

## **EuroQUAM Review Panel**

### **Consensus Report**

**13 February 2012**

The EuroQUAM programme has been very successful on the basis of the scientific achievements presented and the impressive output in terms of high quality publications. The programme gathered some of the most excellent research groups in the field of ultra-cold atoms and molecules in Europe and it has substantially contributed to keep the European lead in many areas of ultra-cold matter physics.

The scientific cooperation of the project members on the European level has definitely benefitted from the EuroQUAM EUROCORES programme. It has allowed the coordination of research and has made less likely the duplication of efforts. This assessment is supported by the fact that the final reports in their majority stress this point in particular as the joint work and exchanges between the groups will continue beyond the conclusion of the programme.

It is considered that overall, the programme has proved to be very successful and that it has delivered its goals. Some of the results obtained have even exceeded the initial expectations. The achievements did not always match the original objectives but this is completely natural in fundamental research projects with high risk/high gain.

The degree of interaction between theoretical and experimental groups was really superb and shows that a lot of progress is to be expected from such collaborative efforts. The collaborations took place between principal investigators but also amongst young scientists.

Most of the groups noted that the networking activities and exchanges within the Collaborative Research Projects (CRPs) were strongly hindered by the fact that insufficient funds were available for internal CRP meeting and visits. This issue should have been addressed properly during the programme in order to allow such interactions.

#### **1. Scientific achievements**

The scientific achievements of the CRPs are in general excellent as it is clear from the impressive publication records of almost all projects. Some projects have shown a high degree of collaboration while others have worked very well on a more traditional basis of pre-existing networks. Some of the CRPs noted that joint publications should not be used as indicator of effective collaborations, however the complete lack of significant joint publications represents an issue.

Following the Final Conference, EuroQUAM published a topical Issue on "Cold quantum matter" in the European Physical Journal D edited by the six Project Leaders. This represents an important achievement and an excellent overview of the programme's result.

Some of the highlights from EuroQUAM CRPs include:

- CIGMA : Direct measurement of two-body correlations above and below the phase-transition to quantum degeneracy and direct comparison of interactions between different atomic species of

metastable atoms ; development of experiments and theory on anomalous phase matching in four-wave-mixing in colliding BECs published in Phys. Rev Lett.

- CoPoMol : Calculations of the potential energy surfaces and collisions showed that sympathetic cooling of ND<sub>3</sub> by Rb was unlikely to work in an electrostatic trap; demonstration of the possibility of trapping Rb and ND<sub>3</sub> in alternating current traps and development of methods for overlapping ND<sub>3</sub> in an AC trap and Rb in a magnetic trap ; collision calculations provided evidence that sympathetic cooling should work much better with light atoms than heavy ones. Results were published in several articles in Phys. Rev. Lett. and other journals.
- DQS: Implementation of the Fermi-Hubbard model and observation of the Mott-insulator transition with fermionic atoms and the Anderson localization of a non-interacting Bose-Einstein condensate ; creation of a 2-D rotating optical lattice and observation of vortex nucleation. Several articles appeared in Phys. Rev. Lett. and other journals.
- FerMix: Development of a general approach to probe the thermodynamics of strongly interacting quantum gases and its demonstration for spin mixtures of Li6 atoms - this work was published in Nature and Science and has a strong impact on the whole research of ultracold quantum gases and goes far beyond the present CRP ; full characterization of interaction properties in the main mixture of two different fermionic species (Li6 and K40 atoms), and demonstration of the first strongly interacting Fermi-Fermi mixture by investigating its hydrodynamic expansion. Results were published in several Phys. Rev. Lett. articles.
- QuDipMol: Realisation of an ultracold gas of LiCs molecules in the rovibrational ground state and identification of effects associated with the large dipole moment ; identification and interpretation of Rb-Cs Feshbach resonances ; demonstration of new approaches to create mixed species BECs and the identification of appropriate molecular pathways leading to the formation of a nearly quantum degenerate gas of RbCs molecules – these were published in Phys. Rev. Lett., Science, and Nature Physics.
- CMCC: preparation of cold molecules by opto-electrical cooling; demonstration of the the collective strong coupling of ion Coulomb crystals to an optical cavity field and its theoretical investigations ; self-organization of quantum degenerate gases in resonators and cooling of Coulomb ion crystals; unforeseen advances in the extension of cavity-mediated and mirror-mediated cooling to optomechanical structures and semiconductor devices. Results appeared in Phys. Rev Lett. and Science.

## 2. Networking, training and dissemination

A good number of networking and dissemination activities have been organised. All groups seem to have benefitted from EuroQUAM conferences and several projects have organised satellite conferences or additional meetings. There has been a substantial exchange of visitors and some exchange of students and postdocs. Some projects organised schools and workshops for the benefit of the whole cold matter community with a very positive impact on the research in the field.

The following **networking activities** within the programme are highlighted:

- The inauguration conference in Barcelona (April 2008) was essential to gather all groups and initiate the collaborations within the network
- The EuroQUAM satellite meeting on Cold and Ultracold molecules in Durham (April 2009) was important for networking with groups working on molecules formation in Fermi gases
- Schools in Oxford (September 2008) and Les Houches ( October 2009) provided important opportunities for training of young researchers.
- The EuroQUAM final conference in Ischgl (September 2010) was the most important event for dissemination and contacts across CRPs, scientists outside the EuroQUAM network and the general public. This conference gathered about 200 participants with half of them belonging to EuroQUAM. Strong public

relation activities, accompanying the conferences led to excellent visibility in international and local media including an article in the Frankfurter Allgemeine Zeitung.

As noted by most projects, the networking and exchanges within the CRPs were strongly hindered by the lack of dedicated funds for CRP internal meetings and visits. Student and post-doc exchanges are at the very core of EUROCORES-style collaborations. The Scientific Committee wished throughout the Programme to use networking funds to support such visits, particularly within CRPs where they would do most good, but this was not possible due to EUROCORES rules. Support from inter-CRP visits by the central networking funds would have been highly beneficial for the projects and, in particular, for the PhD students.

In summary, inter-CRP **networking** activities have been substantial and at a high level, although some CRP's have done better in this category than others. These activities were extremely useful and had a strong impact on collaboration as well as on the spreading of the EuroQUAM programme results. The network meetings have proved their purpose, since many collaborations have started from there. The programme has encouraged the PI's to take many initiatives in that direction and the results have been substantial.

**Training** activities were generally excellent and the best results have been achieved when young scientists moved from one country to another to participate in the research carried out in that country. These young scientists will benefit from these activities throughout their careers and thus this represents an investment that will repay itself many times.

The scientific results have been published in scientific journals and the list of publications is really impressive and in some cases has led to a review paper from which the whole scientific community can benefit. However, **dissemination** of the research results towards the general public was somewhat lacking and the outreach to the general public of this programme has been limited. There have been activities in this area surrounding the final conference in Austria in 2010, but on the whole this could have been better. One recommendation is that the ESF tries to pursue more aggressively the outreach of such a joint European network to the general public. On the whole this should strengthen the belief in the advantages of Europe for the general public.

In summary, the collaborations and the research funding have led to outstanding scientific results which would not have been achieved without the programme so there is a clear added value for science in Europe. The project has substantially contributed to keep the lead of Europe in many areas of ultra cold matter physics.

### 3. Realisation of the EuroQUAM programme's potential and additional suggestions

The mechanism of **funding allocation** of the programme is quite complicated. In addition, initial commitments by national funding agencies were partially withdrawn in the course of the programme creating problems to some of the CRPs. Top groups were excluded due to non-participation of national funding agencies as some European countries either declined participation in EuroQUAM or relied on funding already allocated to research groups to support EuroQUAM projects. A simpler mechanism with more flexibility to allocate funds has to be sought. For example agencies, can pay quotes to ESF in proportion to the amounts of funding their own researchers received in the past leaving more freedom to the program to allocate funds in specific projects but keeping the right to regulate the funding in the long run.

Some external funding (perhaps from EU) to cover small portions of projects which otherwise can block the whole program has to be sought.

Additional suggestions:

- Create an explicit **intra-CRP scheme for exchanges** and reserve a consistent part of funding to this purpose. In particular it would be important to facilitate the collaboration between experimental groups. This could be obtained by a short-time exchange-program for PhD students or PostDocs. Several CRPs complained about the lack of funding for intra-CRP meetings. This could be improved

by putting more emphasis on networking activities at the moment of the call so that enough money is allocated for this in the projects. It would be ideal to get specific money for networking, for example from the EU, which would help to more effectively increase the level of cooperation across Europe.

- The **time duration** of the programme was clearly too short. Some results of the networking were just starting to produce a positive dynamics when program ended! It would be useful to increase the duration of a programme up to 5 years.
- **Inter-CRP collaborations** have been very useful. However some CRPs did not use enough the possibilities offered by the funding available for this purpose. A more explicit information about such funds could be helpful.