



BEC in Poland
Workshop of ESF framework: Quantum Degenerate Dilute Systems
18/05/2007 – 19/05/2007
National Laboratory for Atomic, Molecular and Optical Physics, Toruń, Poland

Scientific Report

1. Summary

The “BEC in Poland” workshop took place in the National Laboratory for Atomic, Molecular and Optical Physics, in short FAMO Lab, national-level research facility, in Toruń in 18-19 May. 49 physicists and students including 12 speakers participated in the meeting.

The main idea of the workshop was to focus on the future measurements on the new BEC, first in the Central-East Europe, obtained March 2 this year in the FAMO Lab and to remind new ideas on possible experiments, feasible with the new BEC apparatus.

The workshop lectures were divided in four panels. The first panel was devoted to the current research of BEC interactions with optical potentials. Various aspects of the interaction cold atoms with properly prepared light including vortex excitations were presented during the second panel. The third panel was dedicated to the Bose-Einstein Condensate mixtures. These three panels introduced the current BEC research in laboratories cooperating with Polish BEC physicists.

Eventually the biggest panel with subsequent discussion took up the whole second day of the meeting. This panel covered the directions of the BEC research in Poland.

All the lectures are available on the web page:

http://famo.fizyka.umk.pl/bec_in_poland/index2.php?s=programme

2. Description of the scientific content of the workshop and discussion at the event

The workshop was opened by a short talk by Michał Zawada in which the set-up of the FAMO Lab BEC as well as its basic properties were described.

After the opening, participants visited the FAMO Lab which consists of three laboratories: BEC and Cold Atoms lab, Ion Trap lab and Quantum Engineering lab.

Next then, started **the first panel “Talks on current research on BEC in Europe“:**

- *Experiments with a Bose-Einstein condensate in a quasiperiodic potential: searching for new quantum phases* by Chiara Fort from LENS, Florence

Summary of this lecture:

- Introduction: novel quantum phases in a disordered potential
 - LENS approach to the disorder: quasi-periodic optical potential
 - Strongly interacting bosons in a quasi-periodic lattice: Bose glass phase
 - Weakly interacting bosons in a quasi-periodic lattice: Anderson-like localization
- *Experiments on the superfluidity of a Bose-Einstein condensed gas and future work on rotating lattices* by Chris Foot from University of Oxford
- Summary of this lecture:
- Superfluidity - tested by the response to rotation:
 - TOP trap - rotating elliptical potential
 - Observation of the scissors mode - damping
 - Nucleation of vortices
 - Rf-modified magnetic trapping - toroidal trap (persistent current)



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- Rotation of optical lattice - artificial B-field
- Quantum effects in ratchet-like potentials by Tobias Salger from Bonn University
Summary of this lecture:
 - Static lattices:
 - Optical multiphoton lattices created by higher-order Raman-transitions
 - Experimental realization of Two-, Four- and Sixphoton-lattices
 - Superposition of two lattice harmonics - possible Ratchet-like potentials
 - Moving lattices:
 - Bloch oscillations in a Two- and Fourphoton lattice - comparison of the effective masses
 - Phase-dependent tunneling rate in ratchet-like potentials - possible control of the band gap

The second panel, “BEC and Atomic Physics:

- Photo-associative spectroscopy of weakly bound Rb2 molecules, Lu-Fano method analysis, Shaped dipole potentials for cold atom manipulation by Laurence Provust from LAC, Orsay
Summary of this lecture:
 - Photo-associative spectroscopy of weakly bound Rb2 molecules:
 - Lu-Fano method analysis
 - Precise determination of the potentials
 - Formation of cold molecules – cold chemistry
 - Shaped dipole potentials for cold atom manipulation:
 - Arbitrary shaped dipole potentials
 - Reconfigurable potentials
 - Time-dependent shaped potentials
- Generating solitonic and vortex excitations in BEC via a potential sweep by Jakub Zakrzewski from Jagiellonian University, Kraków, Kraków

Summary of this lecture:

- Solitons and vortices in BEC's:
 - Solitons: Phase imprinting method
 - Vortices: Conversion between two components
 - Vortices: Laser stirring
 - Other propositions
- New approach:
 - Solitons for noninteracting bosons by a potential sweep
 - Vortices - two potential sweeps
 - Interacting bosons
 - Level crossings for interacting systems

The third panel, “Discussion on condensate mixtures”:

- Single realization of the collision of two BEC by Marek Trippenbach from University of



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Warsaw

Summary of this lecture:

- Slow collisions:
 - Lumpy structure in the momentum distribution of scattered atoms - spikes in the column density
 - Analogous to the speckles in the light beam produced by a multimode laser
- Spontaneous four-wave mixing of atoms
- Tuning the interactions in K-Rb mixtures: heteronuclear molecules and non-interacting Bose-Einstein condensate by Giacomo Roati from LENS, Florence

Summary of this lecture:

- Introducing our systems: K-Rb mixtures:
 - ^{40}K - ^{87}Rb degenerate mixture
 - Feshbach analysis: collisional properties
 - Tuning the interactions: collapse and phase-separation
 - Observation of heteronuclear K-Rb molecules
- ^{39}K - ^{87}Rb degenerate mixture:
 - Feshbach analysis: collisional properties
 - **^{39}K Bose-Einstein condensate with tunable interactions**
 - Bloch oscillations
- Density fluctuations in a two-component Bose-Einstein condensate by Krzysztof Sacha from Jagiellonian University, Kraków, Kraków

Summary of this lecture:

- Example of quantum density fluctuations
- N-conserving version of the Bogoliubov theory for one-component BEC and density measurements
- Two-component BEC case and density fluctuations close to the phase separation condition

The fourth panel, “Discussion on directions of the BEC research in Poland”

- Short time density fluctuations by Mirosław Brewczyk from University of Białystok

Summary of this lecture:

- Excitation spectrum of a uniform weakly interacting Bose gas
- Photoassociation of molecules
- Dissipative dynamics of a vortex
- Decay of multiply charged vortex
- Phase coherence of a condensate at finite temperatures
- Determination of the critical velocity for superfluidity
- Dynamics of spinor condensates at finite temperatures

- Fluctuations of the condensate population as a function of temperature by Mariusz Gajda from Polish Academy of Science, Warsaw

Summary of this lecture:

- Statistical Ensembles



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- Bose-Einstein condensation of the ideal gas in a harmonic trap
- Relative population of a condensate
- Microcanonical and Canonical Fluctuations of Condensate
- Fluctuations of the ideal Bose gas in 3D harmonic trap
- *Oscillations of the condensate and their damping* by Kazimierz Rzażewski from Polish Academy of Science, Warsaw
Summary of this lecture:
 - Inducing quadrupole oscillations of the condensate
 - Past experimental results
 - Classical fields approximation
- *Simple experiments with BEC's in magnetic traps* by Maciej Lewenstein from ICFO, Barcelona
Summary of this lecture:
 - Creating vortices via phase imprinting
 - Creating BEC “cocktails” via trap shaking
 - Two component BEC in random Raman field:
 - Breaking the continuous symmetry
 - Disorder induced order
 - Control of the relative phase

After the last panel there was the open discussion about the future of the BEC research in Poland. The discussion took whole afternoon. The participants focused on two topics: improvement of the present BEC set-up in the FAMO Lab and scheduled experiments with BEC in the FAMO Lab.

3. The assessment of the results and impact of the event on the future direction of the field

The main result of the “BEC in Poland” workshop is a clear schedule of the nearest experiments with the BEC in the FAMO Lab. The current plan is as follows:

1. Measurements of condensate oscillations and their damping as well as other dynamics properties of the condensate as a function of the condensate fraction
2. Bragg spectroscopy with adjustable momentum transfer to the BEC and slow collisions of BEC
3. Interactions of BEC with 1D tightly focused beam: sound wave generation and potential sweep

A cooperation between theoretical and experimental physicists was established for all these experiments.

The second most important consequence of the workshop is connected with the fact that part of the participants, especially students, came from the centers which do not engage in the cold atoms physics. It was a great opportunity to learn what is the present-day research in this field of science for these Polish physicists. We hope that this meeting will boost experimental studies on quantum degenerate systems in Poland.



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4. Meeting Final Programme

18 May 2007

9:00-9:30 Opening of the workshop

9:30-11:00 Visit in the FAMO LAB and presentation of the BEC apparatus

Talks on current research on BEC in Europe

11:00-11:40 Chiara Fort, *Experiments with a Bose-Einstein condensate in a quasiperiodic potential: searching for new quantum phases*

11:40-12:20 Chris Foot, *Experiments on the superfluidity of a Bose-Einstein condensed gas and future work on rotating lattices*

12:20-13:00 Tobias Salger, *Quantum effects in ratchet-like potentials*

13:00-14:20 Lunch

BEC and Atomic Physics

14:20-15:00 Laurence Provust, *Photo-associative spectroscopy of weakly bound Rb₂ molecules, Lu-Fano method analysis, Shaped dipole potentials for cold atom manipulation.*

15:00-15:40 Jakub Zakrzewski, *Generating solitonic and vortex excitations in BEC via a potential sweep*

15:40-16:00 Coffee Break

Discussion on condensate mixtures

16:00-16:40 Marek Trippenbach, *Single realization of the collision of two BEC*

16:40-17:20 Giacomo Roati, *Tuning the interactions in K-Rb mixtures: heteronuclear molecules and non-interacting Bose-Einstein condensate*

17:20-18:00 Krzysztof Sacha, *Density fluctuations in a two component Bose-Einstein condensate*

18:00-24:00 Dinner (Conference Barbecue) and visit in the Toruń Centre for Astronomy

19 May 2007

Discussion on directions of the BEC research in Poland

9:00-9:25 Mirosław Brewczyk, *Short time density fluctuations*

9:25-9:50 Mariusz Gajda, *Fluctuations of the condensate population as a function of temperature*

9:50-10:20 Kazimierz Rzążewski, *Oscillations of the condensate and their damping*

10:20-11:00 Maciej Lewenstein, *Simple experiments with BEC's in magnetic traps*

11.00-16:30 Lunch and sightseeing of Toruń

16.30-20:00 **Prospects of scientific cooperation between the Toruń FAMO Lab and other European laboratories.**

20:00 Closure



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5. The full list of speakers and participants

1. Andrzej Bielski KL FAMO, UMK, Toruń
2. Mirosław Brewczyk University of Białystok
3. Franciszek Bylicki KL FAMO, UMK, Toruń
4. Jan Chwedeńczuk University of Warsaw
5. Stanisław Chwirot KL FAMO, UMK, Toruń
6. Roman Ciuryło KL FAMO, UMK, Toruń
7. Tomasz Dohnalik Jagiellonian University, Kraków
8. Jolanta Domysławska KL FAMO, UMK, Toruń
9. Chris Foot University of Oxford
10. Chiara Fort LENS, Florence
11. Mariusz Gajda Polish Academy of Sciences, Warsaw
12. Rafał Gartman KL FAMO, UMK, Toruń
13. Wojciech Gawlik Jagiellonian University, Kraków
14. Włodzimierz Jastrzębski University of Warsaw
15. Wojciech Koczorowski Poznań University of Technology
16. Dawid Kucharski Poznań University of Technology
17. Maciej Lewenstein Institute of Photonic Science, Barcelona
18. Daniel Lisak KL FAMO, UMK, Toruń
19. Piotr Masłowski KL FAMO, UMK, Toruń
20. Piotr Mazerewicz Poznań University of Technology
21. Piotr Migdał University of Warsaw
22. Józef Musielok University of Opole
23. Bartłomiej Oleś Jagiellonian University, Kraków
24. Ewa Paul-Kwiek Pomeranian University, Słupsk
25. Laurence Provost Laboratoire Aimé Cotton, Orsay
26. Czesław Radzewicz University of Warsaw
27. Giacomo Roati LENS, Florence
28. Kazimierz Rzążewski Polish Academy of Sciences, Warsaw
29. Ryszard S. Trawiński KL FAMO, UMK, Toruń
30. Krzysztof Sacha Jagiellonian University, Kraków
31. Tobias Salger Bonn University
32. Tadeusz Stacewicz University of Warsaw
33. Ewa Stachowska Poznań University of Technology
34. Jacek Szczepkowski Pomeranian University, Słupsk
35. Józef Szudy KL FAMO, UMK, Toruń
36. Ryszard Tanaś Adam Mickiewicz University, Poznań
37. Ryszard Trawiński KL FAMO, UMK, Toruń
38. Marek Trippenbach University of Warsaw
39. Adrian Walaszyk Poznań University of Technology
40. Marcin Wilczewski Gdańsk University of Technology
41. Martin Wilkens Potsdam University
42. Marcin Witkowski University of Opole
43. Jerzy Zachorowski Jagiellonian University, Kraków
44. Jakub Zakrzewski Jagiellonian University, Kraków
45. Jarosław Zaremba KL FAMO, UMK, Toruń
46. Michał Zawada KL FAMO, UMK, Toruń
47. Karolina Zawada Jagiellonian University, Kraków
48. Paweł Zin University of Warsaw
49. Marek Żukowski, University of Gdańsk