Contribution ID: **149** Type: **online talk**

Possible ΣNN Resonant States

Wednesday 29 June 2022 17:45 (15 minutes)

A recent JLab experiment exploiting the ^{3}H(e,e'K$^+$)$^3_\Lambda$n reaction to investigate the existence of a threshold $^3_\Lambda$n resonance that would place constraints on the Λn scattering length, observed a structure in the spectrum that was interpreted to be a ΣNN resonance [1,2]. Such a ΣNN resonance could have isospin T=0 or T=1. Garcilazo argued in 1987 on the basis of rank-one separable potentials that no T=2 ΣNN bound state or resonance should exist [3]. Stadler et al. later demonstrated that there was little possibility of a T=2 bound state or narrow resonance based on the Juelich one-boson exchange potential [4]. However, continuum Faddeev calculations were needed to address the existence of T=0 and T=1 ΣNN resonance states.

In 1993 Afnan et al. found that a near threshold T=0 resonance should exist while exploring Λd elastic scattering on the basis of a separable potential model of the ΛN-ΣN coupled channel interaction [5]. Later, Garcilazo et al. utilizing a separable potential approximation to a chiral constituent quark model of the hyperon-nucleon interaction, concluded that the T=0 and T=1 spin-1/2 channels of the ΣNN system were the only attractive channels which might support near threshold resonances, the T=1 channel being the more attractive [6]. In 1992 Barakat et al. had attempted to observe a ΣNN resonance in an experiment at BNL in which a ^{3}He(K$^-$,π^+) in flight K$^-$ beam was used [7]. No quasibound structure appeared in the spectrum. However, Harada et al. [8] performed a distorted wave impulse calculation in 2014 which reproduced the Barakat ^{3}He(K$^-$,π^+) spectrum with no evidence of a resonance, but their model results did indicate that a T=1 resonance should be seen in a ^{3}He(K$^-$,π^-) in flight experiment.

Because the ^{3}H(e,e'K$^+$)ΣNN electro-disintegration reaction should produce both T=0 and T=1 resonances, if they exist, we have revisited our Λd elastic scattering calculation and confirmed our results for the T=0 ΣNN resonance in our s-wave separable potential calculation. In addition we have located the T=1 ΣNN resonance pole in our model. In our calculation the two poles are quite close to one another in terms of the real part of the energy. In contrast to the calculation by Garcilazo et al., our T=0 channel is the more attractive. Thus the details of the theoretical hyperon-nucleon interactions matter. However, based upon the two Faddeev-type calculations, it seems fair to say that the T=0 and T=1 resonances are likely to lie close to one another, and it will be difficult to say explicitly from the existing data[1,2] what is the resonance content of the observed structure in the spectrum. We should note that when we expanded our separable potential model to include a tensor force in the NN spin-triplet interaction, the pole position
of the T=0 resonance was little changed, as one would anticipate, whereas the T=1 resonance showed less attraction. Unfortunately, we do not have a tensor force to include in the ΣN interaction.

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Session Classification: 3; Wed-IVb