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Deuterated clathrate hydrates for neutron moderation and reflection in future high-flux sources of very cold neutrons

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Fully deuterated clathrate hydrates are a promising class of materials for diffuse neutron reflection and for moderation to much lower energies than current cold neutron sources. These inclusion compounds are available with a variety of weakly neutron absorbing guest molecules. Due to their large unit cells they offer better diffusion properties than common reflector materials within a much larger cold-neutron wavelength range up to 2 nm (Clathrate Structure II) or 2.4 nm (CS I). There, they outperform not only graphite or beryllium, possessing much smaller Bragg cut-offs and larger absorption, but also the best imaginable nanostructured materials. Local modes of the guest molecules offer interesting opportunities for neutron moderation. They provide incoherent inelastic scattering channels able to remove kinetic energy stepwise from the neutron, without being suppressed due to typical low densities of phonon states at low energies, as there are no kinematic restrictions due to dispersion relations. Inelastic magnetic scattering in fully deuterated O2-clathrate hydrate has recently been identified as a promising moderator material [1]. It possesses an experimentally established non-dispersive inelastic neutron scattering signal with 0.4 meV energy transfer due to the zero-field splitting of molecular oxygen. Based on calculated cross sections for magnetic neutron scattering and a stationary neutron transport equation for an infinite, homogeneous medium with Maxwellian neutron sources, strong cooling effects are to be expected, requiring only ordinary liquid-helium temperatures, no external magnetic field and no neutron polarisation. An experimental program has been started at the ILL to measure S(q,omega) in absolute units not only for this material but also for other clathrate hydrates to investigate the strength of various molecular rotational and local translational modes. The goal is to establish a data base for a realistic modelling of moderator/reflector geometries in novel neutron sources.

[1] O. Zimmer, Neutron conversion and cascaded cooling in paramagnetic systems for a high-flux source of very cold neutrons, Phys. Rev. C 93, 035503 (2016)

Poster back-up

No

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