A model for non-thermalized neutron spectra emitted from para-hydrogen

At spallation and reactor cold neutron sources, neutrons are cooled by moderators. At high power neutron sources, such as the Japan Proton Accelerator Research Complex (J-PARC), European Spallation Source (ESS) and the Spallation Neutron Source (SNS) only few moderator materials are practical, due to the high radiation environment near the moderator and cooling demands. One of the very popular materials, used at J-PARC and planned for ESS, is the spin singlet state of $\text{H}_2$, para-hydrogen. This study assesses the non-Maxwellian neutron spectral structure achieved in para-hydrogen moderators, which is due to the complexity of the inelastic scattering cross section below 50 meV. The analytical description of a thermalized spectrum with slowing down components are discussed, then a formula is developed which is a good description of this non-equilibrium para-hydrogen neutron spectrum. These analytical descriptions are fitted to the thermal and cold neutron spectra expected at the European Spallation Source according to the baseline configuration, as described in the Technical Design Report (TDR). The results of the fits have been implemented in McStas 2.0 and is used throughout the ESS instrumentation community. Though not shown here it is worth noting that the spectra for different heights of moderators in the more recent ESS geometry have also been fitted to this para-hydrogen spectrum model, the fits have been implemented and released in McStas 2.1.

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