Neutron imaging – new perspectives on old objects

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The Laboratory of Neutron Scattering and Imaging of the Center of Neutron and Muon Sciences at PSI provides neutron and X-ray capabilities for investigating, non-destructively, invaluable cultural heritage objects and artefacts. Neutron imaging is a tool provided at our large scale neutron source in order to enable the investigation and characterisation of inner structures and in particular to provide insights where other techniques such as X-ray imaging fail [1]. Neutron imaging provides several advantages overcoming limitations of X-ray imaging, such as higher penetration power for many elements, in particular metals, while providing at the same time high sensitivity for hydrogen and hydrogen containing materials such as plastics, water/humidity, glues, conservation media, corrosion products etc. In addition, the contrast between neighboring elements in the periodic table is often significant for neutrons, while it vanishes for X-rays. This implies that the complementary contrast of X-rays and neutrons is often useful to identify specific materials, which one modality alone would fail to distinguish. Therefore, we also offer bi-modal neutron and x-ray tomography on our neutron instruments. Here we will introduce our techniques and approaches along a series of examples. Among these an investigation of lead amulets, which we virtually unroll and, thus unfold the hidden inscriptions on their inside [2]. Together with the study of an ancient golden lock, where the 3D reconstruction unravels the inner mechanism of the artefact [3], these are examples requiring the high penetration of neutrons.

The complementarity of neutrons and X-rays and the potential to combine both modalities is illustrated by the case of a sword found in lake Zug (CH) [4]. Here, some metal parts show better contrast in the X-ray data, while the wooden handle can only be resolved well in the neutron image. However, the bi-modal approach can also be used for detailed segmentation and identification of the different phases based on bi-modal histograms, like demonstrated in a study of corroded iron objects [5]. This approach has led to a collaborative project involving not only our group and cultural heritage scientists from HE-Arc and Aventicum, but also material scientists from ETHZ and EPFL as well as Nagra, all sharing an interest in longterm corrosion within soil and other porous media such as concrete.

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