Contribution ID: **11** Type: **not specified**

Microscopic Modeling of Inelastic Scattering: Applications to Surrogate Reactions and Exotic Nuclei

Monday 25 August 2025 14:15 (45 minutes)

Accurate modeling of neutron-induced inelastic scattering is essential for enhancing the predictive capabilities of nuclear reaction codes, particularly for short-lived nuclei where experimental data are limited. Inelastic scattering can proceed through multiple mechanisms, including compound nucleus formation and decay, as well as direct and pre-equilibrium emissions. We have developed a unified microscopic framework integrating the Jeukenne–Lejeune–Mahaux (JLM) folding optical potential with quasiparticle random phase approximation (QRPA) excitations, employing coupled-channels or distorted-wave Born approximation formalisms.

The microscopic model has undergone rigorous validation against extensive experimental data on stable nuclei, both structurally and reaction-wise. Neutron and proton elastic and direct inelastic scattering on spherical and deformed targets have been benchmarked for numerous stable nuclei, including Pb, Bi [1], and actinide [2]. Additionally, recent analyses of neutron-induced inelastic scattering with gamma emission (n,n'γ) on isotopes such as W (182,184,186W) [3], 232Th [4], and 238U [5] at GELINA to further showcase the versatility of our approach.

Importantly, our microscopic model, based on an effective nucleon-nucleon interaction, allows its application to both neutron and proton projectiles, and potentiallycomposite projectiles via double-folding potentials. For example, the same framework was successfully applied to proton inelastic scattering on neutron-rich Ni isotopes [6] and neutron-deficient Sn isotopes [7] in inverse kinematics. These studies highlight the complementarity between neutron-induced and proton-induced reactions, as proton probes predominantly sense neutron densities, providing constraints complementary to electromagnetic observables. Comparison of calculated and measured (p,p') cross sections allowed extraction of neutron-to-proton excitation ratios, validating QRPA predictions and nuclear structure models [6, 7]. The study of the pygmy dipole resonance in 140Ce via the (n, n′γ) reaction at NFS-SPIRAL2 [6] further illustrates the versatility and interest of our microscopic approach for nuclear structure studies.

Additionally, the model has proven effective in surrogate reaction studies, exemplified by the (α, α′)reaction on 240Pu to constrain neutron-induced reactions on short-lived 239Pu [9]. Recent pioneering inverse-kinematics experiments using heavy-ion storage rings, such as (p, p′) on 208Pb as a surrogate for neutron capture on 207Pb [10], further underscore its capability in extracting neutron-induced reaction observables indirectly.

Thus, our microscopic model demonstrates broad applicability and predictive power, particularly suited for reactions involving exotic nuclei. We will review its foundations and validations, discuss recent progress, and explore future applications, particularly emphasizing neutron-induced reactions on short-lived nuclei.

References

1 Dupuis, M., Bauge, E., Hilaire, S. et al. Progress in microscopic direct reaction modeling of nucleon induced reactions. Eur. Phys. J. A 51, 168 (2015).
2 M. Dupuis, G. Haouat, J.P. Delaroche, E. Bauge, J. Lachkar. Challenging microscopic structure and reaction models for nucleon scattering off nuclei in the A=208 mass region. Physical Review C, 2019, 100 (4), pp.044607.
3 G. Henning, M. Dupuis, M. Kerveno, et al., "Improving the accuracy of 182,184,186W(n,n'γ) cross section calculations", Phys. Rev. C, submitted, under review (2025).
4 E. Party, "Etude des r´eactions (n, xn) pour les noyaux fertiles / fissiles du cycle du combustible innovant au thorium", Th'ese de doctorat dirig´ee par Dessagne, Philippe Physique Strasbourg 2019, PhD thesis (2019).
5 M. Kerveno, M. Dupuis, A. Bacquias, et al., "Measurement of 238U(n, n′ γ) cross section data and their impact on reaction models", Phys. Rev. C 104, 044605 (2021).
6 L. Cort´es, M. Dupuis, V. Lapoux, et al., "Inelastic proton scattering in inverse kinematics on neutron-rich Ni isotopes", Phys. Rev. C 97, 044315 (2018).
7 A. Corsi, M. Dupuis, V. Lapoux, et al., "Neutron-deficient sn isotopes probed via proton inelastic scattering" , Physical Review C 99, 034313 (2019).
8 M. Vandebrouck, J.-L. Lecouey, M. Dupuis, et al., "Study of the pygmy dipole resonance using neutron

inelastic scattering at ganil-spiral2/nfs", Il Nuovo Cimento C 47, Proceedings of the Technical Meeting on Neutron-induced Reactions on Short-lived Nuclei, 19 (2024).
9 R. P´erez S´anchez, B. Jurado, V. M´eot, et al., "Simultaneous determination of neutron-induced fission and radiative capture cross sections from decay probabilities obtained with a surrogate reaction", Phys.Rev. Lett. 125, 122502 (2020).
10 M. Sguazzin, B. Jurado, J. Pibernat, et al., First simultaneous measurement of the γ-ray and neutron emission probabilities in inverse kinematics at a heavy-ion storage ring, and companion measurement of neutron-emission probability with surrogate reaction, Phys. Rev. C 111, 024614 (2025); Phys. Rev. Lett.134, 072501 (2025), Companion papers, 2025.

Author: DUPUIS, Marc (CEA, DAM, DIF)

Presenter: DUPUIS, Marc (CEA, DAM, DIF)

Session Classification: Monday II