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The invariance of interactions under the CPT transformation is a consequence of the basic postulates of the modern field theory (the Lüders-Pauli theorem[1,2]). The experimental test of the CPT invariance is therefore a test of these postulates. Gotow and Okubo[3] were the first to pay attention to that possibilities of a direct test of the CPT invariance occur in the study of the polarization effects in antiproton-proton elastic scattering

$$\bar{p} + p \rightarrow \bar{p} + p \tag{1}$$

The authors[3] have given, however, no relations between simplest- observables the experimental test of which would be a direct test of the CPT invariance. Here we will show that from the CPT invariance follow the relations

$$\begin{aligned} \vec{P}^{(1)}\vec{n} &= \vec{A}^{(2)}\vec{n} \\ \vec{P}^{(2)}\vec{n} &= \vec{A}^{(1)}\vec{n} \end{aligned} \tag{2}$$

where $\vec{n} = \frac{\vec{p} \times \vec{p}\,'}{|\vec{p} \times \vec{p}\,'|}$ is the normal to the scattering plane ($\vec{p}$ and $\vec{p}\,'$ are the momenta of the initial and the final antiprotons in c.m.s.), $\vec{P}^{(1)}$ ($\vec{P}^{(2)}$) is the antiproton (proton) polarization in scattering of unpolarized particles, $\vec{A}^{(1)}$ ($\vec{A}^{(2)}$) is the asymmetry in the scattering of an antiproton polarized beam on an unpolarized target (an unpolarized beam on a polarized proton target). Let us denote the scattering matrix in c.m.s. by $M(\vec{p}\,', \vec{p}\,)$. Then, as is known

$$\begin{aligned} P_i^{(1)} &= \frac{1}{4\sigma_0}\, Sp\, \sigma_{1i}\, M M^+ , \qquad & P_i^{(2)} &= \frac{1}{4\sigma_0}\, Sp\, \sigma_{2i}\, M M^+ \\ A_i^{(1)} &= \frac{1}{4\sigma_0}\, Sp\, M \sigma_{1i}\, M^+ , \qquad & A_i^{(2)} &= \frac{1}{4\sigma_0}\, Sp\, M\, \sigma_{2i}\, M^+ \end{aligned} \tag{3}$$

where σ_0 is the differential cross section for the scattering with unpolarized particles in c.m.s. The spin matrices of the antiproton and the proton are denoted by σ_{1i} and σ_{2i} respectively. If the interactions responsible for the scattering process (1) are invariant under the CPT transformation then the scattering matrix satisfies the following requirement

$$M^T(\vec{p}\,', \vec{p}\,) = U^{-1} P(1,2)\, M(-\vec{p}, -\vec{p}\,')\, P(1,2)\, U \tag{4}$$

Here $P(1,2)=\frac{1}{2}(1+\vec{\sigma}_1\vec{\sigma}_2)$ is the spin variable exchange operator, U is the unitary matrix satisfying the conditions

$$U^{-1}\sigma_{1i}U=-\sigma_{1i}^{T}$$
$$U^{-1}\sigma_{2i}U=-\sigma_{2i}^{T} \tag{5}$$

while the symbol T denotes the transpose. By rotating at the angle π round the vector $\vec{m}=\frac{\vec{p}'-\vec{p}}{|\vec{p}'-\vec{p}|}$ and using invariance under rotations we get

$$M(-\vec{p},-\vec{p}')=(\vec{\sigma}_1\vec{m})(\vec{\sigma}_2\vec{m})M(\vec{p}'\vec{p})(\vec{\sigma}_1\vec{m})(\vec{\sigma}_2\vec{m}). \tag{6}$$

By means of eqs. (3) -(6) we find easily relations (2). These relations are, thus, a consequence of only invariance under the CPT transformation and the invariance under rotations. In the general case when the S-matrix invariance under the CPT transformation is not assumed the scattering matrix can be represented in the form

$$M(\vec{p}',\vec{p})=M_1(\vec{p}',\vec{p})+M_2(\vec{p}',\vec{p}) \tag{7}$$

where

$$M_1^{T}(\vec{p}',\vec{p})=U^{-1}P(1,2)M_1(-\vec{p},-\vec{p}')P(1,2)U$$
$$M_2^{T}(\vec{p}',\vec{p})=-U^{-1}P(1,2)M_2(-\vec{p},-\vec{p}')P(1,2)U \tag{8}$$

Instead of (2) we have in this case

$$\sigma_0(\vec{P}^{(1)}\vec{n}-\vec{A}^{(2)}\vec{n})=\mathrm{Re}\,Sp(\vec{\sigma}_1\vec{n})M_1M_2^{+}$$
$$\sigma_0(\vec{P}^{(2)}\vec{n}-\vec{A}^{(1)}\vec{n})=\mathrm{Re}\,Sp(\vec{\sigma}_2\vec{n})M_1M_2^{+} \tag{9}$$

The violation of relations (2) would mean that the S-matrix is not invariant under the CPT transformation. If it turned out that within the experimental errors the polarization $\vec{P}^{(1)}\vec{n}$ and the asymmetry $\vec{A}^{(2)}\vec{n}$ (or $\vec{P}^{(2)}\vec{n}$ and $\vec{A}^{(1)}\vec{n}$) coincided then by means of (9) it would be possible to determine an upper limit of the amplitude noninvariant under the CPT transformation. Experiments on the check of the C(T) invariance of the strong interactions/4/ show that an upper limit of the ratio of the amplitude noninvariant under the charge conjugation C to the C invariant amplitude is of the order of 1% (for T of the order of 2-3%). The parity nonconservation effects recently observed in nuclear reactions are compatible with the assumption that the nonconservation of parity is due to the weak interactions only/4/. Thus, the test of the validity of relations (2) needs difficult experiments in which the polarization and the asymmetry would be measured with high

accuracy. In conclusion we note that using (4) and (6) it is easy to obtain relations between other observables. We give here some of them

$$\begin{aligned} D^{(1)}_{\ell m}&=-D^{(2)}_{m\ell}\,; & D^{(1)}_{m\ell}&=-D^{(2)}_{\ell m}\,;\\ K^{(1)}_{\ell m}&=-K^{(1)}_{m\ell}\,; & K^{(2)}_{\ell m}&=-K^{(2)}_{m\ell}\,;\\ C_{\ell m}&=-P_{m\ell}\,; & C_{m\ell}&=-P_{\ell m}\,; \end{aligned} \tag{10}$$

For the determination of the above quantities see, e.g., ref./5/.

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