The kaonic atoms 'puzzle': what next?

E. Friedman

Racah Institute of Physics, the Hebrew University, Jerusalem, Israel

The expression 'kaonic atoms puzzle' refers to an apparent conflict between phenomenological optical potentials obtained from fits to kaonic atom data and the corresponding potentials constructed from more fundamental approaches [1,2]. Whereas the best-fit phenomenological potentials have for the real part typical depths of 180 MeV at nuclear-matter densities, best-fit $t\rho$ potentials are less than half that deep. Moreover, the corresponding depths of chiral-motivated potentials [3] are typically only 30-40 MeV. This topic attracted attention since the mid-1990s because of its implications for neutron stars. Extrapolating the deep potentials to 3-4 times the normal nuclear density, condensation of K^- mesons could take place, which has non-negligible effects on the equation-of-state, see [4] for a recent reference. Condensation at these densities is not possible with the shallow potentials. The depth of the antikaon-nucleus potential is relevant also to recent theoretical speculations and experimental indications [5] for the existence of bound states of antikaons in light nuclei with binding energies of the order of 100 MeV. If confirmed, that will clearly exclude the shallow potentials.

Careful re-analyses of the world's data on kaonic atoms could not suggest an explanation to the puzzle. Removing from the data base the nuclear species which contribute most to the increased χ^2 for the shallow potentials, (130 for 65 data points for the $t\rho$ potential against 85 for the deep potential), we still get the two (deep and shallow) solutions from the χ^2 fits. Repeating some of the 30-40 years old experiments seems the only way to proceed but it is unrealistic to repeat measurements on more than 20 targets. We therefore studied the possibility of selecting a small sub-group of targets that will be representative of the full set.

Five targets have been selected that cover the whole range of the periodic table, where the width of the 'lower' level is between 0.5 and 3 keV and the yield of the 'upper' level is at least $\approx 10\%$. These are C, Si, Ni, Sn and Pb. For the last two the separated isotopes of ^{120}Sn and ^{208}Pb are highly recommended. It is found that with any 4 of the 5 targets it is possible to observe all the features of the potentials found in global fits.

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E-mail: elifried@vms.huji.ac.il