



UNIVERSITÀ  
degli STUDI  
di CATANIA

DIPARTIMENTO DI FISICA E ASTRONOMIA  
Ettore MAJORANA

DOTTORATO DI RICERCA IN FISICA

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## Clusters in Atomic Nuclei

2 CFU

### Teaching staff

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### Program of the course:

**1 – Modern view of particle decay of nuclear states.**  $\alpha$ -decay: Coulomb and centrifugal barrier effects. Hindrance factors. Decay towards excited states of the daughter nucleus. Odd-nuclei and  $\alpha$  - decay. Geiger-Nuttal law and fine-tuning problems. Electron screening effects. Selection rules in  $\alpha$  - decay. Test of parity violation in strong interactions. Semi-classical calculations of  $\alpha$  spectroscopic factors. Rose & Jones experiment and cluster radioactivity.

**2 – A summary of decays and reactions useful to test clustering in nuclei.** Beta decay and electron capture. Nuclear Fluorescence resonance. Resonant elastic and inelastic scattering of  $\alpha$  particles.  $\alpha$  -transfer reactions. Sequential break-up of nuclei. Analysis methods to extract nuclear structure properties from experimental data.

**3 -  $\alpha$  - clustering in light nuclei.** Self-conjugate nuclei: their peculiar properties. Lifetime of  $^8\text{Be}$  states and Coulomb barrier effects. Isotopes of Be and nuclear dimers. Nuclear Orbitals.  $\sigma$  and  $\pi$  bonding in nuclei. Coriolis effect on molecular rotational bands. The  $^{12}\text{C}$  case. The “Hoyle state”: its properties and mysteries. The anthropic principle. Signatures of Bose-Einstein condensation in nuclei. A novel view of light nuclei structure: the Algebraic Cluster Model (ACM). Symmetries and Group theory in light nuclei. n-rich and p-rich isotopes of carbon. Nuclear molecules. Effects of  $\alpha$  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