ESF Science Meeting:
"Solitons and nonlinear phenomena in degenerate quantum gases" (SOLIQUANTUM)
Final Report

1   Summary

The conference SOLIQUANTUM took place in Cuenca (Spain) as projected on Sept. 27-30, 2006.

The aim of the conference was to bridge the areas of nonlinear waves and degenerate quantum gases. Specifically, to bring together experts on BEC and degenerate fermi gases with experts on soliton theory and nonlinear waves, many of which have already contributed to the first of these fields. 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 series of conferences which was initiated in 2005 with SOLIBEC should be continued because of its interest for the interchange of information between the different communities present there.

In general the talks were well designed (everybody used multimedia projectors) according to the recommendations given by the commitee 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 discussions at the event

The workshop was organized around eight themes in 12 sessions with a total numer of 39 presentations divided into invited and contributed presentations. There were also seven contributions in poster format. In what follows I list those themes and their content

2.1   Solitons

This was one of the main topics of the conference and this is why this theme was splitted into several sessions (3). The first one included two talks by experimentalists on recent results and projected experiments on soliton generation and collisions (Cornish and Khaykovich) in Bose-Einstein condensates. This was complemented with several theoretical talks on soliton interactions related to planned experiments on soliton collisions (Adams, Khaykovich and Gerdjikov) and a poster on the same subject including the description of regular an chaotic dynamics in soliton collisions (Andrew Martin). Also a vision of solitons as elementary excitations was provided by Pitaevskii in his talk.The second session devoted to solitons included contributions on the stability of solitons in the presence of nonlinear dissipation (Perez-Garcia), solitons in ring trap geometries (Salasnich) and mathematical methods for finding solitary wave solutions of GP equations (Alfimov). The last session on solitons included contributions on discrete solitons including the possibility of implementing with quantum switches and quantum memories (Sanpera), on the quantum reflection and dissipative motion of matter wave solitons (Brand) and the nonlinear transport phenomena

mediated by solitons in Bose-Einstein condensates with disorder (Pavloff). A similar system was also studied in the poster of Clement who discussed the transport of coherent interacting matter-waves in a 1D random potential.

Finally, another poster (Tsuchiya) studied the stability and excitations of solitons in 2D Bose-einstein condensates modelled by the Kadomtsev-Petviashvili equation.

2.2 Vortices

This was other topic of interest during the conference. There were contributions on general vortex phenomenology (Volovik), dynamics and interaction of vortices in multicomponent Bose-Einstein condensates (Berloff) and vortex nucleation in rotating systems (Jackson). The role of symmetries and group theory in the selection of specific vortex patterns in systems with discrete symmetries was studied by Ferrando. Finally there was a contribution on virial relations for solutions of vortex type (Komikeas). Also other sessions contained phenomena involving vortices (gap-vortices, Kivshar).The thermal instabilities of doubly quantized vortices were presented in a poster by Gawryluk.

2.3 Lattices

The manipulation of quantum matter using optical lattices is other of the hot topics in the field of matter waves. This was another theme of the conference with six talks (2 sessions) devoted to this subject including: Bose-Einstein condensates (Fallani) and Bose-Fermi mixtures (Ahufinger) in disordered optical lattices, dissipative effects (Franzosi), modulational instabilities and Landau-Zener tunneling (Kuzmiak), "spintomics" (Lewenstein), symmetry breaking of multicomponent BECs with linear coupling in optical lattices (Malomed) and subdiffractive BECs in spatio-temporally modulated lattices (Staliunas). Multidimensional phenomena were also covered by Kivshar who presented novel localized structures resembling truncated nonlinear Floquet-Bloch modes. Rotating lattices were discussed also in the poster by Cuevas.

The role of impurities in a lattice was discussed by Carr, who presented a full picture on nonlinear band theory for a Kronig-Penney potentials and Brazhnyi who showed a tricky yet simple way to control and move gap solitons using a localized potential.

Finally a simple and efficient method to generate gap solitons in BECs was proposed in Trippenbach's talk.

2.4 Managed interactions

The subject of this session was to focus on phenomena which can arise at the mean-field level when the scattering length is either modulated in time (using e.g. time dependent magnetic fields) or made spatially dependent (e.g. by using optical control of Fechbach resonances). Michinel described spontaneous solitonic emission and the "soliton machine gun" in a BEC with spatially dependent nonlinearity. Kartashov described surface solitons appearing in the interface between regions with different scattering length in multidimensional scenarios. Finally, Kevrekidis discussed several scenarios including either time-modulation (stabilized solitons) or spatial modulations of the scattering length.

Also a poster by Belmonte presented a rigorous mathematical theory for the stability of solitons in systems with localized attractive inhomogeneous interactions.

Comparing this session with the corresponding one in the previous conference SOLIBEC there was a clear evolution from systems with time-modulated nonlinearities to systems with spatially modulated scattering length which allow for much richer behavior and should be easy to implement in experiments using optical control of Feschbach resonances or spatially varying magnetic fields when only smooth modulations are required.

2.5   Bosons and Fermions

This was another of the conference themes appearing in different sessions (Ahufinger, Konotop, Salerno, Adhikari, Guilleumas). In the session devoted specifically to this topic there were different theoretical talks using approaches such as the Thomas-Fermi-Weizacker theory to study mean field instabilities (Guilleumas), the so-called mean-field-hydrodynamic model (Adhikari) also to study fermionic collapse and soliton formation (Adhikari) and Hartree-type models to study both the properties of Bose-Fermi mixtures in optical lattices (Salerno) and in a poster by Karpiuk to study three-dimensional bright solitons. Finally the talk by Konotop presented yet another model (Wadati's one, which is valid for a number of bosons much smaller than that of fermions) and discussed localizaed models and gap solitons in the framework of this theoretical approach.

There was a general agreement on the need of new mean field-like models able to describe the dynamics (not only static properties) of Bose-Fermi mixtures in the case of comparable number of bosons and fermions, which corresponds to many present interesting experimental situations.

2.6   Long-range interactions

Dipolar BECs have been obtained and studied in the last years and their theoretical modellin involves much more complicated non-local nonlinearities (i.e. long range interactions). There was an experimental presentation on this subject (Fattori) and two theoretical ones devoted to different aspects of solitons in these systems (Santos) and to general properties of nonlinear Schrödinger equations with nonlocal nonlinearities (Krolikowski).

2.7   Coupled systems

Coupled systems were present in many talks including Boson-Fermion mixtures, multicomponent BECs, etc. A remarkable additional contribution was that of Oberthaler who studied two weakly linked degenerate Bose gases and reported different nice phenomena. Also the poster by Ilya Merashin studied coupled systems (coupled multicomponent BECs in optical lattices).

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

We think that the event will have a great impact on the research on nonlinear waves and nonlinear dynamics in degenerate quantum gases. There were many participative discussions after each talk with suggestions, open questions, etc. The general atmosphere was very colaborative.

The meeting provided a better mutual knowledge and an opportunity 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 many participants fixed topics for future cooperation with other participants.

Many participants indicated that because of the tight focus of the conference the meeting had being overy useful, 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).

SOLIQUANTUM
Programme

	Wednesday, 27	Thursday, 28	Friday, 29	Saturday, 30
9:00	*Buses from Hotel Leonor de Aquitania and Hotel Alfonso VIII to the conference site*			
9:30-10:00	Formal inauguration & Conference info (1)	*Lattices* Chairman: Salerno L. Fallani	*Managed interactions* Chairman: Vekslerchik H. Michinel	*Closing session* Chairman: Brand V. Konotop
10:00-10:30	*Solitons* Chairman: Konotop S. Cornish	B. Malomed	P. Kevrekidis	Y. Kivshar
10:30-11:00	Coffee break			
11:00-11:30	C. S. Adams	K. Staliunas	Y. Kartashov	M. Trippenbach
11:30-12:00	L. Khaykovich	V. Ahufinger	*Bosons&Fermions* Chairman: Oberthaler M. Salerno	L. Carr
12:00-12:15	Discussion break			Lunch
12:15-12:45	L. Pitaevskii	*Vortices* Chairman: Berloff A. Ferrando	S. K. Adhikari	Bus departs from Politechnical school at 13:00 providing connection with buses to Madrid at 14:00 and 14:30. Both buses arrive to Madrid at
12:45-13:05	V. Gerdjikov	S. Komikeas	M. Guilleumas	
13:05-15:15	Lunch			
15:15-15:45	*Vortices* Chairman: Ferrando G. Volovik	*Solitons* Chairman:Michinel A. Sanpera	*Long-range interactions* Chairman: Brand M. Fattori	
15:45-16:15	N. Berloff	J. Brand	L. Santos	
16:15-16:35	B. Jackson	N. Pavloff	W. Krolikowski	
16:35-17:05	Coffee break			
17:05-17:35	*Solitons* Chairman:Michinel V. Perez-Garcia	*Lattices* Chairman: Konotop M. Lewenstein	*Coupled systems* Chairman: Malomed M. Oberthaler	
17:35-17:55	G. Alfimov	V. Kuzmiak	V. Brazhnyi	
17:55-18:15	L. Salasnich	R. Franzosi		
18:30-	Buses to the old city of Cuenca (guided tour). Dinner.	Buses to the hotels		
		20:30 Buses to the conference dinner (Recreo Peral).	Free (2)	

(1) The registration desk will be open on Tuesday Sept. 26 from 18:00 to 20:00 and during the conference.

(2) The organization does not cover this dinner. We suggest you to look through the touristic information to find many interesting places in the city.