Comment on "Spin-Spin Dependence of Total Cross Sections as an Effect of Static Nuclear Deformation"

In a recent Letter,[1] Hnizdo and Kemper (HK) investigated the effect of static deformation of polarized target nuclei on total cross sections for polarized neutrons. They showed that coupling through the spin-orbit interaction leads to transfer of orbital angular momentum in elastic scattering if the polarized target nucleus is deformed and has spin $I > \frac{1}{2}$. This quadrupole reorientation (QR) effect gives rise to a spin-spin cross section, σ_{ss}, and HK state that QR alone, without any spin-spin potentials, leads to differences in $n_{pol} + {}^{27}Al_{pol}$ total cross sections having the magnitudes observed by us.[2] While this is an interesting effect, we point out here that it does not account for the spin-spin dependence we observed, and is also not as large as estimated in HK. Further, QR effects were implicitly included in our analysis with real and imaginary spin-spin potentials V_{ss} and W_{ss}, since QR is simulated by a predominantly imaginary spin-spin potential.

As is known from the theory of scattering, it is always possible to parametrize elastic scattering by potentials. The spin-spin components of these potentials will give rise to oscillatory behavior of σ_{ss} with energy. The zero crossings of σ_{ss} are determined by the strength and geometry of the total scattering potential, and will occur at quite different energies for $V_{ss} \neq 0$ compared to $W_{ss} \neq 0$. These features have been noted previously, even for situations involving deformed nuclei.[3,4]

The σ_{ss} value in our experiment[2] providing the strongest indication of nonzero V_{ss} is at 5 MeV, close to the maximum of sensitivity for $V_{ss} \neq 0$. This datum point is not reproduced in Fig. 1 of HK and was excluded from their comparison because of sensitivity to compound-nuclear (CN) effects. This is not valid. CN effects can be simulated by part of W_{ss}, and around 5 MeV σ_{ss} is insensitive to W_{ss}. To fit this point with only an imaginary potential would require $W_{ss} > 2$ MeV, leading to even larger σ_{ss} values at higher energies where there is no reason to believe that CN effects should be smaller.

Reference 4 in HK quotes quadrupole moments Q_2 for ^{27}Al of 15 and 38 e^2 fm^4. But two subsequent analyses[5] of the latter value reduced it to 15 e^2 fm^4, consistent with current compilations.[6] This is half the value used in HK, thus reducing the QR effect by a factor of 2.

The absorptive character of QR is seen by a comparison of Fig. 1 of HK with the $W_{ss} = -150$ keV curve of our Fig. 2. Both curves cross zero near 4 MeV and reach maxima between 8 and 10 MeV. This suggests that the QR mechanism is associated mainly with spin-dependent removal of flux, that is, with W_{ss} rather than with V_{ss}. To construct a potential which approximates QR effects, one can use methods developed for calculating dynamic polarization potentials in heavy-ion scattering.[7] The conclusion of this analysis (to be described in detail elsewhere) is that, as in Ref. 7, nuclear quadrupole coupling produces a predominantly absorptive potential which falls off with distance much more slowly than its real part.

In conclusion, HK have uncovered an interesting mechanism whereby some of σ_{ss} is generated by the interplay of spin-orbit forces and nuclear deformation. This mechanism contributes primarily to W_{ss}, however, and its effects on σ_{ss} can be distinguished from that of V_{ss} by energy dependence.

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