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A new scattering kernel for superfluid helium

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We present the development of a model to describe the interactions of neutrons in normal and superfluid He-4 at temperatures below 2.17 K. The model was constructed based on the separation of the single-phonon and multi-phonon excitations at low temperatures. Below around 3.4 Å-1, the single-phonon excitations are described exactly by the dispersion relation, while the multi-phonon excitations and the single-phonon excitations above this limit, are included using the phonon expansion approach in the Gaussian approximation. A frequency spectrum, derived from the experimentally observed phonon-roton excitations, is used throughout the calculation, except of course in the single-phonon term over the momentum transfer range where the quasiparticle dispersion curve exists. The model can be used to calculate UCN production from down scattering processes, as the exact dispersion curve is included, and can also be used for the design of optimized target/moderator geometries at a neutron source as the first and second sum rules are well satisfied. We have modified the software NJOY to include this description, making it possible create thermal scattering libraries in the ACE format to be used in Monte-Carlo simulation of the production of ultra-cold neutrons from He-4.

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