

**Report on the final meeting of the ESF network „POLATOM“ called
POLATOM2015,
Bad Honnef, Germany, June 20th-24th 2015
School June 20th-21st, Conference June 22nd-24th**

The final conference of the POLATOM network followed the layout of the two major preceding network meetings in Chersonissos, Crete in 2011 and in Cambridge, UK in 2012. The Physik-Zentrum in Bad Honnef was ideally suited to accommodate a two-day School intended mainly for research students, followed by a three-day network conference. The organizing committee consisted of Hartmut Haug, Goethe-Uni. Frankfurt, Germany (chair), of Georg Bruun, Uni. of Aarhus, Denmark and of Servaas Kokkelmans, Eindhoven Uni. of Technology, Netherlands. The conference secretary was Marie-Hélène Haußels, Goethe-Uni. Frankfurt. At this institution the financial transfers have been carried out.

The basic goals of the school and meeting were:

- Presentation of the progress made in the 5 years of the network in the fields of degenerate quantum gases both in ultra cold atoms and in micro-cavity exciton polaritons, emphasizing the common ideas such as quantum coherence, topological defects like vortices and solitons, non-equilibrium effects, and common theoretical concepts like the Gross-Pitaevskii equation and Feshbach resonances.
- Active participation of the younger scientists of the network with exchange research reports at the end of the School and 2-minutes oral presentations of all posters by mainly younger scientists.
- Encourage personal contacts between the researchers in ultra cold atoms and micro-cavity polaritons.
- Including a section of potential devices applications from both fields.

The organizers asked the following international programme committee for suggestions of invited speakers and for the selection of the submitted papers as contributed talks and poster presentations.

Programme Committee: Martin Zwierlein, MIT, USA; Frédéric Chevy, ENS, France; Nigel Cooper, Cambridge, UK; Benoit Deveaud, EPFL, Switzerland; Iacopo Carusotto, Uni. of Trento, Italy; Pavlos Savvidis, Uni. of Crete, Greece.

The web page of the conference was <http://itp.uni-frankfurt/POLATOM2015/> and the registrations and submissions had to be sent to haussels@physik.uni-frankfurt.de.

School, June 20th-21st 2015

Starting on Saturday after lunch and ending after exchange reports by young researchers on Sunday evening with a barbecue dinner, the School consisted of three 45 min. lectures given by each of the three leading physicists in their field, namely

- **Fédéric Chevy**, Strongly correlated quantum gases
- **Benoit Deveaud**, Quantum gases of polaritons in micro-cavities
- **Iacopo Carusotto**, Analogies and differences in the theoretical description of quantum fluids of atoms and of polaritons.

27 participants followed the lively presentations and participated in discussions of various aspects covered in the three lectures. As mentioned already, the School ended with a few reports from young researchers reporting on their experiences with exchanges within the network. Erik van der Wurff, Uni. of Utrecht, described a very productive 6 months visit at the Uni. of Dresden. Similarly Pietro Massignan, ICFO, Spain, reported on several shorter visits in Cambridge which turned out to be very helpful for his research work. The young researchers suggested to announce the possibilities of exchange visits within ESF networks to a broader audience and keep the time between applications and research visits shorter.

That cold atoms and polaritons were not treated as separate fields which have not much in common can be seen from a letter of a research student Ms. Wench Wu, Uni. of Illinois who wrote after the meeting. I quote: „Thanks for organizing this fantastic conference! As an experimentalist working on ultracold atoms I learnt a lot from the talks on polaritons, and these talks encourage me to think about the possibilities to apply similar detection methods, such as pump-probe spectroscopy, into cold atom systems.“

The program of the School is attached as annex I.

Conference June 22nd - 24th 2015

58 scientists participated in the Conference, including all participants of the preceding School. The following invited talks (length 50 min, including 5 min. discussion) have been given

- **Cristiano Ciuti (Uni. Paris Diderot)**, Theory of strongly correlated photonic systems
- **Jeremy Baumberg (Cambridge)**, Accelerating and spinning polariton condensates with light
- **Iacopo Carusotto (Uni. Trento)**, Plenary talk, Results and perspectives after 5 years of interdisciplinary research on cold atoms and polaritons
- **Ben Lev (Stanford)**, presented by **Alicia Kollar (Stanford)**, Beyond mean-field physics with multimode cavity QED
- **Tilman Pfau (Uni. Stuttgart)**, Dipolar gases: From Chromium to Dysprosium
- **Frédéric Chevy (ENS)**, Superfluid Bose-Fermi mixtures
- **Alberto Amo (LPN Marcousis)**, Polaritons on honeycomb lattices

The sessions have been chaired by the following colleagues: Deveaud, Chevy, Ciuti, Bruun, Kokkelmans, Carusotto, Proukakis, Kavoulakis, Vina, and Amo.

As can be seen from these invited talks and the attached program, a balance between the cold atom and polariton research fields was attempted as much as possible. Particularly Iacopo Carusotto addressed in a 60-min Plenary Talk what has been reached in the interdisciplinary research in the network, making interesting analogies of black hole physics and that of BEC.

The research students found it particularly nice, that we allowed for each poster a two-min. talk with two powerpoint slides informing everybody about the topic of the poster and why one should come to see it.

In a last session potential technological applications was discussed, starting with polaritons in a honeycomb lattice. The band structures of these etched lattices resemble that of graphene with its Dirac cones. For atoms single-site addressability for quantum simulators in a photonic lattice have been discussed.

Georgios Kavoulakis, the head of the steering committee of POLATOM gave on Wednesday a final report over the activities in the network including a survey of the costs for the various activities. In general, the audience agreed that the ESF POLATOM network which encouraged interdisciplinary work between atom and polariton physics had its high merits in times where an ever increasing specialization takes place in modern science.

The program of the conference is attached as annex I

Main results of POLATOM2015

In conclusion the last meeting showed that the mutual understanding of the research on quantum gases in ultra-cold atoms and in micro-cavity polaritons is greatly improved. The researchers in both fields came in much better contact than in the past. In general the work on ultra-cold atoms deals with a much broader variation of the interaction strength expressed in terms of the scattering length between the atoms. Moreover, the sign of the scattering length can be changed by magnetic fields at Feshbach resonances. Correspondingly a rich scenario of crossovers between various phases of quantum gases exist in cold atoms. The understanding of the atomic gases in terms of strongly correlated systems is well developed.

On the other hand, the quantum coherence of polaritons is easily be studied in the properties of the photons which leak out of the cavity. Therefore the observation and understanding of coherence in non-equilibrium quantum gases is strongly developed in the polariton research. Most likely, micro-cavities with condensed polaritons can in the near future be pumped electrically at room temperature, and thus integrated in electro-optical nano-structures and devices.

In conclusion, future contacts of both fields should be very beneficial to both of them.

ANNEX I: Programs

Program of the School

June 20th , 2015:

11:45	Arrival of the participants and check in
12:30	Lunch and coffee
14:30	Lecture 1: Frédéric Chevy
15:15	Lecture 2: Frédéric Chevy
16:00	Coffee break
16:30	Lecture 3: Iacobo Carussotto
17:15	Lecture 4: Iacopo Carussotto
18:30	Dinner

June 21st , 2015:

9:00	Lecture 5: Benoît Deveaud
9:45	Lecture 6: Benoît Deveaud
10:30	Coffee break
11:00	Lecture 7: Frédéric Chevy
12:30	Lunch and coffee
14:30	Lecture 8: Iacopo Carussotto
15:15	Lecture 9: Benoît Deveaud
16:00	Coffee break
16:30	Exchange reports
18:30	Barbecue Dinner

Program of the conference

June 22nd , 2015:

9:00	Cristiano Ciuti	Theory of strongly correlated photonic systems
9:50	Luis Viña	Momentum space interferences and coherences
10:10	Richard Schmidt	Decoherence of impurities in ultracold atoms
10:30	Coffee break	
11:00	Giacomo Valtolina	Transport of 6 Li atoms through a thin barrier
11:20	Paolo Comaron	Stochastic modelling of x-polariton condensates
11:40	Grégory Sallen	Noise-induced polariton transitions opt. bistability
12:00	Jan Arlt	Stabilized production of cold atoms at the shot noise limit
12:30	Lunch	
14:00	Jeremy Baumberg	Accelerating and spinning polariton condensates with

		light
14:50	Hartmut Haug	Induced oscillations and rotations of Vortex-anti-vortex pairs
15:10	Christian Schneider	Polariton condensates in complex potential landscapes
15:30	Stravros Komineas	Continuous and discontinuous dark solitons in polaritons
15:50	Mitchell Anderson	Lower and upper polariton spinor interactions in GaAs mc's
16:10	Coffee break	
16:30	Arie-Willem de Leeuw	Many-body phenomena in BEC's in a dye-filled mc
16:50	Santiago Caballero-Benitez	Emergent many body quantum phases in optical lattices with cavity fields
17:10	Félix Marsault	2 nd -order time correlations in a polariton micropillar
17:30	Poster presentation	
18:30	Dinner	
19:30	Poster section with bier for free	

June 23rd, 2015:

9:00	Plenary Talk of Iacopo Carusotto	Results and perspectives after five years of interdisciplinary an cold atoms and polaritons
10:00	Elife Ö. Karabulut	Spin-orbit coupled BEC: from single particle to many-body effects
10:20	Nick Proukakis	Dynamics of multi-component condensates
10:40	Coffee break	
11:00	Florent Baboux	Polariton condensation in flat energy bands
11:20	Alicia Kollár	Beyond mean-field physics with multimode cavity QED
12:30	Lunch	
13:30	Tilman Pfau	Dipolar gases: From Chromium to Dysprosium
14:20	Jami J. Kinnunen	Momentum resolved spectroscopy in a dilute Fermi liquid
14:40	Pietro Massignan	Strong coupling Ansatz for 1D Fermi Gas in a harmonic pot
15:00	Pierbiagio Pieri	Bose-Fermi mixtures with pairing
15:20	Fédéric Chevy	Superfluid Bose-Fermi Mixtures
16:10	Coffee break	
16:30	Nikolaj T. Zinner	Magnetism and dynamics of strongly interacting 1D systems
16:50	Zhigang Wu	Supersolid phase and BKT phase transition in dipolar Fermi gas
17:10	Erik van der Wurff	Number fluctuations in Bose-Einstein Condensate of Light
17:30	Marco Mancini	<i>Postdeadline talk</i>
19:00	Get together in vineyard Broel with obligatory registration	

June 24th, 2015:

9:00	Check out	
9:30	Alberto Amo	Polaritons in honeycomb lattices
10:20	Tarun Johri	Single-site addressability for a quantum simulator
10:40	Coffee break	
11:00	Christof Dietrich	1D whispering gallery mode polariton BEC
11:20	Claud�ric Ouellet-Plamondon	Multiple polariton modes of coupled QW's in a planar cavity
11:40	Sebastian Klembt	Polaritons as out-of-equilibrium refrigerant gas
12:00	Round-up discussion with Georgios Kavoulakis	
12:30	Lunch and departure	

ANNEX II: Participants

Dr. Iacopo Carussotto (University of Trento, I)
Dr. Alberto Amo (LPN, F)
Prof. Jeremy Baumberg (University of Cambridge, UK)
Prof. Frédéric Chevy (ENS, F)
Prof. Cristiano Ciuti (University of Paris Diderot, F)
Alicia Kollar (Stanford University, USA)
Prof. Tilman Pfau (University of Stuttgart, D)
Dr. Mitchell Anderson (EPFL, CH)
Prof. Jan Arlt (Aarhus University, DK)
Florent Baboux (CNRS Paris, F)
Dr. Santiago Francisco Caballero Benitez (University of Oxford, UK)
Paolo Comaron (Newcastle university, UK)
Arie-Willem De Leeuw (Utrecht university, NL)
Dr. Christof P. Dietrich (University of Würzburg, D)
Prof. Hartmut Haug (Goethe University Frankfurt, D)
Tarun Johri (Eindhoven University of Technology, DK)
Dr. Elife Karabulut (Selcuk University, TR)
Dr. Jami Kinnunen (Aalto University, FIN)
Dr. Sebastian Klembt (CNRS Grenoble, F)
Prof. Stravros Komineas (University of Crete, GR)
Felix Marsault (CNRS Paris, F)
Dr. Pietro Massignan (IPS, ES)
Claudéric Ouellet-Plamondon (EPFL, CH)
Prof. Pierbiagio Pieri (University of Camerino, I)
Prof. Proukakis Nick (Newcastle university, UK)
Dr. Grégory Sallen (EPFL, CH)
Dr. Christian Schneider (University of Würzburg, D)
Dr. Richard Schmidt (Harvard University, USA)
Giacomo Valtolina (LENS, I)
Erik van der Wurff (Utrecht University, NL)
Prof. Luis Viña (University of Madrid, ES)
Dr. Zhigang Wu (Aarhus University, DK)
Prof. Nikolaj Zinner (Aarhus University, DK)
Carlos Anton-Solanas (University of Madrid, ES)
Dr. Raphaël Butté (EPFL, CH)
Rasmus Søggaard Christensen (Aarhus University, DK)
Dr. Agnieszka Cichy (Goethe University of Frankfurt, D)
Albert Gallemi (University of Barcelona, ES)
Frederik Görg (ETHZ, CH)
Dr. Francesc Malet Giralt (VU University, NL)
Marek Nečada (Aalto University, FIN)
Katharina Royan (University of Saarland, D)
Alexandra Roussou (University of Crete, GR)
Matthias Schmitt (University of Stuttgart, D)
Rasmus Skannrup (Eindhoven University of Technology, DK)
Dandan Su (Goethe university of Frankfurt, D)
Holger Suchomel (University of Würzburg, D)
Dr. Nina Voronova (University of Moscow, RU)
Wenchao Xu (University of Illinois, USA)
Tao Yin (Goethe university of Frankfurt, D)
Prof. Georg Bruun (Aarhus University, DK)
Prof. Benoît Deveaud (EPFL, CH)
Prof. Georgios Kavoulakis (TEI of Crete, GR)
Dr. Kokkelmans Servaas (Eindhoven University of Technology, DK)
Yago Del Valle-Inclan Redondo (University of Cambridge, UK)
Laura Tropic (University of St Andrews, UK)