

REPORT QUDEDIS Exchange Grant 1759:

## Disorder-Induced Order in BCS Theory

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May 21, 2008

From November 11 2007 to January 12 2008 I visited Professor Krzysztof Sacha at the Jagellonian University in Krakow. Previously to the visit, we had worked on disorder-induced ordering effects in coupled Bose-Einstein Condensates and developed models to study ultracold fermionic BCS systems.

In particular, we were interested in the following system. Take a large reservoir of superfluid molecules formed by pairs of fermionic atoms and a comparably small number of the same fermions in the BCS state. Introduce a coupling between the superfluid reservoir and the BCS fermions that is random but real. Our preliminary analysis suggested that we would find the gap function to be of fixed complex phase with respect to the condensate wavefunction of the superfluid molecules.

During my stay, we developed numerical simulations for the above mentioned system. The first versions were based on spacial discretizations of the physical problem. However, we soon found that computation times would exceed any useful timeframe. Therefore, using the results from these simulations, we built a completely new code rooted in the plane-wave basis of the problem. Hereby, we were able to speed-up our programs enormously while keeping numerical accuracy. We verified the computer simulations in 1D, 2D and 3D for ordered and, in 1D even for disordered systems using alternative computational code. Towards the end of my stay, I gave a seminar on the project and about our findings.

The main result of this collaboration is that we found clear evidence for disorder-induced ordering to appear in BCS systems through intense numerical studies. Our self-consistent simulations compute a result iteratively. All simulations converge and seem to confirm the complex phase of  $\pi/2$  in the gap function.

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After these simulations confirmed our analytical models, we are finalizing the numerical studies and are starting to write an article on the findings of this project. This collaboration opened the door to more complex and more realistic experimental scenarios, leading towards close collaboration between Barcelona and Krakow as well as experimental groups working in the field.