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Towards the Development of a Compact Very Cold Neutron Source for the High Brilliance Neutron Source (HBS)

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Very cold neutron (VCN) sources present an exciting opportunity for scientists to access unprecedented length and time scales, and achieve improved resolution in neutron experiments [1]. VCNs are defined over a wide spectral range, from 1 meV (9 Å) down to a few hundred neV (> several 100 Å). Recent advancements in the development of thermal scattering kernels for candidate very cold neutron (VCN) moderator and reflector materials under the HighNESS project [2] have opened opportunities for exploring conceptual designs of VCN sources tailored to emerging high-intensity compact accelerator-driven neutron sources (HiCANS) like the High Brilliance Neutron Source (HBS) [3]. In contrast to the expansive moderator designs typical of large reactor and spallation sources, HiCANS, with a smaller source, necessitate highly efficient and compact moderator solutions. For the ESS, moderator concepts have been developed based on solid deuterium; however, at the HBS, a hydrogen-rich moderator is required to effectively slow neutrons to the VCN energy range within the limited volume that aligns with the HBS footprint. Methane, a well-established and highly efficient neutron moderator is a promising candidate to serve as a VCN moderator since it possesses a desirable low-lying rotor mode at ~ 1 meV. Liquid parahydrogen (l-pH_2) is a known efficient cold neutron moderator since it is able to convert thermal neutrons to cold neutrons via a single interaction. Various geometrical configurations combining methane and l-pH_2 have been considered to harness the complementary properties of both materials in potential designs of a VCN moderator for the HBS. Monte Carlo simulations using the PHITS particle transport code were conducted to evaluate the performance of these configurations when fed by the HBS tantalum source. This study presents a comparative analysis of the results obtained for various moderator geometries considered when compared with a pure, low dimensional l-pH_2 cold source.

References

[1] J.M Carpenter and B.J. Micklich, ANL (05/42) (2005).

[2] V. Santoro et al, (2023). Nuclear Science and Engineering, 198 31–63 (2023)

[3] Baggemann J. et al. (2023). Technical Design Report HBS Volume 2 –Target Stations and Moderators. Grafische Medien, Forschungszentrum Jülich GmbH. ISBN 978-3-95806-710-3.

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