Role of Near Threshold Resonances in Intermediate Energy Nuclear Physics

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The presence of a resonance close to the threshold strongly effects the dynamics of the interacting particles at low energies. Production of the life essential element ^{12}C in ^{4}He burning in sun is a classic example of such a situation. In intermediate energy nuclear physics, this situation arises in the interactions of a η-meson with a nucleon and that of a K^--meson with a proton at low energies, where both these systems have a resonance or a bound state near their thresholds, resulting in a strong attractive interaction. If putting these mesons in a nuclear environment produces a strong attraction, it is possible that, in nature there may exist η- and K^--nuclear bound states. Such a tantalizing possibility has led to experimental and theoretical programs to hunt for them. These efforts have produced positive results [1, 2].

For the eta meson experimental observation of an η-nucleus quasibound state has come using photon beam at Mainz Microtron facility (MAMI) and the proton beam at the COSY facility, Julich. Both these experiments follow the strategy that:

1. The dynamics of the η-meson is governed by the S_{11}, $J^\pi(\text{spin}^{\text{parity}}) = \frac{1}{2}^-$ resonance, the excited state, N*(1535) of the nucleon. This state is just 49 MeV above the $\eta - N$ threshold and has a width Γ=150 MeV. It, thus, covers the whole low energy region of the $\eta - N$ interaction. It decays into πN and ηN channels with about equal probability.

2. For an η bound state the S_{11} resonance can not decay into $\eta - N$ in free state. It can decay only to $\pi - N$. Furthermore, as the Fermi momentum is not large, the S_{11} is practically at rest in the nucleus. Consequently, the emerging $\pi - N$ come out back to back.

Thus, both the experiments detect a pion and a nucleon in coincidence with their 4-momenta fully measured. The Mainz group has seen a $^{3}He_\eta$ state. The binding energy and width of the mesic state is reported to be [-(4.4± 4.2)-i(25.6±6.1)] MeV [3]. The COSY-GEM group has reported to have seen the $^{25}Mg_\eta$ bound state with the binding energy (-13.13±1.64) MeV and width around 5 MeV [4].

Above experimental observations have been supported by theoretical calculations.

First indication of the existence of the K$^-$ bound nuclear state came in the FINUDA measurements of the stopped K$^-$ absorption in Li, C and other nuclei [6]. These experiments using the FINUDA spectrometer installed at the DAΦNE collider detected a Λ hyperon and a proton in coincidence following K$^-$ absorption at rest in several nuclei. The emitted $\Lambda - p$ pair was found to emerge back to back in all target nuclei, and had their invariant mass distribution peaking significantly below the sum of a kaon and two protons in free state (2.37 GeV). If it is assumed that the $\Lambda - p$ pair emitted from a "K$^-$-pp" system in the nucleus, this mass shift implies a bound "K$^-$-pp" system in nuclei with the binding energy above 100 MeV.

Theoretically, there exists several calculations which suggest existence of above state with varying binding energies [5].

The talk gives a brief critical overview of above studies, emphasizing especially the ef-

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forts due to BARC.

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