Experiments at MIT-Bates(I. Nuclear Physics)

著者	Tamae T.
journal or publication title	核理研研究報告
volume	33
page range	48-50
year	2000-12
URL	http://hdl.handle.net/10097/30978

Experiments at MIT-Bates

T. Tamae

Laboratory of Nuclear Science, Tohoku University, Mikamine, Taihaku-ku, Sendai 982-0826

We have been collaborating with a group of University of Massachusetts since 1988 for experiments at MIT-Bates. Bates Experiment #89-09 (Measurement of the Elastic Magnetic Form Factor and the Threshold Breakup of ^{3}He at High Momentum Transfer) was accepted in 1989 and performed in 1997. Data analysis of the experiment was completed using one and a half years. A new proposal, Bates-Experiment #97-03 (Virtual Compton Scattering on the Proton Below Pion Threshold) has been scheduled in the early summer of 2000.

I. Bates Experiment #89-09 Measurement of the Elastic Magnetic Form Factor and the Threshold Breakup of ^{3}He at High Momentum Transfer[1]

The ^{3}He elastic magnetic form factor was measured at five different momentum transfers between $Q^2 = 5.75$ and $42.6\ \mathrm{fm}^{-2}$; the two highest points are in the unexplored region. The experiment was performed at the MIT-Bates Linear Accelerator Center using a 1% duty-factor electron beam and a high-density cryogenic ^{3}He gas target. Scattered electrons were detected with a magnetic spectrometer (OHIPS) at a scattering angle of 160°. The ^{3}He target system was operated at a temperature of 23 K and a pressure of 50 atm. The length of the target cell was 19.6 cm. The spectrometer detector system consisted of two layers of vertical drift chambers for tracking, a gas Cherenkov detector and a lead-glass shower counter for particle identification, and three layers of plastic scintillators for triggering and timing.

Figure 1 compares our magnetic form factors to previously published values; Coulomb contributions were assessed from the sum-of-Gaussian fit to published results. The new data at $Q^2 = 18.8$ and $21.8\,\mathrm{fm}^{-2}$ agree with existing data, which consequently strengthen the conclusion that the diffraction minimum lies close to $Q^2 = 18\,\mathrm{fm}^{-2}$. In contrast, data at $Q^2 = 36.3$ and $42.6\,\mathrm{fm}^{-2}$ appeared considerably smaller than what would be anticipated by extrapolating the existing Saclay results. The calculations represented in Fig.1 are by Hadjimichael *et al.* [1], Marcucci *et al.*[2], and Strueve *et al.*[3], as well as by impulse approximation (IA).

In calculations without non-nucleonic effects, a diffraction minimum of the squared magnetic form factor $|F_M(Q^2)|^2$ of ^{3}He due to a destructive interference between S- and D-state components of the

[1]Collaboration: Tohoku University (I. Nakagawa, T. Suda, T. Tamae), University of Massachusetts (J. Shaw, S. Churchwell, X. Jiang, B. Asavapibhop, M.C. Berisso, P.E. Bosted, K. Burchesky, R.S. Hicks, A. Hotta, R.A. Miskimen, G.A. Peterson, S.E. Rock, K. Wang), MIT-Bates (F. Casagrande, W. Turchinetz), University of Virginia (A. Cichocki), Teikyo University (T. Kobayashi)

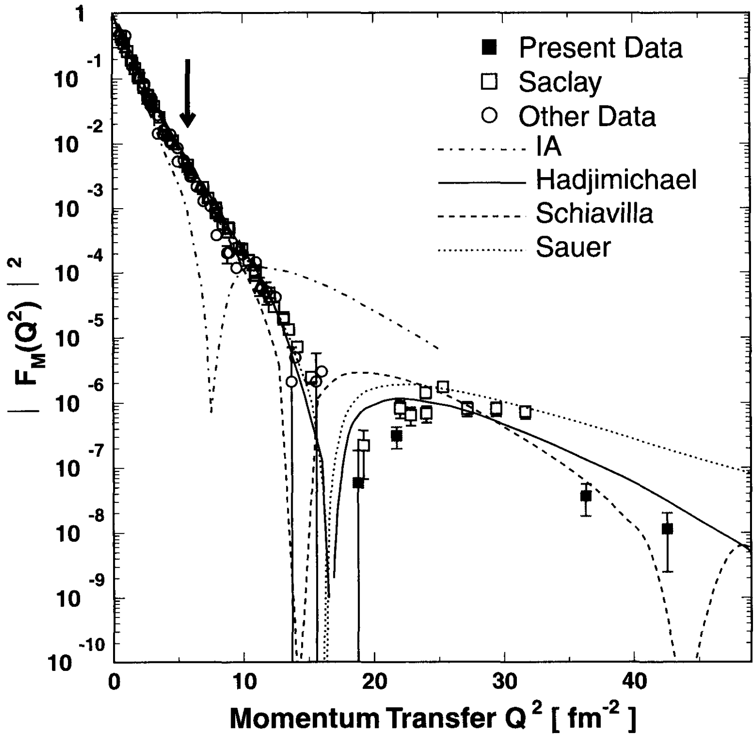

Fig.1. The elastic magnetic form factor of ^{3}He. Present results are represented by solid squares, Saclay data [4] by open squares, and other data [5] by open circles. The arrow indicates our measurement at $Q^2 = 5.75$ fm^{-2}.

ground state wave function lies near $Q^2 = 8$ fm^{-2}, in striking disagreement with the experimental results. A dramatic upward shift in Q^2 is qualitatively explained by calculations that include meson-exchange and Δ-isobar currents. Significant differences are observed in the various theoretical predictions at $Q^2 \geq 30$ fm^{-2}. For the high momentum transfers probed in this experiment, the theoretical results are sensitive to the non-nucleonic effects, and also to the assumed form of the nucleon form factor. The calculation by Marcucci *et al.* predicts the first diffraction minimum at too low Q^2. The trend of the calculation by Strueve *et al.* is to overestimate the high Q^2 results by an order-of-magnitude. This may be due to the large Δ-isobar component in the model. Although the prediction of Hadjimichael *et al.* remains close to the experimental results for $F_M(Q^2)$ throughout the entire Q^2 range, the Coulomb form factor of ^{3}H calculated by this group lies far from the data. In conclusion no existing theoretical calculation satisfactorily accounts for the available data of the both trinucleons ^{3}H and ^{3}He.

In the kinematical region spanned by our data there is mounting theoretical evidence of the need to consider relativistic dynamics and quark-gluon degrees-of-freedom. Additional incentive for further theoretical developments is provided by a planned experiment [6] at Jefferson Laboratory that seeks to measure the ^{3}He magnetic form factor out to $Q^2 > 60$ fm^{-2}.

References

[1] E. Hadjimichael, B. Goulard, and M. Bornais: Phys. Rev. C**27** (1993) 831.

[2] L.E. Marcucci, D.O. Riska, and R. Schiavilla: Phys. Rev. C**58** (1998) 3069.

[3] W. Strueve, Ch. Hajduk, P.U. Sauer, and W. Theis: Nucl. Phys. **A465** (1987) 651.

[4] J.M. Cavedon *et al.*: Phys. Rev. Lett. **49** (1982) 986.
A. Amroun *et al.*: Phys. Rev. Lett. **69** (1992) 253 ; Nucl. Phys. **A579** (1994) 596.

[5] H. Collard *et al.*: Phys. Rev. **138** (1965) B57.
M. Bernheim *et al.*: Lett. Nuovo Cimento **5** (1972) 431.
J.S. Mc Carthy *et al.*: Phys Rev. C**15** (1977) 1396.
P.C. Dunn *et al.*: Phys. Rev. C**27** (1983) 71.
C.R. Ottermann *et al.*: Nucl. Phys. **A436** (1985) 688.
D.H. Beck *et al.*: Phys. Rev. Lett. **59** (1987) 1537.

[6] G.G. Petratos *et al.*: JLab proposal E89-021.