Unscented Transform Kalman filter for Optical model parameter uncertainty quantification

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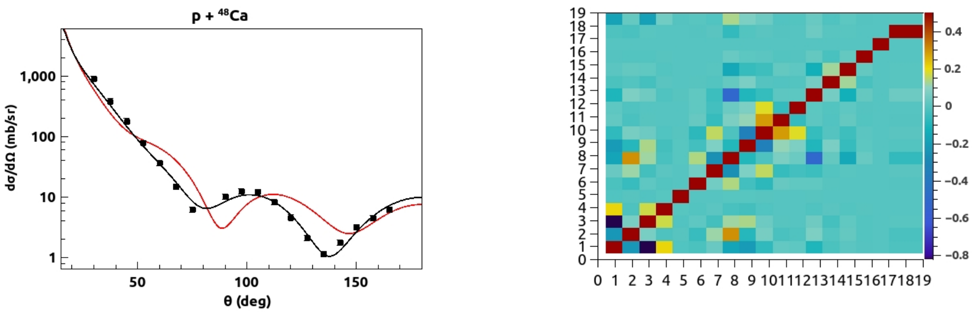
Uncertainty quantification of the nuclear reaction model parameters is crucial for estimating the uncertainties associated with the model predictions. Different techniques like χ^2 minimization [1, 2], Extended Kalman Filter [3], Monte Carlo techniques [4, 5] have been used in the past for the parameter estimation and uncertainty quantification, all of these have their own pros and cons. In the present study, we have used the Unscented Transform Kalman filter (UTKF) for the optical model parameters estimation and uncertainty quantification successfully [6]. UTKF has the advantage over Extended Kalman Filter and χ^2 minimization that it does not require to calculate the partial derivatives of the model outcomes with respect to the parameters and also propagates uncertainties through the nonlinear functions better than these two methods. Also UTKF takes very less computation time and power as compared to the Markov chain Monte Carlo methods. UTKF uses a deterministic method called unscented transform to propagate the uncertainties through the model functions. We have calculated the optical model parameters and their covariance matrix using the experimental data from EXFOR and DWBA calculations for differential cross sections for elastically scattered neutrons and protons.



(a) (b)

FIG. 1: (a)Predictions for elastic scattering differential cross sections for $p +^{48} Ca$ at $E_p = 12MeV$, using new parameters (in black) and initial parameters (in red), (b) correlation matrix of the optical model parameters (v_1, v_2, v_3, v_4, w_1, w_2, d_1, d_2, d_3, v_{so1}, v_{so2}, w_{so1}, w_{so2} and r_c respectively).

Global optical model parameters of Koning and Delaroche have been used as the initial estimates in the study. DWBA calculations were performed for different proton and neutron induced reactions to optimise their respective optical model parameters. Results from present study for $p +^{48} Ca$ at proton energy 12 MeV are presented in Fig.1. Results for different neutron and proton induced reactions will be discussed in detail during the conference. This study shows that UTKF technique can be used efficiently for the estimation of the optical model parameters with detailed uncertainty quantification for the neutron and proton induced reactions. It is also concluded that there are significant correlations among some parameters while others are only weakly correlated to each other.

References

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