NUCLEAR REACTIONS INVOLVING THREE PARTICLE SYSTEMS

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1. Introduction

The three body nuclear reactions are of special interest in the nonrelativistic nuclear physics. Understanding of those will favour the progress in investigations of structure and dynamics of ensembles of strongly interacting particles.

Similarly to usual binary processes, the three-body nuclear reactions are very sensitive to the nature of particle coupling; however the dominant factor is the three-body dynamics. We know at present a number of exact microscopic nonrelativistic quantum mechanical formulations of the three body problems and various approaches to solve them. At the same time, the now existing theory of nuclear reactions is mainly phenomenological and starts from different models, which have no microscopic justifications.

Disadvantages of the up-to-date nuclear reaction theory are specified to a great extent by the many-body nature of the processes under consideration. Nuclear reactions are being usually studied by means of effective two-particle approach, i.e. one introduces a phenomenological potential with some free parameters, which should fit the experimental data. To take into account the many body nature of the nuclear reactions, the theorists at best introduce coupling between different two-particle channels. Nevertheless, the theory is able to give a satisfactory description of the elastic and inelastic scattering, the knockout and the stripping.

Three interacting particles are the simplest ensemble, which can take part, besides elastic scattering, also in rearrangement and in breakup. One may believe, that applications of the exact three-body approaches to the description of nuclear processes may essentially improve the theory of nuclear reactions and advance our comprehension of nuclear dynamics. Unlike the traditional approaches of the nuclear reaction theory, the three-body approximation allows to find immediately the effective potentials in terms of the initial interactions. As all considerations involved take properly into account both the three-body dynamics and the channel coupling, the
three-body approximation is a good ground to investigate not only
the direct processes but also the nuclear resonance phenomena.

The above mentioned questions were discussed for many times in
the preceding Conferences. There is a number of review papers, in
which the three-body problem [1-8] and the relationship between that
and nuclear reactions [9,10] were considered in detail. Special at-
tention was also paid to the deuteron breakup by nucleons [11-13].
Up to the present we have achieved some progress in our understan-
ding of the physics of three body processes, but not to the extent
which seems to be available. This is due to the great amount of work
and to technical difficulties. Naturally, I cannot give account of
the formal theory and technical details of applications in my con-
tribution. Neither is it possible to pay attention to all advances
after the last meeting; those are presented in many contributions
at this Conference.

The main purpose of my contribution is to consider the peculia-
rities of the three body processes and to discuss various ways of
their detailed investigation. I shall restrict myself by only some
of them, which seem to me the most interesting in spite of their sim-
licity (it is worth mentioning, that having formulated the ques-
tions correctly we still do not know the complete answers).

What is the difference between the three- and the two-body pro-
cesses? Does there exist any fundamental difference? And if so, is
there the same difference between the processes involving three and
four particles and so on? It is clear, that were the answer to the
last question positive, the three body problem would be of partial
interest and would not be worth a serious consideration, as such
problems (and maybe even more complicated ones) would be too nume-
rous. In other words, which are the parts of the two- and the three-
particle processes in the much more general many body problem?

The two-body reactions stand extraordinarily apart from all
other few- and many-body processes. The two-body problem always may
be reduced by means of transformation into the center-of-mass system
to the single-particle one, namely, that of particle motion in the
field of some potential. If the range of nuclear forces is finite,
the asymptotic scattering phase determines the wave function behavi-
our in the whole space (excluding the finite region of interaction).
In such a case all observable parameters of the process may be ex-
pressed in terms of the phase.

N > 2 processes have none of these peculiarities. There is no
fundamental distinction of the three body processes from those in-