CONTINIOUS SPECTRA OF LIGHT CHARGED PARTICLES FROM INTERACTION OF 30 MeV ENERGY PROTONS WITH COPPER

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The development of the new generation of nuclear energy systems with a high level of safety (Accelerator Driven System (ADS)), consisting of a proton accelerator, the neutron production target and sub critical reactor are deployed in many countries. At creation of such devices for correct modeling of the neutron flux the data on the spectral composition and angular distributions of secondary protons and light charged particles produced by primary proton beam are required. This work continues the series of investigations of double differential and integral cross sections for reactions on candidate nuclei for the structural elements of projected nuclear power plants.

The experimental data were obtained using 7 and 30 MeV proton beams from isochronous cyclotron U-150M (Fig.1), at the Institute of Nuclear Physics of Kazakhstan. Measuring-computing complex was adapted for the measurement of the inclusive spectra of protons and α-particles in the wide energy range of the emitted particles. The measurements of cross-sections of nuclear reaction products were carried out using a scattering chamber, equipped with a rotary spectrometer of charged particles, collimation system and the Faraday cup to measure the number of particles passing through the target. The aluminum was chosen as an object of investigation because it is a widely used constructional material in different nuclear plants. A self-supporting natural aluminum foil having thickness of 3.7 mg/cm^2 was used as target.

The secondary protons and α-particles were detected at angles from 30 to 135^o in steps of 15^o using a ΔE-E counter telescopes. The detection systems consisted of two double telescopes to detect the different secondary light charged particles. The Si-CsI telescope was mounted from 100 μm silicon detector and 25 mm E CsI scintillator to register secondary protons from p+^{27}Al reaction at 30 MeV proton energy. The Si-Si telescope was mounted from 30 μm silicon detector and 2 mm E silicon detector to register secondary protons from p+^{27}Al reaction at 7 MeV proton energy and secondary α-particles from at 30 MeV proton energy.

Systematic errors of measured cross sections were mainly due to the uncertainty in the thickness of the target determination (<5%), the current integrator calibration (1%) and the solid angle of the spectrometer (1.3%). The energy of the beam of accelerated particles was measured with an accuracy of 1.2%. The angle of the registration was recorded with an accuracy of 0.50. The total systematic error did not exceed 10%.

Angular integrated energy differential cross-sections of reactions ^{27}Al(p,xp) and (p,xα) averaged over 0.5 MeV are shown in Figures 2,3.

An analysis of the experimental results of reactions (p,xp) and (p,xa) on the nucleus ^{27}Al was done within the exciton model of decay of nuclei, which was a statistical approach able to describe the transition of the excited nucleus in equilibrium state. It was widely used in the interpretation of many experimental results. Theoretical calculations were carried out within the framework of the computer code PRECO-2006 [1], optimized for the case under consideration.

In addition to the exiton model, calculation based on quantum-mechanical theory of the preequilibrium decay have been carried out in frame of EMPIRE II code [2].

The comparison of theoretical and experimental integrated cross-sections of the reactions (p,xp) and (p,xa) on the nucleus ^{27}Al are presented in Figure 2-4.

Figure 1

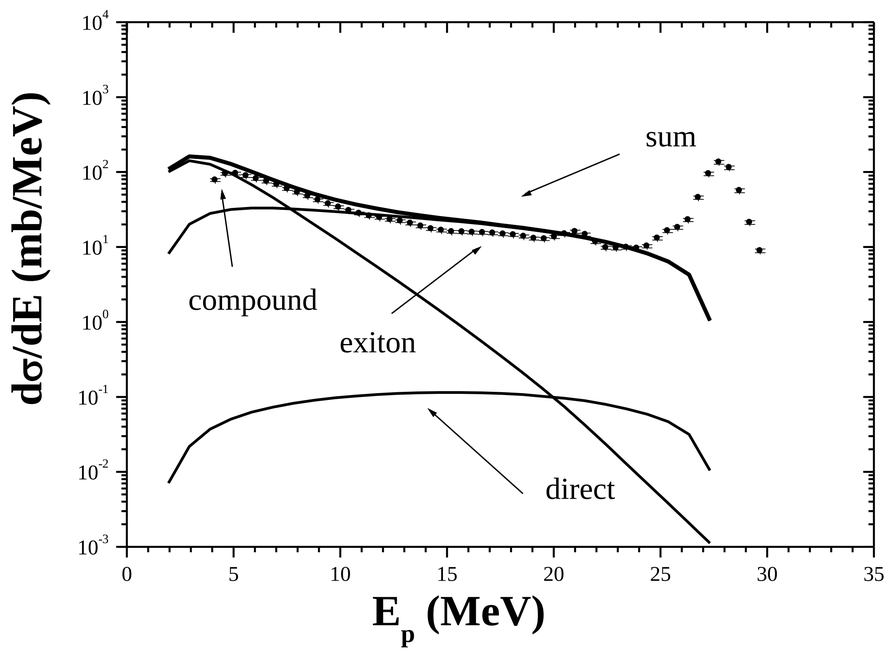

Figure 2. Comparison of experimental integral cross sections of reactions ^{27}Al(p,xp) at 30 Mev with the PRECO 2006 calculations

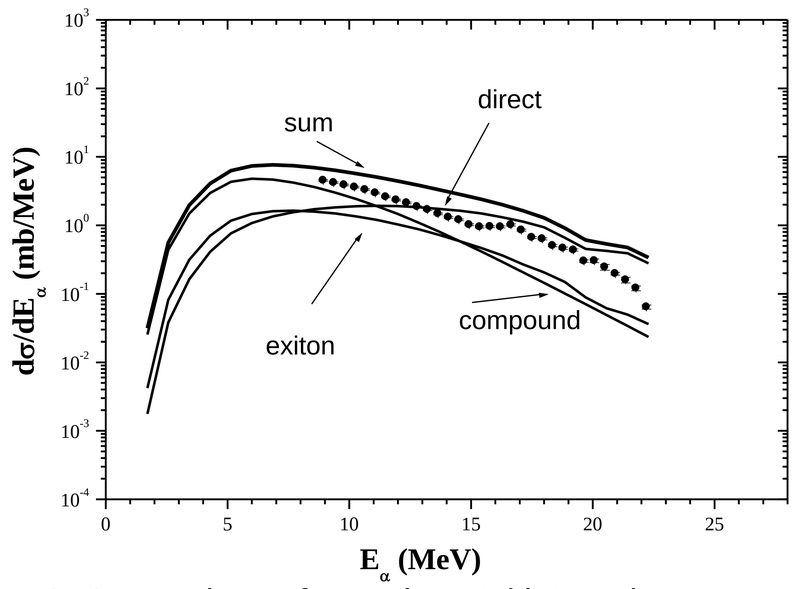

Figure 3. Comparison of experimental integral cross sections of reactions ^{27}Al(p,xα) with the PRECO 2006 calculations

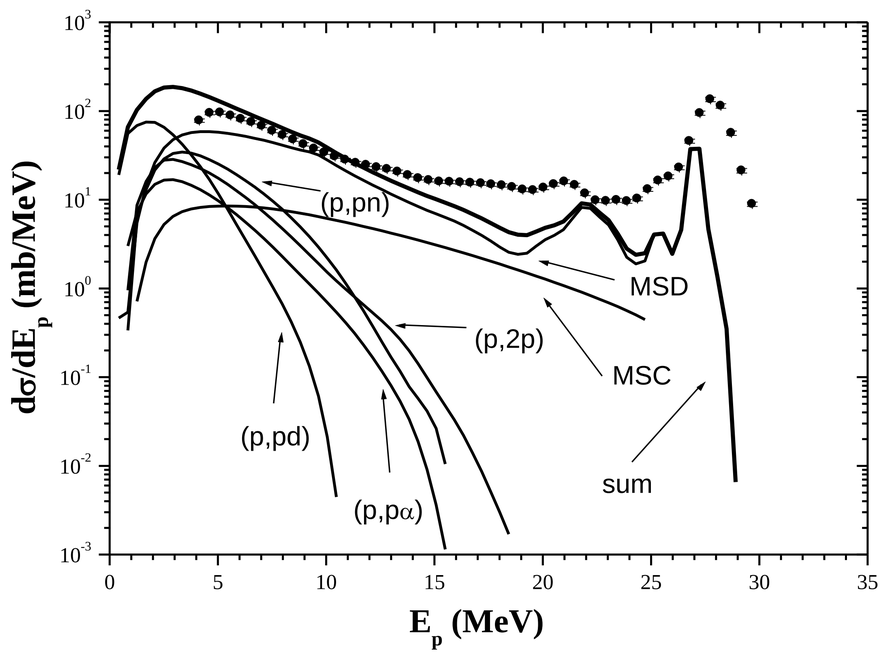

Figure 4. Comparison of experimental integral cross sections of reactions ^{27}Al(p,xp) with the EMPIRE II calculations

REFERENCES

1. Kalbach, C, PRECO 2006: Program for Calculating Pre Equilibrium and Direct Reaction Double Differential Cross Sections, Feb. 2006, no. LA 10248 MS.
2. M. Herman, G. Reffo and H.A. Weidenmuller, Nucl. Phys. A536 (1992) 124. EMPIRE v2.13.Private communication.