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Double (n-γ) and Triple (n-n'γ) Angular Correlations in Neutron Inelastic Scattering on 12C

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Understanding (n-γ) and (n-n'γ) correlations is crucial for analyzing inelastic neutron scattering processes and assessing the impact of direct and compound nucleus mechanisms on nuclear reactions. However, there are few experiments measuring (n-n'γ) correlations with 14 MeV neutrons, and most of these studies, conducted over 40 years ago, suffer from poor accuracy and limited angular range [1-5]. Recent measurements of (n-n'γ) correlations in the inelastic neutron scattering on ^{12}C [6] show discrepancies with earlier results. Therefore, obtaining data with better statistics and higher angular resolution is of great interest.

At the TANGRA facility in Dubna, an experiment is underway to measure angular correlations (n-n'γ) in the inelastic scattering of 14.1 MeV neutrons on ^{12}C using the tagged neutron method. The setup includes twelve 1-meter-long plastic scintillation detectors, each equipped with two photomultiplier tubes (PMTs). Ten detectors are positioned around the target in the reaction plane, while two are placed perpendicular to it. These detectors offer a time resolution of approximately 3 ns and a spatial resolution of about 20 cm, enhancing angular resolution and enabling the separation of gamma rays from neutrons based on their time-of-flight.

A theoretical approach is proposed to describe the double differential cross section of gamma radiation in inelastic neutron scattering. This approach considers the directions of the incident neutron, scattered neutron, and gamma quantum. It uses rotationally invariant functions of three vectors, as described in [7]. Our formula for angular correlations includes S-matrix elements, which can be obtained using the TALYS program for calculating nuclear reaction cross sections. Theoretical calculations were performed using the TalysLib library [8] to optimize the optical potential parameters. This was done to accurately describe the angular distribution of inelastically scattered neutrons.

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