Production and study of neutron-rich hypernuclei. Physics and potentialities at FAIR/R3B

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SCIENTIFIC ISSUE

Hypernuclei are atomic nuclei where a nucleon is replaced by a hyperon (Λ,Σ, Ξ, Ω). The case most frequently observed experimentally is the replacement of a nucleon by a Λ. The Λ differs from neutron mainly on two points. It carries a charge of strangeness (S =-1) and has a slightly greater mass of 1115 MeV. Therefore its presence modifies the characteristics of the "conventional" nucleus and it may be used as a probe of the latter. Not affected by Pauli blocking it can take up the whole available phase space, even the deepest levels. Moreover its presence can *i*) affect the size for small nuclei where the incompressibility of nuclear matter is less important [1], *ii*) change the shape of the nuclei (although all models do not agree on this point [2]), *iii*) make stable some nuclei that are not without it (e. g. ${}^{8}_{\Lambda}$He [3], ${}^{6}_{\Lambda}$H [4]) and *iv*) lead to hypernuclei far beyond the neutron or proton driplines. Besides the hypernuclei with a large ratio n/p objects are privileged to study the interactions Λ-nucleon and Λ-nucleus. In return, the nucleus is the most appropriate place to study interactions Hyperon-Baryon, because the beams of hyperons are far too rare. If the Λ-nucleus potential is fairly well known, that is not the case of the Σ-nucleus potential, since even its sign is debatable [5]. However the Λ-nucleon potential has still grey areas. For example, a charge symmetry breaking (CSB) was observed in the mirror nuclei (e.g. ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He). It indicates that the Λ-Proton potential is more attractive than the Λ-Neutron potential. The origin could be due to the strong ΛN $\longleftrightarrow$ ΣN coupling, because of the similar masses of Λ and Σ [6]. Another area is the study of the Λ decay in the nucleus. The free Λ decays via the mesonic channel (Mesonic Weak Decay), but this channel is reduced in the nucleus by the Pauli blocking of the emitted nucleon. Nevertheless some exceptions can be mentioned [7] : i) the light nuclei or when Λ is at the surface (low density of nucleons), ii) when Λ has enough energy giving to the emitted nucleon an energy that can be larger than the Fermi energy (and thus Pauli blocking does not occur) and iii) the case where the attraction of the nuclear medium reduces the energy of the emitted pion which has the effect of increasing the nucleon energy (which is not Pauli blocked then). The other channel, which is then the most important one in the nucleus, is the Non Mesonic Weak Decay (ΛN $\rightarrow$ NN and NN $\rightarrow$ ΛNN).

Experiments in this field are already operated at various international laboratories (MAMI, JLAB in the US, FINUDA at DAΦNE and J-PARC in Japan) or planned (SPHERE at JINR (Russia), PANDA and HypHY at FAIR) [8]. Compared to exotic nuclei, exotic hypernuclei offer a new degree of freedom - strangeness - to constrain the nuclear structure theories [6]. At GSI, the study of hypernuclei with Heavy Ion Beams (HypHI) has started [9]. This program is also foreseen in the scope of the FAIR project. The R3B setup [10] with the new high acceptance GLAD spectrometer and very thick liquid hydrogen targets [11] may offer new opportunities for exclusive measurements and complementary studies of neutron-rich hypernuclei.

In summary, the goals of the workshop are

1. to review the latest achievements in the spectroscopy of hypernuclei,
2. to discuss our understanding on strangeness production from both the elementary process and the hypernuclei production from nuclear collisions,
3. to examine which probes and experimental techniques are the most promising to obtain clearest observables regarding nuclear shell structure and quantum many-body problems,
4. to discuss future possibilities at FAIR/R^3B and their competitiveness compared to other existing or future projects.

PROGRAM

January 19	January 20	January 21
09h00 H. Tamura	09h00 J. Pochodzalla	9h00 T. Saito
10h30 **Break**	10h30 **Break**	10h30 **Break**
11h00 E. Botta	11h00 A. Botvina	11h00 T. Aumann
12h30 **Lunch**	12h30 **Lunch**	12h30 **Lunch**
14h00 F. Garibaldi	14h00 N. Buyukcizmeci	14h00 open discussion
15h30 **Break**	15h30 **Break**	15h30 **End**
16h00 open discussion	16h00 I. Vidana	
17h30 **End**	17h30 **End**	

Titles of the foreseen presentations are :
— **H. Tamura** : Present status and future prospects of hypernuclear physics at J-PARC,
— **E. Botta** : Hypernuclear physics studies with FINUDA,
— **F. Garibaldi** : High resolution hypernuclei studies at Jefferson lab,
— **J. Pochodzalla** : hypernuclei studies at MAMI and PANDA,
— **A. Botvina** : Formation of hypernuclei in relativistic ion collisions,
— **N. Buyukcizmeci** : Mechanisms of production of hypernuclei in nuclear reactions,
— **I. Vidana** : Hyperons, hypernuclei and neutron stars,
— **T. Saito** : Neutron-rich hypernuclei and the HyPHI project at GSI and FAIR,
— **T. Aumann** : The R3B setup and physics program.

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