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Analysis of 1^+ excitations in ^{16}O with polarized protons inelastic scattering reaction

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Nuclei ^{16}O have closed shells in LS scheme and shouldn't have 1^+ excitations. Nevertheless there are at least three excitations of these type observed in (p,p'γ), (e,e') and (p,p') reactions at energies 16.22, 17.14 and 18.79 MeV. Also there are three analog states in ^{16}N and ^{16}F nuclei. It is needed to include in valence space at least $1p_{1/2}$ and $1d_{5/2}$ shells in spherical shell model to produce such excitations. Due to correlations in the ground state the level $1p_{1/2}$ becomes only partly packed. Probability that both proton and neutron occupy the $1p_{1/2}$ shell for such limited valence space is only about 70 percent. Excitation of 1^+ levels is the result of reorientation of spins of protons and neutrons in $1p_{1/2}$ and $1d_{5/2}$ shells. It is supposed that these levels have isospin equal to 1 as we see analog levels in the adjacent nuclei.

We made shell model calculations for different valence spaces including $1p_{1/2}$-$1d_{5/2}$-$2s_{1/2}$ space, $1p_{1/2}$-1d-2s space and 1p-1d-2s space. Also different hamiltonians were used. The best result we got for the $1p_{1/2}$ -1d - 2s valence space and an unsatisfactory result for thd 1p-1d -2s valence space. Meanwhile even for the $1p_{1/2}$ -1d - 2s valence space we got only qualitative description of the energies of excitations and the reduced probabilities of radiation excitation of these levels. Also the theory predicts more 1^+ levels then have been observed in the experiments.

Excitations 1^+ in nuclear are characterized by spin and current transition densities which are different for different levels. Inelastic electron scattering excite both but inelastic proton scattering at zero degree excite mainly spin degrees of freedom. Comparing these two types of 1^+ levels excitation we can deduce the role of spin and current degrees of freedom in every excitation. Unfortunately, the accuracy of this method is not too high. In this work we study the influence of the type of excitation (spin or orbital) on the characteristics of the polarization of the inelastically scattered protons at small angles, precisely on the diagonal coefficients of depolarization. For such unnatural parity excitations the sum of this coefficient at zero angle is nearly equal to one: $D_{LL} + D_{NN} + D_{SS} \approx -1$. Also $D_{NN} = D_{SS}$, but the ratio D_{NN}/D_{LL} is different for different excitations. We inverstigate the dependence of the value of this ratio on the type of the excitaion.
emphasized text

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