Excitation Functions of ^{58,60,61}Ni (n,p), ^{54,56,57}Fe (n,p) and ^{52,53,54}Cr (n,p) Reactions

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Introduction

The usual materials suitable for the reactor structures are stainless steel with Fe, Cr and Ni as main constituents. The main effect of structural material on reactor neutron balance consists in absorption of MeV neutrons via (n, p) and (n,α) reactions which have thresholds in the range of few MeV. Thus the precise knowledge of (n, p) cross sections is quite essential in the reactor technology. The present situation of (n, p) reaction cross section data on isotopes of Ni Fe and Cr is still discrepant because preparing a mono energetic neutron source for activation experiment in this energy region (threshold to 20 MeV except ~ 14 MeV) presents some difficulties. More recently, the theoretical understanding of nuclear reactions have been further developed and nuclear reaction models are refined to the extent that with appropriate parameterization, nuclear models can be used for inter-and extrapolation and for consistency checks of experimental cross-section data; and for reasonably accurate prediction of "unmeasurable data". EMPIRE 3.0 [1] (most recent and versatile reaction model code has opened up options for calculating cross-sections for various reaction channels. In the present work, we have computed excitation functions of ^{58,60,61}Ni (n, p), ^{54,56,57}Fe (n, p) and ^{52,53,54}Cr (n, p) reactions from threshold to 20 MeV and compared these with the existing experimental data as well as with evaluated data files.

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Calculations

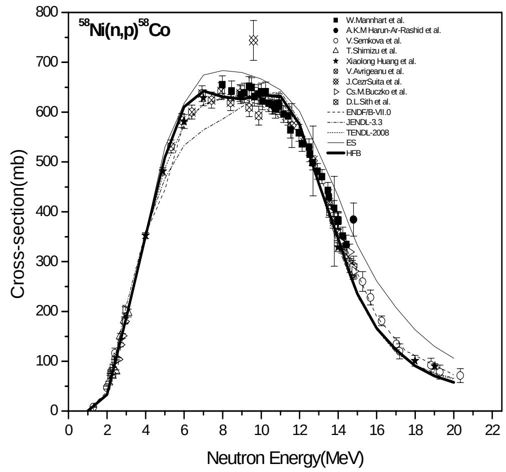
The cross-section are calculated using full featured Hauser-Feshbach statistical model with pre-equilibrium effects by invoking DEGAS [2] option in EMPIRE-3.0. The nuclear structure inputs like nuclear masses, discrete energy levels and level denisities of the nuclides involved in the calculations are taken from latest compilation available in RIPL-3 [3].The optical model potentials for neutrons and protons used in these calculations are the global parameterization of Koning [4].

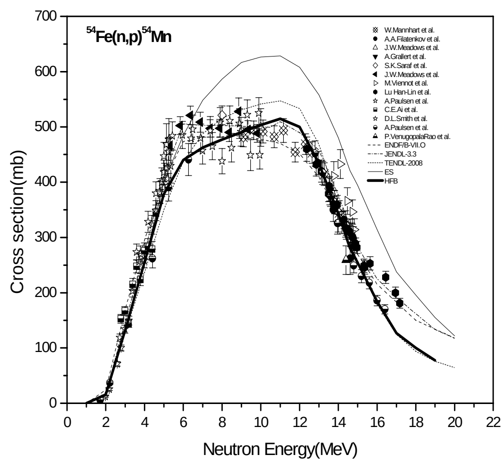
EMPIRE 3.0 accounts for various models describing level densities and includes several parameterization of these. In each case, an equal parity distribution $\rho(E,J,\pi)=\frac{1}{2}\rho(E,J)$ is assumed, except when microscopic parity-dependent tabulated RIPL-3 level densities are used. The level density plays an important role in determining the (n, p) reaction cross-sections. Therefore, we studied the effect of two different level density formalisms viz. (i) Empire specific level density and (ii) Parity dependent level densities based on Hartee-Fock-Bogolyubov model adjusted for collective enhancement and neutron resonance spacing.

Results and Discussion

The computed cross-sections together with the experimental data taken from EXFOR data library [5] and the evaluated data files (ENDF/B-VII.0 [6], JENDL-3.3 [7],TENDL-2008 [8]) were plotted for all cases. Fig. 1 & 2 show the illustrative cases of ^{58}Ni(n,p) and ^{54}Fe(n,p). As can be seen from figure the calculated values of cross-section for (n,p) reactions are in reasonable agreement with experimental & evaluated data files for ^{58}Ni,^{54}Fe with option of neutron & proton potential by Koning (global) and Parity dependent level density (HFB) formalism. While in the case of Empire-specific level density, the values of cross-section show discrepancy from experimental and evaluated data files. We have calculated the (n, p) reaction cross sections for Other isotopes of Ni, Fe & Cr also and got the similar results.

We conclude that the parity dependent level densities along with Koning global optical potential parameter for neutron in entrance channel and proton in exit channel are quite suitable in predicting (n, p) reaction cross-section for nuclides A≈50-60 from threshold to ~ 20 MeV.





Figs. 1 & 2 Empire 3.0 based excitation Functions of (n,p) reactions along with Experimental data and evaluated data files (ENDF/B-VII.0, JENDL-3.3, TENDL-2008)

ES Empire specific approach for level density calculations.

HFB Parity-dependent level densities based on Hartee-Fock- Bogolyubov model.

Acknowledgement

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References

[1] Nuclear Data Sheets 108 (2007) 2655-2715

[2] Betak,E. and Oblozinsky,P. INDS(SLK)-001, Vienna,1993

[3] http://www-nds.iaea.org/RIPL-3/(2008)

[4] Koning, A.J. and Declaroche,J.P. ;Nucl. Phys. A 713,(2003)231.

[5] http://www-nds.iaea.org/exfor July2009

[6] Evaluated nuclear data ,ENDF BNL,Nuclear Data sheets 107,2931(2006)

[7] Japenese Evaluated Nuclear Data Library , Version3 Revision-3:JENDL-3.3J Nucl .Sci. Technol.39(2002)1125

[8]TENDL-2008 Talys-based Evaluated Nuclear data library (Netherlands,NRG 2008) www.talys.eu/tendl-2008