Signature of α-clusters in light nuclei

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Nuclear clustering is an important concept in nuclear physics and it plays an important role in determining the structure of particularly the light nuclei. It is conjectured that nucleons inside the nucleus may also exist in the form of compact closely-packed cluster of four nucleons (two-neutrons and two protons, *i.e.*, ^{4}He nucleus). This concept of the existence cluster in nuclei was first used in nuclear physics to explain the phenomenon of radioactivity. The α-cluster configuration in light α-like nuclei around their corresponding cluster break-up thresholds was first introduced by Ikeda and his co-workers [1]. Most of the α-cluster states in nuclei are known to be particle unbound above this threshold. So, studying these particle/cluster decays, one can extract valuable information about the structure of these nuclei, which is believed to play vital role in understanding the cluster configurations in nuclei that cannot be described within the standard shell model. Some of the cluster sates (e.g., the Hoyle state in ^{12}C) play crucial roles in explaining the elemental abundances in stellar nucleosynthesis process.

In recent years, there has been lot of interest in the study of cluster states using resonance particle spectroscopy with special emphasis on the structure of second 0^{+} excited state of ^{12}C at 7.65 MeV, the famous Hoyle state, which has a strong 3α cluster structure and is believed to play a central role in the nucleosynthesis. From nuclear structure point of view, the Hoyle state is `different' from other excited states of carbon, which is manifested in its 3α-cluster configuration; standard as well as no-core shell model calculations failed to reproduce the energy of the state [2]. The structure of this state is being considered to be a very exotic in nature ranging from 3α-linear chain like structure to diffuse Bose gas as well as Bose Einstein condensate [3, 4]. Existence of several states has been predicted theoretically above the alpha decay threshold, which still need to be identified in order to understand the cluster structure of ^{12}C in particular and the origin of clustering in nuclei as a whole [3]. The existence of similar states called the Hoyle analogue states in nuclei other than carbon has also been predicted and experimental search is going on to know the precise properties of those states. In this presentation, details of the studies performed to unravel the cluster structure in light nuclei will be discussed.

References:

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