INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Ghanashyam Meher
Roll Number	:	146121004
Programme of Study	:	Ph.D.

Thesis Title: **Efimov Universality in Exotic Strange and Charm Nuclei: A Low-energy Effective Theory Framework**

Name of Thesis Supervisor(s)	:	Dr. Udit Raha
Thesis Submitted to the Department/ Center	:	Physics
Date of completion of Thesis Viva-Voce Exam	:	12/01/2023
Key words for description of Thesis Work	:	Pionless effective field theory, Low-energy, Two- and three-body universality, Faddeev equation, STM equation, Efimov effect, Renormalization group, Limit cycle, Exotic nuclei, and Halo/ Cluster system

SHORT ABSTRACT

The present thesis deals with the investigation of low-energy two- and three-body universality that could manifest in exotic strange and charm nuclei. To supplement the plethora of existing works based on potential models on such systems, the main objective of this thesis is to employ a model-independent effective field theory (EFT) framework as a modern systematic computational tool for understanding the underlying binding mechanism without reference to inherent (microscopic) short-distance details. In particular, pionless EFT or its variant, so-called the *Halo/Cluster* EFT, provides a versatile theoretical technique to specifically search for the feasibility of Efimov mechanism in halo-like nuclear clusters. Here we presented leading order EFT investigations of the putative S-wave bound hypernuclear cluster states, such as the iso-doublet mirror partners ($_{\Lambda}^{5}{}_{\Lambda}$H, $_{\Lambda}^{5}{}_{\Lambda}$He) in the (J=1/2, T=1/2) channel, as well as the Ξ^-nn cluster in the (J=1/2, T=3/2) channel, in the strange sector. The mirror clusters are studied as 2Λ (double-Λ-hyperon) halo systems with a composite core, identified either as a triton (t) or helion (h). Whereas, the Ξ^-nn system is studied as a 2n-halo system with a Ξ-hyperon elementary core. Furthermore, in the charm sector, we studied the putative 2n halo-bound D^0nn system in the (J=0, T=3/2) channel invoking an idealized zero-coupling-limit ansatz which excludes all effects of decay and coupled channels dynamics. The general EFT formalism involves the diagrammatic construction of a system of Faddeev-like three-body integral equations embodying the re-scattering dynamics in the momentum-space representation. Using momentum cut-off regulators in the integral equations which are significantly larger than the hard scale of the EFTs, the three-body contact interaction becomes cyclically singular indicating the onset of renormalization group (RG) limit cycles with discrete scale invariance. Thus, our results formally indicate the manifestly Efimovian nature of each of the cluster systems leading to ostensible Efimov states. However, the paucity of current empirical information to determine various free EFT parameters precludes definitive conclusions on the feasibility of such systems being realistically Efimov-bound. Nevertheless, despite phenomenological limitations, the thesis amply demonstrates the predictability of the EFT analyses by illuminating various remnant features of Efimov universality at a qualitative level. Constraining the cut-off dependence of double-

Λ separation energy and the corresponding three-body scattering lengths of the ($_{\Lambda}^{5}{}_{\Lambda}$H, $_{\Lambda}^{5}{}_{\Lambda}$He) mirrors, predicting the Phillips-line correlation curves for the $_{\Lambda}^{5}{}_{\Lambda}$H, $_{\Lambda}^{5}{}_{\Lambda}$He and Ξ^{-}nn systems, and finally, demonstrating the structural universality of the ground state of a plausible D^{0}nn halo-bound cluster by determining its geometrical features (e.g., matter density form factors, mean square radii, etc.), were some of the predictable features emphasized in this thesis.