Assignments of J^{π} in ^{58}Ni via (α,α') and (^{6}Li, d) reactions

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Measurements of ^{58}Ni$(\alpha,\alpha')^{58}$Ni angular distributions have been extended to small angles and disagreements between J^{π} assignments based on earlier (α,α') and (^{6}Li, d) measurements have been explained and resolved.

[NUCLEAR REACTIONS ^{58}Ni(α,α'), $E_{\alpha}=30$ MeV; measured $d\sigma/d\Omega$, deduced J^{π} for 5.59 and 6.02 MeV levels.]

It has been remarked[1] that the results of a study of the ^{54}Fe(^{6}Li, d)^{58}Ni reaction are inconsistent with the spin assignments of two levels of ^{58}Ni arrived at earlier via several studies of the ^{58}Ni$(\alpha,\alpha')^{58}$Ni reaction. In the case of the 6.02 MeV level the observed (α,α') angular distribution had been interpreted as indicating $J^{\pi}=3^{-}$.[2] However, the ^{54}Fe(^{6}Li, d)^{58}Ni reaction produced a clear $L=1$ angular distribution indicating a 1^{-} assignment.[1] In the case of the 5.59 MeV level, three different (α,α') results were available: Bruge *et al.*[2] assigned it $J^{\pi}=2^{+}$, Jarvis *et al.*[3] found $J^{\pi}=4^{+}$, and Inoue[4] suggested unresolved $J=4$ and $J=5$ levels. In this case the (^{6}Li, d) data were found consistent with $L=5$ or $L=6$.[1]

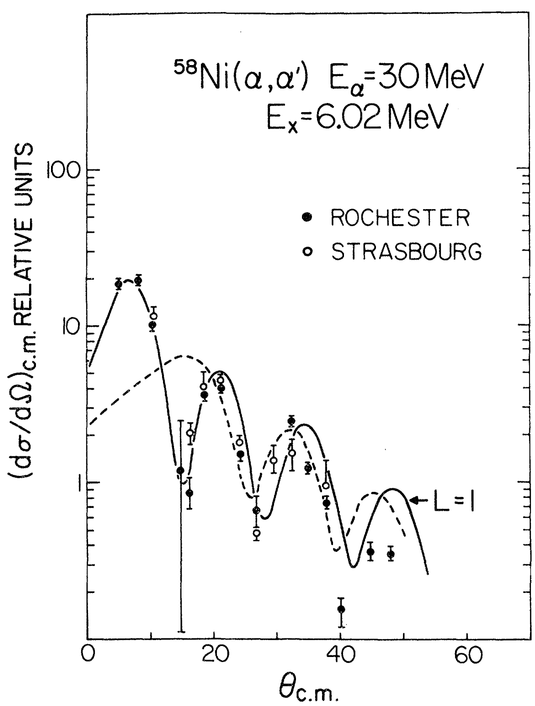

FIG. 1. Angular distribution for excitation of the 6.02 MeV state of ^{58}Ni. Curves: solid line zero-range DWBA with $L=1$; dashed line same, with $L=3$. The distinction between the curves is clear at angles less than 20°. The DWBA parameters used were Set 2 of Ref. 4.

In an attempt to resolve these disagreements we have made new (α,α') measurements (at 30 MeV), extending the angular distributions down to $\theta_{lab}=5°$. Two sets of measurements were made: the first at Strasbourg, with a Browne-Buechner magnet and photographic plate recording; the second at Rochester, with an Enge split-pole spectrometer and a spark counter data acquisition system.[5] The Strasbourg data were normalized to the Rochester data, angle by angle, usually via the strongly excited 4.475 MeV $J^{\pi}=3^{-}$ level, but when that line was saturated, via the 4.40 MeV

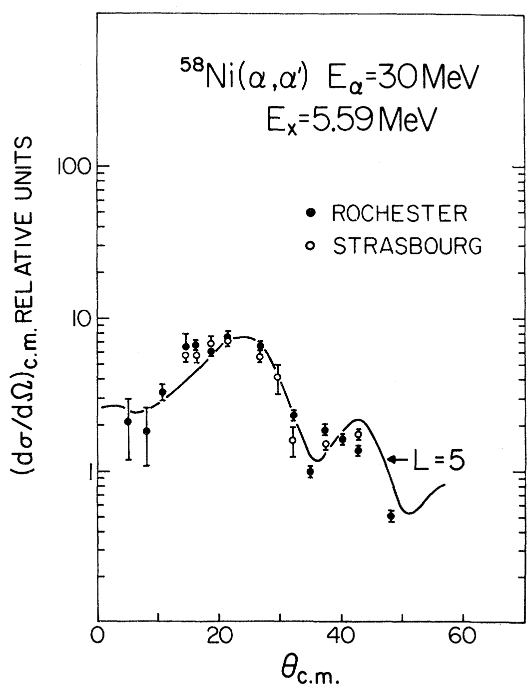

FIG. 2. Angular distribution for excitation of the 5.59 MeV level of ^{58}Ni. The curve: zero-range DWBA with $L=5$. (Same DWBA parameters as in Fig. 1.)

$J^\pi = 4^+$ level.

For the 6.02 MeV level the results in the region $\theta_{c.m.} < 20°$ (Fig. 1) are in excellent agreement with the $L = 1$ distorted wave Born approximation (DWBA) curve and in clear disagreement with the $L = 3$ curve, while in the region $\theta_{c.m.} \geq 20°$ a clear distinction is not seen. We conclude that the $J^\pi = 1^-$ assignment is correct and that the 3^- assignment was made erroneously because the data from the earlier (α, α') measurements did not go below about $\theta_{c.m.} = 18°$, hence did not allow unambiguous discrimination.

For the 5.59 MeV level the results (Fig. 2) are less striking. A fair fit is found with an $L = 5$ DWBA curve. No other L value gives a reasonably good fit. We conclude that if a single level is involved it must have $J^\pi = 5^-$. The possibility that another weakly excited level is present—perhaps with $J^\pi = 2^+$—is not excluded.

In summary, it has been shown that the (α, α') and $(^6$Li,$d)$ results are consistent with each other, that the 6.02 MeV level of ^{58}Ni has character 1^-, and that a level at 5.59 MeV has character 5^-. These results illustrate that the identification of 1^- states is much more readily made via $(^6$Li,$d)$ reactions (when they are possible) than via (α, α'), because of the distinctive character of the angular distributions from the former and because of the experimental difficulties usually encountered in making (α, α') measurements at small angles.

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