the Technische Universität München (Germany) and the INES facility at the ISIS spallation source of the Rutherford Appleton Laboratories in the UK.

The goals of the measurements were:

– the evaluation of the performance of the imaging systems in terms of linearity, spatial resolution and dynamic range, together with the dependence of these quantities on the detection system;
– the study of the attenuation of the beam intensity as a function of the target thickness for different materials and the comparison of the neutron penetration capabilities with thermal and fast neutrons;
– the analysis and the interpretation of radiographs and tomographs of some few artistic objects in order to assess the obtainable information with these techniques.

In the following, after the description of both apparatus, the main results will be presented.

Materials and methods

The INES and NECTAR facilities

INES, the Italian Neutron Experimental Station (Celli et al. 2006; Grazzi et al. 2007), is an apparatus designed for material investigations through diffraction measurements with thermal and epithermal neutrons at the ISIS neutron source of the Rutherford Appleton Laboratories (UK). Neutrons are produced by spallation through the collision of a pulsed proton beam on a tungsten target and slowed down to the energy range 7.8 meV to 5 eV. The cross section of the INES beam, at the sample position, is a square of about $4 \times 4\,cm^2$ size with a uniform intensity of 1.1×10^7 neutrons/$cm^2 \times s$ and an L/D ratio of about 90. The INES facility features a mechanical instrumentation, used to translate and rotate the test object, and a detector, positioned at a distance between 1 and 10 cm from the object, composed by a scintillator described in the following section and a CCD camera. The latter (The Imaging Source DMK21BF04) is a low price commercial product because the radiation damage imposes frequent replacements. It is segmented in 640 × 480 pixels, each corresponding to a region of about 100 × 100 mm^2 of the image field, and works at room temperature. The CCD is read out through an 8 bit ADC, leading to a nominal dynamic range of 256 grey levels; the maximum integration time is 30 s. To evaluate possible limits of this camera, a second CCD camera with a larger nominal dynamic range (12 bit) and with the possibility to set wider time intervals for the signal acquisition (Allied Vision Technology Manta G-032B) has been used.