# Reaction cross section for $p$-Fe

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## Introduction

The ground state properties of nuclei having proton and neutron numbers between $Z$=20 and 28 exbibit remarkable features. The investigation of mean-square charge radii obtained using measurements by laser spectroscopy indicates an interesting appearance and disappearance of a kink at the neutron shell gaps in this region [1]. The behaviour gives insights into the understanding of the nuclear structure of the nuclei lying far from the line of $\beta$-stability. Most of the knowledge on the ground state properties in this region is based on information from stable isotopes. There is very few information available from the measurements of charge radii of radioactive nuclei: both neutron-rich and neutron-deficient. It is well-known that the nuclear charge radii and reaction cross section can be associated and the behaviour of this correlation can be studied systematically. One can use this association for making a prediction of reaction cross section once the target radial matter densities and charge radii are known accurately.

The Fe isotopes ($Z$=26) is an interesting case as the $Z$ and $N$ lies in the vicinity of shell closure ($N$=$Z$=28). In the present work, we are interested in a prediction of cross sections $p$-Fe using optical model (OM) analysis. The OM analysis requires both the target radial matter densities of Fe nuclei as well as the interaction between the protons and target Fe nuclei. The target radial matter densities are calculated in relativistic Hartree-Bogoliubov (RHB) framework. This model is based on density-dependent meson-exchange (DD-ME2) relativistic energy density functional theory [2]. The Jeukenne-Lejeune-Mahaux-Bruyeŕes (JLMB) energy- and density-dependent [3] has been used for the nucleon-nucleon interaction. In the folding model approach here, the target radial matter densities from RHB have been folded with the JLMB interaction to obtain the proton optical potentials for even Fe isotopes. The resulting real and imaginary parts of the folded optical potentials are used to compute the differential and reaction cross sections for 65 MeV-proton elastic scattering from even $^{48-60}$Fe isotopes. The details of the calculations are given in the Ref. [4–6].

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## Results

To ascertain the validity of the calculation, the ground state nuclear properties such as binding energy and charge radii for even Fe nuclei have been first calculated and then compared with the available experimental data. The differences in the binding energies between calculated and the corresponding data for Fe isotopes have been found to be small. Also, the differences in the square of the mean-square charge radii between neighbouring even isotopes of Fe were compared with that measured experimentally by laser spectroscopy and were found to be in good accord with the available data. Once the calculation methodology is firmly established, we proceed to calculate the optical model potentials for proton scattering from even isotopes of Fe. The normalised target densities are then folded with JLMB interaction to obtain the OM potentials. The real and imaginary parts of the central potential are calculated in the microscopic approach. The real and imaginary parts of the spin orbit interaction are included in a phenomenological manner. These potentials are further used to calculate the differential cross-section ($d\sigma/d\Omega$) and $\sigma_R$ of the stable nuclei ($^{54,56}$Fe).

In general, an overall normalization was re-

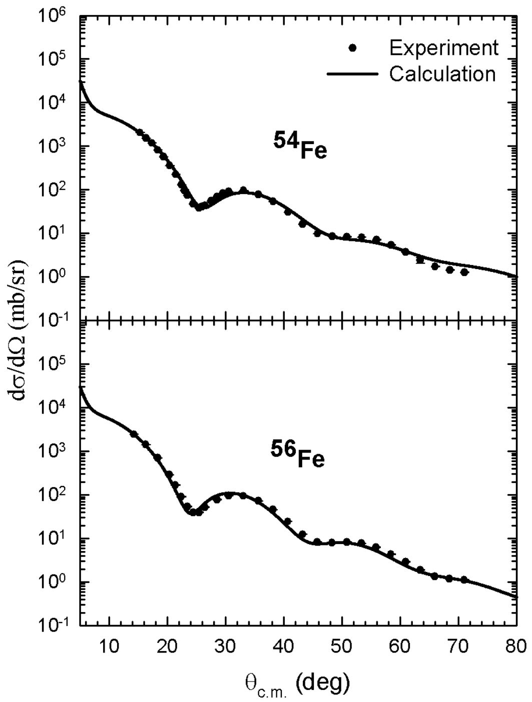


FIG. 1: The calculated elastic scattering differential cross-section ($d\sigma/d\Omega$) for stable Fe isotopes.

quired in the calculated optical model potentials such that $d\sigma/d\Omega$ shows good agreement with data. The $d\sigma/d\Omega$ for the stable isotopes of Fe are plotted in Fig. 1. It is clear from the figure that the calculated and experimental cross sections show good agreement.

Inorder to make a prediction of $\sigma_R$ for the neutron-rich and -deficient isotopes, $^{48-60}$Fe, we have taken the average normalization values for real and imaginary central parts of the potentials obtained for stable isotopes ($^{54,56}$Fe). While for the spin-orbit part, the treatment is the same as adopted for p-Ti isotopes [4]. The averaged normalization values for the potentials were used in the calculation of the $d\sigma/d\Omega$ and the $\sigma_R$ for unstable Fe isotopes.

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