SNSS Seminar Series, 17th November 2020, Time 13.00 – 15.00 pm

Theme 1: Neutron Imaging

With the upcoming opening of the ESS, this is an exciting time to be involved in neutron research in Sweden. At SNSS we aim to strengthen our community by fostering new collaborations and showcasing the excellent science already taking place. Our seminar series will focus on the science facilitated by the first ESS beamlines, to highlight the existing strengths with the national and international communities and initiate collaborations for the future.

On 17th November at 13.00 our first seminar theme is 'Neutron Imaging'. The programme will include a brief introduction to the technique including an outlook of ongoing and future developments, followed by scientific presentations from the fields of bone imaging, engineering (microstructure variations) and archaeology.

1300 - 1305 Welcome (Maths Karlsson, Chair SNSS)

1305 - 1340 *'An introduction to Neutron Imaging with a focus on Geomechanics'*
Alessandro Tengattini (Università Grenoble-Alpes / ILL)

1340 - 1400 *'Dual modality neutron and X-ray tomography data from skeletal tissues with a metallic implant'*
Elin Törnquist (Division of Biomechanics, Lund University)

1400 - 1425 *'Revealing localized microstructure and temperature variations by wavelength selective neutron imaging'*
Robin Woracek (ESS)

1425 - 1450 *'Neutron imaging and applications in archaeology'*
Anna Fedrigo (STFC, ISIS Neutron and Muon Source)

Register for the seminar here:

SNSS Seminar registration

Abstracts

'An introduction to Neutron Imaging with a focus on Geomechanics'

Alessandro Tengattini, (*Università Grenoble-Alpes / ILL*)

Neutron imaging is a powerful non-destructive method for probing matter in 3D, capable of tackling questions from a plethora of scientific areas. A range of advanced imaging techniques are also rapidly developing and expanding the range of available contrast options, such as phase contrast, and polarised neutron imaging. Due to its non-destructive nature, it is possible to acquire multiple 3D volumes as the sample evolves, for example through chemo-thermo-hydro-mechanical loading, which in turn allows the spatio-temporally resolved quantification of processes. Recent technological developments even allow the simultaneous acquisition of highly complementary x-ray tomographies.

This presentation will review the fundamental elements of neutron imaging with a particular focus on key examples in geomechanics and attempt to provide a quick overview of the advanced techniques developed in recent years and provide an outlook of ongoing and future developments.

'Dual modality neutron and X-ray tomography data from skeletal tissues with a metallic implant'

E. Törnquist [a], S. Le Cann [a,b], E. Tudisco [c], A. Tengattini [d,e], E. Andò [e], N. Lenoir [d,e], J. Hektor [f], D. B. Raina [g], M. Tägil [g], S. A. Hall [h], H. Isaksson [a]

[a] Biomed. Eng., Lund University (LU), Sweden, [b] MSME, CNRS, UPEC Créteil, France, [c] Geotech. Eng., LU, Sweden, [d] ILL, Grenoble, France, [e] Univ. Grenoble Alpes, CNRS, Grenoble INP, 3SR, France, [f] LUNARC, Lund Univ., Sweden, [g] Orthopedics, LU, Sweden, [h] Solid Mechanics, LU, Sweden,

Background

Bone is a complex hierarchically structured tissue whose mechanical properties are optimised for fracture resistance in healthy bone. Degenerative disorders and trauma reduce bone strength and fracture resistance, and often result in the need for medical interventions involving implants. The long-term stability of the implants relies on adequate bone-implant integration, which is defined by the quantity and quality of the bone tissue near the implant. To evaluate implant integration, neutron tomography (NT) has shown promising results as a complementary technique to X-ray tomography (XRT), which is the state-of-the-art in bone research, as a way of limiting image artefacts in proximity of metallic components (1,2).

Aims/Objectives

The current study aims at elucidating the complementary nature of NT and XRT for evaluating skeletal tissues and bone ingrowth around a metal implant.

Methods

Specimens consisted of proximal rat tibiae implanted with hollow titanium screws left to integrate for 6 weeks. After harvest, the specimens were dried and imaged with high resolution NT and XRT at the D50 NeXT beamline at Institute Laue-Langevin, France (3). Multimodal registration, as described in (4,5) and implemented in (6), used the joint histogram to identify grey values of phases and their individual distribution for registration. The complementary nature of both imaging modalities was investigated by looking at differences in featured structures and image quality in terms of contrast and amount of bone formation around the implant.

Findings and Conclusions

Analysis of the joint histogram and resulting phase segmentation obtained from the registration showcase the complementary nature of the two modalities in that structures are visualised differently in NT and XRT (Figure 1). Due to the difference in how neutrons and X-rays interact with matter, soft tissues (which is hydrogen-rich) are better captured with NT than with XRT. Severe artefacts around the metallic implant pollute the XRT images. The lack of artefacts close to the implant in NT enables clearer visualisation of the bone-implant ingrowth and immediate interface.

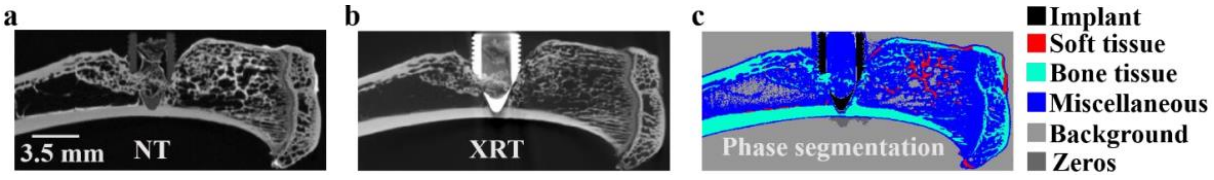

Figure 1. Representative sagittal slices of registered NT image (a), XRT image (b), and phase segmentation obtained from the registration of the images (c). Both NT and XRT images are displayed in the grey scale interval 0-255.

References

1. Isaksson H, et al., Bone (2017); 2. Le Cann S, et al., J Mech Behav Biomed Mater (2017); 3. Tengattini A, et al., Nucl Inst Methods Phys Res A (2020); 4. Tudisco E, et al., Meas Sci Technol. (2017); 5. Roubin E, et al., Cem Concr Compos. (2019); 6. Stamati O, et al., J Open Source Softw. (2020)

'Revealing localized microstructure and temperature variations by wavelength selective neutron imaging'

Robin Woracek (*ESS*)

The introduction of wavelength selective neutron imaging opened unprecedented opportunities for an advanced non-destructive characterization of materials. This presentation will highlight how diffraction contrast allows to follow martensitic phase transformations in 3D by spectral neutron tomography as well as showcase its capability to reveal and interpret local texture variations in additively manufactured components. Finally, examples that exploit variations of inelastic scattering processes will be shown that allow to distinguish the internal temperature of metals as well as between liquid water, supercooled water and ice.

'Neutron imaging and applications in archaeology'

Anna Fedrigo (*STFC, ISIS Neutron and Muon Source*)

Scientific investigations and archaeometric studies have played a major role in the field of archaeology, especially with regard to materials transformed through human activity, like metals. The investigation of metal artefacts can be invaluable for our knowledge of manufacturing processes and their technological evolution over the centuries, and for choosing the best conservation and restoration techniques. Neutron imaging techniques are used to shed light on the inner structure of composite materials and their manufacturing techniques, revealing some otherwise invisible details of their assembly methods, phase distribution and extent of the corrosion. In addition, the combined use of X-rays and neutrons provides additional element-dependent information which is fundamental in case of multi-phase objects. The work covers various examples of neutron imaging investigations of archaeological and Museum objects, spanning, e.g., from Viking swords to Samurai helmets.