INT-09-01: EFT's and the Many-Body Problem

- INT program organizers: Calvin Johnson, Dick Furnstahl, Erich Ormand, and Bira van Kolck
- INT program coordinator: Laura Lee
- Goal: Tie together EFT, MBT (many-body theory), and DFT communities
- *Can we have a unified framework for systematic and controlled reduction of the degrees of freedom for these disparate disciplines? How do we transplant information about reduced degrees of freedom from one community to another?*
- Three Big Questions:
  1. How do EFTs evolve with A, and can we at some point extrapolate smoothly?
  2. How can we put the many-body dependence of EFTs in a tractable form into MBTs?
  3. How can we use EFTs to constrain DFTs?

Big Question #1

- How do EFTs evolve with A, and can we at some point extrapolate smoothly?
  - How far in A (and density) can one push the pionless EFT? Could it be that it holds for nuclear matter?
  - The main current issues for the pionful EFT are power counting and convergence; the many-body aspect is the size and form of few-body forces, including the role of the delta isobar.
  - How can we calculate with EFT for $A \geq 4$?

Big Question #2

- How can we put the many-body dependence of EFTs in a tractable form into MBTs?
  - MBT methods have used EFT potentials as input in the same manner as phenomenological ones. Is there a more efficient/correct way to marry EFT and MBTs? E.g., treating corrections to the leading potential in perturbation theory or defining the EFT directly within the discrete small SM spaces
  - How can we improve the many-body methods? E.g., how does one derive simultaneous effective operators (for electron scattering, beta decay, etc.) along with the interaction itself? Can we justify approximations or selection of certain contributions (such as done, e.g., in the coupled-cluster method) with an EFT power counting?
  - Can we develop other EFTs specifically for many-nucleon systems? E.g., there is an EFT for halo nuclei, which explores the separation in energy between halo and core nucleons.
  - re Can the choice of EFT fields be exploited to either minimize, or put into a form convenient for MBT and DFT, the three/many-body interaction?

Big Question #3

- How can we use EFTs to constrain DFTs?
  - Constraining the nuclear EOS from fits of energy functionals to nuclei involves uncontrolled extrapolations at present. At low densities, where the pionless EFT is applicable, there are close connections to cold-atom physics. At higher densities inadequately constrained many-body forces are a serious concern. How can EFT help to provide much-needed controlled extrapolations and theoretical error bars?
  - Since DFT can be cast in the form of an effective action approach, it is immediately compatible with EFT in principle. How do we implement this in practice? E.g., how to do power counting for the energy functional for a given EFT?
  - What are the possible EFT's for nuclear matter? E.g., are nucleon-only degrees of freedom adequate? What is the role of pions and chiral symmetry? Can we write an EFT around the Fermi surface? Does Pauli blocking make the EFT (more?) perturbative? Is there a covariant EFT that can explain and improve the successes of "relativistic mean field" phenomenology?

Frequently Asked Questions Web Page

`http://www.physics.ohio-state.edu/~ntg/intfaq`

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