# Analysis of the preequilibrium angular distributions in the 45-MeV $(p, n)$ reaction

Georgios Mantzouranis
*Max-Planck-Institut für Kernphysik, Heidelberg, West Germany*
(Received 9 July 1976)

We present a comparison between the angular distributions calculated from the generalized exciton model and recent experimental material for the 45-MeV proton induced $(p, n)$ reaction. A good description of the data is achieved.

[NUCLEAR REACTIONS $(p,nx)$; $E=45$ MeV; Calculations of the preequilibrium angular distributions and comparison with experiment.]

Recently neutron spectra resulting from bombardment of targets of $^{48}Ca$, $^{90}Zr$, $^{120}Sn$, and $^{208}Pb$ with 45 MeV protons have been measured at angles between 0° and 160°.[1] The comparison of the data with the intranuclear-cascade calculations shows a large disagreement at backward angles.[1] In this report we present an analysis of these data according to the generalized exciton model as it has been formulated in Refs. 2 and 3. This model is based on a quantum statistical master equation which describes the dissipation of the memory of incident direction.

The calculations were carried out in the manner

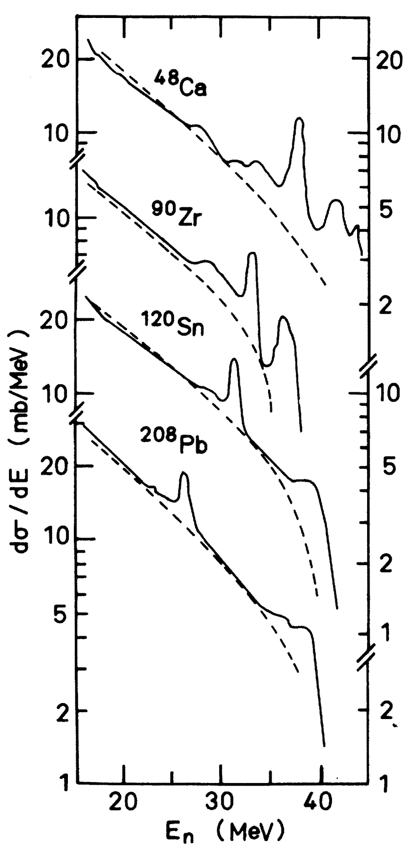


FIG. 1. The angle-integrated neutron spectra for 45 MeV protons. The dashed curves represent the calculations.

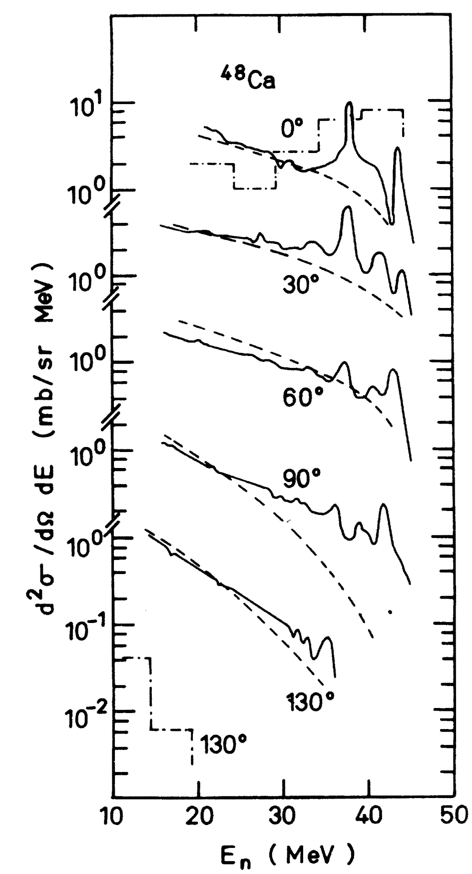


FIG. 2. Neutron spectra from $^{48}Ca$ at indicated angles. The dashed curves represent the calculations according to the generalized exciton model while the dot-dashed lines show the corresponding results using the cascade model (Ref. 1).

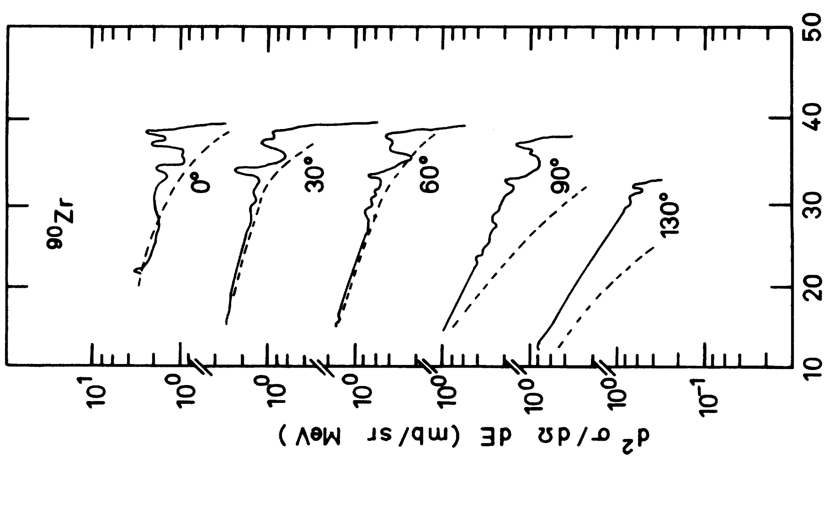


FIG. 3. Same as Fig. 2 but for $^{90}$Zr.

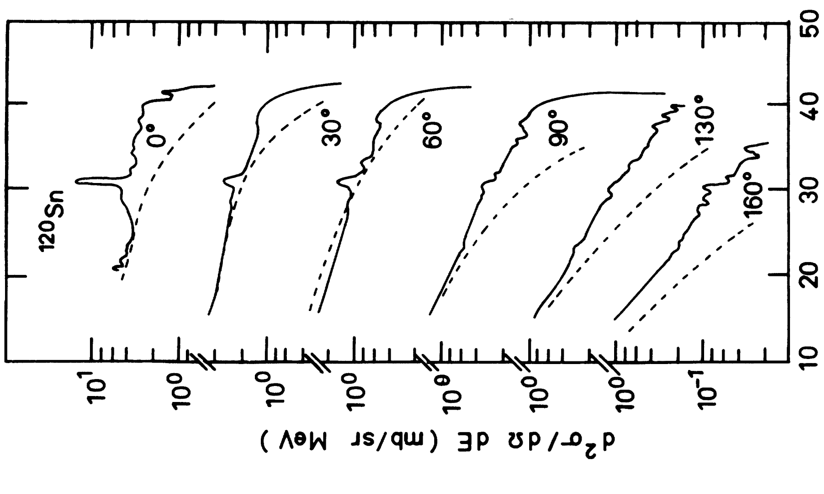


FIG. 4. Same as Fig. 2 but for $^{120}$Sn.

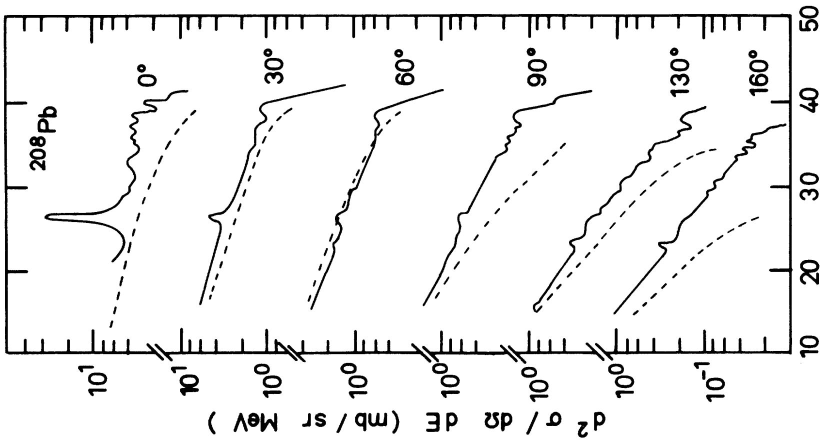


FIG. 5. Same as Fig. 2 but for $^{208}$Pb.

described in Ref. 3. The initial condition used was the (2p-1h) configuration with an angular dependence $\alpha \cos\theta\,[\theta < 90°]$. The free parameter in the exciton model which corresponds to the "mean-free path inside the nucleus" has been chosen so as to fit the measured value of the angle-integrated spectrum for (25–30) MeV outgoing neutrons. The results are shown in Fig. 1. The experimental data have structure (mainly the isobaric analog state), but the exciton model has no mechanism to reproduce such nuclear structure effects.

For the differential cross section $d^2\sigma/d\epsilon d\Omega$ there is no additional parameter in the model. The results are shown in Figs. 2–5. The agreement with experiment is in general good. For purposes of comparison we have also shown in Fig. 2 for the $^{48}$Ca($p,n$) reaction the results of calculations using the cascade model[1] at 0° and 130°. It is seen that the exciton model predicts too little intensity at backward angles, but there is, even in the most backward angles (160°), an order-of-magnitude agreement with the data in contrast to the cascade calculations. This conclusion also holds for the other targets for which the results taken from the generalized exciton model are shown in Figs. 3–5. The modification formulated in Ref. 3 of the over-simplified angular dependence of the initial condition which has been used in the present calculation would lead to an even better agreement with the data.

As already reported in Ref. 1 the Hauser-Feshbach contribution is very small at the energy region considered here. The most important contribution to the spectra at backward angles originates from the decay of the (3p-2h) configuration, and of more complicated states. These states are populated during the evolution of the system according to the master equation.[3]

Similar data exist for the same target nuclei but for lower bombarding energies, viz. 35 and 25 MeV.[4] The agreement of the generalized exciton model with these data is of the same quality as for the presented 45 MeV data.

The author is grateful to Dr. A. Galonsky for sending data prior to publication and to Professor H. A. Weidenmüller for a reading of the manuscript.

---

[1] A. Galonsky, R. R. Doering, D. M. Patterson, and H. W. Bertini, Phys. Rev. C 14, 748 (1976).

[2] G. Mantzouranis, D. Agassi, and H. A. Weidenmüller, Phys. Lett. 57B, 220 (1975).

[3] G. Mantzouranis, H. A. Weidenmüller, and D. Agassi, Z. Phys. A276, 145 (1976).

[4] R. R. Doering, A. Galonsky, D. M. Patterson, and F. E. Serr, Michigan State University Report No. MSUCP-29 (unpublished).