J-PARC Proposal Short Abstract

Precision spectroscopy of Kaonic Helium3 *3d* → *2p* X-rays

Beamline: K1.1 or K1.8BR

Beam: 0.75 GeV/c K^-

Intensity$^-$: 0.33 x 10^6 / spill (for K1.1), 0.19 x 10^6 / spill (for K1.8BR) @ 30 GeV, 9 μA

Flat-top: 0.7 sec (3.53 sec/spill)

Target: liquid ^{3}He (1.2 g/cm^2)

Beam time: 2 days (for K1.1) / 3.5 days (for K1.8BR) (assuming full intensity @ 30 GeV, 9 μA) + 10 days (commissioning)

Total number of K^- beam: 16 x 10^9

Abstract

We propose to measure the strong-interaction shift of *3d*→*2p* X-rays of kaonic helium 3 atom with a precision better than ~2 eV as a J-PARC DAY-1 experiment.

The motivation for the measurement of *2p* level shifts of kaonic helium 3 and 4 atoms arose from the discovery of the narrow state, strange trybaryon $S^0(3115)$, in the ^{4}He(stopped K^-, *p*) spectrum measured by the KEK-PS E471 collaboration. Akaishi and Yamazaki have propounded the deep optical potential which accommodates deeply-bound kaonic nuclear system being one of the interpretations of this state. Using this potential with the coupled channel potential for $\Sigma\pi$ decay channels, they predicted possible large shifts (~|10|eV) of *2p* level of the kaonic helium 3 and 4 atoms, and opposite sign for both atoms, attractive for K^--^{3}He and repulsive for K^--^{4}He, within their predicted region (200~300 MeV) of real part of the potential strength between K^- and ^{3}He / ^{4}He. On the other hand, almost all theories except for the Akaishi-Yamazaki's have predicted ~0 eV shift for the kaonic helium atoms. If the measured *2p* energy shifts were <~|10| eV for either atom and of predicted signs, the strongly attractive potential advocated by Akaishi and Yamazaki will be justified. This will therefore endorse the picture $S^0(3115)$ being a kaon-nucleus deeply bound state.

Very recently, we have measured the shift of *3d*→*2p* X-rays of kaonic helium 4 atom (KEK-PS E570) using Silicon Drift Detectors, SDD, which have high energy resolution ~185 eV (FWHM) at 6.5 keV (cf. ~300 eV for past experiments). The *3d*→*2p* X-ray has been observed about 1500 events whose statistics could be obtained about 20 days with working 8 SDDs. We will then achieve ~2 eV of the statistical error of the shift.

Here, we propose to measure the shift of *3d*→*2p* X-rays of kaonic helium 3 atom using 12 SDDs with same statistical precision (~2 eV) as that of E570 for a DAY-1 experiment. The shift of the kaonic helium 3 atom has not as yet measured. We will have 3 times higher SDD acceptance by optimizing the location of the SDDs and 2 / 3.5 times higher stopped K^- yield at J-PARC K1.1 / K1.8BR beamline than those of E570. We will thus have 1500 events of *3d*→*2p* X-rays with only 2 days (for K1.1) / 3.5 days (for K1.8BR). Even in one-order lower beam intensity case, such as beginning of the beam time especially for the DAY-1 experiment, we can perform the proposed experiment within 20 / 35 days. The measurement together with that of kaonic helium 4 atom measured by E570 collaboration will provide a crucial information to understand the nature of the $S^0(3115)$.