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Solid CH4 at medium power: The multi-temperature moderator

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Abstract

The use of solid CH4 as a moderator material, is made extremely complex caused by the release stored energy and swelling that occurs due to the radiation. The limit of a solid methane moderator is currently determined by the neutronic heat load.

Solid CH4 has an extremely low heat conductivity (3 mW/cm K) and is extremely sticky, both of these features are normally mitigated against by various means, e.g. lling slowly via a liquid state and by using a heat transfer medium, e.g lling the moderator with an Al foam. In all of these cases, the goal has been to make the whole moderator solid CH4, however it is only the last couple of collisions undergone by the neutron that determine the spectra shape of the output spectrum. The actual requirement is that the centre of the moderator is suciently neutronically dense to allow the moderation of fast neutrons (>1eV) from the target/reactor core, and has a spectral temperature that is only one/two collisions away from the desired temperature. We can use the two unique physical properties (conductivity and surface adhesion) of CH4 to set up a moderator with an outside skin of very cold CH4 and maintain an inner core of liquid CH4, simply by cooling from the outside via a He channel, which is eectively neutron transparent, and by adding Al foam of the required depth on the viewed faces. The thermal load on the moderator from the neutron flux is sucient to maintain this state and the poor thermal conductivity of CH4 allows that liquid state to exist without beam for many hours and be reformed in minutes.

If the extremely high surface bonding strength of CH4 is exploited, then the inner core can be filled with Mesitylene/Xylene/Toluene mixture, via a process of condensing the CH4 to the solid from the gas phase in which it bonds extremely strongly to the cold surface. Then after sucient CH4 gas has been added, the moderator is back lled with MXT mixture. This does two things: (a) reduces the radiation damage since there is so little methane, (b) the vinyls that are produced are soluble in the liquid MXT solution.

This moderator has an additional feature that the CH4 can be cooled into the type II state (<20.4K), which although it loses much of its cross-section, which makes it a poor choice for a complete moderator, but this is unimportant here because it is only a thin layer and can still act to lower the spectral temperature of the moderator without signicant loss in intensity.

We present simulation work and experimental work that is the basis for an ongoing ISIS design of this moderator for insertion into the second target station. This shows that this kind of moderator is expected to increase the long-wavelength ux at the same time as giving us an easy to operate moderator.