Contribution ID: **77** Type: **not specified**

Scattering of unstable particles

Wednesday 6 September 2023 11:10 (30 minutes)

The scattering $R + T \to A + X$, where A and X are known sets of particles, is discussed. With known momenta of all participants, process is described by the scattering amplitude and cross section.

Real colliding particles exist in the form of wave packets — superpositions of monochromatic states with some spread Δp. In many cases, the amplitude change in the Δp interval is negligible and the mentioned quantities describe the observed phenomena ({\it monochromatic plane wave approximation — MPWA}).

If the particle R is unstable, then there are points in the space of final states where our process can be represented as a cascade two-stage process $(R \to A + B) \oplus (B + T \to X)$ with real intermediate particle B. At these points, the amplitude diverges {\it (t-channel singularity)} and the cross section does not exist — MPWA is not applicable. For physical scattering, these divergences are smoothed out by the non-monochromaticity of the initial wave packet. It gives a finite probability of the process. The result depends not only on the average values of the momenta, but also on the properties of wave packet determined by the mechanism of its preparation.

Similar phenomenon for s-channel is well known. For the scattering of slow neutrons on Uranium, cross section at $p \to 0$ diverges while probability of process is finite {\it (s-channel singularity)}.

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Session Classification: Plenary