Proc. Sixth Int. Symp. Polar. Phenom. in Nucl. Phys., Osaka, 1985
J. Phys. Soc. Jpn. 55 (1986) Suppl. p. 1034-1035

7.8

Experimental Limits on the Size of Isovector Parity Mixing in ^{20}Ne and Weak Pion Nucleon Coupling+)

N. Kniest, E. Huttel, E. Pfaff, G. Reiter,
S. Tharraketta, A. Hofmann and G. Clausnitzer

Institut für Kernphysik, Strahlenzentrum der Universität Giessen,
D-6300 Giessen, West Germany

Isovector parity nonconservation is of special interest in the study of the parity violating weak nucleon-nucleon force, since it is particularly sensitive to the presence of neutral weak currents, which are expected to produce an enhancement in the weak pion-nucleon coupling constant f_π[1]. However, the observation of the pure isovector part of the PNC-potential between nucleons is limited to a small number of reported experiments ($\vec{n}$+p, ^{6}Li, ^{18}F, ^{20}Ne), from which the only stringent upper limit within the theoretically expected DDH interval[1] presently comes from the ^{18}F-experiment ($f_\pi \leq 1.4\cdot10^{-7}$)[2].

The study of isovector parity mixing in the $J^\pi=1^+$,T=1 level in ^{20}Ne (E_x = 13.482 MeV, Γ=6 keV) has been proposed as a favourable candidate by Gari[3], who calculated α_o decay widths for the Cabibbo and Weinberg-Salam model of weak hadronic interactions.

Experimentally, the parity- and isospinforbidden α_o decay to ^{16}O(g.s.) can be investigated by determinating the size of PNC transverse and longitudinal analyzing powers from asymmetry measurements in the ^{19}F($\vec{p}$,α_o)^{16}O reaction[4], both requiring the position of the quantization axis to be coplanar with the reaction plane. Complementary to our previously reported experiment with transversally polarized protons[5] the narrow 1^+,1 state in ^{20}Ne was populated by resonant capture of longitudinally polarized protons (E_p=670 keV) from the Giessen polarization facility. As this level can only decay to ^{16}O(g.s.) via an admixture of negative parity, an interference effect of the order 10^{-3} is expected[3,4] between the PNC-transition amplitude and parity allowed transition amplitudes.

The PNC helicity asymmetry has been measured at eight energies around the 1^+ resoncance energy, using a set up of two detector rings, each equipped with four surface barrier detectors at Θ_{LAB} = 90° (ϕ=0°, 90°, 180°, 270°) and covered with 10 μm Al foils to stop elastically scattered protons and low energy α particles. The small resonance width required thin C-^{7}LiF-C solid targets of $\sqrt{2}$x(10-35-10)nm, which have been installed in the geometrical center of each ring. A careful control and correction of instrumental asymmetries has been applied to each spectrum, supported by on-line monitoring residual transverse polarization components, beam displacement, correlated effects, control parameters, the corresponding γ-ray spectrum as well as the asymmetries of the ^{7}Li($\vec{p}$,α)α reaction. To avoid apparative asymmetries from spin reversal the polarization was switched between 'on' and 'off' (62 Hz) and has been determined from intermediate measurements with transverse polarization in the same experimental set up via the reaction ^{19}F($\vec{p}$,α_o)^{16}O (P_Z=0.70,I_T≈300 nA). The target current ratios were measured in a Faraday cup and additionally determined from the ^{7}Li($\vec{p}$,α)α peak integrals.

Within 370 h pure measuring time the data for the longitudinal analyzing power (including the statistical uncertainties of the corrections) show no significant evidence for the expected size of the interference effect. A description of the dispersionlike energy behaviour by a two parameter least squares fit[5,6] resulted in A^{PNC}=(15.0±7.6)10^{-4} with $P(\chi^2>\chi^2_{min})$=67%, taking the χ^2+1 criterion for the determination of the quoted error.

+)Work supported by the Deutsche Forschungsgemeinschaft

The corresponding α_o decay width Γ^{PNC} can be obtained from the formulae of ref. 4, if pure two level parity mixing with the overlapping $J^{\pi}=1^-$, T=0 state (E_x=13.462 MeV, $\Gamma\approx$200 keV) is assumed. However, the R-matrix analysis of a recent σ- and A_y measurement[7] gave rise for a reduction in the strength of this 1^- level, a possible contribution of a second 1^- level at 13.519 MeV (Γ=33 keV) and the consideration of direct reaction mechanism. On these experimental grounds a more general analysis on the base of five regular amplitudes ($l_p\leq 2$) and one PNC amplitude (l_p=0) has been developed. From a comparison with the experimental maximum of A^{PNC} the amplitude for the PNC α_o transition and Γ^{PNC} can be obtained without further theoretical assumptions. Table I contains the results from the present helicity experiment in comparison with those of the same analysis, applied to the data of ref. 5 and 6.

Table I: Summary of the PNC parameters deduced from longitudinal and transverse analyzing powers (A_Z,A_X) of the reaction $^{19}F(\vec{p},\alpha_o)^{16}O$ (*) two level analysis; **) general analysis (see text); isovector contributions due to heavy vector meson exchange are neglected)

Ref.	quantity	A^{PNC}x10^4	Γ^{PNC}x10^6eV*)	f_πx10^7*)	Γ^{PNC}x10^6eV**)	f_πx10^7**)
-	A_Z	15.0±7.6	0.7±1.1	0.2±0.7	5.6±5.9	0.5±1.8
5	A_X	10 ±10	0.3±1.1	0.1±0.6	1.6±3.2	0.3±1.1
6	A_Z	66 ±24	12.6±30.0	0.8±2.7	108.7±84.0	2.2±7.5

To set a significant limit of f_π a parametrization in terms of the coupling constant is necessary and new nuclear structure calculations including $2\hbar\omega$ calculations for the positive parity states are needed. As long as these are not available one can presently obtain values for f_π by use of the Cabibbo value for Γ^{PNC} from ref. 3. The assumption of a factor of 5 for its uncertainty produces the main part of Δf_π.

With the present results of A^{PNC}, containing a threefold higher statistical accurancy than the data of ref. 6, the large PNC-effect of ref. 6 must be questioned.

With the presented limit of f_π a large amount of the theoretically expected DDH interval can be ruled out. This statement is consistent with the limits from the ^{18}F experiment[2] and a recent parametrization involving experiments with mixtures between different isospin components of the PNC potential[8] and favours the proposal of ref. 9, to weaken the DDH best value for f_π to one third ($f_\pi=1.5\cdot10^{-7}$).

Finally one may conclude, that the enhancement due to neutral weak current contributions to the weak hadronic interaction seems to be smaller than originally expected from theory.

References

1) D.Desplanques et al., Ann.Phys. 124 (1980) 449.
2) E.G.Adelberger and W.C.Haxton, priv. com.
3) M.Gari, in: Interaction Studies in Nuclei, edited by H.Jochim and B.Ziegler (North Holland, Amsterdam, 1975) p. 307; and priv. com.
4) P.G.Bizzeti and P.R.Maurenzig, Nuovo Cim. A56 (1980) 492.
5) N.Kñiest et al., Phys.Rev. C27 (1983) 906.
6) J.Ohlert et al., Phys.Rev.Lett. 47 (1981) 475.
7) O.Traudt, PHD-thesis, Mainz, 1979 (unpublished).
8) J.Lang et al., Phys.Rev.Lett. 54 (1985) 170.
9) W.C. Haxton et al., Phys.Rev.Lett. 45 (1980) 1677.