TRINUCLEON BOUND STATE PROPERTIES AND FORM FACTORS WITH THE B.K.R. POTENTIAL

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The triton binding energy, S' - and D-state probabilities are determined using the B.K.R. potential. Neglecting mesonic corrections, the charge and magnetic form factors are computed for ^3H and ^3He. They show a diffraction minimum at $q^2 = 14.4\ fm^{-2}$.

Recently, much progress has been made in solving the three-body problem, especially as applied to the three-nucleon system, either by starting from the Faddeev equations, by using variational techniques or by making expansions to 'angular harmonics' [1]. One of the reasons for doing these three-nucleon calculations is to have a possible way to distinguish between two-body potentials which produce identical on-shell behaviour. One step in this direction was the use of very elaborate interactions such as the Hamada-Johnston (HJ) [2] or the Reid soft-core potential (RSC) [3] as input in the three-nucleon system [4, 5]. These potentials fit equally well the nucleon-nucleon phase shifts and have the same long range behaviour prescribed by one-pion exchange, but they differ in the repulsive core region. In order to gain more insight in the role and the character of this inner region one could compare three-nucleon observables calculated with several realistic potentials, which possess in different ways repulsion (hard-core, soft-core, flat-core, non-local, boundary condition).

In this note we present results obtained with the Faddeev equations for the ^3H and ^3He ground state using the Bressel-Kerman-Rouben (BKR) potential [6] which is essentially the same as the HJ-potential except that the hard core is replaced by a finite square well of larger radius (0.7 fm). Since the BKR-potential was given in coordinate representation and we needed it in momentum representation for our calculations, we performed numerically the necessary Fourier transforms. As a check of this procedure we recalculated the singlet and triplet phase shifts and found good agreement with the quoted values of ref. [6].

Retaining only s-waves for the singlet and s- and d-waves for the triplet channel, the Faddeev equations reduce to a coupled set of three integral equations in two continuous variables. For details we refer to ref. [5]. Using a simple iterative method [7] for solving the resulting equations we calculated the binding energy and the wave function of the triton-ground state.

In table 1 we present our results for the ^3H-ground state energy E_T, the S'- and D-state probabilities and the rms charge- and magnetic-radii of ^3He and ^3H. A first and interesting conclusion is the fact that the triton binding energy

Table 1
Triton binding energy $E(^3H)$, S'-probability $P(S')$, D-state probability $P(D)$ and charge- and magnetic radii for ^3He and ^3H.

Quantity	Calculated
$E(^3H)$	-6.2 ± 0.2 MeV
$P(S')$	1.4 %
$P(D)$	7.8 %
$\langle r^2\rangle^{\frac{1}{2}}_{ch}$ (^3He)	2.09 fm
$\langle r^2\rangle^{\frac{1}{2}}_{mag}$ (^3He)	2.13 fm
$\langle r^2\rangle^{\frac{1}{2}}_{ch}$ (^3H)	1.87 fm
$\langle r^2\rangle^{\frac{1}{2}}_{mag}$ (^3H)	2.02 fm

for the BKR-potential is almost the same as that calculated for the RSC- and HJ-potentials [4, 5]. Also in view of the fact that these potentials have similar D-state probability, it is tempting to suggest that for a given deuteron D-state probability as far as the binding energy is concerned it is difficult to dinstinghuish between local potentials for which the repulsion starts at about the same core radius but which have different forms in the inner region. In order to obtain agreement with experiment the contributions from relativistic effects [8] and three-body forces [9] should add as much as ~ 2 MeV to the calculated binding energy. These contributions will also affect the wave function [10] but since estimates, especially for the three-body interactions and their specific form are very crude we will not consider them here. The other three-nucleon observables (table 1) also agree quite well with those obtained with the RSC- and HJ-potentials.

Recent experiments [11] on the charge- and magnetic form factors of ^{3}He show a diffraction minimum at $q^2 = 11.6$ fm^{-2} followed by a secondary maximum at 18 fm^{-2}. It is clear, as already shown by different calculations, that the position of the dip at these high q^2-values is a very sensitive parameter for the nucleon-nucleon interaction in the repulsive core-region. Model calculations [12] and other ones for the RSC- [13] and HJ-potentials [10] show that the position of the minimum varies between 12 fm^{-2} and 17 fm^{-2} depending on the repulsive character of the interaction. In order to test the BKR-potential also for this particular feature the charge- and magnetic form factors were calculated up to 20 fm^{-2}. The wave function used for these calculations was determined in the same way as described in ref. [13] by dropping the d-wave matrix elements of the two-body T-matrix in the Faddeev equation. As a result of this simplification the triton binding energy was found to be 6.5 MeV while $P(\mathrm{S}') = 1.8\%$. The results of the form factors are shown in fig. 1 and 2 together with the experimental points. We found a dip at about 14.4 fm^{-2} in the ^{3}He charge form factor *. Also the secondary maximum was produced which however has insufficient intensity similarly as found in the case of the HJ- and RSC-potential. It is clear from a comparison with the ^{3}He results for the HJ- (minimum at q^2 = 12.6 fm^{-2}) and the RSC-potential (minimum at q^2 = 17 fm^{-2}) that one cannot simply increase the thickness of the repulsive core but one has also to consider the very nature and strength of the

*This is in qualitative agreement with the result obtained by McMillan [14].

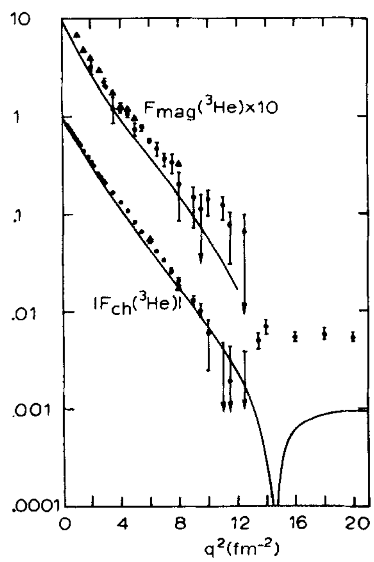

Fig. 1. The calculated charge- and magnetic form factors for ^{3}He together with the expermental points given in ref. [11] and [15].

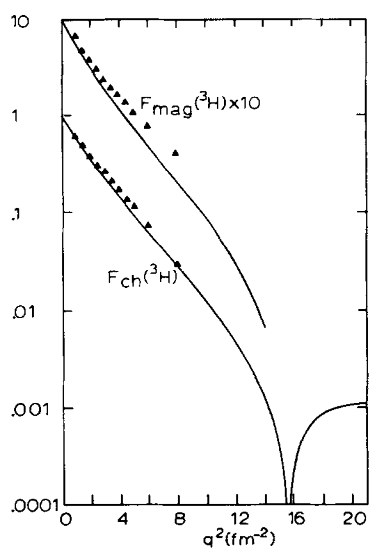

Fig. 2. The calculated charge- and magnetic form factors for ^{3}H together with the expermental points given in ref. [15].

repulsion, together with reliable estimates for mesonic corrections.

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