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学位論文題目	THE PHOTOPION PRODUCTION IN THE ^{3}He AND ^{3}H (ヘリウム3とトリトンにおけるπ中間子の光生成)
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論文目次

論 文 内 容 要 旨

The photopion production of ^{3}He (γ,π^+) ^{3}H has been described by the PWIA so far. But the disagreement between the theoretical and experimental estimation has been remained unsatisfactory, especially in the region over the $\triangle$ resonance due to the disregard of the FSI.

It is necessary to treat the full rescattering processes microscopically to desribe the FSI in photopion production of few-nucleon system. But it is not only too troublesome due to the complexity of processes, but also the convergence of the rescattering series is not guaranteed. Moreover, in the $\triangle$ resonance region the validity of the perturbation expansion expansion may be doubtful because of the large coupling constant of $\triangle$.

Therefore we have calculated the reaction using two kinds of optical potentials. One is the SMC optical potential and the other is the Kim's potential. As for the large angle in elastic pion scattering, the calculated results using these optical potentials are inferior to the results by other theoretical optical potentials. But in the angular region where we are interested in for the reaction of ^{3}He (γ,π^+) ^{3}H, we are convinced from our results of pion scattering that these optical potential are eligible for use in this reaction.

Our results using the DWIA give significant improvements to the theoretical results calculated by the PWIA. Also our results show that we should not be free from the consideration of the $E_{1+}(3/2)$ contributions as well as FSI in the description of the small pion angular region as in the elementary case. The effect from $E_{1+}(3/2)$ contribution is manifest in low momentum transfer as in $Q^2=1.0$ and 0.48 fm^{-2} of Fig.1.

The $\triangle$-h approach has been known to be very successful for the description of the photopion reaction of p shell nuclei where the resonant reaction is dominant. But in the reaction where the non-resonant reaction becomes dominant, it has the uncertainty in multipole amplitude's transformation from on-mass shell to off-mass shell as in the CGLN method. The strong interference of the non-resonance and resonance part makes the application of $\triangle$-h concept unsatisfactory in this reaction.

And we proposed that the polalized photon beam might be suitable to the separation of non-resonance and resonance reaction and the polalized target with polalized photon beam may be an interesting method of the suppression of the $\vec{\sigma}\cdot\vec{\epsilon}$ term. The supression is very useful in studying the secondary important interaction term. It may render a useful key to further understanding of the electro-magnetic structure of the three body nucleus.

On the other hand, the EPM is very intuitive and simple model for the photopion production of ^{3}He and ^{3}H, since the three-body nucleus have the same quantum number as the nucleon. But the primitive EPM calculation which used the PV Born terms as the photopion production amplitude fails to reproduce the experimental results, because the PV Born terms amplitude do not incorporate the structure of nucleus. PV Born terms (or BL Born terms) was very successful as the elementary amplitude for the IA of nucleus photopion production, because in the case of nucleon the t dependence in form factors is small. But in the case of the nucleus, since the spatial extension influences on the t dependence of form factors because of large β_i (i=V, M, A, P) (for example, β_A in the three body nucleus is about ten times to β_A in nucleon), we cannot be free from considering the form factor dependence. This failure in usual EPM lead us to present a model which can consider the form factor dependence positively.

Our-current algebra model have the reasonable dependence of form factors and it has shown a good agreement with the experimental results above threshold as in shown in Fig. 2. Going to the higher incident energy region, the contribution from △ resonance plays a very important role. We have to have information about form factors wherein one of nucleons in nucleus have changed into △. By the dispersion theory, basically, it is possible, but in EPIA one needs the wave function with the 2N+△ component.

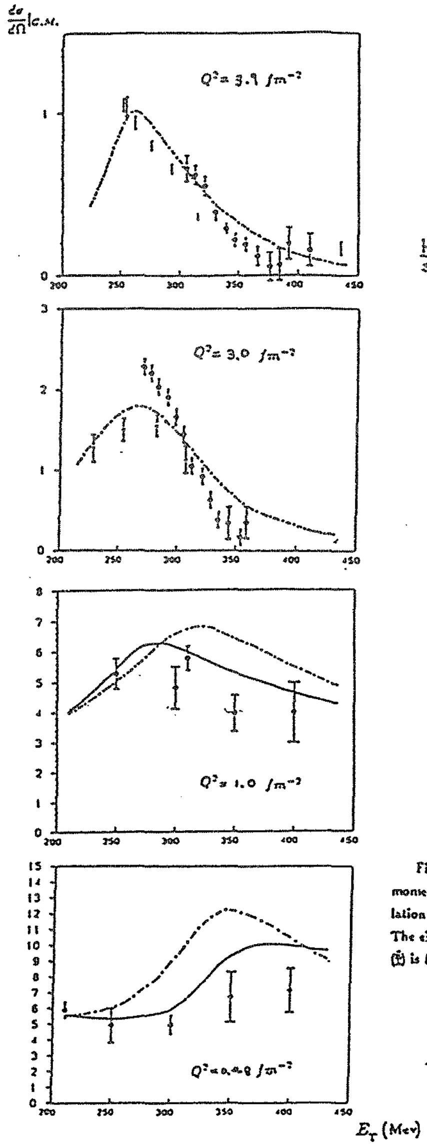

Fig. 1

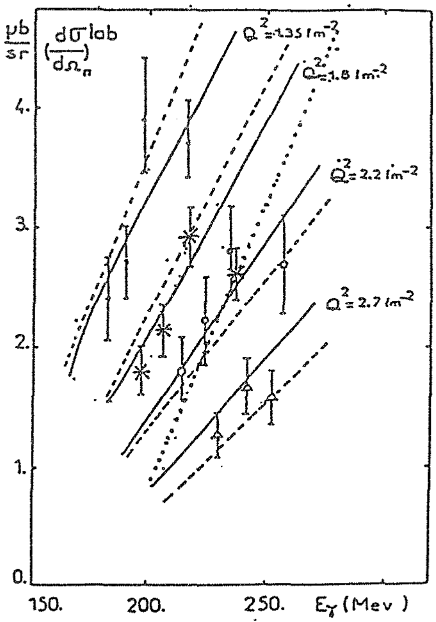

Fig 2 The solid line is I.A. calculation where we have used the 34 angular-momentum channel wave function of Sendai group, the dashed line is EPM calculation with our model and the dotted line is EPM calculation with PV Born terms (Q^2 = 1.9 fm^{-2}). The experiment is from Ref.11. The (⨀) is for Q^2=2.7 fm^2, (Q) is for Q^2=1.3 fm^2, (✳) is for Q^2=2.2 fm^2, (△) is for Q^2=2.7 fm^2.

Fig. 1 The results of DWIA and $E_1^+(3/2)$ contribution

The 5 channel wave function has been used. The solid line is from DWIA+ $E_{1+}(3/2)$. The dash-dotted line is for only DWIA calculation.

論文審査の結果の要旨

^{3}He によるパイ中間子の光生成反応^{3}He $(\gamma,\pi^+)^3$H で生成された中間子は平面波として出て行くという PWIA 法に従って解析されて来た。しかしこの方法では，入射光子のエネルギーの増加による π^+の角度分布の変化を説明することが出来なかった。この理論と実験の間の不一致を除く為には，π^+と^{3}H の終状態相互作用を考慮しなければならない。しかし，この過程の複雑さから微的に取扱うのは不可能であり，また多重散乱級数の収束性も保証されない。このことは特に△共鳴が起こるよりも高いエネルギー領域の現象について言える。

このような事情を背景として，本論文では π^+と^{3}H の相互終状態相互作用をあらわすものとして，π 中間子の原子核による散乱の解析に用いられた二種類の光学ポテンシャルを用い，π 中間子の波の平面波からの歪みの効果を考慮した解析（DWIA 波）を行なった。その結果理論計算による値と実験結果はよく一致することが示された。

π 中間子の光生成に関しては，従来△共鳴のおこるエネルギーでは核子が光を扱って△となり，△から π^+が放出されると共に△は再び核子となるという△－空孔機構が主な過程であると考えられていた。他方△が関与しない低いエネルギーではクロル・ルーダマン項とよばれる偏極光子と核子の相互作用により核子のスピンが反転する機構が重要な寄与を与えることが知られていた。これに対し本論文では両者の干渉が重要であることを示した。

次いで，本論文では，△共鳴が出来るよりも低いエネルギーにおける^{3}He $(\gamma,\pi^+)^3$H 過程の理論的取扱いに関する新しい方法を提唱した。すなわち，核子は^{3}He や^{3}H と同じスピンを持つので，^{3}He や^{3}H の空間的拡がりを考慮に入れれば π^+中間子の光発生は，核子による光発生の理論がそのままつかえるのではないかと考えて低エネルギーの角度分布をよく説明することに成功した。

本論文は，千明起が自立して研究活動を行なうに必要な高度の研究能力と学識を有することを示している。よって千明起提出の論文は理学博士の学位論文として合格と認める。