Testing $\Lambda(1405)$ with K-mesic atoms

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The search for nuclear states of $\bar{K}$ is pursued actively in several laboratories with various experimental techniques (ref. [1] offers a summary). The attraction in K-nuclear systems is due predominantly to the $\Lambda(1405)$ state. Properties of this state, in particular the position and width in the elastic $\bar{K}N$ channel are uncertain. Hence, calculations of the binding energies and widths of the $\bar{K}$-nucleus and in particular the $\bar{K}$-few-nucleon states are very uncertain. We suggest two tests of the $\Lambda(1405)$ shape.

(1) The measurements of level widths in K-mesic atoms may determine the absorptive part of $\bar{K}N$ scattering amplitude in the subthreshold region

$$a_{\bar{K}N}(E = -E_S - E_{recoil}) \tag{1}$$

where E_S is the the separation energy of a nucleon and E_{recoil} is the recoil energy of $\bar{K}N$ pair relative to the nucleus. With a proper choice of nuclei and atomic levels one can detect the energy dependence of Im $a_{\bar{K}N}(E)$ and this dependence can reflect the shape of $\Lambda(1405)$. The best conditions are offered in the uppermost accessible atomic levels which involve the valence nucleons of known E_S and calculable E_{recoil}. The existing data indicate a sizable energy dependence of Im $a_{\bar{K}N}(E)$ but the experimental uncertainties are large. New measurements and new targets are suggested.

(2) Direct radiative transitions from the atomic states of K^-p system to the $\Lambda(1405)$ may also test the shape of the latter. The chances for $K^-p \to \Lambda(1405), \gamma$ transitions are calculated to be about $5 * 10^{(-4)}$ of the $K^-p \to \Sigma, \pi$ transitions in the (n,P) atomic states. That offers a chance for a successful experiment.

[1] AMADEUS Project, LNF-Frascati, C. Curceanu.

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