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C1Po1E-04: Development status of the in-situ measurement system for ortho-to-parahydrogen fractions for the ESS cryogenic moderator system

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At the ESS target, high energy spallation neutrons are produced by impinging a 5 MW proton beam on the high-Z material, tungsten. The proton beam is pulsed with a repetition of 14 Hz and a pulse length of 2.86 ms. The moderator system consists of a water pre-moderator and two liquid hydrogen cold moderators, which are optimized to achieve a high cold neutron brightness. The neutronic performance of the cold moderators degrades rapidly with the decreasing parahydrogen fraction below 99.5%. The neutron collisions in the cold moderators increase the orthohydrogen fraction unless compensated by the ortho- to parahydrogen conversion driven by the catalyst system. Therefore, the Cryogenic Moderator System (CMS) is equipped with an ortho-parahydrogen (OP) catalyst to maintain the desirably high parahydrogen fraction. The ortho-to-parahydrogen ratio will be measured by the in-situ measurement system (OPMS) by means of a Raman spectroscopy currently being developed. A dedicated sampling line with a sapphire window for the OPMS has been designed in order to continuously measure fractions of ortho- and parahydrogen from and to the moderators. The sampling line has been installed at the ESS site in 2022. It could be demonstrated that our developed sapphire window, through which the laser and backscattered photons travel, can endure the required pressure and thermal cycles in liquid hydrogen environment. We have confirmed that there was no harmful leak by the helium leak testing after both 3,000 pressure-cycles between 0.1 and 1.7 MPa in liquid hydrogen and 100 thermal-cycles between 250 K and 20 K. The Raman optics system with a precision of 0.1% parahydrogen fraction is developed to detect an undesirable shift towards a higher orthohydrogen fraction caused by para-to-ortho back conversion driven by the neutron collisions in the cold moderators.

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