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Enhancement of Cross-section Feedback Module for Temperature Coefficient in STREAM/RAST-K

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1. Introduction

This paper introduces an enhancement process of STREAM/RAST-K in order to produce more accurate temperature coefficients. STREAM/RAST-K is a 2-step approach code system for neutron transport/diffusion analysis aiming to reactor core simulation. Verification and validation (V&V) of the code system have been ongoing [1]. In particular, the case matrix for group constants and cross-section feedback module work well for the steady-state simulation: RAST-K follows STREAM reference solution less than 30 pcm in hot states. However, it is found that STREAM/RAST-K needs some improvements to get accurate reactivity coefficients in cold states; thus, both STREAM and RAST-K make up for the weak points.

An interpolation method of a cross-section for temperatures in STREAM partially changes to consider thermal scattering cross-section characteristics of H in H_2O, which is as known as s(α,β). The full case matrix including the cold state, which needs generating few-group constants required for RAST-K, restructures densely. RAST-K also changes the existing 2D/1D cross-section interpolation to the 3D/2D cross-section interpolation. This paper presents improved results of moderator temperature coefficients (MTC) regarding temperature from the cold zero power (CZP) to the hot zero power (HZP) in an entire cycle by these enhanced methods.

2. Cross-section Interpolation in STREAM

2.1. H in H_2O neutron thermal scattering cross-section

The multi-group cross-section library used in STREAM reduces ENDF raw data to 72 groups through NJOY code and produces them on average seven temperature points for all isotopes. Equations for temperature, such as Doppler Broadening, can express most types of cross-sections; thus, it is easy to produce cross-sections for a specific temperature. On the other hand, H in H_2O thermal scattering cross-section is challenging to express in a specific equation according to temperature, so it relies on experimental data only. Therefore, STREAM uses the H in H_2O thermal scattering data from specific temperature points provided by the ENDF. Among the nine temperature point libraries provided in ENDF/B-VII.1, seven temperature point libraries, which are at 293.6, 400, 500, 550, 600, 650, and 800K, were used.

2.2. Change of cross-section interpolation in STREAM

Cross-sections of most isotopes are linear according to the square root of temperature (Fig. 1), whereas thermal scattering cross-section of H in H_2O tends to be nonlinear, as shown in Fig. 2.

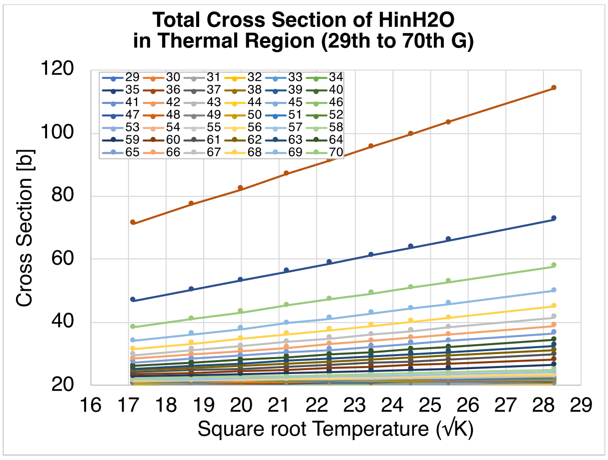

Fig. 1. Total cross-section of H in H_2O as a function of √temperature in thermal region. 72th group is the lowest energy group.

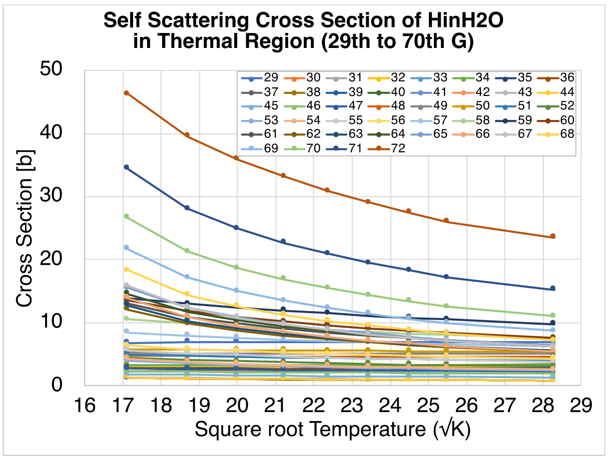

Fig. 2. Self-scattering cross-section of H in H_2O as a function of √temperature in thermal region. 72th group is the lowest energy group.