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ABSENCE OF $\eta \rightarrow 2\pi$ DECAYS AND CONSERVATION OF SPATIAL AND COMBINED PARITIES

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It is shown that the absence of the $\eta \rightarrow 2\pi$ decay imposes restrictions on possible violations of P and CP invariance in strong interactions.

In this article we would like to note that the experimental absence of the $\eta \rightarrow 2\pi$ decay significantly restricts possible violations of P and CP invariance in strong interactions. In this connection we wish to stress the importance of a search for these decays. The conservation of P parity is verified in low energy nuclear experiments[1] to an accuracy $R \sim 10^{-8}$–10^{-12}. Here R stands for the upper limit of the ratio of the squares of the odd P and even P amplitudes. At high energies conservation of P parity has been tested to an accuracy $R \sim 10^{-1}$.[2] Conservation of CP parity (more precisely—T invariance) has been verified to an accuracy $R \sim 10^{-3}$ and only at low energies.[3] It has been proposed to test CP-parity conservation in the scattering of antiprotons on protons.[4] The experimental absence of the decays $\eta \rightarrow 2\pi$ makes it possible to obtain the value $R \sim 10^{-7}$–10^{-9} at an energy of 550 MeV (mass of the eta meson).

The pseudoscalar η meson with positive C parity has negative CP parity and the $\eta \rightarrow 2\pi$ decay is forbidden if either CP or P parity is conserved. If the P- or CP-violating interaction were of the same strength as the usual strong interaction then the $\eta \rightarrow 2\pi$ decay would have a width of the order of tens of MeV, which is according to theoretical estimates some 5–6 orders of magnitude bigger than the width of the experimentally observed "electromagnetic" decays $\eta \rightarrow 3\pi$ and $\eta \rightarrow 2\gamma$. This is due to the fact that, in contrast to the $\eta \rightarrow 3\pi$ decay, the $\eta \rightarrow 2\pi$ decay would not be forbidden by the selection rules of G parity. Since experimentally the $\eta \rightarrow 2\pi$ decay has not been seen it follows that $R \sim 10^{-5}$–10^{-6}. If it could be established experimentally that $\Gamma(\eta \rightarrow 2\pi)/\Gamma(\eta \rightarrow 2\gamma) < 10^{-3}$ then we would have $R \sim 10^{-8}$–10^{-9}. This limit is lower than the limit given for possible nonconservation of P parity by experiments at low energy, and considerably higher than the presently known limit for possible nonconservation of CP parity.

The indicated estimates contain an uncertainty due to the fact that it is not known how to normalize the amplitude which violates P or CP invariance (i.e., it is not known what would the width $\eta \rightarrow 2\pi$ be if the strong interactions violated P or CP invariance 100%). This uncertainty will be reduced to some extent when the ratio $\Gamma(K_2^0 \rightarrow 2\gamma)/\Gamma(K_1^0 \rightarrow 2\pi)$ is experimentally determined, since it is known that these decays are due to the weak V-A interaction which violates P invariance 100%. The ratio

$$\frac{\Gamma(\eta \rightarrow 2\pi)}{\Gamma(\eta \rightarrow 2\gamma)} \frac{\Gamma(K_2^0 \rightarrow 2\gamma)}{\Gamma(K_1^0 \rightarrow 2\pi)}$$

may serve as a measure of the possible CP- or P-parity nonconservation in strong interactions, i.e., as a definition of the quantity R. Grishin and Podgoretskiĭ[5] have suggested the use of the ratio $\Gamma(\eta \rightarrow 3\pi)/\Gamma(\eta \rightarrow 2\gamma)$ to test isotopic spin conservation in strong interactions. We note that this ratio also characterizes C-parity conservation in a P-parity conserving interaction. As a measure of G- and C-parity nonconservation one may use the ratio

$$\frac{\Gamma(\eta \rightarrow 3\pi)}{\Gamma(\eta \rightarrow 2\gamma)} \frac{\Gamma(K_2^0 \rightarrow 2\gamma)}{\Gamma(K_2^0 \rightarrow 3\pi)},$$

since the $K_2^0 \rightarrow 3\pi$ decay is a normal weak decay, not suppressed by the selection rule $\Delta T = 1/2$. Taking into account the difference in the masses of the η and K_2^0 mesons gives rise to a factor $1/2$ in the expression for R. Taking this factor into account is a matter of taste.

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