

WORKSHOP ON MANY-BODY OPEN QUANTUM SYSTEMS: FROM ATOMIC NUCLEI TO QUANTUM DOTS

DATE: 22 – 26 FEBRUARY 2010

ORGANIZERS:

Jan Vaagen (Univ. of Bergen, NORWAY)

Wolfgang Schleich (Univ. of Ulm, GERMANY)

NUMBER OF PARTICIPANTS: 27

MAIN TOPICS:

- Exotic structure and response in atomic and nuclear systems under extreme conditions
- Entanglement, condensates and universality
- Laser – BEC analogy
- Continuum dynamics of nuclei
- Efimov states, halos and few-body resonances
- Ab-initio no-core shell model and light nuclei
- Gamow-shell model for open quantum systems
- Coupled-cluster calculations for neutron rich nuclei

SPEAKERS:

H. Ahlers (Hannover, Germany)

V.S. Bagnato (Sao Paulo, Brazil)

J. Bergou (New York, USA)

R. Id Betan (Oak Ridge, USA)

A. Bonaccorso (INFN Pisa, Italy)

D. Fedorov (Aarhus, Denmark)

C. Forssén (Gothenburg, Sweden)

U. Guenther (FZ-Dresden-Rossendorf, Germany)

G. Hagen (Oak Ridge, USA)

I. Jex (Prague, Czech Republic)

R. Kaiser (Nice, France)

W. Leidemann (UNITN, Italy)

H. Lenske (Giessen, Germany)

N. Michel (Jyväskylä, Finland)

P. Navez (Duisburg, Germany)

N. Orr (Caen, France)

S. Orrigo (Coimbra, Portugal)

M. Ploszajczak (Caen, France)

A. Sadreev (Krasnoyarsk, Russia)

W. Schleich (Ulm, Germany)

M.O. Scully (Texas A&M and Princeton, USA)

H. Simon (GSI Darmstadt, Germany)

M. Štefaňák (Prague, Czech Republic)
M. Zaccanti (Firenze, Italy)
M. Zhukov (Gothenburg, Sweden)

SCIENTIFIC REPORT:

Aim and Purpose

Small Many-body Open Quantum Systems (MBOQS), whose properties are profoundly affected by environment, i.e. continuum of decay channels, are intensely studied in various fields of physics (nuclear physics, atomic and molecular physics, quantum optics, ect.). These different many-body systems, in spite of their specific features, have generic properties which are common to all weakly bound/unbound systems close to threshold.

The workshop started with a talk by Marlon Scully on fluctuations of a Bose-Einstein condensate (BEC) and its description in a master equation approach having much in common with the quantum theory of the laser. In follow-up talks on BEC's V.S. Bagnato discussed turbulence and fragmentation, P. Navez gap and screening effects and H. Ahlers described a planned experiment in which a BEC is created in a capsula dropped in a tower. The benefit of exploiting microgravity lies in extending evolution times of condensates in an environment unperturbed by trapping potentials. With an increasing sensitivity of interferometers, tests in fundamental physics of gravity, relativity, and theories beyond the Standard Model will thus eventually become possible. The discussion of ultracold gases has been rounded up by a presentation of M. Zaccanti on an exploration of Efimov physics in ultracold gases. The Efimov effect, Feshbach resonances, recombination reactions and other phenomena were also looked at by D. Fedorov from the standpoint of universality in few-body systems of particles with short-range interactions, where certain properties of the system do not depend on the details of the interactions.

A major fraction of the workshop on MBOQS was devoted to a thorough discussion of phenomena in nuclear structure and nuclear reactions. Talks on recent experiments studying single-neutron unbound states of light nuclei (N. Orr) and correlations in light exotic systems at relativistic velocities (H. Simon) were accompanied by talks from nuclear theorists on unbound nuclei studied by projectile fragmentation (A. Bonaccorso), on nuclear halo formation and breakup (M. Zhukov), on continuum spectroscopy of light exotic nuclei (S. Orriga), on continuum dynamics of nuclei (H. Lenske), and on the calculation of continuum reactions without continuum wave functions (W. Leidemann). These considerations of primarily nuclear reaction aspects were complemented by a consideration of particular features of nuclear structure in talks on the ab-initio no-core shell model applied to light nuclei (C. Forssén), on coupled-cluster calculations for medium-mass and neutron-rich nuclei (G. Hagen), on the interacting shell model for open quantum systems (M. Płoszajczak), on the description of weakly bound and resonant nuclei with the Gamow shell model (N. Michel), and on a calculation of alpha decay using a complex energy basis (R. Id Betan).

Finally, the workshop was rounded up with talks on a critical overview of the concept of entanglement (J. Bergou), on quantum networks and random unitary interactions (I. Jex), on quantum walks, localization and recurrences (M. Štefaňák), on cooperative scattering and disorder (R. Kaiser), on resonances induced by bound states in the continuum in a two-level nonlinear Fano-Anderson model (A. Sadreev), and on mathematical models of PT quantum mechanics and their behavior in the vicinity of spectral singularities (U. Guenther).

The workshop ended with a general talk by Wolfgang Schleich on the role of the inertial and gravitational mass in quantum mechanics. He showed that in complete agreement with classical mechanics the dynamics of any quantum mechanical wave packet in a linear gravitational potential is solely governed by the ratio of the gravitational and the inertial mass. In contrast, the spatial modulation in the corresponding energy wave function, that is the wave vector, is determined by the third root of the product of the two masses. Only in the semiclassical limit and appropriately away from the turning point is the equivalence principle retrieved, that is the velocity of the particle is governed by the ratio of the two masses. Moreover, the discrete energy spectrum of a particle constrained in its motion by a linear gravitational potential and an infinitely steep wall depends on the inertial as well as the gravitational mass with different powers.

Results and Highlights

The workshop did not only have the character of an interdisciplinary meeting but has shown a sustained growth and dynamics of the wide field of open quantum systems. The topics discussed within five days ranged from the physics of ultra cold gases and Bose-Einstein Condensation (BEC), the laser-BEC analogy, entanglement, quantum networks and random unitary interactions to the physics of nuclei. A thorough discussion of the latter clearly constituted the major part of the workshop and has shown how the growing interest into the theory of MBOQS is associated with experimental efforts in producing weakly bound/unbound nuclei close to the particle drip-lines and studying structures and reactions with those nuclei. The workshop was full of lively discussions between the participants from different communities in the wide field of small MBOQS and the success achieved in understanding generic properties of those systems since the last ECT* workshop on this topic has become evident.