Nuclear Data for the OMEGA Project

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In order to provide a reliable database for the OMEGA project, two types of the evaluated data files will be compiled at the JAERI Nuclear Data Center in cooperation with the Japanese Nuclear Data Committee. One is the JENDL Actinoid File which contains neutron induced-reaction data for about 90 actinoid nuclides, and the other is the JENDL High Energy File for neutron and protons up to a few GeV.

JENDL Actinoid File

The JENDL Actinoid File will be compiled to meet the data requirements for study of actinide burner reactors. This file will contain the data for about 90 nuclides from ^{208}Tl to ^{255}Fm, in the neutron energy region from 10^{-5} eV to 20 MeV. Table 1 shows the nuclides to be stored in JENDL Actinoid File. Among them, data for about 60 nuclides are already existing in JENDL-3.2. However, reevaluation is needed for data of important minor actinides. The new evaluation will be done for about 30 nuclides. In 1993, a new evaluation was made for ^{244}Pu and ^{237}Pu.[1)]

The neutron cross sections for the fission, (n,2n), (n,3n) reactions have been calculated[2)] consistently for 71 isotopes of $^{227-234}$Th, $^{229-233}$Pa, $^{230-240}$U, $^{235-239}$Np, $^{236-247}$Pu, $^{239-245}$Am, $^{238-251}$Cm, $^{245-249}$Bk and $^{249-252}$Cf using the Hauser-Feshbach code STAPRE[3)] and GNASH[4)]. Shell, superfluid and collective effects in nuclear level density have been taken into account. Neutron transmission coefficients were calculated using the coupled channel code ECIS[5)]. All experimental data available for the above isotopes have been used for model testing. A consistency between theoretical and experimental data was achieved, and the theoretical prediction of neutron cross sections has been made.

JENDL High Energy Files

JENDL High Energy Files will contain the data for neutrons and protons up to 50 MeV and those up to a few GeV. The former files are required for design of a material irradiation test facility for fusion neutronics, and the latter ones for an accelerator-driven radioactive waste transmutation system. The data up to 50 MeV are evaluated, mainly, by means of SINCROS-II system⁶⁾ based on GNASH⁴⁾, ELIESE-3⁷⁾, DWUCK-4⁸⁾ and auxiliary programs. For very light mass nuclei, another code will be used. High priorities are put on H, Li, C, N, O, Al, Si, Cr, Fe, Ni, Cu for the file of neutron-induced reactions, and Li, C, Al, Cr, Fe, Ni, Cu, Mo, W and Ta for proton-induced reactions. The evaluation will be completed at the end of 1995.

The evaluation of nuclear data up to a few GeV is based on the theoretical calculation, systematics of cross sections, and a fitting to available experimental data. The evaluation for H, ^{28,29,30}Si, ^{52}Cr, ^{58,60}Ni, ^{63,65}Cu, ^{208}Pb and ^{209}Bi has been completed already in the energy range up to 1 GeV. ALICE-F⁹⁾ was used for their theoretical calculation except for H. Figure 1 shows the ^{209}Bi(p,x)^{206}Po cross section.

In order to investigate an evaluation method for fissile nuclei, the intranuclear cascade-exciton model taking into account the fission process¹⁰⁾ was used for neutron and proton cross-section calculations in the energy range from 50 MeV to 1 GeV. The calculations showed that the experimental data available for ^{232}Th, ^{235}U, ^{238}U, ^{237}Np and ^{239}Pu for neutrons and protons can be reproduced rather accurately (within 5 to 10 %) by the adopted model which takes account of the fission barrier height values by Sierk¹¹⁾, level density systematics by Iljinov et al.¹²⁾ with ground state shell and pairing corrections by Truran et al.¹³⁾, and with taking into account $B_f(E^*)$ and $B_f(L)$ dependencies. Therefore the intranuclear cascade-exciton model was used for neutron and proton cross-section calculations for ^{232}Th, ^{232}Pa, ^{235}U, ^{238}U, ^{239}Pu, ^{237}Np, ^{238}Np, $^{241-243}$Am and $^{242-248}$Cm in the energy range from 100 MeV to 1 GeV. In the energy range from 20 to 100 MeV the GNASH code⁴⁾ which takes account of the decay of 9 subsequent compound nuclei was used for calculation of neutron fission and (n,xn) cross sections for ^{232}Th, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, $^{241-243}$Am and $^{242-247}$Cm. The fission and (n,xn) reaction cross sections of ^{239}Pu are given in Fig. 3.

Application of the quantum molecular dynamics (QMD) theory is also being investigated, and remarkable progress has been achieved.¹⁴⁾ A new code based on the QMD theory is under development in JAERI, and hopefully it may be a useful tool for high energy nuclear data evaluation. The double-differential cross section of ^{56}Fe(p,xn) at the proton energy of 1.5 GeV is compared with experimental data in Fig. 3. The solid curve shows the result of the QMD+statistic decay model, and the dashed one denotes a result of cascade+evaporation model code NUCLEUS¹⁵⁾. It was found that QMD gives almost identical results on the double-differential (p,xn) reaction cross sections with the conventionally used cascade model. The QMD, however, gives a better prediction of various isotope production cross sections.

References

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Table 1 Nuclides in JENDL Actinoid File

^{208}Tl	×	^{210}Pb	×	^{210}Bi	×
^{210}Po	×	^{222}Rn	×	^{223}Ra	J3
^{224}Ra	J3	^{225}Ra	J3	^{226}Ra	J3
^{228}Ra	×	^{225}Ac	J3	^{226}Ac	J3
^{227}Ac	J3	^{227}Th	J3	^{228}Th	J3
^{229}Th	J3	^{230}Th	J3	^{231}Th	×
^{232}Th	J3,A	^{233}Th	J3	^{234}Th	J3
^{229}Pa	×	^{230}Pa	×	^{231}Pa	J3
^{232}Pa	J3	^{233}Pa	J3	^{230}U	×
^{231}U	×	^{232}U	J3	^{233}U	J3,A
^{234}U	J3	^{235}U	J3,A	^{236}U	J3
^{237}U	J3	^{238}U	J3,A	^{234}Np	×
^{235}Np	×	^{236}Np	J3	^{237}Np	J3,B
^{238}Np	J3,B	^{239}Np	J3	^{236}Pu	J3
^{237}Pu		^{238}Pu	J3,B	^{239}Pu	J3,A
^{240}Pu	J3,A	^{241}Pu	J3,A	^{242}Pu	J3,B
^{244}Pu		^{246}Pu	×	^{247}Pu	×
^{241}Am	J3,B	^{242}Am	J3,B	^{242m}Am	J3,B
^{243}Am	J3,B	^{244}Am	J3	^{244m}Am	J3
^{240}Cm	×	^{241}Cm	J3	^{242}Cm	J3,B
^{243}Cm	J3,B	^{244}Cm	J3,B	^{245}Cm	J3,B
^{246}Cm	J3,B	^{247}Cm	J3	^{248}Cm	J3
^{249}Cm	J3	^{250}Cm	J3	^{245}Bk	×
^{246}Bk	×	^{247}Bk	×	^{248}Bk	×
^{249}Bk	J3	^{250}Bk	J3	^{246}Cf	×
^{248}Cf	×	^{249}Cf	J3	^{250}Cf	J3
^{251}Cf	J3	^{252}Cf	J3	^{253}Cf	J3
^{254}Cf	J3	^{251}Es	×	^{252}Es	×
^{253}Es		^{254}Es	J3	^{254m}Es	×
^{255}Es	J3	^{255}Fm	J3		

A: major actinide, B: important for the actinide burner reactor, J3: already in JENDL-3, ×: no evaluated data

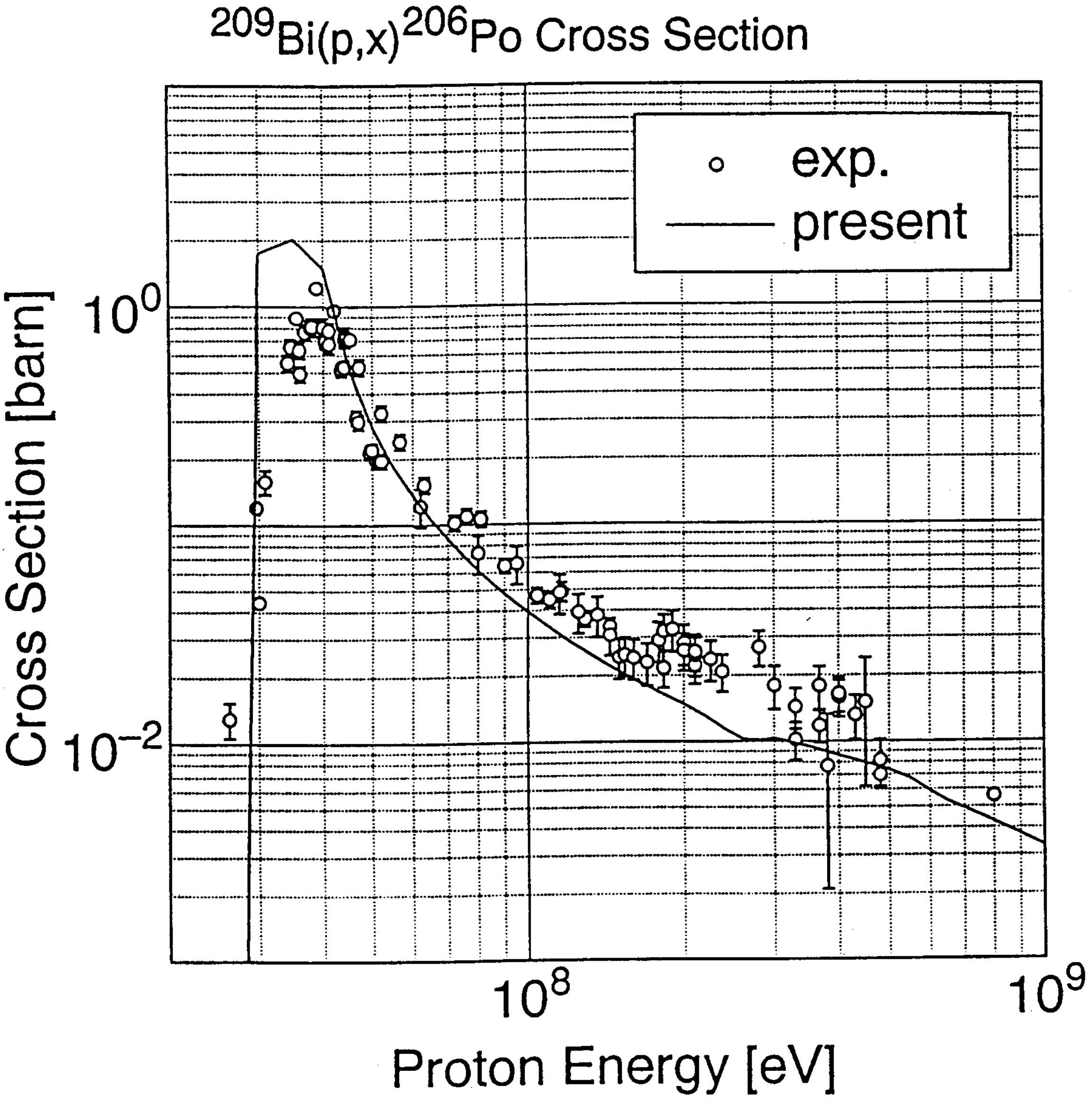

Fig. 1 ^{209}Bi(p,x)^{206}Po Cross Section

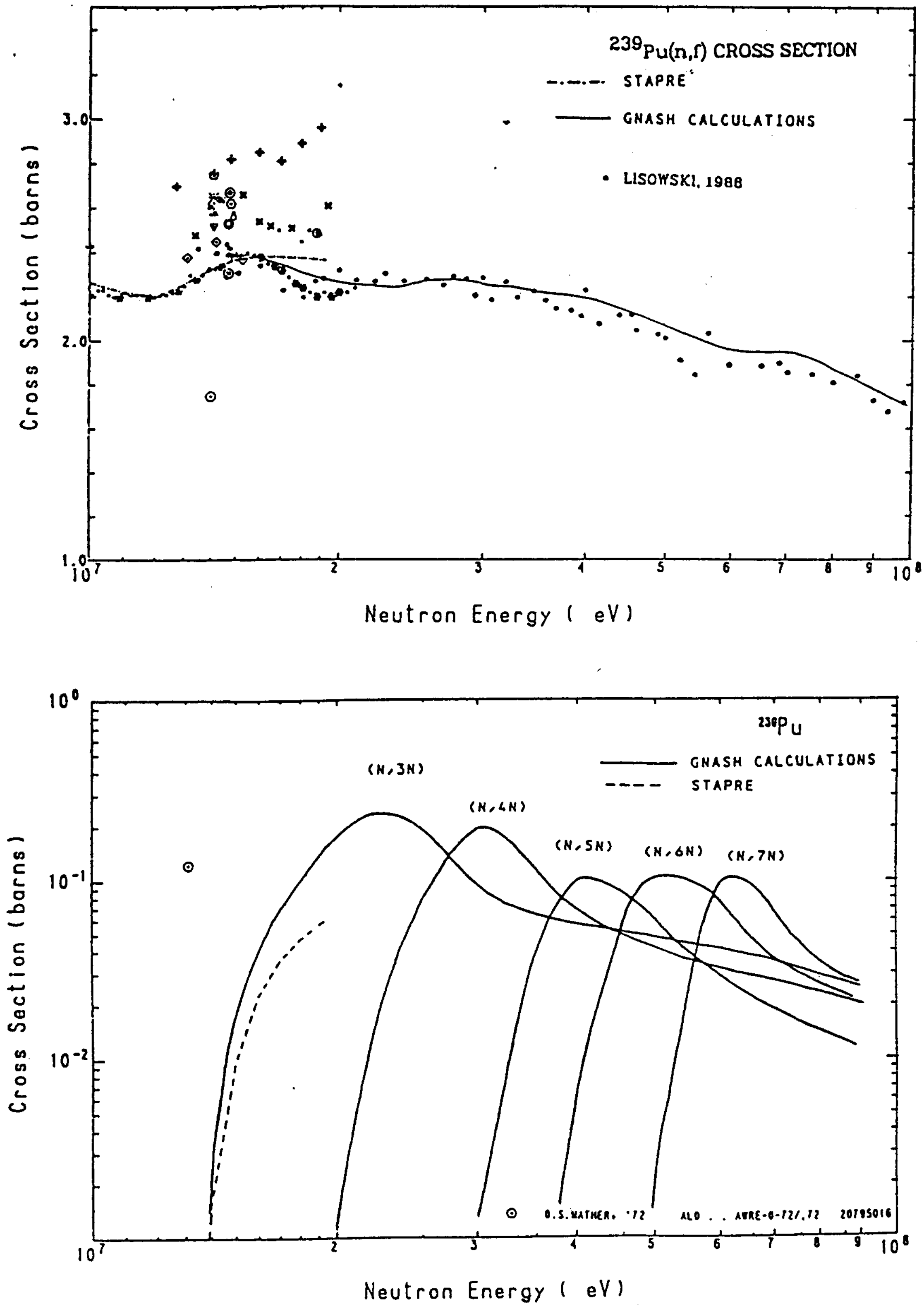

Fig. 2 ^{239}Pu fission and (n,xn) reaction cross sections.

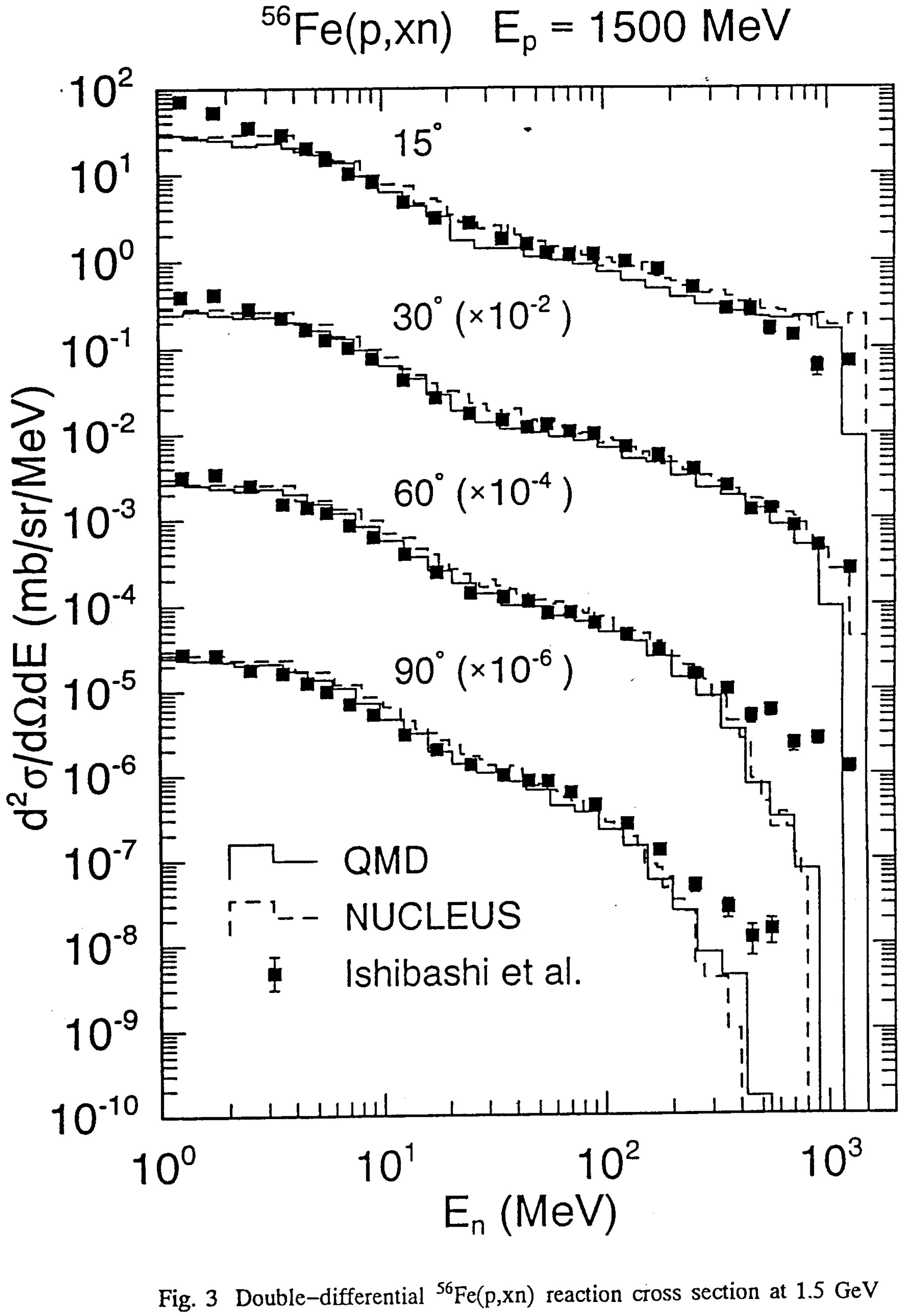

Fig. 3 Double-differential ^{56}Fe(p,xn) reaction cross section at 1.5 GeV