Contribution ID: **12** Type: **Oral presentation**

High-brilliance and high-flux cold neutron source based on high-aspect ratio rectangular parahydrogen moderators.

Recent studies [1, 2] have revealed the remarkable potential of optimized low-dimensional liquid para-H2 moderators in enhancing cold neutron brightness compared to voluminous moderators. In this research, we introduce a novel analytic approach to calculate the brightness of such moderators. Our findings demonstrate that as the brightness gain is the near-the-surface effect, the high-aspect ratio rectangular cold para-H2 moderators offer even higher cold neutron brightness then the moderator optimized for ESS [3]. We demonstrate that solely the "geometrical" low dimensionality of moderators is not sufficient for achieving substantial brightness gains and that the "physical" low-dimensionality on the scale of the mean free path of thermal neutrons is required. The obtained results are in excellent agreement with MCNP calculations.

To address the trade-off between brightness gain and neutron beam intensity in low-dimensional liquid para-H2 moderators, we propose the chessboard-like and the staircase-like assemblies of moderators with a well-developed total surface. This configuration ensures wide, intense neutron beams while preserving the high brightness of the narrow moderator.

The stacked staircase moderator geometry offers a solution to partially overcome the limitations posed by the inhomogeneous thermal neutron flux distribution around the reactor core or spallation source target. By implementing this geometry, it becomes possible to achieve brightness gains ranging from 2.5 to 3.5 times when compared to single flat para-H2 moderators of the same width.

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Session Classification: Target and Moderator