Science Meeting – Scientific Report

***Proposal Title**: Summer Program on "Synthetic gauge fields for atoms and photons"*

Application Reference N°: 4649

1) Summary

The Summer Program on "Synthetic gauge fields for atoms and photons" has taken place as anticipated at the Physics Department of Trento University during the period July 1st-July 12th, 2013.

The event has consisted of two full weeks of scientific activities. On every day from Monday to Friday of both weeks, two long seminars have taken place, typically in the morning from 11h-11h45 and then from 11h45-12h30. The full program of the seminars is included as Annex A. In the remaining time, participants were accommodated in offices of the Physics Department where they could perform individual and/or team research in a pleasant environment.
On average, we had around 25 participants simultaneously present in Trento, in addition of course to the local researchers from the BEC Center and other Trento institutions. The higher number of participants as compared to the original proposal was possible thanks to the larger number of available offices in the Department as compared to our original expectation. The full list of participants is included as Annex B; for each of them, the dates of stay in Trento are also marked.

On Saturday 6th, a special event has been organized to celebrate prof. Lev Pitaevskii's 80th birthday. Prof. Pitaevskii is an outstanding scientist who has been continuously giving fundamental contributions to the fields of many-body physics and ultracold atomic gases for more than 50 years. Since 1998 he works at the University of Trento and at the BEC Center. His 80th birthday has been the occasion to gather old and new friends and collaborators for a one-day workshop of intense scientific exchanges.
This workshop has consisted of a series of 6 long talks by top-class scientists (including 3 Nobel Laureates, S. Haroche, E. Cornell and A. Leggett) during the day (see the program in Annex C) and a celebration gala dinner in the evening. The participation to this special event has been remarkable, with at least 70 people coming from all over the world to attend the workshop and celebrate prof. Pitaevskii. The full list of registered participants is given in Annex D. On Sunday 7th, all participants to the Summer Program have been invited for a social excursion to the Garda lake.

2) Description of the scientific content of and discussions at the event

According to the fundamental concept of the POLATOM network, this event has gathered researchers active in the fields of ultracold atoms and of quantum fluids of polaritons and photons. The idea of "synthetic gauge fields" is in fact a common theme of the two fields that has attracted an enormous interest in the last few years. Our goal was to put the two fields in contact and stimulate scientific interactions: to this purpose, the program of the workshop has been organized in a way to have an alternate sequence of talks in the two fields and force speakers to be as much interdisciplinary as possible.

Our impression is that our efforts have been successful. On one hand, the atomic community has realized the impressive developments made by the experimental researchers in photonics and polaritonics who have recently demonstrated spin-orbit coupling effects as well as photonic topological insulator devices. On the other hand, the photon/polariton community has learnt from the atomic one about the most modern theoretical tools to describe these systems and about the most interesting physical effects that can be observed and studied in their systems.

One of the main themes discussed during the workshop has been the effect of the so-called "spin-orbit coupling" terms on the properties and the dynamics of quantum gases. This subject has been addressed from many different sides by G. Baym, J. Ho, S. Chen, Li Yun, Hui Hu, L. Santos, V. Shenoy, C. Sa de Melo. In particular the appearance of new quantum phases of matter in low-dimensional systems has been discussed as well as the nature of the phase transitions connecting them. While several atomic experiments have been already investigating this physics for a couple of years, the first experimental observation of spin-orbit coupled polariton gas was reported at the workshop by A. Amo: an interesting discussion has followed about its theoretical description in microscopic terms.

Another subject of intense discussions has been the quantum simulation of non-abelian dynamical gauge fields using atomic systems: several speakers have illustrated their proposals in this direction, namely P. Zoller, B. Reznik, M. Lewenstein and interesting debate has followed. A significantly easier proposal in the direction of studying dynamical gauge fields was put forward by P. Ohberg. In spite of considerable difficulties, a strong experimental effort is being devoted to these challenges by several groups using atomic gases, while for the specific problem of non-abelian dynamical gauge fields it is not clear yet whether polariton gases can be of any utility.

On the other hand, several presentations have put in evidence the great power of photons in the study of topological insulator systems: when the bands have non-trivial topological properties (say a non-trivial Chern number in 2D), robust chiral edge states appear on the surface of the sample, analogous to what happens in electronc gases in the so-called quantum Hall regime. Most remarkably, these edge states may have very useful applications in photonic technology. Their experimental observations has been reported for different physical systems by M. Hafezi, Y. Plotnik and M. Rechtsman. The possibility of instead directly addressing their bulk properties has been theoretically investigated by I. Carusotto in close connection with related works in the atomic context that was presented by N. Cooper and N. Goldman.

Finally, several leading experimentalists in ultracold atom physics have presented their latest results, even without direct relation with the subject of synthetic gauge fields.

These general talks by Z. Hadzibabic, M. Zwierlein, T. Esslinger, I. Bloch have provided an excellent overview of the most recent themes in this field and will hopefully stimulate analogous advances in the polaritonic field.

In addition to the formal activities of the workshop, participants were warmly encouraged to self-organize sessions on more specialized subjects of interest for several participants: as an example, on Tue 4th a special session on was organized by P. Massignan with several short presentations by the participants on different topics, ranging from atomic gases in synthetic dimensions (P. Massignan), to RF spectroscopy (Hui Hu) and instability of supercurrents (T. Ozawa).

The special event for Lev Pitaevskii's birthday had a more classical one-day conference format, with a series of talks by world-class scientists, including top-class scientists as R. Grimm, G. Baym, J. Ho, M. Inguscio as well as the Nobel Laureates S.Haroche, A. J. Leggett and E. Cornell. Even if unable to be personally present, the two latter ones were enthusiastic to participate on videoconference from oversea. All the six speakers gave remarkable presentations on subjects of current interest for the broad audience of old and new Lev Pitaevskii's friends that were present at the workshop.

3) Assessment of the results and impact of the event on the future directions of the field

For what one can judge a few weeks only after the event, our impression as organizers -confirmed by the feedback of the participants- is that the event has been successful and has opened a season of reinforced exchanges between the two communities. The interest of the community in our workshop is witnessed by the number of high-level researchers who have spontaneously applied to participate after seeing the announcement posted on the POLATOM webpage or the link on the BEC Center homepage. In addition to the invited speakers, we indeed had a good number of additional applications: thanks to extra space allowed to us by the Physics Department we have been able to provide office space to almost all of them. A specific attention has been paid to the logistics of offices so to host participants in neighboring offices and have all of them going all together to the canteen for lunch.

As a result of this (and other analogous) events, a generation of young researchers trained in both fields is finally starting to emerge: the present workshop has provided them an ideal opportunity to learn the new trends from the main actors and to be updated on the hottest problems in the field. Following this workshop, several among the leading researchers in photon/polariton gases have got familiar with each others' research and with the conceptual tools that were developed during the years to describe condensed matter systems first and then ultracold atomic gases. In our expectations, this will provide a boost to the fields of polaritonics and photonics comparable to the 2006 realizaton of a polariton BEC and the following observation of superfluidity in 2008. Seen from the point of view of atomic physics, the advances in polariton and photon fluids and the different range of diagnostic tools will provide an important alternative point of view on a common physics putting in evidence unexpected questions and challenging the consolidated conceptual picture. Combined together as they will hopefully be in the next years, these two streams are expected to keep giving dramatic boosts to the general field of many-body physics.

The affection and respect that a world-wide community has for prof. Pitaevskii was apparent in the number of people that decided to participate to the celebration workshop

on Sat. 6th. In addition to this, the outstanding scientific level of the speakers offered an excellent event where the participants to the two-week Summer Program as well as all prof. Pitaevskii's friends had the chance of discussing recent developments in fields of highest scientific interest.

4) Annexes:

- Annex A: Program of the two-weeks Summer Program
- Annex B: List of participants to the Summer Program
- Annex C: Program of the one-day special event on Saturday July 6th in celebration of Lev Pitaevskii's 80th birthday
- Annex D: List of registered participants to the July 6th special event

Summer Programme on *Synthetic Gauge Fields for Atoms and Photons*

Scientific Program

(updated version, June 28th)

Monday July 1st (Room 207)

15.00-15.30 Welcome

15.30-16.15 Gordon Baym - Condensation of bosons with Rashba-Dresselhaus spin-orbit coupling

16.15-17.00 Nigel Cooper - Adiabatic preparation of vortex lattices

Tuesday July 2nd (Room 205)

11.00-11.45 Jason Ho - How weak spin-orbit coupling can lead to dramatic many body effects in low-d systems ?

11.45-12.30 Sylvain Nascimbène - Realizing one-dimensional topological superfluids with ultracold atomic gases

Wednesday July 3rd (Room 205)

11.00-11.45 M. Rechtsman & Y. Plonik - Artificial gauge fields and topological protection in photonic lattices

11.45-12.30 Eugene Demler Exploring universality of many-body states with synthetic matter

Thursday July 4th (Room 206)

11.00-11.45 Allan Mac Donald - Dipolariton Condensates

11.45-12.30 Shuai Chen - Generation and Exploration of the Spin-Orbit Coupled Bose Gas

Friday July 5th (Room 206)

09.45-10.30 Zoran Hazdibabic - Uniform and Unitary Bose gases

10.30-11.00 Coffee Break at Povo 1 building bar

11.00-11.45 Benni Reznik - Simulating lattice gauge field theory with ultracold atoms

11.45-12.30 Alberto Amo - Spin-orbit coupling in polariton condensates

12.30-14.30 Lunch Break

14-30-15.15 Peter Zoller - Quantum Simulation of Abelian and Non-Abelian Dynamical Gauge Fields with Cold Atoms and Ions

15.15-15.45 Break

15.15-16.30 Martin Zwierlein - Heavy solitons in a Fermionic Superfluid

16.30-17.15 Iacopo Carusotto - Quantum Hall effects with light

Saturday July 6th (Auditorium Dipartimento di Lettere, downtown Trento)

All Day - Lev Pitaevskii 80th Birthday Celebration

Full program available at http://lev80.science.unitn.it

Sunday July 7th

All day - Excursion to Garda Lake
Departure at 9h30 from Grand Hotel Trento, in front of the Trento train station

Monday July 8th (Room 206)

09.45-10.30 Patrik Ohberg - Interacting gauge theories with BECs

10.30-11.00 Coffee Break at Povo 1 building bar

11.00-11.45 Li Yun - Spin-orbit coupled Bose-Einstein condensates: new dynamical properties

11.45-12.30 Duncan Haldane - A geometrical reinterpretation of the Laughlin state: Mott-Hubbard physics and the fractional quantum Hall effect

12.30-14.30 Lunch Break

14-30-15.15 Tilman Esslinger - Quantum Magnetism and Thermoelectricity

15.15-15.45 Break

15.45-16.30 Hui Zhai - Effects of synthetic gauge fields from shaking optical lattices

16.30-17.15 Mohammad Hafezi - Bosonic quantum Hall physics: from optical photons to circuit QED systems

Tuesday July 9th (Room 206)

11.00-11.45 Fernando Sols - Quantum transport in quantum gases: Hawking radiation and synthetic fields

11.45-12.30 Hui Hu - Unconventional superfluidity in spin-orbit coupled atomic Fermi gases

Wednesday July 10th (Room 206)

14.30-15.15 Luis Santos - Trapped Bose-Eisntein condensates with spin-orbit coupling

15.15-16.00 Vijay Shenoy - Fermions in synthetic non-Abelian gauge fields: from rashbons condensates to novel hamiltonians

17.30- 19.30 Visit to MUSE, the new Museum of Natural Sciences in downtown Trento

Thursday July 11th (Room 205)

11.00-11.30 Immanuel Bloch - Probing quantum matter in topological Bloch bands

11.30-12.00 Belen Paredes - TBA

12.00-12.45 Nathan Goldman - Imaging topological insulating states with cold atoms

12.30-14.30 Lunch

14-30-15.15 Carlos Sa De Melo - Parity violation in ultra-cold fermions in the presence

of			spin-orbit coupling and crossed Zeeman fields: normal state, superfluid and Feshbach molecules
15.15-16.00	Maciej Lewenstein	-	Quantum simulators of lattice gauge theories

Friday July 12th

Free discussions and informal sessions

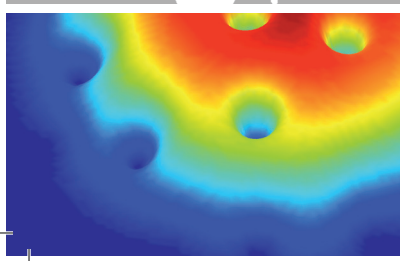
For more information: zanon@science.unitn.it

LIST OF PARTICIPANTS

NAME	STAY
1. Alberto Amo (CNRS, Marcoussis)	1-8 July
2. Gordon Baym (UIUC, Urbana-Champaign)	1-12 July
3. Immanuel Bloch (LMU, Munich)	6 July, 10-12 July
4. Georg Bruun (Aarhus University)	3-7 July
5. Iacopo Carusotto (Bec Center, Trento)	1-12 July
6. Shuai Chen (University of Science and Technology of China, Hefei)	1-7 July
7. Roberta Citro (INFN, Salerno)	2-7 July
8. Nigel Cooper (University of Cambridge)	1-12 July
9. Jean Dalibard (LKB-ENS, Paris)	1-7 July
10. Eugene Demler (Harvard University, Cambridge, USA)	1-8 July
11. Tilman Esslinger (ETH, Zurich)	7-10 July
12. Leonardo Fallani (LENS, Firenze)	5-12 July
13. Nathan Goldman (ULB, Bruxelles)	3-12 July
14. Rudolf Grimm (University of Innsbruck)	6-7 July
15. Zoran Hadzibabic (University of Cambridge)	1-7 July
16. Mohammad Hafezi (University of Maryland, College Park)	1-12 July
17. Duncan Haldane (Princeton University)	5-12 July
18. Jason Ho (Ohio State University, Columbus)	1-12 July

19. Serge Haroche — 6-7 July
    (Collège de France and ENS)
20. Hui Hu — 1-12 July
    (Swinburne, Australia)
21. Massimo Inguscio — 6-7 July
    (LENS and University of Florence)
22. Gediminas Juzeliunas — 1-12 July
    (Vilnius University)
23. Maciek Lewenstein — 5-12 July
    (ICFO, Barcelona)
24. Yun Li — 1-12 July
    (Bec Center, Trento)
25. Allan MacDonald — 1-6 July
    (University of Texas, Austin)
26. David Marcos — 3-5 July
    (Universität Innsbruck)
27. Giovanni Martone — 1-12 July
    (Bec Center, Trento)
28. Pietro Massignan — 1-6 July
    (ICFO, Barcelona)
29. Sylvain Nascimbene — 1-4 July
    (LKB-ENS, Paris)
30. Patrik Ohberg — 1-12 July
    (Heriot Watt University, Edinburgh)
31. Tomoki Ozawa — 1-12 July
    (Bec Center, Trento)
32. David Papoular — 1-12 July
    (Bec Center, Trento)
33. Lev Pitaevskii — 1-12 July
    (Bec Center, Trento)
34. Yonatan Plotnik — 2-11 July
    (Technion, Haifa)
35. Alessio Recati — 1-12 July
    (Bec Center, Trento)
36. Mikael C. Rechtsman — 2-9 July
    (Technion, Haifa)
37. Benni Reznik — 1-6 July
    (Tel Aviv University)
38. Carlos Sa de Melo — 10-12 July
    (Georgia Institute of Technology, Atlanta)
39. Grazia Salerno — 1-12 July
    (Bec Center, Trento)
40. Luis Santos — 1-11 July
    (Leibniz Universität Hannover)
41. Vijay B. Shenoy — 1-12 July
    (Indian Institute of Science, Bangalore) –
42. Fernando Sols — 5-12 July
    (Universidad Complutense de Madrid)

43. Sandro Stringari 1-12 July
(Bec Center, Trento)
44. Edward Taylor 4-10 July
(McMaster University, Canada)
45. Shunji Tsuchija 1-7 July
(Tokyo University of Science)
46. Onur Umucalilar 1-12 July
(Universiteit Antwerpen)
47. ZengQiang Yu 1-12 July
(Bec Center, Trento)
48. Qi Zhou 3-10 July
(The Chineese University of Hong Kong, Hong Kong)
49. Erez Zohar 1-6 July
(Tel Aviv University)
50. Peter Zoller 1-8 July
(Universität Innsbruck)
51. Martin Zwierlein 4-8 July
(MIT, Cambridge, USA)



Invitation to

LEV PITAEVSKII 80th Birthday Celebration

6 July 2013

Auditorium, Department of Humanities
University of Trento, via Tommaso Gar 14 - Trento

UNIVERSITY OF TRENTO - Italy

INO-CNR
ISTITUTO NAZIONALE DI OTTICA

EUROPEAN SCIENCE FOUNDATION

Organizer
BEC Center
INO-CNR - Department of Physics
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LEV PITAEVSKII 80th Birthday Celebration

Programme

9.30	Opening and welcome addresses
10.00	**Rudolf Grimm**, *University of Innsbruck*
10.40	Coffee break
11.20	**Serge Haroche**, *Collège de France and ENS*
12.00	**Gordon Baym**, *University of Illinois*
12.40	Lunch
14.30	**Federico Capasso**, *Harvard University*
15.10	**Jason Ho**, *Ohio State University*
15.50	Coffee break
16.30	**Eric Cornell**, *University of Colorado**
17.00	**Anthony J. Leggett**, *University of Illinois**
17.30	**Massimo Inguscio**, *LENS and University of Florence*

* videoconference

Lev Pitaevskii 80th Birthday Celebration
Trento, 6 July 2013

SPEAKERS

Rudolf Grimm, University of Innsbruck
Serge Haroche, Collège de France and ENS
Gordon Baym, University of Illinois
Jason Ho, Ohio State University
Anthony Leggett, University of Illinois*
Eric Cornell, University of Colorado*
Massimo Inguscio, LENS and University of Florence

*videoconference

EXTERNAL REGISTERED PARTICIPANTS

Amo Alberto
Astrakharchik Grisha (Grigori)
Balbinot Roberto
Balibar Sebastien
Baranov Micha (Mikhail)
Baym Gordon
Berloff Natalia
Bloch Immanuel
Bruun Georg
Calarco Tommaso
Castin Yvan
Chevy Fred (Frederic)
Chiofalo Marilù
Chwedenczuk Jan
Cooper Nigel
Dalibard Jean
De Chiara Gabriele
Demler Eugene
Dicastro Carlo
Modugno Michele
NaegerlHanns-Christoph
Ohberg Patrik
Paredes Belen
Parola Alberto
Pavloff Nicolas
Pilati Sebastiano
Prokovev Nikolaj
Reatto Luciano Roati Giacomo
Rzazewski Kazik (Kazimierz)
Salasnich Luca
Salomon Christophe
Sanpera Anna
Santos Luis
SchreckFlorian
Shenoy Vijay
Shuai Chen Shuai
Sinatra Alice
Smerzi Augusto

Ertmer Wolfgang
Fallani Leonardi
Fattori Marco
Ferlaino Francesca
Fetter Sandy (Alexander)
Goldman Nathan
Grimm Rudi (Rudolf)
Guilleumas Muntsa (Montserrat)
Hadzibabic Zoran
Hafezi Mohammad
Haldane Duncan
Ho Jason
Holland Murray
Holzmann Markus
Hu Hui
Jing Zhang Jing
Juzeliunas Gediminas
Laloe Franck
Lewenstein Maciek (Maciej)
Lobo Carlos
MacDonald Allan
Minguzzi Anna
Spagnolli Giacomo
Strinati Giancarlo
Svistunov Boris
Taylor Ed
Toigo Flavio
Trombettoni Andrea
Tsuchiya Shunji
Umucalilar Onur
Walraven Jook
Wantanabe Gentaro
Weise Wolfgang
Wouters Michiel
Zaccanti Matteo
Zaremba Eugene
Zbigniew Idziasek
Zhai Hui
Zhang Jing
Zoller Peter
Zwerger Willi (Wilhelm)
Zwierlein Martin