

THEXO JRA

Theory support to the experiment

- Nuclear structure: U. Brussels (P-H Heenen)
U. Warsaw (J. Dobaczewski)
- Nuclear reactions: U Vienna (H. Leeb)
- Nuclear astrophysics: U. Basel (F-K. Thielemann)
- Meetings and workshops: ECT*

Topics

- Structure of stable and exotic nuclei
 - Evolution of single-particle states in function of proton and neutron numbers
 - Coupling between single particle and collective modes
 - Description of nuclear masses
- Nuclear reaction theory for weakly bound nuclei
 - Describing differential and correlation observables
- Nuclear theory of astrophysical relevance
 - Prediction of astrophysically important reactions across the nuclear chart
 - Asymmetry energy of nuclear matter and the nuclear equation of state

People working on the project

- Post docs: S. Baroni, K. Washayama, J. Yao (ULBrussels)
D. Tarpanov (UWarsaw)
T. Rauscher (UBasel)
- Ph D student: Th. Srdinko (U Vienna)

Post docs at the four universities are also contributing to the project

Collaborations with several theory groups in Europe: CENBG, SPhN (France), Jyväskylä (Finland), GSI, TUD, (Germany)...

Collaborations on specific topics with experimental groups:
KULEuven, Jyväskylä, Liverpool, Atomki, GSI....

Nuclear structure

- Several important steps in the description of odd nuclei:
 - Several developments to improve the description of odd nuclei:
 - polarization corrections for odd nuclei (see highlights)
 - tensor interaction for odd nuclei
 - Study of energy density functionals and their adjustment
 - inclusion of deformed nuclei in the fitting protocol
 - Application of our beyond-mean-field method to a large number of nuclei around the neutron deficient Pb isotopes

- New developments:
 - determination of ground state densities and of transition densities including bmf correlations (see highlights)
 - breaking of symmetries: inclusion of octupole correlations in bmf (fission barriers, ...)
 - complete rewriting of the franco-belgian cranking code to allow for general symmetry breakings

Primary Focus: Construction of versatile reaction code GECCOS

flexible easy-to-use code which handles the most frequent reaction mechanisms, allows default calculations based on included tables of nuclear structure information

Scientific Topics:

Breakup reactions

- Description of breakup based on eikonal approximation
- Adaption of Lorentz Integral Transformation to breakup reactions

Microscopic Nucleon-Nucleus Optical Potentials

- Nucleon Optical Potentials for the scattering off Excited Nuclei

Nuclear physics for astrophysics

- A) A full set of cross section predictions for neutron-, proton, and alpha-induced reactions with present nuclear input is available from the BASEL website
<http://www.nucastro.org>

A final set will be created with input by our THEXO partners and provided results from microscopic nuclear structure calculations.

- (B) at present we provide equation of state tables based on covariant density functionals

at the website <http://phys-merger.physik.unibas.ch/~hempel/eos.html>

We are also involved in a bigger effort (together with our THEXO partners from GSI and GUF) within the CompStar Network, where also the final optimized EoS table(s) will appear (together with a manual for their application)

<http://www.compose.obspm.fr>

Achievements

- **performed global sensitivity study of cross sections and reaction rates to variations** in widths and level densities, proton- and alpha optical potentials derived from scattering experiments, employed new mass measurements (Q-values) for nuclei far from stability, tested fission barrier heights and fragment distributions in astrophysical applications, tested target g.s. vs. excited state contributions in astrophysical environments at finite temperatures, studied the importance of direct capture contributions.

in collaborations with ATOMKI-HAS, GSI/TUD, GUF, JYU

Highlight: **resolved the “apparent” long-standing alpha potential problem by inclusion of Coulomb Excitations (see highlights)**

- **constraints on symmetry energy S and density dependence L coming from experiment, theory, and observation**
neutron skin thickness (Zn, Pb), dipole polarizability of ^{208}Pb , giant resonance properties, isospin diffusion in heavy ion collisions, systematics of binding energies;
chiral effective field theory, quantum Monte Carlo; neutron star observations;
 $S=29\text{--}31\text{ MeV}$, $L=40\text{--}60\text{ MeV}$
- utilized these constraints to **new density functionals for nuclear Interactions in the astrophysical, high density, equation of state (EoS)**, investigated the importance of light nuclear clusters and nuclei at subsaturation densities, applied to astrophysical conditions at finite temperatures
in collaboration with GSI and GUF

Workshops

Two workshops already organised at the ECT*:

The shell evolution and the role of correlations in very neutron rich nuclei
(November 2011)

Reactions of Exotic Nuclei and the Impact of Nuclear Structure
(October 2012)

Both gathering for 3 days around 30 participants from THEXO and outside

Next meeting:

July 2013

Nuclear Structure and Astrophysical Applications:

46 participants, experimentalists and theoreticians. General discussion on specific problems in the confrontation of theory and experiments and in some new developments performed within (and outside) THEXO

Around 20 publications where the support of ENSAR has been acknowledged

Future

Most of the developments still need to be continued, we expect to make still major progress in:

- The description of odd nuclei
- A new modular code for mean-field calculations
- The GECCCOS code, Generalized Coupled-Channel System
- In principle, a workshop will be organized in the spring of 2014