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DIRECT-INTERACTION CONTRIBUTIONS TO 3 Mev NEUTRON INELASTIC SCATTERING FROM Fe AND Pb

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RESEARCH CONTRIBUTION

Proposed Session No. 4 (Nuclear Reaction Mechanisms)

Title: Direct-Interaction Contributions to 3-Mev Neutron Inelastic Scattering from Fe and Pb

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Abstract:

The presence of direct interactions in neutron inelastic scattering appears to begin to contribute to the excitation of the first states in Fe^{56} and Pb^{206} at 3 Mev. The angular distributions show a small preference for forward-hemisphere scattering compared to symmetric distributions at 2.2 Mev. The direct-interaction theory is in qualitative (though not detailed) agreement with the nonsymmetric component.

DIRECT-INTERACTION CONTRIBUTION TO 3-Mev NEUTRON INELASTIC SCATTERING FROM Fe AND Pb

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The dominant reaction mechanism of neutron inelastic scattering on medium and heavy nuclei at intermediate energies is compound-nucleus formation and decay. For example, Rosen and Stewart[1] find for 14-Mev neutrons on bismuth and tantalum that only about 10 to 15% of the emerging neutrons can be attributed to direct interactions. These are the high-energy neutrons that populate the low-lying states in the nucleus.

A few experiments at low energies have been carried out.[2] In particular, for a bombarding energy of 2.2 Mev, Landon et al.[3] find that the angular distribution from the first excited state in Fe^{56} ($Q = -0.850$ Mev) is isotropic, and from Pb^{206} ($Q = -0.803$ Mev) is very nearly symmetric about 90 deg, both consistent with the statistical model of the compound nucleus. However, evidence has been cited,[4] suggesting a contribution from the direct reaction process to the neutron inelastic scattering from Pb^{206} at incident energies as low as 3 Mev. It was argued that the cross section for excitation of the 0.803-Mev state as a function of bombarding energy should reach a maximum just above threshold and then fall, because of the competition in the compound-nucleus decay provided by the large number of states that become accessible. (There are about 20 levels between 1.3 and 3.5 Mev.) However, the experimental evidence shows no indication of the expected fall-off.

This was interpreted as meaning that the direct-interaction process becomes increasingly important as the energy in increased, and sustains the cross section beyond the energy at which the compound-nucleus contribution is expected to decrease.

To test the conjecture that direct interactions are contributing to the 0.803-Mev level in Pb^{206} at a neutron bombarding energy as low as 3 Mev, one of us (L.C.) has measured the angular distribution of neutrons from this level.[5] The angular distribution indeed is forward peaked (see figure) in contrast with the very nearly symmetric angular distribution found by Landon et al.[3] at a slightly lower bombarding energy.

There does not exist a tractable theory for handling situations where the compound-nucleus and direct-interaction modes are both important. One can at best examine the predictions of the two theories as if both operated separately. The angular distribution at 2.2 Mev bombarding energy is symmetric,[3] consistent with the statistical theory, and with about the same ratio of $\sigma(180^\circ)/\sigma(90^\circ)$ as shown in the figure for 3-Mev bombarding energy; one is therefore tempted to attribute the extra scattering at forward angles to direct interactions. Indeed a calculation of the direct-interaction angular distribution based on the theory of Reference 4 yields an asymmetric angular distribution with a high forward cross section.

The cross section for excitation of the first excited state in Fe^{56} has also been measured. In this case slight forward peaking is observed, again in contrast with the results at 2.2 Mev, at which the cross section is isotropic. The direct-interaction theory predicts slightly stronger forward-hemisphere scattering, in qualitative agreement with the nonisotropic component of the observed cross section.

These results suggest that the direct-interaction mechanism for inelastic scattering from medium and heavy nuclei may be present at lower bombarding energies than had previously been contemplated.

REFERENCES

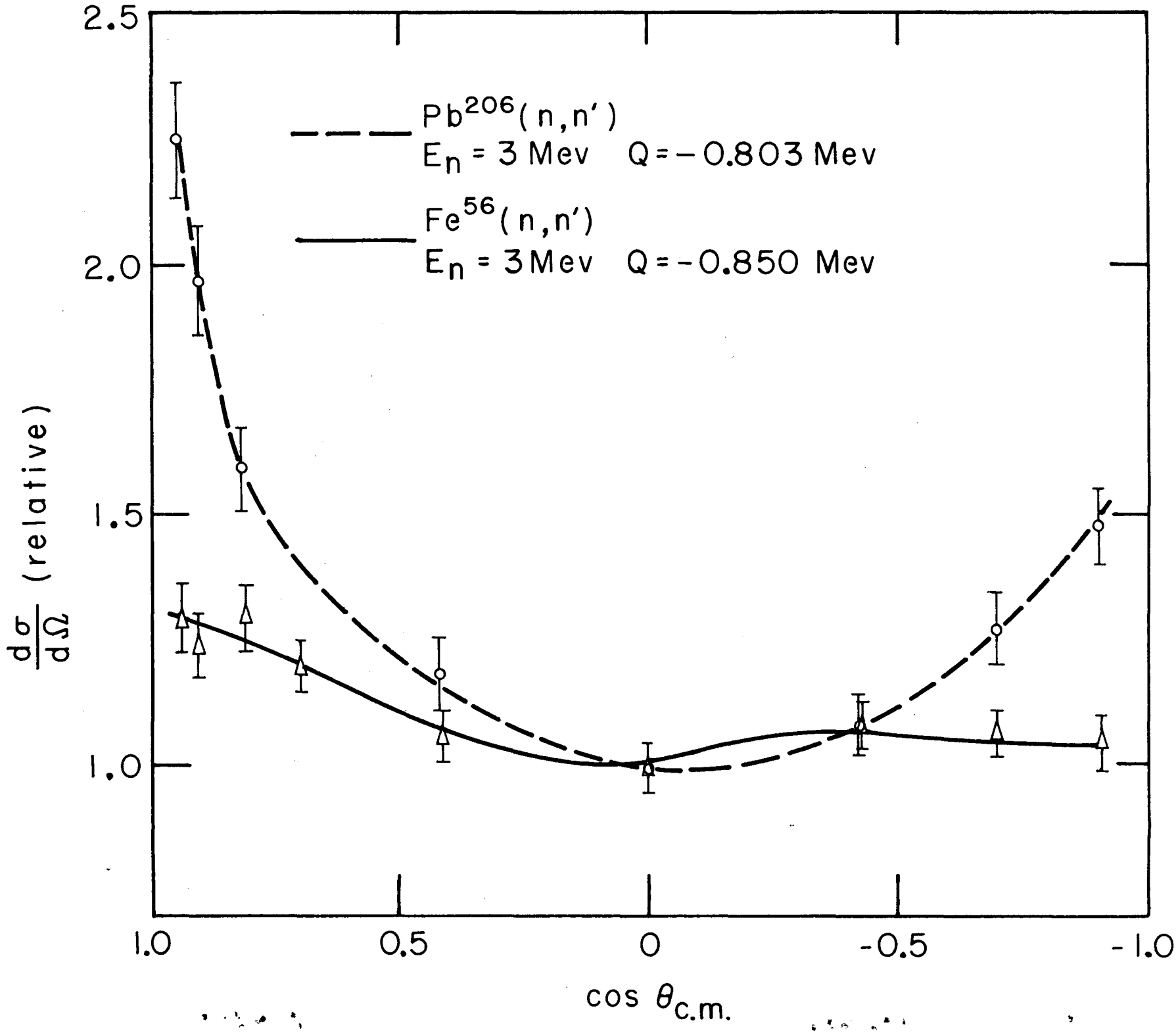
1. L. Rosen and L. Stewart, Phys. Rev. 107, 824 (1957).

2. L. Cranberg and J. S. Levin, Phys. Rev. 103, 343 (1956).

3. H. H. Landon, A. J. Elwyn, G. N. Glasoe, and S. Oleksa, Phys. Rev. 112 1192 (1958).

4. N. K. Glendenning, Phys. Rev. 114, 1297 (1959). See Section VII 6.

5. Details of the apparatus can be found in : E. R. Graves and L. Rosen, Phys. Rev. 89, 343 (1953); L. Cranberg, in Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955 (United Nationa, New York, 1956), Vol. 4, Paper P/577.


Pb206(n,n')
En = 3 Mev Q = -0.803 Mev
Fe56(n,n')
En = 3 Mev Q = -0.850 Mev
2.5
2.0
1.5
1.0
dσ/dΩ (relative)
1.0
0.5
0
-0.5
-1.0
cos θc.m.