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РОЗРАХУНКИ ПЕРЕРІЗІВ (n, 2n) ТА (n, p) РЕАКЦІЙ ДЛЯ ЯДЕР ^{69,71}Ga І ^{75}As ДО 20 МеВ

Вивчалися перерізи нейтронно-індукованих реакцій ^{69,71}Ga(n, 2n), ^{69,71}Ga(n, p), ^{75}As(n, 2n) та ^{75}As(n, p) для енергій до 20 МеВ. Три теоретичних коди (EMPIRE 3.2, TALYS 1.6 і ALICE/ASH) використовувалися для модельних розрахунків на основі теорій Вайскопфа - Івінга і Хаузера - Фешбаха. Теоретичні розрахунки порівнювалися: з результатами, отриманими за деякими емпіричними формулами, розробленими в різних дослідженнях; з оціненими наборами ядерних даних (JENDL-4.0u2 (2012), TENDL-2015, JEFF-3.2 (2014), ENDF/B-VIII.0 (2018)); з наявними в літературі експериментальними даними.

Ключові слова: ядерні реакції, ^{69,71}Ga, ^{75}As, TALYS 1.6, EMPIRE 3.2, ALICE/ASH, поперечний переріз.

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РАСЧЕТЫ СЕЧЕНИЙ (n, 2n) И (n, p) РЕАКЦИЙ ДЛЯ ЯДЕР ^{69,71}Ga И ^{75}As ДО 20 МэВ

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Изучались сечения нейтронно-индуцированных реакций ^{69,71}Ga(n, 2n), ^{69,71}Ga(n, p), ^{75}As(n, 2n) и ^{75}As(n, p) для энергий до 20 МэВ. Три теоретических кода (EMPIRE 3.2, TALYS 1.6 и ALICE/ASH) использовались для модельных вычислений на основе теорий Вайскопфа - Ивинга и Хаузера - Фешбаха. Теоретические вычисления сравнивались: с результатами, полученными по некоторым эмпирическим формулам, разработанным в разных исследованиях; с оцененными наборами ядерных данных (JENDL-4.0u2 (2012), TENDL-2015, JEFF-3.2 (2014), ENDF/B-VIII.0 (2018)); с существующими в литературе экспериментальными данными.

Ключевые слова: ядерные реакции, ^{69,71}Ga, ^{75}As, TALYS 1.6, EMPIRE 3.2, ALICE/ASH, поперечное сечение.

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CROSS-SECTION CALCULATIONS OF (n, 2n) and (n, p) REACTIONS FOR ^{69,71}Ga and ^{75}As TARGET NUCLEI UP TO 20 MeV

In the present research, neutron induced reaction cross sections of ^{69,71}Ga(n, 2n), ^{69,71}Ga(n, p), ^{75}As(n, 2n) and ^{75}As(n, p) were investigated up to 20 MeV. Three theoretical calculation codes (EMPIRE 3.2, TALYS 1.6 and ALICE/ASH) were used for model calculations based on the Weisskopf - Ewing and Hauser - Feshbach theories. The results of theoretical calculations were compared with some empirical formulas developed by different researches, with evaluated nuclear data sets (JENDL-4.0u2 (2012), TENDL-2015, JEFF-3.2 (2014), and ENDF/B-VIII.0 (2018)) and also with the available experimental data found in literature.

Keywords: nuclear reactions, ^{69,71}Ga, ^{75}As, TALYS 1.6, EMPIRE 3.2, ALICE/ASH, cross section.

REFERENCES

1. E. Tel et al. The study of the (n, 2n) reaction cross-sections for neighbor deformed nuclei in the region of rare-earth elements. Acta Physica Slovaca 54(2) (2004) 191.
2. R.A. Forrest, J. Kopecky, Statistical analysis of cross sections – A new tool for data validation. Fusion Engineering and Design 82(1) (2007) 73.
3. S.L. Goyal, P. Gur. Empirical relation and establishment of shell effects in (n, 2n) reaction cross-sections at 14 MeV. Pramana - J. Phys. 72 (2009) 355.
4. E. Tel. Study on Some Structural Fusion Materials for (n, p) Reactions up to 30 MeV Energy. Journal of Fusion Energy 29 (2010) 332.
5. P. Collery et al. Gallium in cancer treatment. Crit. Rev. Oncol. Hematol. 42 (2002) 283.
6. H.S. Yu, W.T. Liao. Gallium: Environmental Pollution and Health Effects. In: *Encyclopedia of Environmental Health* (Burlington: Elsevier, 2011) p. 829.
7. K. Shibata et al. Evaluation of Neutron Nuclear Data on Arsenic-75 for JENDL-4. J. Nucl. Sci. Technol. 47(1)

(2010) 40.
8. M. Herman et al. EMPIRE-3.2 Malta modular system for nuclear reaction calculations and nuclear data evaluation. User's Manual, 2013. INDC(NDS)-0603, BNL-101378-2013.
9. A. Koning, S. Hilaire, S. Goriely. TALYS-1.6 A Nuclear Reaction Program. User Manual. 1-st ed. (NRG, The Netherlands, 2013).
10. C.H.M. Broeders et al. ALICE/ASH - Pre-compound and evaporation model code system for calculation of excitation functions, energy and angular distributions of emitted particles in nuclear reactions at intermediate energies. Report FZK 7183 (2006).
11. W. Hauser, H. Feshbach. The Inelastic Scattering of Neutrons. Phys. Rev. 87 (1952) 366.
12. H. Feshbach, A. Kerman, S. Koonin. The statistical theory of multi-step compound and direct reactions. Annals of Physics 125(2) (1982) 429.
13. R. Capote et al. RIPL – Reference Input Parameter Library for Calculation of Nuclear Reactions and Nuclear Data Evaluations. Nuclear Data Sheets 110 (2009) 3107.
14. A. Gilbert, A.G.W. Cameron. A composite nuclear-level density formula with shell corrections. Can. J. Phys. 43 (1965) 1446.
15. A. Iwamoto, K. Harada. Mechanism of cluster emission in nucleon-induced pre-equilibrium reactions. Phys. Rev. C 26(5) (1982) 1821.
16. A.J. Koning, J.P. Delaroche. Local and global nucleon optical models from 1 keV to 200 MeV. Nucl. Phys. A 713 (2003) 231.
17. A. Koning, D. Rochman. Modern Nuclear Data Evaluation with the TALYS Code System. Nuclear Data Sheets 113 (2012) 2841.
18. W. Dilg et al. Level density parameters for the back-shifted fermi gas model in the mass range 40 < A < 250. Nucl. Phys. A 217 (1973) 269.
19. C. Kalbach. Two-component exciton model: Basic formalism away from shell closures. Phys. Rev. C 33 (1986) 818.
20. M. Blann, H.K. Vonach. Global test of modified precompound decay models. Phys. Rev. C 28 (1983) 1475.
21. M. Blann. ALICE-91. Statistical Model Code System with Fission Competition. RSIC Code. PACKAGE PSR-146. 1991.
22. V.F. Weisskopf, D.H. Ewing. On the Yield of Nuclear Reactions with Heavy Elements. Phys. Rev. 57 (1940) 472.
23. D. Wilmore, P. E. Hodgson. The calculation of neutron cross-sections from optical potentials. Nuclear Physics 55 (1964) 673.
24. F.D. Bechetti, Jr., G.W. Grenlees. Nucleon-Nucleus Optical-Model Parameters, A > 40, E < 50 MeV. Phys. Rev. 182 (1969) 1190.
25. A. Aydin et al. A New Comparison of Empirical and Semi-empirical Formulae for the (n, ^{3}He) Reaction Cross-sections at 14 - 15 MeV. Journal of Fusion Energy 27(4) (2008) 314.
26. A. Aydin, E. Tel, A. Kaplan. Calculation of 14 - 15 MeV (n, d) Reaction Cross Sections Using Newly Evaluated Empirical and Semi-empirical Systematics. Journal of Fusion Energy 27(4) (2008) 308.
27. R. Doczi et al. Investigations on (n, p) cross sections in the 14 MeV region. IAEA Nuclear Data Section Report. INDC(HUN)-032, Distr. L. 1997.
28. A.Yu. Konobeyev, Yu.A. Korovin. Semi-empirical systematics of (n, 2n) reaction cross section at energy of 14.5 MeV. Nuovo Cimento A 112(9) (1999) 1001.
29. W.D. Lu, R.W. Fink. Applicability of the Constant-Nuclear-Temperature Approximation in Statistical-Model Calculations of Neutron Cross Sections at 14.4 MeV for Medium-Z Nuclei. Phys. Rev. C 4 (1971) 1173.
30. V.M. Bychkov et al. Cross sections for the (n, p), (n, α) and (n, 2n) threshold reactions. INDC (CCP)-I46/U. (IAEA, Vienna, 1980).
31. Y. Ikeda et al. Activation cross section measurements for fusion reactor structural materials at neutron energy from 13.3 MeV to 15.0 MeV using FNS facility. JAERI 1312,Tokai-mura (1988).
32. E. Tel et al. A New Empirical Formula for 14 - 15 MeV Neutron-Induced (n, p) Reaction Cross Sections. J. Phys. G: Nucl. Part. Phys. 29 (2003) 2169.
33. E. Tel et al. Semi-empirical systematics of (n, 2n), (n, α) reactions cross sections at 14 - 15 MeV neutron energy. International Journal of Modern Physics E 17 (2008) 567.
34. C. Konno et al. Activation cross-section measurements at neutron energy from 13.3 to 14.9 MeV. JAERI-Reports No. 1329 (EXFORCODE: #22637) (1993).
35. Y. Kasugai et al. Systematics for (n, p) excitation functions in the neutron energy between 13.3 and 15.0 MeV. Ann. Nucl. Ener. 23(18) (1996) 1429.
36. C.H.M. Broeders, A.Yu. Konobeyev. Semi-empirical systematics of (n, p) reaction cross-section at 14.5, 20, and 30 MeV. Nucl. Phys. A 780 (2006) 130.
37. EXFOR/CSISRS: http://www.nndc.bnl.gov/exfor/exfor00.htm
38. M. Bormann et al. Some excitation functions of neutron induced reactions in the energy range 12.6 - 19.6 MeV. Nucl. Phys. 63(3) (1965) 438.

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