From femtoscience to nanoscience: nuclei, quantum dots and nanostructures

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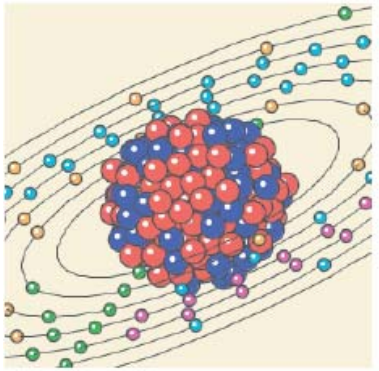

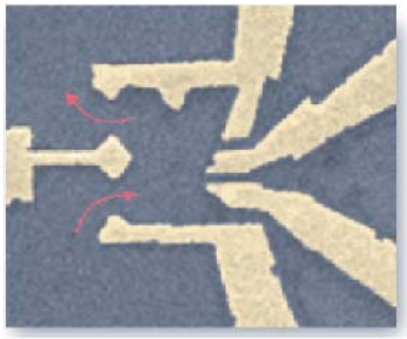

- The program will focus on correlated quantum systems in which finite-size effects are important: nuclei, quantum dots and nanostructures.

- It will bring together the nuclear and mesoscopic physics/nanoscience communities.

Nuclei: a more quantitative description requires the inclusion of correlations beyond the mean field – an outstanding problem in the field.

Mesoscopic systems: the single-particle (mean field) degrees of freedom are by now well understood. However, in almost-isolated structures, many-body correlations are important and they modify the single-particle properties.

The program will explore several topics that are of common interest to the nuclear and mesoscopic/nanoscience communities:

- Effective interactions to describe the low-energy degrees of freedom.

  Integrate out the high energy degrees of freedom

  Configuration-interaction shell model: Lee-Suzuki transformation (unitary)
  Anderson model $\Rightarrow$ Kondo Hamiltonian: Schrieffer-Wolf transformation

  Renormalization group (RG) approach in finite systems.

• Superfluidity or superconductivity in finite-size systems (e.g., nuclei and ultra-small metallic grains)

The crossover between the bulk BCS limit and the fluctuation-dominated regime (in which BCS theory is no longer valid). Methods have been developed in both communities to treat fluctuations in this regime.

•.The coupling to the continuum

Important in weakly bound nuclei.

In quantum dots, the "continuum" corresponds to the conduction electrons in the leads.

• Quantum chaos in many-particle systems

Statistical properties of complex many-body systems are often described by random matrix models.

The crossover between the regular (Poissonian) regime and the random matrix regime has an interesting but not yet fully understood connection with the many-body Anderson localization problem.

• Cold trapped atomic condensates

A well-defined strongly interacting system that offers theorists in both the nuclear and mesoscopic communities a unique opportunity to explore various theoretical approaches.

• Quantum dynamics in confined geometries

Describe the quantum evolution of a finite many-body system in which the coupling between its components is varied in time.

Spin and superconducting qubits.

The transition between a Mott insulator and a superfluid in atomic systems.

Nuclear spin dynamics plays an important role in the coherent manipulation of quantum dots spin qubits.