"Beyond-Mean-field" calculations: status

I. Projected-GCM calculations using realistic functionals

- PAV / II / axial. sym. HFB / GCM Q_{30} / Gogny-Skyrme / "Spanish"-"Francophone" groups
- PAV / N, Z, J / axial. sym. HFB / GCM Q_{20} / Skyrme / "Francophone" group
- PAV / N, Z, J / axial. sym. HFB / GCM Q_{20} / RHB / "German" group
- PAV / J / axial. sym. HFB / GCM Q_{20} / Gogny / "Spanish" group
- VAP / N, Z / axial. sym. HFB / Skyrme / "Polish" group
- VAP / P / spher. sym. HF / Skyrme / "Spanish"-"German" group
- PAV / J / triax. cranked HF / Skyrme / "Polish" group
II. Results (not only ground-state bulk properties)

♣ Low-energy spectroscopy; i.e. vibrational and rotational states including their coupling

♣ E.M. transition probabilities in the laboratory frame of reference

♣ Extend the applicability of EDF to light nuclei; i.e. spectroscopy of $^{16}O$

♣ Study of disappearance of magic shells including dynamical correlations; i.e. $\sim^{32}Mg$

♣ Shape coexistence of complicated systems; i.e. $\sim^{186}Pb,^{72}Kr$

♣ Isomers and fission barriers including correlations; i.e. $^{240}Pu$

♣ Correlation energies, r.m.s radii, $S_{2N}$; i.e. systematic over $\sim 500$ even-even nuclei
III. Achievements and limitations at this point

♣ Spectroscopy is coming out good on a qualitative level without any adjustment but:
  • Not all type of states available (i.e. $\gamma$ bands)
  • Only even-even nuclei
  • Too spread out spectra
  • Mixing of shapes not always good (see $B(E\lambda)$)
  • Overall precision to be improved
♣ Correlation energies improve mass/radii systematics but
  • Not good enough yet

IV. Extending the calculations

♣ Projection and mixing of cranked/triaxial states... underway but difficult
♣ More modes coupled together: GCM on $Q_{2m}$, $Q_{30}$ and $\Delta +$ corresponding projections... feasible
♣ Odd and odd-odd nuclei... difficult

V. Formal questions and difficulties

♣ Most remaining defects are due to deficiencies of the starting functional
♣ Not a density functional... no HK theorem to back up our "beyond-mean-field" calculations
♣ Following the phase of $\langle \Phi_L | \Phi_R \rangle$ become difficult in more involved cases
♣ Symmetry restorations need to be formulated in a general way for an functional approach
♣ Extension from $E[\varphi, \Omega, \ldots; \varphi, \Omega, \ldots]$ to $E[\varphi', \Omega', \ldots; \varphi, \Omega, \ldots]$ unclear ⇒ contractions to be used?
♣ Calculations are ill defined in the functional context...