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Evaluation of ^{238}U Inelastic Scattering Cross Section

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Introduction

There are significant discrepancies in the ^{238}U(n,n') cross section among major evaluated nuclear data files in the world. It is the reason why owing to insufficient and scattered data in available experiments, evaluators is forced to produce the outcome by using personally-chosen nuclear reaction models and they must moreover adopt uncertain parameters in their calculation. The evaluated values strongly depend on the used models and parameters, which have not been established so certainly as they are mutually agreeable. The other object which the evaluators apply the model calculation for the inelastic scattering process is that they can consistently produce the partial cross sections for energy levels and angular distributions of emitted-neutrons, whose experimental information is very scarce.

In the present status, accordingly, it may be difficult that the members of the sub-group agree at this meeting on the selection of a specific evaluation, because the evaluators of every files have individually a proper scenario in their files. However, in order that the coordinator completes the final report on the evaluation of the ^{238}U inelastic cross section as soon as possible, he proposes the tasks for the members at the last section in this paper to prepare the draft of the final report.

In the following section, the issues in the evaluation of ^{238}U(n,n') is briefly pointed out .

Discrepancies in the Evaluated Data Files

A comparison of the total cross section of ^{238}U(n,n') in the evaluated data files is shown in Fig. 1, including JENDL-3.2, ENDF/B-IV, JEF-2, BROND-2, and CENDL-2. The report titled "Database for ^{238}U inelastic scattering cross section evaluation" [1] was published in 1993 to provide a common database for the work in the subgroup. At the time, JENDL is the old version JENDL-3. In JENDL-3.2, all the data of ^{238}U(n,n') has been revised and the report on the study is published [2, 3]. It seems that BROND-2 and CENDL-2 have recently revised, but the coordinator has not at hand information about the data of ^{238}U(n,n') in them. The final report should be written on the basis of the latest information.

Available Experimental Data

Total Inelastic Scattering Cross Section

Although the data shown in Fig. 1 were presented as total (n,n') cross section in the experimental reports, the question whether they can be identified as the authentic total (n,n') cross section is uncertain, because some are calculated referring own measurements and some have insufficient energy resolution to separate the inelastic from the elastic part in the secondary neutron spectrum. Therefore, it is not necessary to require the severe agreement between the evaluated and measured one. A measurement of the total (n,n') cross section is so quite difficult that reliable experiments are not expected for an evaluator to produce outcomes only depending on available experiments.

Partial Inelastic Scattering Cross Sections

There are many measured partial (n,n') cross sections and angular distributions of secondary neutrons whose data are summarized in Ref.1. Examples are shown in Figs. 2 and 3 comparing the data in the files. They are so scattered that evaluators can not draw the curves from them and rely on the model calculation mentioned above.

As new data are not published since 1993, the available experiments are as same that the ones at the time.

Double Differential Cross Section

Measured Double Differential Cross Section(DDX) is useful for evaluators to inspect their own procedures at estimating differential quantities such as the level excitation functions and angular distributions of secondary neutrons by comparing between the DDX calculated from their outcomes and measured DDX. For effective inspection, the energy resolution of secondary neutron detection in the available DDX must be informed to the evaluators. In JENDL-3.2 evaluation, the DDX data of Ref.4 is used.

Theoretical Models and Parameters Used in Evaluation

As a nucleus of ^{238}U is deformed, the appropriate theoretical models and parameters must be adopted in the evaluation of the $^{238}U(n,n')$ cross sections with calculations. As an example, the ones applied in the JENDL-3.2 evaluation[2] are summarized here to clarify the point at issue.

The energy levels are distinguished to ones belonging to a ground state rotational band, and quadrupole and octupole vibrational bands, and others. The compound process contribution is calculated with Hauser-Feshbach-Moldauer theory using the spherical optical model parameters of Madland and Young[5]. The direct process

contribution is calculated with the coupled-channels model using the deformed optical potential parameters proposed by Bruyères-le-Châtel group[6]. For the low lying levels in the rotational band which are strongly coupled, however, Engelbrecht-Weidenmüller transformation which is an extension of the Hauser-Feshbach theory at existing of strong absorption channels is applied below 1.2MeV. The direct process contribution for the vibrational band levels is produced with the coupled-channels model by using the respective band-coupling-strength β values which are obtained on the basis of the experimental level excitation cross sections near few MeV. The β values are consistent with the γ-ray transition probabilities obtained from Coulomb excitation experiments. The discrete levels are adopted below 1.29MeV and above it the excited levels are assumed to be overlapped. The final data installed in JENDL-3.2 is determined by adjusting the calculated results referring the experimental DDX and total (n,n') cross sections.

Discussion and Proposal

As the evaluators of the files have produced their own results on the individual guiding-principles as mentioned above, we should compare each other the data and methods used in their evaluations. To do this study, the coordinator proposes the following tasks.

(1) Inform the detailed evaluation procedures for the ^{238}U(n,n') cross section in every evaluated data files in writing to the coordinator. They will be distributed to the members of the subgroup as soon as he receives and be included in the final report as the appendices.

(2) After comparing among the evaluations on the basis of the information, the coordinator will work out the draft of the final report and distribute it to the members to exchange their views.

(3) The final report will be issued by the end of this October, on the coordinator's own responsibility.

References

[1] Y.Kanda,N.Fujikawa, and T.Kawano : "Database for ^{238}U inelastic scattering cross section evaluation", JAERI-M-93-205, (1993).

[2] T.Kawano et al.,Proc.Int.Conf.Nucl.Data for Sci. and Technol.,Gatlinburg,USA,May 9-13, 1994, p.652.

[3] Y.Kikuchi, ibid.p.685.

[4] M.Baba et al.,Nucl. Sci. Technol., 27, 601(1990)

[5] D.G.Madland and P.G.Young, Proc. Int. Conf.Neutron Phys. and Nucl. Data for Reactors and Other Applied Purposes, Harwell,UK, Sept. 25-29, 1978, 0.349.

[6] G.Haouat, et al. Nucl. Sci. Eng., 81, 491(1982)

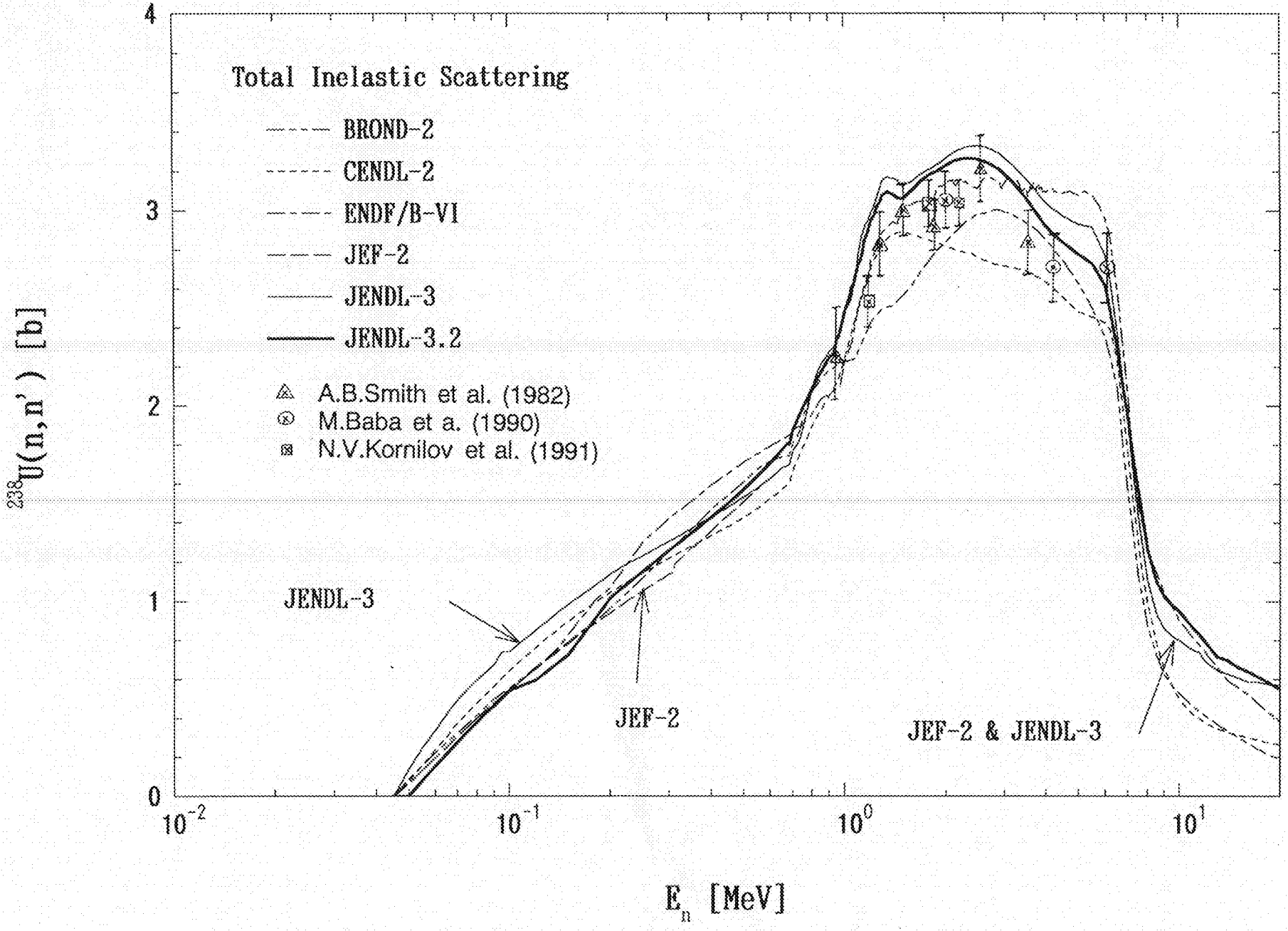

Fig.1 Comparisons of the data files and experiments of the Total inelastic scattering cross section.

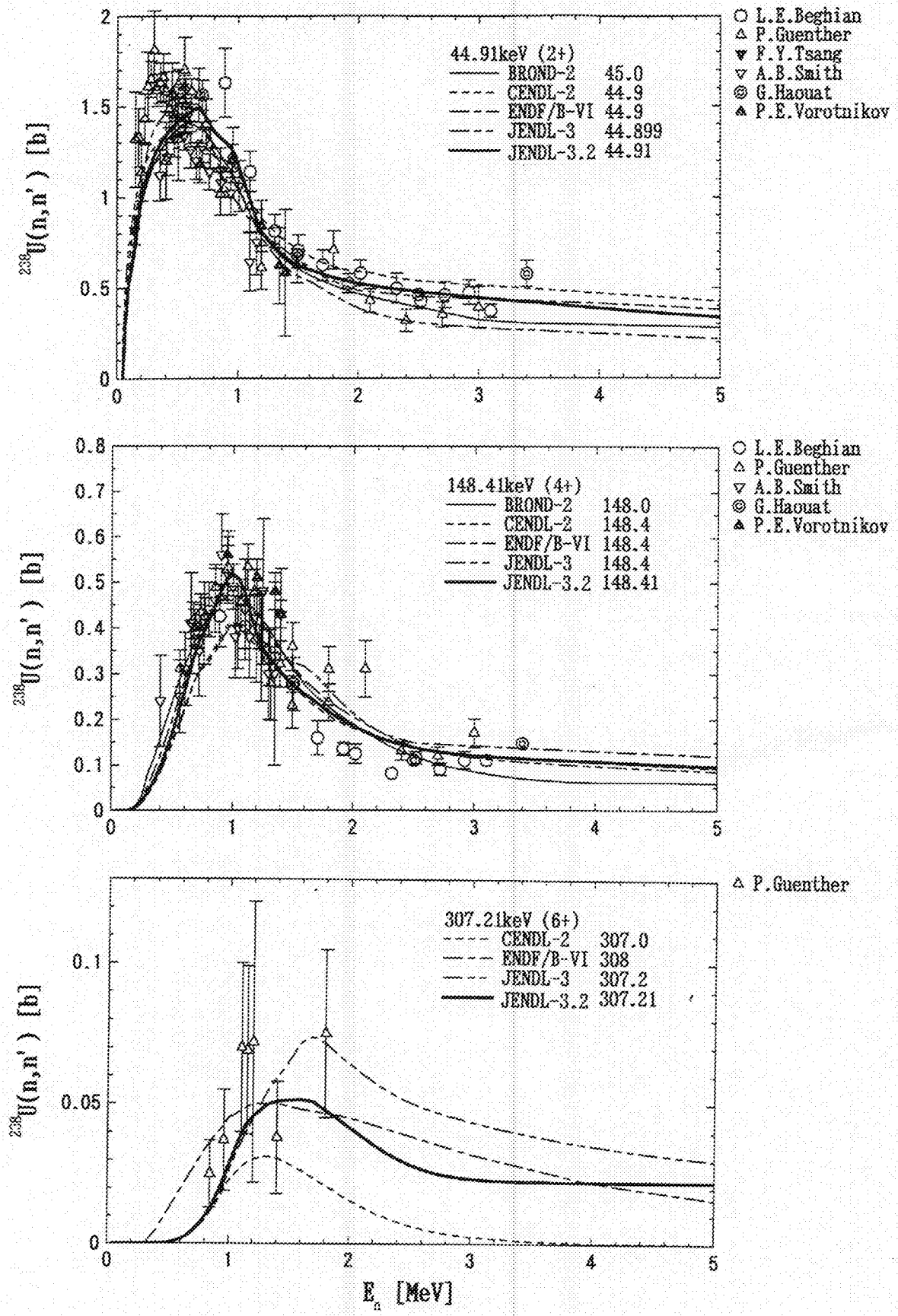

Fig.2 Comparisons of the calculated and the experimental inelastic scattering cross sections to the ground state rotational band levels.

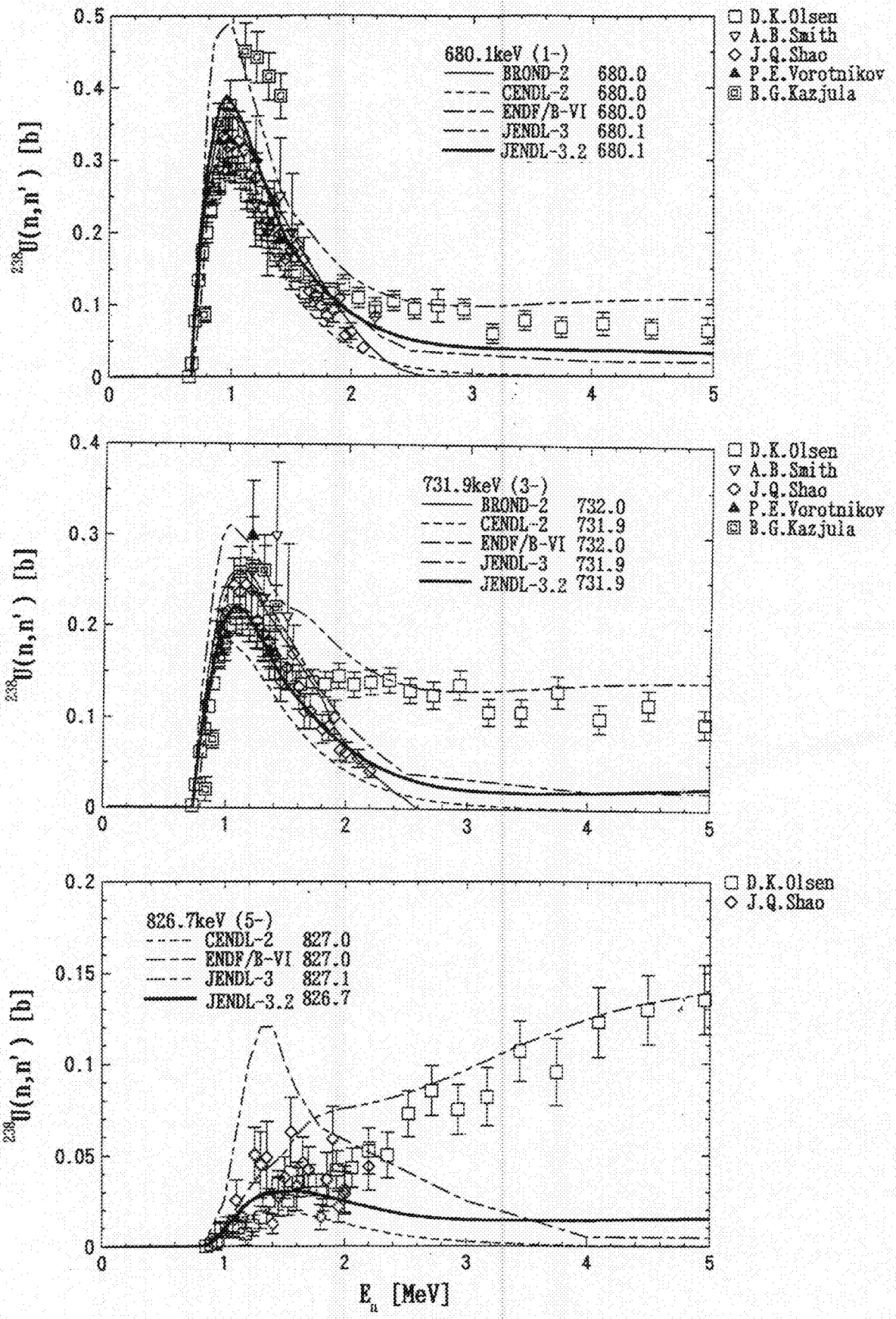

Fig.3 Comparisons of the calculated and the experimental inelastic scattering cross sections to the octupole $K^{\pi} = 0^{-}$ band levels.