4. 12. 00

ESS reference moderator characteristics for generic instrument performance evaluation.

F. Mezei, ESS Instrumentation Task Leader, mezei@hmi.de

1. Preamble:

The following approximate expressions for ESS moderator fluxes and line shapes have been established in collaboration with D. Filges and S. M. Bennington form the ESS Target and Moderator Task. They are primarily based on recent neutronics calculations at SNS, with further input from calculations in Japan, Los Alamos, etc. The various calculations more or less good agreement on pulse line widths and neutron spectra, while there is quite some inconsistency on the absolute flux values. The ESS Target and Moderator Task team will investigate these open questions, and the present reference data will be updated correspondingly.

2. Definitions:

Time average neutron wavelength spectra are given in units of n/cm^2/s/Å/sterad, called FU (flux unit) in what follows. The same unit is used in the familiar ILL yellow book.

$$\mathbf{M(l,T) = 2\,a^2\,l^{-5}\,exp(-a/l^2)}$$

is the normalized Maxwellian spectrum, i.e. its integral over wavelength **l** between 0 and ∞ equals 1. **l** is measured in units of Å, **T** is the effective spectral temperature in K, and **a = 949 / T.**

$$\mathbf{F(t,t,n)= [exp(-t/t) - exp(-nt/t)]\; n / (n\text{-}1) / t}$$

is the normalized pulse shape function, i.e. its integral over time **t** from 0 and ∞ equals 1. **t** is the long time decay time constant of the pulse, and **n** pulse shape parameter. Two values of **n** are used in the present: **n = 20** (in which case the FWHM pulse length is **0.87t**, and **n = 5** (in which case the FWHM pulse length is **1.32t**)

The moderator spectra are given as the instantaneous time dependent flux in FU units for a single pulse. Since time in FU units is measured in seconds, **t** and **t** must also be expressed in sec. At the present approximation the flux across the 12 cm x 12 cm flat moderator surfaces can be assumed uniform and isotropic (within ± 45° from perpendicular emission).

3. Reference moderator spectra

The instantaneous flux distributions functions $\Phi_i(t,\lambda)$ defined below are 0 for t<0, with the proton pulse assumed to arrive at t = 0.

a) Ambient H_2O moderators, short proton pulses

a1) Decoupled poisoned moderator (in FU units, time t in s, wavelength λ in Å):

$$\Phi_1(t,\lambda) = 9*10^{10}M(\lambda,325)F(t,22*10^{-6},5) + 4.6*10^{10}[1+ \exp(2.5\lambda-2.2)]^{-1}\lambda^{-1}F(t,7*10^{-6}\lambda,5)$$

a2) Decoupled un-poisoned moderator:

$$\Phi_2(t,\lambda) = 1.8*10^{11}M(\lambda,325)F(t,35*10^{-6},5) + 9.2*10^{10}[1+ \exp(2.5\lambda-2.2)]^{-1}\lambda^{-1}F(t,12*10^{-6}\lambda,5)$$

a3) Coupled moderator:

$$\Phi_3(t,\lambda) = 4.5*10^{11}M(\lambda,325)[F(t,80*10^{-6},20) + F(t,400*10^{-6},20)] +$$
$$+ 9.2*10^{10}[1+ \exp(2.5\lambda-2.2)]^{-1}\lambda^{-1}F(t,12*10^{-6}\lambda,5)$$

b) Liquid H_2 moderators, short proton pulses

b1) De-coupled poisoned moderator:

$$\Phi_4(t,\lambda) = 2.7*10^{10}M(\lambda,50)F(t,49*10^{-6},5) + 4.6*10^{10}[1+ \exp(0.9\lambda-2.2)]^{-1}\lambda^{-1}F(t,7*10^{-6}\lambda,5)$$

b2) De-coupled un-poisoned moderator:

$$\Phi_5(t,\lambda) = 5.4*10^{10}M(\lambda,50)F(t,78*10^{-6},5) + 9.2*10^{10}[1+ \exp(0.9\lambda-2.2)]^{-1}\lambda^{-1}F(t,12*10^{-6}\lambda,5)$$

b3) Coupled moderator:

$$\Phi_6(t,\lambda) = 2.3*10^{11}M(\lambda,50)F(t,287*10^{-6},20) + 9.2*10^{10}[1+ \exp(0.9\lambda-2.2)]^{-1}\lambda^{-1}F(t,12*10^{-6}\lambda,5)$$

c) Long pulse moderators (2 ms proton pulse length assumed)

c1) Coupled ambient H_2O moderator:

$$\Phi_7(t,\lambda) = 1500 \int_0^{0.002} \Phi_3(t-t',\lambda)\, dt'$$

c2) Coupled liquid H_2 moderator:

$$\Phi_8(t,\lambda) = 1500 \int_0^{0.002} \Phi_6(t-t',\lambda)\, dt'$$