

ESF Science Meeting: "Solitons in Bose-Einstein condensates" (SOLIBEC)

Final Report

1 Summary

The conference SOLIBEC took place in Almagro, Ciudad Real (Spain) as projected on Feb. 9-12, 2005.

The aim of the conference was to bridge the areas of nonlinear waves and BEC. Specifically, to bring together experts on BEC with experts on soliton theory and nonlinear waves, many of which have already contributed to the field of BEC. The main goals of the conference were to stimulate mutual knowledge, to identify and address new problems and to find new subjects and frameworks for cooperation.

The atmosphere during the event was very cooperative and stimulating and many cooperations were started during the conference. At the end of the conference there was the feeling that this conference should be repeated in no more than two years.

Although a few key speakers could not attend the workshop they were very well represented by researchers of their respective research groups. In general the talks were well designed (everybody used multimedia projectors) according to the recommendations given by the committee and on time. Many of the participants were young and active researchers in the field and this contributed to create a climate of constructive cooperation.

The presence of experimentalists and theoreticians was very convenient and both communities were strongly interested in the proposals and questions of the other.

2 Description of the scientific content and discussion at the event

The workshop was organized around seven thematic sessions each devoted to an specific subfield of the research area of solitons in Bose-Einstein condensates. Most sessions were started with a longer talk given by an experimentalist focusing on his own work but with some tutorial character. The remaining talks within the sessions were divided either on invited or contributed (Student) presentations. In what follows I list those sessions.

2.1 BEC and lattices

This session was devoted to BECs in quasi-one dimensional lattices. The topics considered in this session ranged from generalities on lattices to discrete solitons (Morsch, Kevrekidis), weakly modulated optical lattices (Kuzmiak) and the motion of discrete solitons assisted by nonlinearity management (Cuevas).

2.2 Bright solitons

After the talk by Khaykovich on experimental results on bright solitons there were interesting contributions ranging from those devoted to a better understanding to aspects of the original experiments which have been controversial (Al Khawaja and Gawryluk) to the mathematical modelling of interactions of N -solitons taking into account the external potential (Gerdjikov) and new types of nonlinear "bright" waves such as the nonlinear X-waves proposed by C. Conti. Also in this session it was proposed how to use a BEC (or any cold-atom system on which transparency can be induced electromagnetically) to generate novel types of spatial optical bright solitons (Michinel).

2.3 Coupled systems

The session on coupled systems was devoted to different types of problems where coupling between subsystems plays an important role. The first talk by Gati was partially devoted to lattices and partially to multi-well potentials which lead to an effective coupling. Fernando Sols discussed a system with Josephson coupling leading to Shapiro resonances. There were also two contributions devoted to solitons in multicomponent BECs: one on dark solitons (Brazhnyi) and other on bright (symbiotic) solitons (Pérez-García).

Other systems in which coupling appears are ultracold boson-fermion mixtures. This was the topic of two contributions by Karpiuk (solitons) and Guilleumas (vortices). There was an enormous interest on those systems and many discussions on their proper modeling and prospects for the observation of novel nonlinear structures in those systems.

2.4 BEC and lattices (II)

This session was a continuation of the first one and again mostly devoted to nonlinear phenomena in quasi-1D condensates in lattices. The topics addressed were the behavior of BECs and solitons in disordered and inhomogeneous potentials (Fallani, Trombettoni) and the control of lattice solitons (Ahufinger).

2.5 Feshbach resonance management (FRM)

After the talk by Hulet on experimental capabilities on the tuning of the interactions for Bose and Fermi gases there were several talks on the theory of nonlinear waves in systems with periodically varying nonlinearity. These ranged from a mathematical result on the impossibility of achieving stabilization without changing the sign of the nonlinearity (Konotop) to the analysis of 3D stabilization with phenomenological losses (Saito) and stabilized solitons in multicomponent BECs (Montesinos). The talk by Valcarcel considered the possibility of inducing Faraday patterns in BECs by modulating appropriately the nonlinearity.

2.6 Multidimensional phenomena in lattices

This session was devoted to multi-dimensional solitons in 1D lattices or solitons in multi-dimensional lattices. Several talks considered the generation of 3D solitons by using a 1D lattice combined with other mechanisms such as FRM (Malomed, Baizakov, Staliunas). Also these phenomena for multicomponent systems were discussed by M. Salerno, who also discussed boson-fermion mixtures in optical lattices. Alexander presented nice numerical results on different types of nonlinear structures in multidimensional lattices such as gap vortices. Finally, using group theory and symmetry arguments Ferrando presented rigorous proofs that certain nonlinear structures (such as symmetric higher charge vortices) cannot exist in 2D lattices.

2.7 Dark solitons, vortices and vortex rings

This session was devoted to "dark" objects including different type of nonlinear structures in multicomponent untrapped BECs (Berloff), control of dark solitons (Proukakis) and soliton collisions and hybrid soliton vortex-ring structures (Brand).

3 Assessment of the results and impact of the event on the future direction of the field.

The event will have a great impact on soliton research in BEC. There were many participative discussions after each talk with suggestions, open questions, etc. The general atmosphere was very collaborative.

The meeting provided a better mutual knowledge provided and a framework to start considering different new problems as well as a revision of what can be expected from old problems. Also in several talks it was studied how to export some ideas from other fields such as nonlinear optics or quantum fluids to predict novel phenomena in the field of trapped BECs.

The new ideas and cooperations between participants in the meeting are too many to be listed here but most participants fixed at least one or two topics for future cooperation with other participants.

The concentration of people working on the same problems allowed to find some consensus on previously debated topics which were open and on which direction to follow to solve them.

Many participants indicated that because of the tight focus on solitons on BEC the meeting had being one of the most useful they had ever attended, specially taking into account its short duration of three and a half days.

Many participants proposed the repetition of this fruitful event in the future (no more than two years).

4 Final programme of the meeting

Wednesday, 9	
9:30 - 10:00	Opening session
Session 1: BEC and lattices	
1.1. Chairman: V. Konotop	
10:00 - 10:40	O. Morsch (Pisa, Italy) <i>Experimental properties of nonlinear matter waves in optical lattices</i>
10:45 - 11:15	P. G. Kevrekidis (Amherst, USA) <i>Discrete solitons in BEC and Optics: Teaching an old dog some new tricks.</i>
11:15 - 11:45	Coffee break
1.2. Chairman: M. Salerno	
11:45 - 12:15	D. J. Frantzeskakis (Athens, Greece) <i>Generation, dynamics and manipulation of bright and dark matter-wave solitons</i>
12:20 - 12:40	V. Kuzmiak (Prague, Czech Republic) <i>Dynamics of matter solitons in weakly modulated optical lattices</i>
12:45 - 13:05	J. Cuevas (Seville, Spain) <i>Motion of discrete solitons assisted by nonlinearity management</i>
13:05 - 15:15	Lunch
Session 2: Bright solitons	
2.1. Chairman: F. Sols	
15:15 - 15:55	L. Khaykovich (Raman Gat, Israel) <i>Towards experimental study of nonlinear dynamics and interactions of bright solitons in Bose-Einstein condensates</i>
16:00 - 16:30	C. Conti (Rome, Italy) <i>Nonlinear X-waves</i>
16:35 - 16:55	U. Al Khawaja (United Arab Emirates) <i>Bright soliton trains of trapped Bose-Einstein condensates</i>
16:55 - 17:25	Coffee break
2.2. Chairman: P. Kevrekidis	
17:25 - 17:45	V. S. Gerdjikov (Sofia, Bulgaria) <i>On Modelling adiabatic N-soliton interactions in external potentials</i>
17:50 - 18:20	H. Michinel (Orense, Spain) <i>Controlling the nonlinear refractive index via quantum coherence and interference</i>
18:25 - 18:45	K. Gawryluk (Bialystok, Poland) <i>Solitons in Bose-Einstein condensates</i>
20:30 -	Dinner

Thursday, 10	
Session 3: Coupled systems	
3.1. Chairman: B. Malomed	
9:30 - 10:10	R. Gati (Heidelberg, Germany) <i>Nonlinear propagation of matter waves in periodic potentials</i>
10:15 - 10:45	F. Sols (Madrid, Spain) <i>Shapiro resonances in atomic condensates</i>
10:45 - 11:05	Coffee break
3.2. Chairman: H. Michinel	
11:05 - 11:25	V. Brazhnyi (Lisbon, Portugal) <i>Stable and unstable dark solitons of coupled nonlinear Schrödinger equations: Applications to two-component BECs</i>
11:30 - 12:00	V. M. Pérez-García (Ciudad Real, Spain) <i>Symbiotic solitons in multicomponent quantum degenerate gases</i>
12:00 - 12:15	Discussion break
12:15 - 12:45	T. Karpiuk (Bialystok, Poland) <i>Solitons in Bose-Fermi mixtures</i>
12:50 - 13:20	M. Guilleumas (Barcelona, Spain) <i>Vortex states in Fermi-Bose mixtures</i>
13:20 - 15:20	Lunch
Session 4: BEC and lattices (II)	
Chairman: M. Salerno	
15:20 - 16:00	L. Fallani (Firenze, Italy) <i>Bose-Einstein condensates in ordered and disordered potentials</i>
16:05 - 16:35	A. Trombettoni (Parma, Italy) <i>Propagation of discrete solitons through inhomogeneous networks</i>
16:40 - 17:10	V. Ahufinger (Hannover, Germany) <i>Towards controlling matter wave lattice solitons</i>
17:10 -	Guided tour to Almagro
20:30 -	Conference Dinner

Friday, 11	
Session 5: Feschbach resonance management	
5.1. Chairman: V. M. Pérez-García	
9:30 - 10:10	R. Hulet (Houston, USA) <i>Tunable interactions in Bose and Fermi gases: From molecular Bose-Einstein condensates to solitons</i>
10:15 - 10:45	V. Konotop (Lisbon, Portugal) <i>Collapse in the Gross-Pitaevskii equation with periodically varying nonlinearity</i>
10:45 - 11:15	Coffee break
5.2. Chairman: P. Kevrekidis	
11:15 - 11:45	H. Saito (Tokyo, Japan) <i>Self-trapped Bose-Einstein condensates stabilized by oscillating interactions</i>
11:50 - 12:10	G. D. Montesinos (Ciudad Real, Spain) <i>Stabilized vector solitons in Bose-Einstein condensates</i>
12:10 - 12:30	Discussion break
12:30 - 13:00	G. J. de Valcárcel (Valencia, Spain) <i>Faraday patterns in Bose-Einstein condensates</i>
13:00 - 15:00	Lunch
Session 6: Multidimensional phenomena in lattices	
6.1. Chairman: J. Brand	
15:00 - 15:30	T. Alexander (Canberra, Australia) <i>Gap vortices and 3D localized structures in lattices</i>
15:35 - 16:05	K. Staliunas (Barcelona, Spain) <i>Nondiffractive Bose-Einstein condensates</i>
16:10 - 16:40	A. Ferrando (Valencia, Spain) <i>Solitons, discreteness and group theory</i>
16:40 - 17:10	Coffee break
6.2. Chairman: V. Konotop	
17:10-17:40	B. Baizakov (Salerno, Italy) <i>Properties of multidimensional solitons in periodic potentials</i>
17:45 - 18:15	M. Salerno (Salerno, Italy) <i>Two-component solitons in mixtures of Bose-Einstein condensates</i>
18:20 - 18:50	B. A. Malomed (Tel Aviv, Israel) <i>Stabilization of three-dimensional matter-wave solitons in an optical lattice</i>
20:30	Dinner

Saturday 12	
Session 7: Dark solitons, vortices and vortex rings	
7.1 Chairman: V. Braznyi	
10:00 -10:30	N. Berloff (Cambridge, UK) <i>Solitary wave complexes in two-component mixture Bose-Einstein condensates</i>
10:35-11:05	N. Proukakis (Utrecht, The Netherlands) <i>Engineering dark soliton dynamics in trapped quasi-1D atomic condensates</i>
11:10 -11:40	J. Brand (Dresden, Germany) <i>Soliton collisions and hybrid soliton vortex-ring structures in BECs</i>
11:40-12:00	Conference closing
12:00-13:15	Lunch
13:15 -	Bus departure to Ciudad Real railway station Arrival about 13:45 (suitable for 14:41 AVE train or 15:47 High speed train)