SCIENTIFIC REPORT on the School
"**Cold atoms, excitons and polaritons**" of the POLATOM ESF research networking programme, hold in Toledo, Spain from May 21 to 23, 2012.

Summary

The main goal of the school was to give a background of the basic aspects of cold-atom, exciton and polariton physics so that students from related fields are able to follow the most recent and exciting developments of these communities. Additional aims were to promote cooperation between the students and to produce synergy among these fields.

The school was organized following the scope of the POLATOM Network, offering the students the opportunity to cross the borders between cold-atom physics and the physics of excitations in semiconductors strong coupled to light. Slightly differently from the first meeting, the lectures of the school have not only covered the most recent advances but went also more deeply on the basic physics and historical developments in these fields, with two lectures by each speaker, lasting 50 minutes each, one in the morning and one in the afternoon.

In this occasion lectures about the most recent and novel achievements of photon condensation have been included in the program. Therefore the physics of condensation and related effects such as superfluidity in matter (cold atoms), light-matter (polaritons) and light (photons) systems have been covered.

Scientific content

The school started on Monday, May 21st at 8:50 with a short welcome by the organizer of the event, Prof. Luis Viña.

The two first lectures on "*Probing non Equilibrium Quantum Dynamics*" by Prof. Jörg Schmiedmayer and on "*Excitons in low dimensional systems*" by Prof. Elisa Molinari were imparted in the first session of the school, which was chaired by Prof. Iacopo Carusotto (one of the co-organizers of the school). The second morning session was devoted to "*Manipulating and measuring the motion of cold traped ions*" and to "*Polariton condensation in microstructures cavities": propagation and optical manipulation*", the lectures were taught by Prof. Jürgen Eschner and Dr. Jacqueline

Bloch, respectively, being the session presided by Dr. Maria D. Martin. In the first afternoon session, chaired by Prof. Abderrazzak Douhal, the second part of the talks of Prof. Jörg Schmiedmayer and Dr. Jacqueline Bloch were completed. The scientific activity of the day finished with the second part of the lectures of Profs. Jürgen Eschner and Elisa Molinari, chairing Prof. Georgios Kavoulakis.

On May 22nd, Profs. Maurice Skolnick and Stefan Kuhr presented their lectures on "*Modulation and propagation of high density polariton states*" and "*New detection methods for ultracold atoms in optical lattices*", respectively in a session presided by Dr. Jacqueline Bloch. After the coffee break, Prof. Alessandro Tredicucci gave his lecture on "*Intersubband polaritons: light-matter interaction in the ultra-strong coupling regime*", followed by the presentation of Prof. Martin Weitz on "*Thermodynamics of a two-dimensional photon gas*", chairing Prof. Elisa Molinari. In the afternoon, Profs. Maurice Skolnick and Stefan Kuhr completed their lectures, chairing Prof. Mark Fromhold. In the evening, presiding the meeting Prof. José M. Calleja, a lecture on "*Shaping light-matter interaction at the speed of light*" was imparted by Prof. Alessandro Tredicucci, followed by a seminar by Prof. Martin Weitz on "*Bose-Einstein condensation of photons*".

On the last day of the school, the first session was devoted to "*Vortices in polariton superfluids*", subject presented by Dr. Francesca Marchetti, and to "*Nonlinear effects in clouds of Bose-Einstein condensed atoms*" taught by Prof. Georgios Kavoulakis, chairing Prof. Maurice Skolnick. The second morning session was presided by Prof. Luis Viña, there Dr. Robin Scott and Prof. Mark Fromhold gave their lectures on "*Numerical methods for the dynamics of superfluid Bose gases: applications to vortices and solitons*" and "*The interplay between ultracold atoms, semiconductor surfaces and quantum electronic systems*", respectively. In the afternoon Dr. Francesca Marchetti completed her lecture and Prof. Georgios Kavoulakis presented a talk on "*Rotational properties of small atomic Bose-Einstein condensates*", presiding Prof. Martin Weitz. The scientific program was completed in a session chaired by Prof. Carlos Tejedor, the third co-organizer of the school, where Dr. Robin Scott gave a lecture on "*Numerical methods for the dynamics of superfluid Fermi gases: applications to vortices and solitons*" and Prof. Mark Fromhold finalized his lecture on "*The interplay between ultracold atoms, semiconductor surfaces and quantum electronic systems*".

The program is presented in the following Table:

Day	Session Chair	Time	Speaker	Title
5/21/2012		8:50-9:00	**Viña, Luis**	Welcome
	Iacopo Carusotto	9:00-9:50	**Schmiedmayer, Jörg**	Probing non Equilibrium Quantum Dynamics (I)
		9:55-10:45	**Molinari, Elisa**	Excitons in low dimensional systems (I)
		10:45-11:15	Coffee	
	María Dolores Martín	11:15-12:05	**Eschner, Jürgen**	Manipulating and measuring the motion of cold traped ions (I)
		12:10-13:00	**Bloch, Jacqueline**	Polariton condensation in microstructures cavities : propagation and optical manipulation (I)
		13:00-15:00	Lunch	
	Abderrazzak Douhal	15:00-15:50	**Schmiedmayer, Jörg**	Probing non Equilibrium Quantum Dynamics (II)
		15:55-16:45	**Bloch, Jacqueline**	Polariton condensation in microstructures cavities : propagation and optical manipulation (II)
		16:45-17:15	Coffee	
	Georgios Kavoulakis	17:15-18:10	**Eschner, Jürgen**	Manipulating and measuring the motion of cold traped ions (II)
		18:15-19:05	**Molinari, Elisa**	Excitons in low dimensional systems (II)

Day	Session Chair	Time	Speaker	Title
5/22/2012	Jacqueline Bloch	9:00-9:50	**Skolnick, Maurice**	Modulation and propagation of high density polariton states (I)
		9:55-10:45	**Kuhr, Stefan**	New detection methods for ultracold atoms in optical lattices (I)
		10:45-11:15	Coffee	
	Elisa Molinari	11:15-12:05	**Tredicucci, Alessandro**	Intersubband polaritons: light-matter interaction in the ultra-strong coupling regime
		12:10-13:00	**Weitz, Martin**	Thermodynamics of a two-dimensional photon gas
		13:00-15:00	Lunch	
	Mark Fromhold	15:00-15:50	**Skolnick, Maurice**	Modulation and propagation of high density polariton states (II)
		15:55-16:45	**Kuhr, Stefan**	New detection methods for ultracold atoms in optical lattices (II)
		16:45-17:15	Coffee	
	José Manuel Calleja	17:15-18:10	**Tredicucci, Alessandro**	Shaping light-matter interaction at the speed of light
		18:15-19:05	**Weitz, Martin**	Bose-Einstein condensation of photons

Day	Session Chair	Time	Speaker	Title
5/23/2012	Maurice Skolnick	9:00-9:50	**Marchetti, Francesca**	Vortices in polariton superfluids (I)
		9:55-10:45	**Kavoulakis, Georgios**	Nonlinear effects in clouds of Bose-Einstein condensed atoms
		10:45-11:15	Coffee	
	Luis Viña	11:15-12:05	**Scott, Robin**	Numerical methods for the dynamics of superfluid Bose gases: applications to vortices and solitons
		12:10-13:00	**Fromhold, Mark**	The interplay between ultracold atoms, semiconductor surfaces and quantum electronic systems (I)
		13:00-15:00	Lunch	
	Martin Weitz	15:00-15:50	**Marchetti, Francesca**	Vortices in polariton superfluids (II)
		15:55-16:45	**Kavoulakis, Georgios**	Rotational properties of small atomic Bose-Einstein condensates
		16:45-17:15	Coffee	
	Carlos Tejedor	17:15-18:10	**Scott, Robin**	Numerical methods for the dynamics of superfluid Fermi gases: applications to vortices and solitons
		18:15-19:05	**Fromhold, Mark**	The interplay between ultracold atoms, semiconductor surfaces and quantum electronic systems (II)

The book of abstracts can be found at:
https://docs.google.com/file/d/0B895mKJUqh29eXJac2NGZlZGTGc/edit?pli=1

Results and impact

The lectures have been opened to students working on other field of physics, not only to those being trained on cold-atoms and polariton physics, who sought extending their knowledge in physics, and to more senior scientists who were interested in educating themselves. Consequently, the school has given the chance to the cold-atom and polariton communities to educate each other, and to other communities to learn about the exciting physics carried out in cold atoms and semiconductor polaritons.

The school, as it was the case during the one held in Crete, was structured to give the maximum opportunity for informal discussion between the lecturers and the students. All the event, lectures and accommodation happened in the same place, Hotel Beatriz in Toledo, what greatly facilitated these discussions also during the coffee breaks and the lunch and dinner time. The students were encouraged repeatedly to ask question and an animated interchange of ideas did happen.

This school has provided a basic knowledge about cold-atom and polariton science to a large number of students and mainly about the common physics underlying the main trends in both fields, and have helped to cross-fertilize these field. The students got also the required background to attend more specialized workshops like, for

example, the one that will be organized by the POLATOM network in Cambride (UK) during the month of September 2012 (http://www.phy.cam.ac.uk/conferences/polatom/).

The complete viewgraphs of the lectures have been made available to the participants in the school through the following links:

https://docs.google.com/open?id=0B895mKJUqh29NGlONkMyTjZQS1U
https://docs.google.com/open?id=0B895mKJUqh29dnF4d0loTlFtd1E
https://docs.google.com/open?id=0B895mKJUqh29b0dWUUViY3FBR1U
https://docs.google.com/open?id=0B895mKJUqh29SjlvczBBTkdHWGs
https://docs.google.com/open?id=0B895mKJUqh29MG5JTWIySHZkSEk
https://docs.google.com/open?id=0B895mKJUqh29LVJMYTQ1eE5ydUk
https://docs.google.com/open?id=0B895mKJUqh29MDFPemlnblUydGM
https://docs.google.com/open?id=0B895mKJUqh29NGN0b3pMbDZ4N0U
https://docs.google.com/open?id=0B895mKJUqh29djg1WjRDZ1dYWDQ
https://docs.google.com/open?id=0B895mKJUqh29ZHRQdnNJRnJmYTA

where the students can study in great detail all the presentation of the school.

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