Comment on "Signature of a πNN Resonance in Pionic Double Charge Exchange at Low Energies"

In a recent Letter Bilger, Clement, and Schepkin [1] proposed the existence of a very narrow ($\Gamma \approx 5$ MeV) isospin-0 πNN resonance with a mass of 2065 MeV and quantum numbers $J^P = 0^-$ in order to explain a peculiar structure observed in double charge exchange cross sections in several nuclei from ^{12}C to ^{48}Ca. In this Comment we want to point out that on the basis of our calculations of the πNN system [2], a 0^- resonance with isospin 0 is not possible. We also want to suggest that if the observed structure in nuclei is real, it could be due to either a 0^- or a 2^- isospin-2 resonance for which there are good indications in our calculations.

We investigated in Ref. [2] the bound state and resonance problem of the πNN system in the various channels with isospin 0 and 2 for $J \leq 2$, taking into account all the relevant NN and πN two-body partial waves (we included all the two-body channels with $J \leq 2$). As we have demonstrated in Ref. [2], the behavior of the coupled NN-πNN system in the channels with isospin 0 is basically determined by the pion-nucleon interaction in the P_{11} partial wave which contains the nucleon pole. In particular, this interaction determines that the NN $^1P_1$ channel is repulsive and the NN $^3D_2$ channel is weakly attractive as inferred also from the low-energy NN phase shifts. The P_{11} interaction also determines that the NN $^3S_1$-$^3D_1$ channel has a bound state (the deuteron) whose wave function comes out very similar to that of phenomenological models (like the Paris potential) including its behavior at short distances.

Furthermore, we found that the 0^- state with isospin 0 is extremely weak [2] (as well as repulsive) and therefore it cannot support a πNN resonance close to threshold like the one proposed in Ref. [1]. This is due to the fact that for the 0^- channel the dominant P_{11} interaction cannot contribute as a consequence of the Pauli principle. If one decomposes the P_{11} amplitude into its pole and nonpole parts [3], the pole part can be identified as a nucleon and therefore if taken together with the spectator nucleon they will be in a Pauli forbidden state. Thus, only the nonpole part contributes; but this part of the P_{11} amplitude is negligible [3]. Consequently, the P_{11} interaction does not contribute and the 0^- channel is extremely weak.

The situation of the πNN channels with isospin 2, on the other hand, is quite different. In this case the dominant interaction is the pion-nucleon P_{33} partial wave that contains the delta resonance. It was shown in Ref. [2] that the 2^- channel is the most likely candidate to have a resonance near threshold, but also the 0^- channel indicates the possibility of a resonance (see Fig. 4 in Ref. [2]). The masses of the resonances with isospin 2 cannot be predicted by the three-body model since they are very sensitive to the range of the pion-nucleon P_{33} interaction in momentum space which can essentially be chosen arbitrarily still being consistent with the two-body data [2]. What is, however, predicted by the three-body model are the rather small widths of the resonances lying close to the three-body threshold [2]. The resonance suggested by Bilger, Clement, and Schepkin lies 47 MeV above the πNN threshold and has a width of only 5 MeV. From the results of Ref. [2] for πNN resonances with isospin 2 we deduce that a resonance with a mass of 47 MeV above threshold will have a width of between 3 and 5 MeV [see the discussion after Eq. (34) in Ref. [2]] which is precisely the size of the width of the resonance proposed by Bilger, Clement, and Schepkin.

Bilger, Clement, and Schepkin [1] have pointed out that the 0^- resonance has to have isospin even (in order to avoid that it decays into two nucleons) and they assumed $I=0$, being supported by a QCD string model calculation [4]. However, the results of our calculation, which is based in mesons and nucleons, suggest that the choice $I=2$ is the appropriate one. Notice that according to the curves shown in Ref. [1], the 2^- resonance predicted by our model will also be a good candidate to explain the peculiar energy dependence of the double charge exchange reaction at $\theta = 5°$. In Ref. [1], they argued that resonances with spin 2 should be ruled out since they produce angular distributions that fall off faster by 2 orders of magnitude between $\theta = 0°$ and $\theta = 70°$ as compared to the angular distribution shown by the data. However, in the forward direction and in particular at $\theta = 5°$, the resonance with spin 2 gives rise to very similar results as the resonance with spin 0 (see the dashed curves in Fig. 2 of Ref. [1]). It should be kept in mind that the signature of a resonance is not the angular distribution but a sharp energy dependence at a fixed angle like the one observed in the data at $\theta = 5°$.

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