Journal of Neutron Research 24 (2022) 73–75
DOI 10.3233/JNR-220047
IOS Press

Editorial

Workshop on very cold and ultra cold neutron sources for ESS

Organised by HighNESS and LENS
Hosted by the ESS, Lund, Sweden 2–4 February 2022

The European Spallation Source (ESS)[1] presently under construction in Lund, Sweden, is designed to become the most powerful facility ever built for research with neutrons. The source of neutrons has at its core a moderator system of unprecedented brightness, which is due to the adoption of the new concept of low-dimensional moderators (a factor 2.5 brighter than the conventional volume moderator initially foreseen for ESS). This moderator system, placed above the large rotating tungsten spallation target, will serve a suite of fifteen neutron scattering instruments which are presently being installed, aiming at starting the user program in 2027, before reaching the full scope of twenty-two instruments at a later date.

The facility was designed with the provision for upgrades: a grid of forty-two beamports was built around the moderators, allowing for more instruments to be added to the suite in unoccupied locations. The possibility to install new instruments can profit from an additional degree of flexibility that was not present in the initial design of ESS: the initial design consisted of two identical, large-volume moderator systems, one above and one below the spallation target, which took all the space allocated around the target for the placement of neutron sources. The adoption of the novel design based on the low-dimensional moderator concept resulted not only in a brighter source, but also in a configuration where only a single moderator system, placed above the spallation target, was sufficient and optimal to serve all the instruments in the initial suite. This left the space below the target available for the placement of a new source. Allowing by design each of the forty-two beamports to view either the upper or lower moderator system, it increased the upgrade possibilities of ESS. A second source, with different characteristics from the first one, can now be designed and installed; the combination of two complementary moderator systems would then not only enhance the range of possibilities of ESS but even enable developments of new instrument concepts.

The HighNESS project (development of High intensity Neutron source at the European Spallation Source)[2] is a three-years EU project whose main goal is to design such a second moderator system within the existing ESS infrastructure. It will provide an engineering study for a cold-neutron moderator, and technical design studies for sources of very cold neutrons (VCN) and ultra-cold neutrons (UCN). The complementarity of this moderator system to the upper, bi-spectral high-brightness moderator is two-fold: first, its high total intensity of cold neutrons enables applications for which this parameter, rather than highest possible brightness, is of paramount importance; second, the extended long-wavelength capabilities generate opportunities to develop novel instrument concepts able to take advantage of VCN and for a next generation of projects with UCN.

The first part of the HighNESS project, which started in October 2020, was dedicated to the design of an intense source of cold neutrons, based on a large-volume liquid deuterium moderator. For the tasks of designing VCN

[1] https://europeanspallationsource.se/
[2] https://highnessproject.eu/

Fig. 1. Valentina Santoro presenting the HighNESS project.

and UCN sources, it became clear that, due to the large range of possibilities and specific challenges for source development, the project would strongly benefit from receiving inputs from the international community. For this purpose, in conjunction with the League of Advanced Neutron Sources (LENS),[3] it was decided to organise the present workshop,[4] which gathered experts in the fields of neutron sources, neutron scattering and fundamental physics. Focusing on long-wavelength neutrons and first presenting the status quo of instrument and source developments, the main goal was to collect new ideas for source design and to discuss their possible implementation at ESS.

The workshop lasted three days, with the first two days mainly dedicated to presentations on the state of the art concerning UCN and VCN sources, and to their applications. For UCN, there is an extensive range of sources under operation or design, with the common denominator of using either superfluid helium or solid D_2 as converter media for the UCN production. These two materials are both being investigated in HighNESS. The scientific case for UCN is well established, and the addition of a new source at ESS would benefit from the high power, leading to high UCN densities. Several options and novel ideas were discussed and they can be fully appreciated in several contributions to these proceedings.

The situation for VCN sources is quite different, as there is presently only one VCN beamline in the world, PF2 at ILL. However, part of the neutron scattering and fundamental physics community has been longing for an intense VCN source for at least 20 years, and several workshops, in particular at ORNL and PSI, were dedicated to design and use of a strong source delivering neutrons in the wavelength range roughly between 20 Å and 100 Å. From the presentations and discussions at this workshop, one can conclude that intense beams extending the wavelength ranges of typical cold-neutron instruments (2–25 Å), to 40 Å or even beyond would be highly beneficial to neutron scattering techniques. The list of instruments that naturally benefit from longer wavelength neutrons includes spin-echo, reflectometry, SANS and imaging instruments. Some examples of the benefits are discussed in a few contributions to these proceedings. Fundamental physics applications would also benefit from having intense VCN beams. In addition, an increase around 8.9 Å would provide more neutrons to generate UCN in superfluid helium. The road towards the construction of an intense VCN source presents many challenges and uncertainties, given the novelty of the ideas. However, there are indications that such a source might be possible. Hopes are based on the possible use of innovative materials that are under study in HighNESS, such as the deuterated clathrate hydrates, but also solid D_2, which can be a strong source of VCN, especially in conjunction with advanced reflectors such as diamond nanoparticles. Such ideas were also discussed at the workshop and can be found in these proceedings.

[3] https://lens-initiative.org/
[4] https://indico.esss.lu.se/event/2810/

Fig. 2. One moment of the workshop. The restrictions due to the COVID-19 pandemic did not prevent a very lively contribution from the participants, some of them shown on the panel at the left.

The third day of the workshop gave room for discussions organized in different focal areas, which helped to reach a deeper understanding of the concepts and possibilities, thus providing guidance for further source studies within HighNESS. The workshop suffered from travel and hosting restrictions due to the pandemic, as can be seen from the nearly empty meeting rooms in Figs 1 and 2. Nonetheless, 157 participants from 23 countries contributed to lively discussions and exchange of ideas, including not only world experts but also many students. We would like to thank all participants and speakers for sharing their expertise, in scrutinizing existing source options and bringing in new ideas. Most of the proposals are represented in the articles compiled in these proceedings and motivate the HighNESS team to analyze them in more detail. The range of possibilities presented there, together with fruitful discussions still ongoing after the workshop, let us feel optimistic to achieve the goals in designing world-leading UCN and VCN sources at ESS for the user community.

The workshop was funded by HighNESS, supported and advertised by LENS. Special thanks are due to the ESS Science Focus Team, in particular to Arno Hiess, and to Andrew Jackson for partially financing the printing of these proceedings, and to ESS for providing the location.

Valentina Santoro – ESS
Markus Strobl – PSI
Luca Zanini – ESS
Oliver Zimmer – ILL
Guest Editors