REFEREE'S REVIEW OF PROJECT

"INVESTIGATION OF RELATIVISTIC FRAGMENTATION OF LIGHT RADIOACTIVE NUCLEI USING NUCLEAR PHOTOEMULSION"

(Project BECQUEREL-C)
Topic -0983-

Collaboration: JINR, Armenia, Romania, Russia, Slovakia, Bulgaria

Making use of the technique of nuclear photoemulsion in experimental studies requires selection of such physical problems, for which application of this method is the only possible one, since it is very cumbersome and its utilization requires the efforts of a large group of collaborators possessing specific working skills as well as special precision equipment.

Only the creation of stable and radioactive beams of nuclei of energies $\sim 1-2$ A GeV at the Nuclotron of the JINR LHE opened up the unique possibility of studying processes of peripheral dissociation of nuclei, which provides the most complete information on excited states of nuclei above their decay thresholds.

These studies are important for obtaining an idea of phase transitions of nuclear matter from the quantum liquid state to the state of a quantum gas, consisting of a large number of nucleons and lightest nuclei in the vicinity of the energy thresholds of the reactions of interest.

On the energy scales, characteristic of the nucleonic and cluster structure of nuclei, these states represent interest for nuclear astrophysics, since they, quite probably, play the part of intermediate states in processes of nuclear synthesis in stars, and then the relationships between various fragments, found in the experiments, may be interpreted as processes inverse to processes of their fragmentation.

Hence it follows that the topic of the Project chosen for investigations is quite important, and utilization of the technique of nuclear photoemulsion chambers, exhibiting a record space resolution, permits to obtain unique information on cluster excitations of light nuclei near their dissociation thresholds, inaccessible to all other techniques for observing such processes. Moreover, obtaining the complete information on the primary and on all the secondary charged particles registered in the photoemulsion layers permits to determine unambiguously the dissociation channels of the incident nuclei and to reveal the most probable ones among them.

The above has been demonstrated very convincingly and illustratively in the Project in the form of a report on the work already carried out during the period of 2002-2007.

Thus, it may be considered that in the presented Project the method of searching for and processing experimental material has been elaborated in detail, and the ways have been indicated for further studies, necessary for enhancing the statistic of unique events and for

revealing new results in analysing photoemulsion layers already exposed to the new beams of the Nuclotron (it is necessary to underline the extremely good scientific relations between the participants of the Project and the designers of new Nuclotron beams).

Comments on the measurement technique

The charges produced as a result of nuclear fragmentation are measured with a high confidence level by counting the δ-electrons, accompanying the outgoing charged fragments, and by measuring their Coulomb scattering making use of the semi-automatic microscopes KSM and IPE-11, as well as the automized device PAVIKOM (PIAS) – here the space precison is 0.5 μm, the angular resolution is $\pm 30\, mrad$; ionization measurements are also not excluded in the case of one- and double-charged fragmnents.

Thus, the photoemulsion technique makes possible the total and reliable resolution of new tasks, based on the investigation of multiple fragmentation of radioactive nuclei ^{9}C and ^{12}N (the layers of emulsion to be analysed have already been exposed in beams of these nuclei and prepared for scanning and further processing).

We underline: Systematic ideas of the generation of multiparticle ensembles of light nuclei are very important for indirect approaches in nuclear astrophysics, and also in scenarios of rapid nucleosynthesis based on multiparticle fusion.

It must be especially underlined, that for resolving the problem formulated in the Project an international collaboration of five member-countries has been created and tested in work, since it possesses the necessary qualification and equipment for scanning, measuring and processing events of peripheral dissociation of light nuclei in various peripheral collisions both on heavy (Ag, Br) and on light (C, N, O) nuclei.

This collaboration, set up back in the 50-ies of the past century, is related to the names of K.D.Tolstoy and M.I.Podgoretskii, and has shown itself to be a group capable of working, that has at its disposal, for this work, sufficient necessary equipment, which, however, requires further improvement and automizing of the scanning and measuring procedures – precisely for this purpose the participants of the Project demand a quite reasonable financial support amounting to 360–400 thousand roubles.

The importance of the topic, the existence of necessary equipment, photoemulsion layers, that have been exposed in the Nuclotron beams required for the analysis, an elaborated measurement technique, as well as the highly qualified personnel of the collaboration permit to recommend inclusion of the "Project BECQUEREL-C" in the plans of work for 2009-2011.

Professor Yu. A. Batusov