

II. B. VERSIONS OF MULTILEVEL R-MATRIX THEORY

Many representations of multilevel R-matrix theory have been developed over the years. For a summary of the more common versions, the reader is referred to the works of Fröhner [FF80, FF00].

Four versions of R-matrix theory are available in SAMMY: the Reich-Moore approximation (Section II.B.1), the single-level (SLBW) and multilevel Breit-Wigner (MLBW) approximations (Section II.B.3), and a variant on the Reich Moore which mimics the full R-matrix (Section II.B.2). An option to include a direct capture component is also provided (Section II.B.4).

The Reich-Moore approximation is the preferred method for most modern evaluations; it is the default formalism for SAMMY runs.

Fröhner, in fact, suggests that the Reich-Moore approximation is universally applicable to all cases: “Experience has shown that with this approximation [Reich Moore] all resonance cross section data can be described in detail, in the windows as well as in the peaks, even the weirdest multilevel interference patterns . . . It works equally well for light, medium-mass and heavy nuclei, fissile and nonfissile.” [FF00, page 60]

For most purposes, Reich Moore is indeed indistinguishable from the exact formulation. Notable exceptions are situations where interference effects exist between capture and other channels. For those cases, small modifications to the SAMMY input will permit the user to mimic the effect of the non-approximated R-matrix; see Section II.B.2 for details.

Occasionally it is not possible to properly describe a cross section within the confines of R-matrix theory, because the reaction includes a direct component. SAMMY has provisions for the user to provide a numerical description of this component; see Section II.B.4 for details.

Also available within SAMMY are both the SLBW and the MLBW formulations (Section II.B.3); these are included for the sake of completeness, for comparison purposes, and because many of the evaluations in the nuclear data files were performed with Breit-Wigner formulae. However, it is strongly recommended that only Reich Moore be used for new evaluations, for several reasons: MLBW is often inadequate; SLBW is almost always inadequate. When it is correct, MLBW gives identical results to Reich Moore. “Ease of Programming” is no longer a valid excuse for using MLBW, since the programming has already been accomplished. Similarly, a slow computer is no longer a legitimate excuse, since modern computers can readily handle the more rigorous formulae.

Finally, it should be noted that SAMMY’s implementation of MLBW does not correspond to the usual definition of MLBW. Instead, SAMMY uses the ENDF [ENDF-102] convention in which only the elastic cross section is truly multilevel, and all other types of cross section are single level.