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Experimental data on large-angle proton-proton scattering showed that the differential cross section of this process for a fixed angle decreases rapidly with energy [1].

As is shown by Orear[2], the data obtained are described by the formula:

$$\frac{d\sigma}{d\Omega} \approx \exp(-Cp \sin\theta) \qquad (1)$$

where p is the momentum and θ is the scattering angle in the centre-of-mass system.

In this note we paid attention to the fact that the mechanism of large-angle scattering in the high-energy region can be conceived of as the scattering at classically forbidden angles well-known in quantum mechanics. In particular, an example of scattering of this kind is the overbarrier reflection.

As is known[3] in quantum mechanics, when considering the process of scattering on the potential $U(r)$ which is an even analytical function of r (having no singularities on the real axis) the scattering amplitude in the high-energy region $E \gg |U|$ in the quasiclassical approximation ($pa \gg 1$) can be represented as:

$$f \approx \exp\left(\frac{2\text{Im}\, r_0}{\hbar} p \sin\frac{\theta}{2}\right) = \exp\left(-\frac{\text{Im}\, r_0}{\hbar}\sqrt{-t}\right) \qquad (2)$$

where $t = -2p^2(1-\cos\theta)$ is the momentum transfer.

The value r_0 can be defined from the usual classical equation which determines the dependence of the impact parameter $\rho(\theta)$ on the scattering angle θ, if the complex values ρ in it are also to be considered. That will correspond to the scattering at angles forbidden in classical mechanics.

For example, for the potential $U = U_0 \exp(-\frac{r^2}{a^2})$, r_0 is slightly dependent on the energy E and on the angle θ and is equal to

$$r_0 \approx i a \sqrt{\ln\left[\frac{E}{U_0}\sin^2\frac{\theta}{2}\right]} \ .$$

Such is the situation in quantum mechanics.

In ref./4/ it was shown that the problem of scattering in quantum field theory can be described by the Schrodinger-type equation with the complex quasi-potential, dependent not only on r, but also on the energy of the system.

The imaginary part of the quasi-potential is a negative definite function and determines inelastic processes in the system.

Using the same arguments/2,5/ as in deducing the formula (2), one can easily make sure that under the same assumptions, in this case too, for a sufficiently smooth complex quasi-potential, the scattering amplitude at an angle θ at high energies satisfies the formula (2), which reproduces very well the characteristic dependence of the differential cross section (1) on the momentum and the scattering angle in the high-energy region.

References

1. G.Cocconi et al. Phys.Rev.Lett., 11, 4999 (1963). W.F.Baker et al. Phys.Rev Lett., 12, 132 (1964).
2. J.Orear. Phys.Rev.Lett., 12, 112 (1964).
3. L.D.Landau and E.M.Lifshits. Quantum Mechanics. Fizmatgiz, 1963.
4. A.A.Logunov and A.N.Tavkhelidze. Nuovo Cim., 29, 380 (1963).
5. A.Z.Patashinsky, V.L.Pokrovsky, E.M.Khalatnikov, JETP, 45, 760, 1963.

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