Charge symmetry breaking in the quark exchange interaction

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Charge symmetry breaking (CSB) of the strong interaction has two obvious origins: (1) the up-down quark mass difference Δm and (2) the electromagnetic interaction. Yet their effects on hadron spectra and hadronic interactions are rather complicated and we do not have a consistent and quantitative picture. In this study we try to understand CSB in nucleon and nuclear force from the quark model viewpoint. Our aim is to study CSB in nuclear force microscopically and to show that the u-d quark mass difference indeed give sizable CSB in all the key quantities, such as
(i) the difference of masses of the neutron and the proton : $\Delta M = M_n - M_p$
(ii) the difference of the scattering lengths of p-p and n-n scatterings : $\Delta a = a_{pp} - a_{nn}$
(iii) the difference of the analyzing powers of the neutron and the proton in the n-p. scattering : $\Delta A(\theta) = A_n(\theta) - A_p(\theta)$
We will compare our results with previous analyses [1,2]. Main difference comes from the introduction of the instanton-induced-interactio in order to reduce ΔM, and also the effects of the quark-quark spin orbit interaction, which is essential to reproduce the large ΔA. Using Δm which reproduces ΔM, we obtained $\Delta a = 1.4$ fm which is consistent with the observed value $\Delta a_{\mathrm{exp}} = 1.5 \pm 0.5$ fm. The result of $\Delta A(\theta)$ for the neutron incident energy $\mathrm{E_n} = 183$ MeV is shown in figure 1.

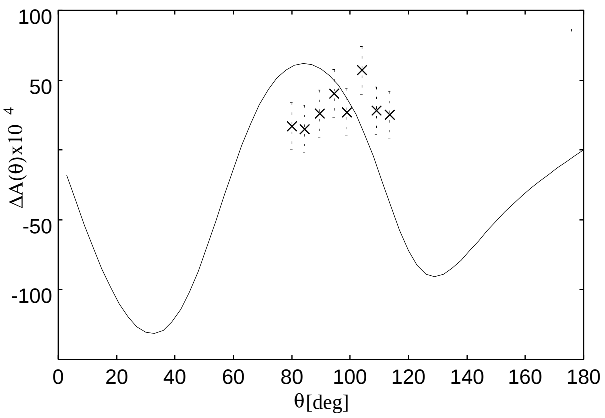

Figure 1: $\Delta A(\theta)$ for $\mathrm{E_n} = 183$ MeV

These results imply that the contribution of Δm is large enough to explain CSB of the N-N interaction and is consistent with the observed value. It should be noticed that the contribution of Δm to $\Delta A(\theta)$ is much larger than that obtained by Bräuer[2] using a similar model.

References

[1] Marc Chemtob and Shin Nan Yang, Nucl.Phys. **A420** (1984) 461.
[2] K.Bräuer, E.M.Henley and G.A.Miller, Phys.Rev.C **34** (1986) 1779.