

Report on the 2009

ECT* Doctoral Training Programme on

“The physics of strongly correlated systems: from quark matter to ultra cold atoms”.

The 2009 ECT* Doctoral Training Programme on “The physics of strongly correlated systems: from quark matter to ultra cold atoms” lasted 12 weeks, from March 30 to June 18, 2009. The coordinators of the programme were Gordon Baym, Chris Pethick and Sandro Stringari.

It was attended by 13 full time and 5 part time students, among which 2 were from the University of Trento. In addition, one mathematician, working in FBK, attended several of the lectures and a post-doc in Povo also attended a few lectures. The list of students is appended at the end of this report. The students were lodged in the guest house in San Dona, an apartment which ECT* rents year round, four students were in an apartment in Dosso Dossi and two in the Foyer College in Gardolo. As in previous Doctoral Training Programmes, the students from Trento only attended a few of the lectures.

The 2009 Doctoral Training Programme, on the subject of Strongly Correlated Systems, was initiated by the Board in 2007. The programme differed from previous ones in that it covered strongly interacting systems in a number of seemingly different fields, namely quantum liquids, high energy heavy ion reactions, trapped cold atoms, the physics of neutron stars, nuclear physics, and low-dimensional systems. Several lecturers pointed out some common features in the theory of the different fields. The students were already engaged in their PhD projects in particular fields and generally had little knowledge of other areas. The programme offered the students a unique opportunity to discover other fields which, according to reports from the students, should serve to expand their perspectives and tools within their own fields.

The group of lecturers included an important number of experimentalists (see the list of lecturers below). Generally the lecturers, aware of the fact the majority of students had no familiarity with other subjects than their own, tailored their lectures to a broader audience. The upshot is that the students were taught a broad range of physics, rather than theoretical techniques.

The lectures were delivered in the mornings and the afternoons were kept free except for student seminars and occasional exercise sessions. The presence at ECT* of the lecturers in the afternoons is a great asset for the students who can discuss with them. The students are also expected to work on their PhD in the afternoons. Several lecturers, who had accepted to lecture for a full week, either arrived on Monday or left on Friday, thereby lecturing one day less. Fantoni was scheduled for one week and lectured during only two days. Such occurrences should be avoided.

Most of the lecturers left lecture notes which were put onto the Wiki page which allowed the students to download them. Two students (Zablocki, Merkl and Maeda) volunteered to write up the lectures of Baym, Giorgini and (most probably) Hatsuda, thereby making them available to the other students.

Each student was required to give a seminar on his ongoing research. This proves to be useful in so far as it develops contacts and discussions between the students. The list of seminars is given below. The seminars are announced on the ECT Web page. Some of the seminars were very informative. A suggestion was made, which might be applied in future Doctoral Training Programmes, namely to group all the student seminars into, say, the first 10 days so as to stimulate more discussion between the students.

The lecturers were encouraged by the coordinators to lecture on the blackboard, and those who did so were the most successful at conveying information to the students. But not all abided by this request. Of course, experimental and computational results need to be projected and a projector was always available.

At the end of the programme, the students were asked to write an informal report on their experience during the Doctoral Training Programme. The reports were handed to the director of ECT*.

The lecture programme.

(The asterisk ** indicates lecturers who are experimentalists.)

During week 1 **Chris Pethick** (NORDITA) and **Gordon Baym** (University of Illinois in Urbana Champaign) gave an overview of the forthcoming lectures. They specified carefully the orders of magnitude of the phenomena, which differ widely when going from cold atoms to RHIC and LHC physics. The lectures were entirely written on the board. The handwritten lectures of Pethick were scanned. The lectures of Baym were written up by Zablocki, one of the students.

Weeks 2 and 3 (which included an Easter break) and part of week 4 were devoted to lectures of **Sandro Stringari and Stefano Giorgini**, both from the physics Department of the University of Trento. The Stringari lectures covered much of present theory of trapped cold atoms. It was a pure PowerPoint presentation with the result that equations were more displayed than derived. Giorgini gave remarkable series of detailed lectures on the board on sampling and Monte Carlo calculations. One of the students Kenji Maeda wrote them up.

During week 4 ****Jens Jørgen Gaardhoje** (Niels Bohr Institute and University of Copenhagen) described high energy heavy ion reactions, explaining what could be observed experimentally. The lectures were a useful account of the experiments and were delivered entirely on the board.

During week 5 ****Peter Braun-Munzinger** (GSI Darmstadt and Technische Universität Darmstadt) lectured during three days and gave essentially descriptive Powerpoint lectures on the experimental aspects of relativistic heavy ion reactions. He also evoked elliptic flow and fluid dynamics with insistence that the fireball is a strongly correlated fluid. His aim was, to use his own words, to give the students “a taste” of the subject.

During week 6 **Stefano Fantoni** (SISSA and INFN) came for only two of the originally planned five days. He spoke about Monte Carlo calculations of nuclear matter and nuclei. The lectures were qualitative Powerpoint presentations.

Week 7 was devoted to lectures by **Martin Zwierlein** (MIT, Cambridge, USA) and **Achim Richter** (ECT* and Technische Universität, Darmstadt). Martin Zwierlein gave a detailed and very useful description of the experimental observations of trapped cold atoms. Achim Richter gave a Powerpoint presentation of collective excitations of nuclei (giant resonances, scissors mode, pygmy resonances, and more) as well as of nuclear astrophysics experiments performed with the electron beam of the Superconducting Electron Linear Accelerator S-Dalinac in Darmstadt. He stressed correspondences of nuclear structure with super-fluidity and pairing and discussed possible connections with Bose-Einstein condensation.

Week 8 was a vacation.

During week 9, **Anna Watts** (University of Amsterdam) described the observations made on pulsars and neutron stars. She insisted on the recent new data coming from satellite based counters as well as from radio telescopes. She gave students reports which they prepared in groups comprising three students and presented at the end of the course.

Week 10 was devoted to lectures of **Tetsuo Hatsuda** (University of Tokyo) and **Gordon Baym** (University of Illinois). Tetsuo Hatsuda described the symmetries of the QCD lagrangian, as well as broken symmetries of the physical vacuum. He also discussed the Nambu Jona-Lasinio model and phenomenological descriptions of QCD phase diagrams. Gordon Baym gave a very informative description of our understanding of conditions which prevail on a neutron star.

During week 11 **Thierry Giamarchi** (University of Geneva) lectured on the physics of low dimensional (mostly one-dimensional) systems, on the Hubbard, Lieb-Liniger models in particular. The lectures were entirely written on the board.

During Week 12 **Jacek Dobaczewski** (University of Warsaw, University of Jyväskylä) discussed density functional methods in nuclear physics.

Seminars delivered by the students.

The full-time students were required to give a seminar, which was announced on the ECT* Web site. The seminars prove to be quite useful for the students and also provide useful information on the work they are doing. The seminar programme is listed below:

Thursday, April 2, **Michael Merkl** (Heriot-Watt University, Scotland): *Non-abelian gauge fields and cold atoms: Zitterbewegung, solitons and vortices.*

Thursday, April 16, **Jussi Kajala** (Helsinki University of Technology): *Josephson effect in a Fermi gas.*

Wednesday, April 22, **Tomoki Ozawa** (University of Illinois, Urbana-Champaign): *Do photons exist? --- Niels Bohr's argument.*

Tuesday, April 28, **Shun Uchino** (University of Tokyo): *Dynamical symmetry in spinor Bose-Einstein condensation.*

Friday, May 8, **Agne Masalaite** (Vytautas Magnus University, Lithuania): *Quark confinement and the nucleon-nucleon interaction.*

Thursday, May 14, **Bhaswar Chatterjee** (Physics Research Laboratory, Ahmedabad, India): *Variational approach to relativistic BCS-BEC crossover with two species of fermions.*

Thursday, May 28, **Juan Francisco Castillo Hernandez** (GSI, Darmstadt): *Multiplicity fluctuations and forward-backward correlations in proton-proton collisions at LHC energies.*

Tuesday, June 2, **Daniel Zablocki** (University of Wroclaw) *Anomalous propagator contributions to mesonic decays - a signature of chiral symmetry restoration?*

Wednesday, June 3, **Kenji Maeda** (University of Tokyo) *Phases of attractively interacting boson-fermion mixtures.*

Tuesday, June 9, **Dario Jukic** (University of Zagreb): *Free expansion of a Lieb-Liniger gas.*

Thursday, June 11, **David Edwin Alvarez Castillo** (Institute of Nuclear Physics, Krakow): *Noise powered glitches in neutron stars.*

List of the participants.

(The last column mentions the subject of the present research PhD project.)

	Surname	Name	Nationality/ Date of Birth	Institute	Period of stay	
1	Alvarez Castillo	David Edwin	Mexico 05/11/1979	Institute of Nuclear Physics PAN, Krakow	27 March - 21 June, full time	Neutron stars
2	Bertaina	Gianluca	Italy 17/02/1983	Università di Trento, Italy	29 March - 19 June, full time	Coherence and superfluidity Bose and Fermi Gases, Monte Carlo techniques.
3	Castillo Hernandez	Juan Francisco	Spain 21/08/1975	GSI, Darmstadt	27 March - 21 June, full time	GSI TCP-Alice collaboration. Charged particle multiplicity in pp collisions at LHC energy.
4	Chatterjee	Bhaswar	India 23/07/1983	Physics Research Laboratory, Ahmedabad, India	25 March - 25 June, full time	BCS-BEC crossover in relativistic systems. NJL applied to quark matter.
5	Congedo	Giuseppe	Italy 25/01/1982	Università di Trento, Italy	25 May - 31 May, part time	Observation of gravitational waves.
7	Jukic	Dario	Croatia 27/06/1984	University of Zageb, Croatia	27 March - 19 June, full time	Expansion of a Lieb-Lininger (one-dimensional) gas . Ultracold bosonic gases.
8	Kajala	Jussi	Finland 08/01/1983	Helsinki University of Technology, Finland	27 March - 22 June, full time	Ultracold Fermi gases.
9	Macri	Tommaso	Italy 04/09/1983	SISSA, Trieste	11 May - 17 May and 08 June - 14 June, part time	Ultra-cold Fermi systems
10	Maeda	Kenji	Japan 01/11/1983	University of Tokio, Japan	03 April- 21 June, full time	Phases of boson-fermion mixture in cold atoms and quark matter.
11	Masalaite	Agne	Lithuania 08/05/1981	Vytautas Magnus University, Kaunas, Lithuania	27 March - 20 June, full time	Levels in multiwell quark models
12	Merkel	Michael	Germany 19/04/1981	Heriot-Watt University, Scotland	28 March - 19 June, full time	Optically induced non-abelian gauge fields in ultra- cold quantum systems.
13	Ozawa	Tomoki	Japan 28/09/1983	University of Illinois, Urbana- Champaign, US	25 March - 22 June, full time	Cold atom physics, two-slit diffraction of highly charged atoms.
14	Raimondi	Francesco	Italy 16/01/1975	University of Jyvaskyla, Finland	10 May - 21 June, part time	Superfluidity in the inner crust of neutron stars.
16	Toivanen	Pekka	Finland 03/03/1983	University of Jyvaskyla, Finland	09 May - 14 June, part time	Dark matter detection. Nuclear density functionals.
17	Uchino	Shun	Japan 04/08/1983	University of Tokio, Japan	27 March - 21 June, full time	Dynamical symmetries in Bose-Einstein condensates, spinor BEC and IBM, group theory in nuclear structure.
18	Zablocki	Daniel	Germany 07/07/1983	University of Wroclaw, Poland	28 March - 21 June, full time	Superconductivity in dense Fermi systems, cross- over in quark matter.

Addendum.

In order to illustrate the importance of requiring each participant to have a medical insurance, I add below a report on a case in which a student had to be hospitalized during the Doctoral Training Programme.

Report on the hospitalization of Bashwar Chatterjee on April 7-9, 2009-05-19

Bashwar Chatterjee, a full time participant of the 2009 Doctoral Training Programme at ECT* in Trento, was hospitalized for two nights, April 7-9, 2009 at the Hospital Santa Chiara in Trento.

On April 7th, at ECT*, he had high fever and was trembling. Upon seeing that he was in a very miserable shape, I drove him to the Santa Chiara Hospital together with Susan Driessen at the emergency reception. They took blood samples and they diagnosed malaria. He was then transferred to the department of Malattie Infettive (Infectious Diseases) and treated there.

Bashwar Chatterjee had arrived in Trento 10 days earlier, on March 28, 2009 from Ahmedabad, India. He said that he began feeling bad about three days prior to his hospitalization.

Bashwar Chatterjee had a medical insurance, the Tata –AIG General Insurance Company Limited, as all students of the Doctoral Training Programme are required to have. His insurance was declared to the hospital upon his admittance. I phoned the insurance in India the day after his hospitalization, and they said that he would have to file a claim and that it would require several days for the claim to be processed. They sent the claim form by fax.

Roberto Dallacosta, who is responsible for security in FBK, was informed. He replied that he would have difficulty in negotiating with the insurance company in India, because of language problems. He left that task to us in ECT*.

The treatment of Bashwar Chatterjee was very effective. His fever dropped and after two nights, the hospital was ready to release him and they supplied him with a medication he was asked to take for several days after. Thereupon the hospital charged Bashwar Chatterjee the sum of 4466 (four thousand four hundred and sixty six) euros. The hospital administration also said that he would not be released from hospital until they had received a written notification by his insurance that they would pay this amount to the hospital. After several telephone conversations and the exchange by fax of several forms, the insurance company in India continued to say that several days were required to process a claim. I succeeded in the hospital to have one of the doctors speak directly to a doctor of the insurance company. The doctor supplied detailed medical information and a few hours later the insurance of Bashwar Chatterjee sent a fax to the hospital accepting to pay the hospital bill. Bashwar Chatterjee left the hospital having only to pay 100 euros, according to the terms of his insurance. He has remained in good health since.