ELECTROMAGNETIC PROCESSES IN THREE-NUCLEON SYSTEMS *

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Abstract: Electromagnetic processes associated with the three-nucleon systems are discussed with an emphasis on recent developments. These include the asymptotic behavior of the $^3\text{He}$ charge form factor, electro- and photo-disintegrations and the electric dipole sum rule for total photo absorption cross-sections.

1. INTRODUCTION

In this talk, a brief review of what we have learned so far about the structure of three-nucleon systems from the electromagnetic processes will be presented with emphasis on recent developments. For most of the previous work on the subject several review papers are available. 1)

For a theoretical model of three-nucleon systems, we choose the non-relativistic quantum theory with a "realistic" nucleon-nucleon static potential which has the one-pion-exchange (OPE) tail and which fits most of the two-nucleon data. The accuracy of such non-relativistic model calculations, based upon either the Faddeev equations or variational method, has now nearly approached that of two-nucleon calculations.

With "realistic" two-nucleon potentials, the Faddeev calculations yield $7 \sim 7.6$ MeV for the binding energy of $^3\text{H}$, compared to the experimental value of $8.5$ MeV. The discrepancy of $1 \sim 1.5$ MeV could be attributed to a combination of several different effects such as the neglect of three-nucleon forces, the on-shell and off-shell variations of the assumed two-nucleon interactions (including in particular tensor force which determines the deuteron D-state probability), relativistic kinematic corrections and the validity

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of a non-relativistic model with a static two-nucleon potential. Certainly, these questions have to be investigated carefully not only for the binding energy discrepancy but also for other properties which are sensitive to these effects.

The $^3\text{H}-^3\text{He}$ binding energy difference, $\Delta E = |E(^3\text{H}) - E(^3\text{He})|$, is experimentally 764 keV. A large fraction of this is the Coulomb energy, $\Delta E_C$, estimated to be $\Delta E_C = 638 \pm 17$ keV\(^2\) from the charge form factors of $^3\text{H}$ and $^3\text{He}$. Other electromagnetic corrections bring the value of $\Delta E_C$ up to $683 \pm 29$ keV\(^3\). The remaining energy difference $81 \pm 29$ keV may be attributed to strong charge-symmetry breaking two- and three-nucleon interactions. (See for details Sauer’s and Phillips’ talks in this Proceedings.)

The calculated probabilities of the trinucleon wave-function components appear to be very similar regardless of the different realistic two-nucleon potentials used. Typically, these calculations give $P(S) \approx 90\%$ (probability of the symmetric S-state), $P(S') \approx 1 \sim 2\%$ (probability of the mixed symmetry S-state), $P(D) \approx 8 \sim 9\%$ (probability of the D-state) and a very small probability of less than 1\% for the P-state.

In section 2, the electromagnetic form factors of $^3\text{He}$ extracted from the elastic electron scattering are discussed, including the new SLAC data for the $^3\text{He}$ charge form factor\(^5,6\). The asymptotic behaviors of the $^3\text{He}$ charge form factor as predicted by several models are compared with the new experimental data. The $^3\text{He}$ magnetic form factor for momentum transfer $q^2 \lesssim 21$ fm\(^{-2}\) is also discussed in this section. In section 3, electrodisintegrations of $^3\text{H}$ and $^3\text{He}$ are discussed with the purpose of investigating the possibility of extracting the neutron electric form factor. The two-body photodisintegration at higher energies is considered in section 4.

Section 5 deals with the recent work on the electric dipole sum rule for $^3\text{He}$ and $^3\text{H}$ associated with total photoabsorption cross-sections. Short concluding remarks are made in section 6.