Particle Oscillations in Absorbing Matter

V. I. Nazaruk
Institute for Nuclear Research of RAS, 60th October Anniversary Prospect 7a, 117312 Moscow, Russia.
E-mail: nazaruk@al20.inr.troitsk.ru

The ab transitions are described by the equations

$$(i\partial_t + \nabla^2/2m - U_a)\Psi_a(x) = \epsilon\Psi_b(x), \quad (i\partial_t + \nabla^2/2m - U_b)\Psi_b(x) = \epsilon\Psi_a(x) \tag{1}$$

(nonrelativistic case). Here ϵ is a small parameter, $U_{a,b}$ are the potentials of particles a and b; ImU_b is responsible for loss of b-particle intensity. The introducing of ImU_b, i.e., the procedure

$$m \to m - i\Gamma/2 \tag{2}$$

is justified for the equation of Schrodinger type $(i\partial_t+\nabla^2/2m-U_b)\Psi_b(x) = 0$. System (1) is not reduced to this equation. We show that scheme given above describes the absorption incorrectly. In particular, the effect of absorption acts in the *opposite* (wrong) direction. This is true for any value of ImU_b, i.e., for week (neutrino oscillations in matter) as well as strong ($n\bar{n}$ conversion in nuclear) absorption.

By the example of the $n\bar{n}$ transitions in the medium

$$(n - \text{medium}) \to (\bar{n} - \text{medium}) \to \text{annihilation products} \tag{3}$$

we calculate directly an off-diagonal matrix element. Due to zero momentum transfer in the $n\bar{n}$ transition vertex the process amplitude is singular. This problem is solved by means of field approach with finite time interval (FTA), which is infrared-free. The approach reproduces all the results in neutrino oscillations as well as standard calculation of the process (3) (in the spatial case that the procedure (2) is used, what is wrong). The connection between FTA and S-matrix theory is studied.

The summary of the results are: (1) The procedure (2) should be used with care. For oscillation problems it is wrong. (2) The absorption in a final states *do not lead to suppression of ab transitions*, contrary to model (1). (3) The FTA is *infrared-free*. It may be useful for the processes with small momentum transfer $q \to 0$. (The part of this material was presented in the e-print paper: V.A.Kuzmin and V.I.Nazaruk, hep-ph/0110182.)