



UNIVERSITÀ
degli STUDI
di CATANIA



DIPARTIMENTO DI FISICA E ASTRONOMIA
“ETTORE MAJORANA”

DOTTORATO DI RICERCA IN FISICA
CICLO XLI A.A. 2025/2026

Clusters in Atomic Nuclei

2 CFU

Teaching staff

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Reception hours: Monday, 11-13

Program of the course:

1 – Theory of nuclear forces: the deuteron – bound and virtual state of the deuteron – spin dependence of nuclear forces – scattering of slow neutrons on protons – scattering on ortho- and parahydrogen – non-central term of nuclear forces – isospin formalism – residual interaction.

2 – A summary of decays and reactions useful to test clustering in nuclei: Resonant elastic and inelastic scattering of α particles. α -transfer reactions. Sequential break-up of nuclei. Analysis methods to extract nuclear structure properties from experimental data – spin-parity and isospin selection rules – Clebsch-Gordan and Racah coefficients in nuclear reactions.

3 – α -clustering in light nuclei. Self-conjugate nuclei: their peculiar properties. Lifetime of ^8Be states and Coulomb barrier effects. Isotopes of Be and nuclear dimers. Nuclear Orbitals. σ and π bonding in nuclei. Coriolis effect on molecular rotational bands. The ^{12}C case. The “Hoyle state”: its properties and mysteries. The anthropic principle. Signatures of Bose-Einstein condensation in nuclei. Nuclear molecules. Effects of α clustering on nuclear astrophysics.

Bibliography:

- [1] A.S. Davydov, Theory of Atomic Nucleus, Nauka
- [2] I.E. McCarthy, Introduction to Nuclear Theory, Wiley
- [3] L. Valentin, Noyaux and Particules, Hermann
- [4] C. Beck (Ed.), Clusters in Nuclei, Springer
- [5] I. Lombardo, Problemi di Fisica Nucleare e Subnucleare, CEA Zanichelli
- [6] I. Lombardo and D. Dell'Aquila, Clusters in light Nuclei, Riv. Nuovo Cim. 46 (2023) 521