STRUCTURE OF FINITE NUCLEI STARTING AT THE QUARK LEVEL

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Traditional nuclear theory starts with non-relativistic two- and three-body forces and concentrates on solving the many-body problem as accurately as possible. For medium and heavy weight nuclei the most successful tool is the density functional approach based upon purely phenomenological, density dependent Skyrme forces. Only recently has it been possible to go to a more fundamental level and derive a density dependent effective force starting at the quark level (P.A.M. Guichon *et al.,* Nucl. Phys. A772 (2006) 1).

Now for the first time this *derived* force has been systematically applied to the properties of finite nuclei across the Periodic Table (J.R. Stone, P.A.M. Guichon, P.G. Reinhard and A.W. Thomas, Phys. Rev. Lett., 116 (2016) 092501). With a far smaller number of parameters (the σ, ω and ρ couplings to the light quarks) for the effective force and the traditional two pairing parameters, the binding energies of a sample of more than one hundred nuclei across the entire Periodic Table were reproduced within 0.35%. The predictions for superheavy nuclei, which were not fit, were particularly promising with the binding energies reproduced with an accuracy of 0.1% and the deformations were also extremely well described.

Another notable successes of this initial study of the QMC Skyrme force was the prediction of shape co-existence between oblate, spherical and prolate shapes in Zr, with N=60 a critical transition point. It also predicted a double quadrupole-octupole phase transition in the Ra-Th region.

We expect to see many applications and developments of this model in the next few years. It is especially interesting in the light of the number of new rare ion facilities worldwide. This presentation will report the latest results using this approach.