Possible measurement of the lifetime of Hydrogen hyperisotopes at J-PARC and JLab

Elena Botta[1]

[1]INFN - Sezione di Torino and Torino University - Physics Department

The measurement of ${}^{3}_{\Lambda}$H and ${}^{4}_{\Lambda}$H Hydrogen hyperisotopes lifetimes has a peculiar similarity from both the chronological and the physical points of view. On the one side, for both hyperisotopes the first determinations were obtained between the 60s and the 70s, by means of visualizing techniques, in experiments featuring (very) limited statistics, and were then followed by a long period with no new experimental results, ended very recently with new determinations by (heavy) ion experiments. On the other side, for both hyperisotopes, values are quite spread, irrespective of the technique used in the measurements, and they are all substantially smaller than the free Λ hyperon lifetime, quite unexpectedly if the hyperon binding energy values are considered. A final precise determination of both lifetimes is thus needed and an experimental effort is required exploiting the present facilities.

The technique of the time delayed spectra can be very hardly used for the hydrogen hyperisotopes since they cannot be produced from He targets in reactions employing only charged meson beams and ejectiles. With the high-intensity and high-resolution (HIHR) beam line at J-PARC it should be possible to envisage the use of the (π^-, K^0) reaction on He targets to produce hydrogen hyperisotopes [1]: in particular, for ${}^{4}_{\Lambda}$H, feasible resolutions and detection efficiencies for the final state K^0 could allow to isolate the ground state of ${}^{4}_{\Lambda}$H and to have production rates comfortable for the lifetime measurement, while a measurement of $\tau({}^{3}_{\Lambda}\mathrm{H})$ seems harder due to the smaller binding energy: in order to limit unavoidable contributions from the free Λ decay it should be necessary to select the lower energy π^- from the 3-body decay, with the complication of a reduction in the counting rate and a more sophisticated detector.

Moreover, the recent advent of high quality and high intensity electron beams at JLab, coupled to the excellent energy resolutions so far achieved with dedicated spectrometers, offers a novel opportunity to produce the hydrogen hyperisotopes out from targets of the He isotopes by means of the (e, e$'$ K$^+$) reaction. A first study showed clearly signals corresponding to the production of ${}^{3}_{\Lambda}$H and ${}^{4}_{\Lambda}$H [2]. As soon as the plan of upgrade in energy and quality of the electron accelerator complex will be achieved it should be possible to get a high statistics time spectrum from the MWD of ${}^{4}_{\Lambda}$H, almost background-free, by exploiting the excellent resolution of the present spectrometers for selecting electroproduction of hypernuclei in the forward direction, $\sim$500 keV [3] coupled to a quite simple apparatus to detect πs from 2-body mesonic decay.

The situation changes for the ^{3}He target. From the first study it is evident a reduction of the production of ${}^{3}_{\Lambda}$H with respect to the free Λ production of 2-3 orders of magnitude [2]; if in addition the small ${}^{3}_{\Lambda}$H binding energy is considered, it is possible to guess that, also at JLab, a precise ${}^{3}_{\Lambda}$H lifetime measurement is quite harder than for ${}^{4}_{\Lambda}$H and would also necessitate of the detection of π^- from the 3-body decay with a dedicated set-up.

The experimental scenario of both J-PARC and JLab facilities will be discussed.

[1] S. Ajimura et al., J-PARC proposal P22 (2006)

[2] F. Dohrmann et al., Phys. Rev. Lett. 93 (2004) 242501.

[3] F. Garibaldi et al., Nucl. Phys. A 914 (2013) 34.