

## **Coslab Workshop**

# **Quantum Vacuum Properties in Condensed Matter Physics and Cosmology**

### **17-20 May 2002**

#### Scientific content of the event and assesment of the results

The workshop was a meeting of about thirty five physicists from various fields: condensed matter physics, relativity, quantum optics. They discussed the properties of the quantum vacuum in condensed matter physics and cosmology with the specific aim to identify and analyze analogies between the two areas. The meeting was characterized by long lectures with lively discussions. It has been a workshop in the true sense of the word.

#### Talks

*17 May: The first evening set the scene of the conference.*

Ted Jacobson, University of Maryland, USA, summarized the challenges and goals in the physics of quantum vacuum as seen from a general relativistic perspective. He emphasized the use of condensed matter analogs to elucidate questions concerning the structure of space-time in quantum gravity.

Kalle-Antti Suominen, University of Turku, Finland, summarized the experimental techniques in the physics of alkali Bose-Einstein condensation. Those techniques can serve as tools to implement analogs of models of astronomical objects in a laboratory.

*18 May: The day was devoted to the physics of Bose-Einstein condensates.*

Yvan Castin, Ecole Normale Supérieure, France, discussed vortex nucleation in Bose-Einstein condensates and in particular he analyzed the role of dynamical instabilities in rotating harmonic traps. His analytic results explained the experimental observations with high accuracy.

Christophe Josserand, Laboratoire de Modélisation en Mécanique, France, analyzed the transonic transition in a flow generated by a moving obstacle in a Bose-Einstein condensate.

Mike Stone, University of Illinois, USA, reported on an elegant description of sound propagation in moving media with vorticity.

Ulf Leonhardt, University of St. Andrews, UK, identified the analog of Hawking radiation in a Bose-Einstein condensate with transonic flow.

Luis Garay, CSIC, Spain, discussed dynamical instabilities at sonic horizons in a Bose-Einstein condensate.

Stefano Liberati, University of Maryland, USA, described a transonic flow of a Bose-Einstein condensate forced by a double Laval nozzle.

*19 May: The day was devoted to Fermi systems and cosmology.*

Shoucheng Zhang, Stanford University, USA, described a four dimensional generalization of the quantum Hall effect and its possible use in realizing a relativistic field theory in this condensed matter analog system.

Grigori Volovik, Helsinki University of Technology, Finland, gave a broad overview of emergent relativistic phenomena in Helium 3.

Jacek Dziarmaga, Los Alamos National Laboratory, USA, elucidated the emergence of effective electromagnetism in superfluid Helium 3 with modified fundamental parameters.

Jean Iliopoulos, Laboratoire de Physique Théorique de l'Ecole Normale Supérieure, France, spoke about quantum field theory in de Sitter space in relation to the dynamics of the cosmological constant and the possibility of a dS/CFT duality.

Robert Brandenberger, Brown University, USA, discussed the increase of the dissipation of the cosmological constant due to quantum fluctuations.

Robert Brout, Service de Physique Théorique, Belgium, discussed the problem of mode dissipation in inflation due to quantum gravity effects.

*20 May*

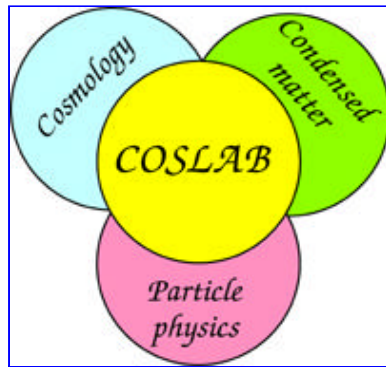
Gabriel Barton, University of Sussex, UK, reviewed in a concise and clear way the Casimir effect in dielectric media and related phenomena such as the Scharnhorst effect.

### *Conclusions*

This was a very useful workshop in the emerging field of condensed matter analogs of gravity. The workshop was ideally suited to foster animated scientific discussions between physicists working on different disciplines. It has served to clarify the goals and the perspective directions of research in this area.

### *Addendum*

After the workshop, Ulf Leonhardt, Stefano Liberati and Dani Arteaga stayed for a couple of days to further discuss the specific issues related to current research and future developments. These additional discussions have been found very useful and constructive.



## COSLAB WORKSHOP



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is supported by the  
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Foundation

Laboratoire de  
Mathématiques  
et Physique  
Théorique  
CNRS UMR 6083

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# *Quantum vacuum properties in condensed matter physics and cosmology*

Domaine Universitaire de la Croix Montoire  
37000 Tours - FRANCE

17, 18, 19 and 20th May 2002

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### Final Program

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The workshop starts Friday 17th May at 16:30 by two introductory lectures.

16.30 - 17.30 Ted Jacobson (Univ. of Maryland, USA).

[Hawking radiation in condensed matter systems:](#)

- 18.00 - 19.00 [What is at stake and where do we stand?](#)  
 Kalle-Antti Suominen (Univ. of Turku, Finland).  
[Bose-Einstein condensation of alkali atoms](#)  
[\(Experiments and theory\)](#)
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Saturday is devoted to several aspects of BEC.

- 09.00 - 10.00 Yvan Castin (LKB, France).  
[Dynamic instabilities of a Bose-Einstein condensate](#)  
[in a rotating harmonic trap :](#)  
[A route to vortex nucleation](#)
- coffe break -----
- 10.15 - 11.15 Christophe Josserand (LMM, France).  
[Transsonic transition](#)  
[in a model of quantum liquids](#)
- 11.30 - 12.30 Mike Stone (Univ. of Illinois).  
[Extension of the Unruh equation](#)  
[to flows with vorticity](#)
- lunch -----
- 15.00 - 16.00 Ulf Leonhardt (Univ. St-Andrews, UK).  
[Evaporation of sonic black holes](#)  
[and Hawking sound](#)
- coffe break -----
- 16.45 - 17.25 Luis Garay (IMAFF, Spain).  
[Sonic event horizons in Bose-Einstein condensates](#)
- 17.40 - 18.25 Stefano Liberati (Univ. of Maryland, USA).  
[Analog models from Bose-Einstein condensation](#)
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Sunday is devoted to fermionic aspects and cosmology.

- 09.00 - 10.00 Shoucheng Zhang (Stanford Univ., USA).  
[Modelling relativistic particles](#)  
[by the 4 dimensional generalization](#)  
[of the quantum Hall effect](#)
- coffe break -----
- 10.15 - 11.15 Grisha Volovik (Helsinki Univ. of Technology, Finland).  
[Emergent relativistic quantum field theory and gravity](#)  
[in vacua of Fermi point universality class](#)
- 11.30 - 12.30 Jacek Dziarmaga (Jagellonian Univ., Poland).  
[Effective electromagnetism in superfluid helium 3](#)
- lunch -----
- 15.00 - 16.00 Jean Iliopoulos (LPTENS, France).  
[Quantum field theory around de Sitter space](#)
- coffe break -----
- 16.45 - 17.25 Robert Brandenberger (Brown Univ., USA).  
[Back reaction of cosmological fluctuations](#)  
[and possible consequences for  \$\Lambda\$](#)
- 17.40 - 18.25 Robert Brout (ULB, Belgium).  
[Mode condensation and the inflaton](#)
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Monday

9.30 - 11.00 Gabriel Barton (Univ. of Sussex, UK).  
[Casimir effects: introduction and update](#)

The workshop ends Monday 20st May at 11:45

## List of participants

Ana Achucarro	(Spain)
Daniel Arteaga	(Spain)
Claude Barrabes	(France)
Gabriel Barton	(UK)
Bruno Boisseau	(France)
Robert Brandenberger	(US)
Robert Brout	(Belgium)
David Campo	(France)
Brandon Carter	(France)
Yvan Castin	(France)
Nicolas Chamel	(France)
Piotr Chrusciel	(France)
Stéphane Detournay	(Belgium)
Jacek Dziarmaga	(Poland)
Uwe Fischer	(Germany)
Luis Garay	(Spain)
Hector Giacomini	(France)
Peter Horvathy	(France)
Jean Iliopoulos	(France)
Ted Jacobson	(US)
Christophe Josserand	(France)
Tamas Kiss	(UK)
Ulf Leonhardt	(UK)
Stefano Liberati	(Italy-US)
Amaury Mouchet	(France)
Max Niedermaier	(France)
Nathaniel Obadia	(France)
Renaud Parentani	(France)
Philippe Spindel	(Belgium)
Michael Stone	(US)
Kalle-Antti Suominen	(Finland)
Michael Volkov	(France)
Grisha Volovik	(Finland)

Shoucheng Zhang	(US)
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