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The Neutron Resonance Transmission Imaging technique for elemental characterization of inhomogeneous samples

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We present the implementation and applications of the Neutron Resonance Transmission Imaging (NRTI) technique, performed at the INES (Italian Neutron Experimental Station)[1] beamline of the ISIS spallation neutron source [2].
This technique relies on the measurement of the neutron beam attenuation due to the resonance absorption of epithermal neutrons (0.3 eV< En < 100 eV) by the nuclei of a material. Since resonance structures appear at specific energy for each nuclide's neutron-induced reaction cross-sections [3], they can be used to identify and quantify elements in materials and objects. Moreover, it is possible to distinguish between isotopes of the same element.
A time and spatial-resolved nGEM (neutron Gas Electron Multiplier)[4] detector is employed for Time-of-Flight (ToF) measurements of the neutron beam transmitted through the object, providing resonance-selective imaging of the isotopic and elemental composition of the samples. Therefore, NRTI allows the localization of isotopes and elements distribution within 2D (and potentially 3D) maps of the bulk of the analyzed object.
The peculiarities of NRTI make it suitable for the characterization of inhomogeneous samples [5,6] and it can be applied to archaeological objects as it is a non-destructive technique. In particular, NRTI can be suitable for metallic artifacts analysis as neutrons can penetrate them up to a few centimeters.
Within this context, several metallic standards have been measured to study the transmission response in function of composition and thickness. The NRTI capability for isotopic imaging will be presented.
Moreover, in order to deepen the feasibility of NRTI in Cultural Heritage applications, a set of crucible fragments related to bronze and brass objects production in Roman Italy (I-II AD)[7] has been investigated through a combination of NRTI and other well-consolidated non-destructive techniques. These crucibles consist of mass-produced terracotta pots, coated with a thick layer of refractory clay. Inside, metallic inclusion related to copper and zinc alloys production can be present. In fact, some fragments show metallic depositions on their surfaces, while others could contain traces inside their volume.
At present, NRTI analysis returned the qualitative elemental composition of the fragments, revealing the presence of brass and bronze. In addition, arsenic, antimony, silver, and lead were detected in their bulk.
These kinds of archaeological samples are an example of inhomogeneous objects that can be interesting to be investigated with the NRTI technique, exploiting its possibility of visualizing the elements (and isotopes) distribution within the bulk.

References

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