

## General

Below follows my report on the PhD thesis of Pierre Tamagno, entitled "Challenging fission cross section simulation with long standing macro-microscopic model of nucleus potential energy surface". I will first summarize my impression of the various chapters of this thesis. At the end, I will give my general impression and judgment.

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## Chapter 1 Introduction

This is a compact general introduction to the world of nuclear data libraries, explaining that there are various alternative descriptions of nuclear data, generally divided into the RRR, URR and fast energy ranges. The importance for applications is summarized and there is a more detailed explanation of the issue of discontinuities between the various energy ranges in a nuclear data library.

## Chapter 2 Collision theory

This chapter contains a rather fundamental, though sufficiently compact, discussion on collision theory. As in the end all models need to be implemented in existing or new software, all relevant codes are briefly described.

## Chapter 3 RRR-Related fission model improvements

The essentials of R-matrix theory are explained, as well as the several approximate representations (SLBW, MLWB, Reich-Moore) that are derived from that. Essential is the extension by Lynn to fission, and that is adequately described as well. The complexity of these models for the description of fission is exemplified by a sub-threshold analysis of Pu240. The impact of class-II resonances is explained. The reader is well prepared for the actual implementation that takes place in the coming chapters.

## Chapter 4 Upgrading the CONRAD code

Again, it is good to see a consistent description of several models that overlap to describe the same process. In this case it is the Hauser-Feshbach and URR description. Of course, essential for these models are their ingredients. The prescription for level density and gamma-ray strength functions are for a large part adopted from TALYS. For the optical model, in-house software is used. The Hill-Wheeler approach is also equivalent to that used in TALYS although in this work the Cramer-Nix model is also used. The author has systematically validated all models by consistent comparisons of

TALYS and CONRAD calculations, ingredient per ingredient. In my view, the working method looks very solid.

#### **Chapter 5 Macro-microscopic models in CONRAD**

In this chapter the FRLDM is constructed so that eventually the Potential Energy Surface can be calculated. Various well-established phenomenological formulas are used, but they are provided with more recent systematics for the various parameters. There are some differences with the work of P Moller. It is made clear that the calculations are very computationally expensive.

#### **Chapter 6 From potential energy surface to fission cross section**

The thesis has been carefully built up to reach this chapter, in which all theoretical models of the previous chapters are combined for the analysis of the fission process. The multidimensional PES is translated into a one-dimensional fission barrier, so it can enter nuclear reaction calculations by means of transmission coefficients. A proper description is given on how the method reduces again to well-known deformation potential curves which determine the transmission coefficients.

The chapter ends with the ONLY weak point of this thesis: there was apparently no time to solve the strong underestimation of the fission cross section calculations for Pu239. The author does however give a few suggestions for the reasons.

#### **Chapter 7 Conclusions and perspectives**

All accomplishments are well summarized. Moreover, several mathematical derivations relevant to the nuclear models are given in appendices.

#### **Overall picture**

This is a very good thesis. In the past decade, a lot of effort have been made to come to a more fundamentally sound physical picture of the fission process in both the resonance and fast range. I believe a big step forward has been made with this work.

The author states "To comply with evaluation realistic constraints, namely in terms of computation time, the macro-microscopic approach has been favored over alternative approaches such as Hartree-Fock-Bogoliubov (HFB) microscopic descriptions". He should bear in mind this is a dangerous statement: there is nothing as time-dependent as computer power. A consistent approach between the two approaches, i.e. using one and the same software package, would shed light on this. Even then, it is probably the method which allows itself the most adjustable parameters which will turn up as winner.

The rivalry between FRLDM and HFB is an old one, and there are members of this jury who are more actively involved in that discussion than me. By extending the macroscopic part of the model by more refined microscopic aspects is a good way forward I think: it is achievable (though this thesis shows how much work it takes), has a finite time for implementation, and can directly be validated against data.

Finally, this thesis is well rounded off to a good piece of work, and there is always work left to do as the author writes in his conclusions, and in particular also at the end of Section 6.6. I sincerely hope that more work from this thesis finds its way to publications, and that this method can rival with phenomenology over a wide range of actinides.

**Standing of the work: Excellent**

**Quality of the thesis: Good**

**Presentation of the work of the thesis: Good**

**Final judgment of the thesis: Excellent/good**