Charge Symmetry Breaking by $\rho - \omega$ Oscillation Model

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Coulomb displacement energies of mirror nuclei, disagreement between proton-proton and neutron-neutron scattering lengths without Coulomb effects and difference in proton and neutron analyzing powers seem to suggest charge symmetry breaking in nucleon-nucleon interaction[1]. One explanation of charge symmetry breaking is due to isospin mixing in ρ and ω mesons. We showed in the previous paper that time development of eigenstates makes isospin mixing because of their mass difference and the $\rho - \omega$ mixing oscillation causes charge symmetry breaking in nucleon-nucleon interactione[2]. We investigated the effects of breaking with assuming that ρ and ω mesons created by strong interaction are isospin eigenstates.

We here reanalyze with the stand point that the observed ρ and ω mesons are mass eigenstates[3]. The original isospin mixing lagrangian density is given by

$$\begin{aligned} \mathcal{L} &= \bar{\psi}\{\gamma^\mu(i\partial_\mu - g_\omega\omega_\mu - g_\rho\tau_3\rho_\mu) - M\}\psi \\ &\quad -\frac{1}{4}F^{(\omega)}_{\mu\nu}F^{(\omega)\mu\nu} + \frac{1}{2}m_\omega^2\omega_\mu\omega^\mu - \frac{1}{4}F^{(\rho)}_{\mu\nu}F^{(\rho)\mu\nu} + \frac{1}{2}m_\rho^2\rho_\mu\rho^\mu + \epsilon\,\omega_\mu\rho^\mu \ . \end{aligned}$$

Here ρ and ω are isospin eigenstates. To eliminate the isospin mixing term $\epsilon\,\omega_\mu\rho^\mu$, we introduce mass eigenstate vector mesons A_μ and B_μ;

$$A_\mu = \omega_\mu\cos\theta + \rho_\mu\sin\theta \quad \text{and} \quad B_\mu = -\omega_\mu\sin\theta + \rho_\mu\cos\theta \ .$$

We identify A_μ and B_μ are observed ω and ρ mesons which are given in the Particle Physics Booklet[4].

To reproduce the branching ratio of ω meson's two-pion-decay $B(A \to 2\pi) = 0.0221 \pm 0.003$, the mixing angle θ should be $2.25° \pm 0.19°$. This mixing angle gives the ρ meson's three-pion-decay branching ratio 0.00011 ± 0.00002. This mixing angle corresponds to the mixing coupling constant $\epsilon = (0.001207 \pm 0.000102)m_\rho m_\omega$.

References

[1] G. A. Miller, B. M. K. Nefkens and L. Šlaus, Phys. Rep. **194** (1990) 1.
[2] S. Ogushi, M. Terasawa and H. Tezuka, Phys. Rev. C **56** (1997) 2382.
[3] H. Tezuka, RIKEN Accel. Prog. Rep. **34** (2001) 43.
[4] Particle Data Group, Eur. Phys. J. C **15** (2000) 1.