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Editorial

Special Issue Advances in Neutron Imaging

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This Special Issue of *Applied Sciences*, "Advances in Neutron Imaging", is published at a time when the COVID-19 epidemic is emerging worldwide. When we began soliciting contributions from the neutron imaging community in 2020, scientific work around the world had nearly come to a standstill. Nevertheless, we could gather highly interesting publications on very different topics of neutron imaging.

Neutron imaging has become one of the fastest growing scientific topics in neutron scattering worldwide. The long tradition of neutron imaging began as early as 1935 in Berlin (Germany), when Hartmut Kallmann and Ernst Kuhn reported on the first experiments with neutron radiography. The invention was based on the conversion of neutrons into gamma rays by means of so-called converter foils in combination with (special) X-ray films. The best spatial resolution at that time was 50 μm and was used for many years for quality control in various industrial applications. At the time, there was no doubt that neutron radiography could not be used for imaging such as X-rays and synchrotron radiation.

However, in the late 1990s, film converter technology was replaced by the available CCD cameras. The spatial resolution of CCD cameras and imaging techniques then underwent rapid development, enabling high-resolution neutron imaging and various applications in materials science and fundamental physics.

However, new imaging signals such as refraction and small-angle scattering of neutrons and new techniques such as dark field imaging, grating interferometry, Bragg edge technique, stress and strain neutron imaging, energy-selective neutron radiography and tomography or phase-contrast neutron radiography and, of course, the use of polarized neutrons opened a wide field of applications in almost all branches of science, ranging from agriculture, automotive industry, archaeology to materials science, cells and hydrogen storage and superconductivity. I guess there is no broader field in science that covers more disciplines than neutron imaging.

In this Issue, a special selection of publications are presented to inform readers about various developments and to encourage them to use neutron imaging for their scientific research and work. Eleven publications report about very different topics from the application of neutron imaging, starting with an instrument at the NEUTRA facility (Switzerland) using neutrons and X-rays that was reported [1], followed by the work of the Australian imaging group, which presented new mathematical methods for reconstructing strain from energy-resolved neutron images [2]. The Swiss imaging group made a second contribution, investigating the mapping of the spatial distribution of pores using neutron microtomography [3], and from Japan a new method was presented dealing with the inner information of crystalline grain realized by wavelength-resolved neutron imaging [4].

A collaboration of two German imaging groups, one from Karlsruhe and one from Munich, with the Swiss imaging group investigated very detailed hydrogen-related processes in zirconium alloys by neutron radiography [5]. A promising approach was submitted by a Japanese collaboration, applying machine learning methods to neutron transmission spectroscopic imaging to solid–liquid phase fraction analysis [6].

The Beijing imaging group operates a similar bimodal neutron and X-ray instrument as the Swiss group, except that it uses a single-electron linear accelerator and has implemented an interesting alternative to the Swiss instrument with a single-source-one-detector system for both neutrons and photons [7]. Another collaboration between a Canadian and two German Institutes studied the influence of external AC fields on magnetic flux trapping of matter in a superconducting state by polarized neutron imaging [8]. Additionally, from the Berlin University of Applied Sciences, Germany, the problem of determination of the spatial resolution of polarized neutrons was investigated mathematically and experimentally [9]. An Italian–Swiss–Korean collaboration used neutron imaging for the microstructural characterization of a single crystal copper rod using monochromatic neutron radiography and tomography [10]. Finally, also from Beijing, a Chinese collaboration presented the mathematics concerning neutron CT reconstruction using a weighted total difference minimization method, which becoming important if only a rather (incomplete) small number of projections are available [11].

With this Special Issue we present a very nice, interesting and distinguished collection on neutron imaging. We thank all authors for their contributions and hope for further submissions on this topic.

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