сообщения
объединенного
института
ядерных
исследований
дубна

E15-86-216

P.Kozma

THE CHARGE SYMMETRY VIOLATION IN THE $^2H(d,\vec{n})^3He$ AND $^2H(d,\vec{p})^3H$ REACTIONS

1986

The charge independence of nuclear forces can be tested in a number of ways. One way is to compare various observables measured in mirror reactions. When exact charge independence holds, polarization observables for these reactions are expected to be identical[1]. The charge symmetry can be broken by the Coulomb interaction. Because Coulomb effects in very light nuclei are small, two body d+d mirror reactions $^2H(d,p)^3H$ and $^2H(d,n)^3He$ are expected to be favourable processes for such an investigation.

In earlier comparisons of analyzing powers for the $^2H(\vec{d},p)^3H$ and $^2H(\vec{d},n)^3He$ reactions below 10 MeV[2-4] some differences in these observables were found when compared at the same incident deuteron energy. The discrepancies in tensor analyzing powers disappeared if these quantities were compared at the same exit channel energy. Hardekopf et al.[5] compared the polarizations of outgoing protons and neutrons for the $^2H(d,\vec{p})^3H$ and $^2H(d,\vec{n})^3He$ reactions from 3 to 10 MeV deuteron energy. Substantial differences in these observables were removed by shifting the deuteron energy scale of the $^2H(d,p)^3H$ reaction in the laboratory system down by about 1.5 MeV[5,6]. This simple method brings the nucleons in the exit channel to the same energy. Nevertheless, it has been found[7] that the simple energy shift does not explain the precise analyzing power data in a wide energy range.

Because of this experimental situation it seems to be worthwile to investigate the d+d mirror reactions at low deuteron energies. We therefore measured the angular distribution of polarized protons emitted from the $^2H(d,\vec{p})^3H$ reaction at about 1 MeV deuteron energy. Our experimental data can be compared with angular dependences of the polarization of outgoing neutrons from the mirror reaction $^2H(d,\vec{n})^3He$ at the same entrance and exit channel energies measured earlier by Galloway et al.[8].

Our experiment was performed on the Van de Graaff accelerator of the Institute of Nuclear Physics in Řež. Deuteron beam was incident on target consisted of a deuterated polyethylene $(CD_2)_n$ foil of thickness about 30 keV[9]. The polarization values were determined from the left-right asymmetry in the scattering of protons from silicon. The proton polarimeter and data analysis procedure have been described in ref.[10]. In brief, a collimated proton beam was incident on a silicon detector used as an analyzer and protons scattered through an angle of 95° were detected by "left" and "right" Si(Li)-detectors. The coincidence spectra due to protons in the analyzer and asymmetry "left" and "right" detector, respectively, were recorded along with spectra due to random coincidences. The polarimeter was mounted on a turntable which could rotate about the proton beam direction as axis so that "left" and "right" hand proton detectors could be interchanged to cancel out any instrumental asymmetry. The correction of measured asymmetry data for a possible nonsymmetrical arrangement of two "left" and "right" scattering planes in the present polarimeter was estimated to be less than 1% in the whole range of reaction angles. The dominant part of the overall errors quoted for the resulting polarization values corresponds to the statistical uncertainty as well as to errors in the background subtraction.

The angular distribution of the polarization of protons from the $^2H(d,\vec{p})^3H$ reaction was measured at the mean deuteron energy 0.975MeV. The analysis of experimental polarization values (see fig.1) was made along with the appropriate differential cross-section values[11,12]. The values of the differential polarization $\sigma_o P^{y'}$ have been analyzed in terms of the Legendre polynomials $P_L^n(\cos\theta)$ as described in[10].

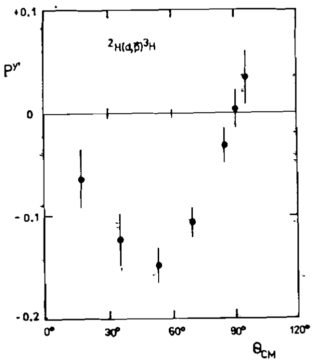

Fig.1. Angular distribution of the proton polarization from the $^2H(d,\vec{p})^3H$ reaction at 0.975 MeV mean deuteron energy.

We compare our experimental results with corresponding Legendre polynomial fits to the $^2H(d,\vec{n})^3He$ mirror reaction data of Galloway et al.[8] at the same entrance and exit channel energies. In ref.[8] precise measurements of angular dependences of the neutron polarization from the $^2H(d,\vec{n})^3He$ reaction at mean deuteron energies 1.04 and

2.44 MeV for Ti-D targets of thickness about 100 and 60 keV, respectively, are reported. In both measurements the polarization values were determined from the left-right asymmetries in the elastic scattering of neutrons on helium.

Comparison of differential polarizations of protons and neutrons emitted from the charge symmetric reactions d+d at the same bombarding energies is displayed in fig.2. The solid curve represents the Legendre polynomial fit to the $^2H(d,\vec{p})^3H$ reaction, the dashed curve is the result of the analysis of the $^2H(d,\vec{n})^3He$ reaction. At first sight, the differences observed from 30° to 90° centre-of-mass angular range are larger than uncertainties of the experimental data. In fig.3 comparison is made at the same exit energy of the nucleons. Again, the solid curve is fit to the data of the $^2H(d,\vec{p})^3H$ reaction, the dashed curve represents the Legendre polynomial fit to the $^2H(d,\vec{n})^3He$ reaction. The results of this comparison show that differences exist practically over the whole angular range. Thus, the simple energy shift proposed earlier[5,6] was not found to be succesfull to remove discrepancies observed at the same entrance channel energy.

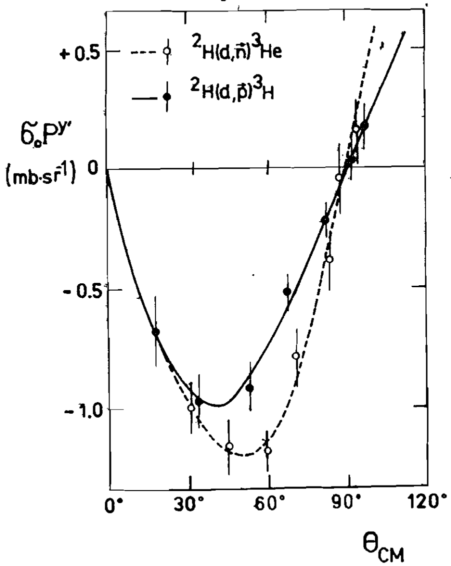

Fig.2. Differential polarization of outgoing nucleons from the d+d mirror reactions at the same entrance energy.

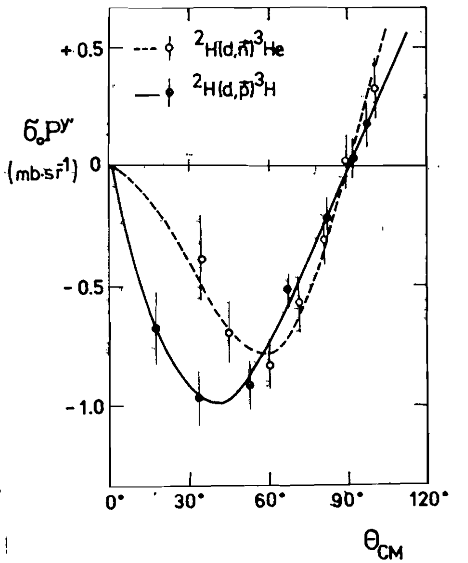

Fig.3. Differential polarization of outgoing nucleons from the d+d mirror reactions at the same exit energy.

It can be concluded that differences observed in measurements of angular distributions of polarized nucleons from the d+d reactions at low energies are larger than experimental uncertainties and must be explained if charge independence of nuclear forces holds.

References

1. Simonius M., in: Lecture Notes in Physics, 1974, 30, p.38.
2. Dries L.J., Clark H.W., Detomo R., Donoghue T.R., Phys. Lett., 1979, B 80, No.3, p.176.
3. Brown R.E., Correl G.G., Schmelzbach P.A., Phys. Rev., 1979, C 20, No.3, p.892.
4. Dries L.J., Clark H.W., Detomo R., Regner J.L., Donoghue T.R., Phys. Rev., 1980, C 21, No.2, p.475.
5. Hardekopf R.A., Walter R.L., Clegg T.B., Phys. Rev., 1972, 28, p.760.
6. Hardekopf R.A., Lisowski P.W., Rhea T.C., Walter R.L., Clegg T., Nucl. Phys., 1972, A 191, p.468.
7. König V., Grüebler W., Hardekopf R.A., Jenny B., Risler R., Bürgi H.R., Schmelzbach P.A., White R.E., Nucl. Phys., 1979, A 331, p.1.
8. Galloway R.B., Hall A.S., Mayouf R.M.A., Vass D.G., Nucl. Phys., 1975, A 242, p.122.
9. Kozma P., Bém P., Benda F., Nucl. Instr. and Meth., 1985, 228, p.579.
10. Kozma P., Bém P., Nucl. Phys., 1985, A 442, p.17.
11. Ganeev A.S., Sov.J.Atom.Energy, Suppl. 5, 1958, p.21.
12. Theuss R.B., McGarry W.I., Beach L.A., Nucl. Phys., 1966, A 80, p.273.

Received by Publishing Department
on April 9, 1986.

Козма П. E15-86-216

Нарушение зарядовой симметрии в ядерных реакциях $^{2}H(d,\vec{p})^{3}H$ и $^{2}H(d,\vec{n})^{3}He$

Точные данные измерений углового распределения поляризованных протонов в ядерной реакции $^{2}H(d,\vec{p})^{3}H$ при энергии около 1 МэВ сравниваются с экспериментальными данными нейтронной поляризации в зеркальной реакции $^{2}H(d,\vec{n})^{3}He$ при тех же самых энергиях во входном и выходном каналах. В обоих случаях различия между поляризацией вытекающих нуклонов в зарядово-симметрических реакциях d + d больше чем экспериментальные ошибки.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1986

Kozma P. E15-86-216

The Charge Symmetry Violation in the $^{2}H(d,\vec{n})^{3}He$ and $^{2}H(d,\vec{p})^{3}H$ Reactions

Precision measurement of the angular distribution of polarized protons from the $^{2}H(d,\vec{p})^{3}H$ reaction at about 1 MeV is compared with experimental polarization data from the mirror reaction $^{2}H(d,\vec{n})^{3}He$ at the same entrance and exit channel energies. In both comparisons differences in polarizations of outgoing nucleons from the d + d charge-symmetric reactions were found to be larger than experimental uncertainties.

The investigation has been performed at the Laboratory of High Energies, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1986

It can be concluded that differences observed in measurements of angular distributions of polarized nucleons from the d+d reactions at low energies are larger than experimental uncertainties and must be explained if charge independence of nuclear forces holds.

References

1. Simonius M., in: Lecture Notes in Physics, 1974, 30, p.38.
2. Dries L.J., Clark H.W., Detomo R., Donoghue T.R., Phys. Lett., 1979, B 80, No.3, p.176.
3. Brown R.E., Correl G.G., Schmelzbach P.A., Phys. Rev., 1979, C 20, No.3, p.892.
4. Dries L.J., Clark H.W., Detomo R., Regner J.L., Donoghue T.R., Phys. Rev., 1980, C 21, No.2, p.475.
5. Hardekopf R.A., Walter R.L., Clegg T.B., Phys. Rev., 1972, 28, p.760.
6. Hardekopf R.A., Lisowski P.W., Rhea T.C., Walter R.L., Clegg T., Nucl. Phys., 1972, A 191, p.468.
7. König V., Grüebler W., Hardekopf R.A., Jenny B., Risler R., Bürgi H.R., Schmelzbach P.A., White R.E., Nucl. Phys., 1979, A 331, p.1.
8. Galloway R.B., Hall A.S., Mayouf R.M.A., Vass D.G., Nucl. Phys., 1975, A 242, p.122.
9. Kozma P., Bém P., Benda F., Nucl. Instr. and Meth., 1985, 228, p.579.
10. Kozma P., Bém P., Nucl. Phys., 1985, A 442, p.17.
11. Ganeev A.S., Sov.J.Atom.Energy, Suppl. 5, 1958, p.21.
12. Theuss R.B., McGarry W.I., Beach L.A., Nucl. Phys., 1966, A 80, p.273.

Received by Publishing Department
on April 9, 1986.

Козма П.
E15-86-216

Нарушение зарядовой симметрии в ядерных реакциях $^{2}H(d,\vec{p})^{3}H$ и $^{2}H(d,\vec{n})^{3}He$

Точные данные измерений углового распределения поляризованных протонов в ядерной реакции $^{2}H(d,\vec{p})^{3}H$ при энергии около 1 МэВ сравниваются с экспериментальными данными нейтронной поляризации в зеркальной реакции $^{2}H(d,\vec{n})^{3}He$ при тех же самых энергиях во входном и выходном каналах. В обоих случаях различия между поляризацией вытекающих нуклонов в зарядово-симметрических реакциях d + d больше чем экспериментальные ошибки.

Работа выполнена в Лаборатории высоких энергий ОИЯИ.

Сообщение Объединенного института ядерных исследований. Дубна 1986

Kozma P.
E15-86-216

The Charge Symmetry Violation in the $^{2}H(d,\vec{n})^{3}He$ and $^{2}H(d,\vec{p})^{3}H$ Reactions

Precision measurement of the angular distribution of polarized protons from the $^{2}H(d,\vec{p})^{3}H$ reaction at about 1 MeV is compared with experimental polarization data from the mirror reaction $^{2}H(d,\vec{n})^{3}He$ at the same entrance and exit channel energies. In both comparisons differences in polarizations of outgoing nucleons from the d + d charge-symmetric reactions were found to be larger than experimental uncertainties.

The investigation has been performed at the Laboratory of High Energies, JINR.

Communication of the Joint Institute for Nuclear Research. Dubna 1986