



Contribution ID: 195

Type: **Oral contribution**

Building nuclei from the ground up

Monday, 26 June 2006 15:20 (20 minutes)

Investigations of rare isotopes in the laboratory are opening the way to understand and clarify the properties of all nuclei and bulk nuclear matter. In this talk I will assess where we stand today in solving the nuclear problem and how future rare isotope facilities will impact our understanding of nuclei and our ability to predict nuclear properties in stellar and other environments. The first part of the nuclear problem concerns our ability to describe complex nuclei from the ground up using as input the basic interactions among protons and neutrons. Indeed, our community is on the verge of discovering how light nuclear systems are built from bare nuclear interactions that have their roots in QCD. I will describe this exciting frontier of research through illustrating recent progress in the nuclear implementation of coupled-cluster methods, a quantum many-body technique that enjoys great success in quantum chemistry. After describing the basic coupled-cluster ideas, I will illustrate their power by reporting on results of ground- and excited state calculations for Oxygen and Calcium nuclei.

This research is supported by the Office of Nuclear Physics, Office of Science of the U.S. Department of Energy under Contract Number DE-AC05-00OR22725 with UT-Battelle, LLC (Oak Ridge National Laboratory).

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Session Classification: 3 Nuclei far from stability

Track Classification: Nuclei far from stability