Evaluation of ^{23}Na (n,2n) Cross Section below 20 MeV

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Introduction

We need nuclear cross section data to explain various processes in development as well as research applications. The data of different experiments for a given reaction remain available in the EXFOR[1] database. But the data in general do not agree with each other and discrepancies do exist. There is a dire need of evaluation of data as various application and specialization rely on accurate data.
Sodium metal has uses in Sodium-cooled Fast Reactor (SFR)as a coolant. ^{23}Na is stable isotope of sodium and unlike water it absorbs less number of neutrons. In this work we are evaluating ^{2}3Na isotope of Sodium metal by removing the errors or discrepancies in Na neutron induced cross section data for (n,2n) reaction and to give best fit.

Evaluation procedure

In EXFOR there exist 20 sets of data of ^{23}Na for (n,2n) reaction channel. In this work we only consider 11 sets out of 20 EXFOR sets (Table 1). The EXFOR data sets without satisfactory monitor cross section information were discarded.

For evaluation procedure we first corrected data with reference to new standard monitor cross section for all data sets. The correction of cross section data has been carried out using ^{23}Na cross section as standard cross section in

$$\sigma_N = \frac{\sigma_{Sn}}{\sigma_{So}}\sigma_O$$

where σ_{So} is the old and σ_{Sn} is the new $^{23}\mathrm{Na}(n,2n)$ cross section retrieved from ENDF/B-VIII.0. There were still large discrepancies present in the data. Figure 1 shows the corrected values of cross section for different data sets. The enrgy of neutron above 14 to 15 MeV is not mono-energetic. It can be observed that Liskein data set (EXFOR entry 20926) is too discrepant in high neutron energy range. Normalization of the data was done with weighted average value of 14.6 MeV for all the data sets in order to remove the discrepancies. Figure 2 represents the 11 sets of normalized data.

TABLE I: Correction information of all experimental data on ^{23}Na (n,2n) cross section

EXFOR Entry	Monitor Cross section	Incident Energy (MeV)
10022	27Al(n,a)	14.6
10776	27Al(n,a)	14.6
11391	27Al(n,a)	14.1
11421	235U(n,f)	13.5-19.39
20926	1H(n,el)	12.63-19.58
22703		13.5-19.5
22754	93Nb(n,2n)	15.913-19.414
32640	63Cu(n,2n)	14.6
30515	27Al(n,a)	15.5-17.9
32514	54Fe(n,p)	13.5-14.8
40136	65Cu(n,2n)	14.2-14.6

Normalization and fitting of data

For construction of Covariance we used total as well as partial errors. Only common errors (e.g. efficiency of detector, branching fraction, thickness, monitor cross section) were used to construct partial errors. Total errors will be used for diagonal entries of covariance matrix and partial errors contribute to non-diagonal entries. Correlation matrix was calculated from covariance matrix [4] using equation

$$V = \frac{V^A_{ij}}{\sqrt{V^A_{ii} V^A_{jj}}} \quad (1)$$

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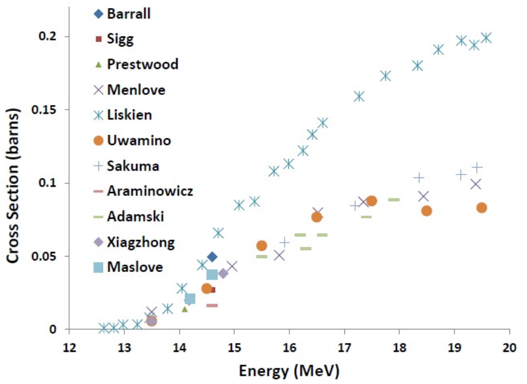

FIG. 1: Corrected cross section data retrieved from EXFOR

Cubic B-spline fitting procedure was used to fit normalized data sets. For smoothing purpose De-Boor spline fitting algorithm was used to fit curves.

The considered data sets were contain 57 data points in the energy range below 20 MeV. Correlation matrices were used as an input in the spline code [2]-[3].

Energy, cross section values and correlation matrix were used as input for spline fit programme where knot points were selected manually. The evaluated data is represented as a solid curve in figure 2(a), and comparison with other data libraries has been done in figure 2(b)[5].

Conclusion

Evaluation of ^{23}Na(n,2n) is attempted in this work and it is found that cubic B-spline gives better result as compared to the linear and quadratic B spline. Special attention was paid to different sources of errors that are common to all data points and corrections are applied accordingly to remove these errors. The evaluated data is consistent with JENDL for low values and lie above JENDL for higher values

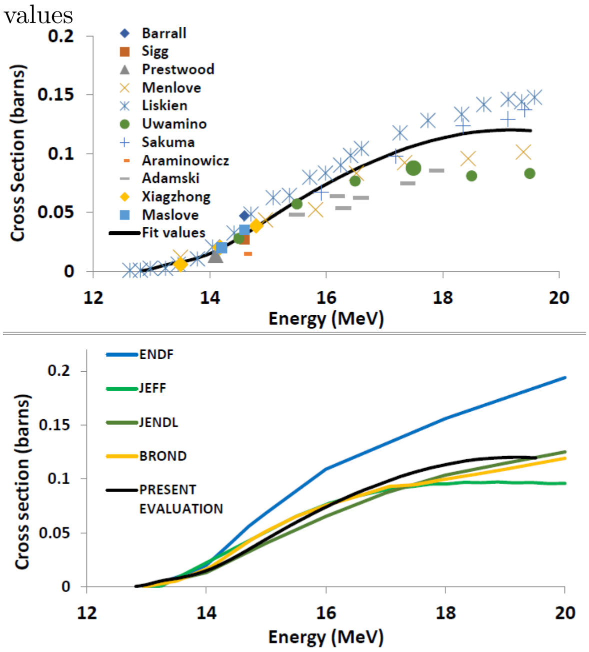

FIG. 2: 2(a): Normalized and B-Spline fitted value for cross section data; 2(b) Comparison of Evaluated data with other evaluation libraries

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