REFEREE REPORT on
Proposal of the project HyperNIS
Strangeness in nucleons and nuclei
theme 02-1-1086-2009/2020

The project concentrates on the study of light hypernuclei. The proposed experiments have two distinguished features: i) hypernuclei (the nucleus contains in addition to nucleons the strange Λ particle) are produced in the nucleus-nucleus collisions due to reaction (p, K^+); ii) the product hypernucleus leaves the target, flies some distance and decays. It allows accurate determination of the hyperfragment and its life time.

At the first step of the considered project the reactions $^7\text{Li} + \text{C} \to {}^{3,4,6}_{\Lambda}\text{H} + \ldots$ will be investigated. The $^3_\Lambda\text{H}$ and $^4_\Lambda\text{H}$ hypernuclei have been observed in early Dubna experiments and in recent HyperHI experiment at GSI ($^6\text{Li} + \text{C}$ reaction). The $^3_\Lambda\text{H}$ and $^4_\Lambda\text{H}$ hypernuclei consist of Λ hyperon and stable nuclear core, deuteron and triton, respectively. There is no such stable core for $^6_\Lambda\text{H}$ hypernucleus and it may exist due to additional binding provided by Λ-particle only.

Few years ago FUNIDA collaboration studied the reaction $K^-_{\text{stop}} + {}^6\text{Li}$ and found three events indicating that $^6_\Lambda\text{H}$ hypernucleus stable against the neutrons emission exists. After the E10 Collaboration working at J-PARC accelerator in Japan announced that no stable $^6_\Lambda\text{H}$ hypernucleus has been obtained in the reaction $^6\text{Li}(\pi^-, K^+)^6_\Lambda\text{H}$. The experiments planned in this project will certainly help to clarify the situation.

The measured cross section of production of hypernuclei $^3_\Lambda\text{H}$, $^4_\Lambda\text{H}$, $^6_\Lambda\text{H}$ in $^7\text{Li} + \text{C}$ reaction will be very useful in the investigations both of strange particle production in baryon-baryon collisions inside the nuclear matter and of the nuclear reactions at the energies of several GeV/nucleon. Also it will be very interesting to measure the life times and binding energies in order to estimate how strange particle effects the binding energies (and compressibility) of neutron rich systems.

The experimental study of gamma-spectra emitted from p-shell hypernuclei shows that the Λ-particle occupies very fast the lowest s-state inside the nuclear mean field. Therefore the ground state of $^6_\Lambda\text{H}$ may be splitted according to the values of total spin of proton-Λ pair ($S = 0, 1$). The possible gap between singlet and triplet states may give some hints about the spin-dependent part of hyperon-nucleon interaction at low energy. This information will be useful for the study of the nuclear matter Equation of State if the creation of strange particles is considered.

The project has several directions for future development. For example, the life time of $^6_\Lambda\text{He}$ is not known and the investigation of $^6\text{Li} + \text{C} \to {}^6_\Lambda\text{He} + \ldots \to {}^6\text{Li} + \pi^-$, reaction will help greatly. The search for the next hyperhydrogen isotope, $^8_\Lambda\text{H}$, are considered, too.

The Λ particle inside hyper-hydrogen isotopes decays weakly into π^- and proton for the alternative mode $\Lambda \to \pi^0 + n$ is suppressed by the Pauli principle. In the heavier hypernuclei (with $Z > 2$) the process $\Lambda \to \pi^- + p$ is blocked by Pauli principle, too. And non-mesonic weak decay of Λ occurs due to weak interaction Λ-hyperon with either one nucleon or few ones. In the literature there are at least five different theoretical models describing the processes. Some time ago L. Majling had shown that even incomplete set of widths of α

decays following the weak non-mesonic decay of ${}^{10}_{\Lambda}$Be and ${}^{10}_{\Lambda}$B hypernuclei will be extremely useful in selecting an adequate model of weak ΛN interaction. So, the experiments planned as the project next step will be very important, too.

All above mentioned allow to consider project "Strangeness in nucleons and nuclei" as very interesting one and I highly recommend to support it.

V. A. Kuz'min
Leading scientific researcher
Bogoliubov Laboratory of Theoretical Physics
E-mail: kuzmin@theor.jinr.ru