

SHORT VISIT GRANT

Awarded to: M. Haque, Institute for Theoretical Physics, Utrecht University, Leuvenlaan 4, 3584 CE Utrecht, The Netherlands.

Short stay of eleven days, to Cambridge and Birmingham (U.K.).
Travel starting May 10, 2006, ending May 20, 2006.
Grant reference number: 1092.

PURPOSE OF THE VISIT

The purpose of the visit was to pursue two separate collaborations with physicists in the United Kingdom.

1. The visit to Birmingham (and Rutherford Lab) was to continue an ongoing collaboration with:
 - (a) Professor Andrew J. Schofield
Theoretical Physics Group, School of Physics and Astronomy
University of Birmingham, Birmingham, U.K.
 - (b) Dr. Jorge Quintanilla
Rutherford Appleton Laboratory, Chilton
Didcot OX11 0QX, U.K.

We have been working on this project since August 2005. The purpose of the visit in May 2006 was to discuss and fix remaining issues and to plan the details of our first article on the topic.

The research concerns electronic states resulting from Pomeranchuk instabilities, which are shape deformation instabilities of Fermi surfaces. We have been studying the finite-temperature phase diagrams of models featuring Pomeranchuk instabilities in the $l = 2$ channel, leading to a non-Fermi liquid with nematic order. The finite-temperature phase diagram contains a transition of the Kosterlitz-Thouless type and a crossover at higher temperatures, corresponding respectively to the disordering of phase and amplitude degrees of freedom.

2. The purpose of the visit to Cambridge was to work on a relatively new project with Dr. Meera M. Parish, at the Theory of Condensed Matter (TCM) group, Cavendish Laboratory. My official host was Professor Peter B. Littlewood.

This research involves pairing and mean-field interactions in a fermionic gas unequal spin-state populations under Feshbach-resonant conditions. The purpose was to study the two-component polarized fermion gas at *unitarity*, the region of effectively infinite interactions, where perturbative or mean-field calculations are difficult to justify.

I spent the first 3 or 4 days in Cambridge (working with M. M. Parish), and the last week traveling back and forth between Birmingham University and Rutherford Laboratory (working with A. J. Schofield and J. Quintanilla).

DESCRIPTION OF THE WORK CARRIED OUT DURING THE VISIT + MAIN RESULTS OBTAINED

1. Pomeranchuk instability

One piece of our work on the nematic state resulting from an $l = 2$ Pomeranchuk instability is the calculation of the phase stiffness of this broken-rotational-symmetry state. During my visit to Birmingham and Rutherford Laboratory, we identified remaining issues with a preliminary calculation we had performed previously. Some of the issues have been resolved, and a more rigorous calculation of the stiffness was started during the visit, and is now being completed.

We also merged calculations performed separately, and fixed conventions and notations. We also planned our first paper to come on the topic. We are hoping to have a preprint ready by early July.

2. Polarized fermions at unitarity

For several months, I had been discussing with M. M. Parish a possible scheme to estimate the mean-field interaction in the resonant regime where the inter-particle scattering length is infinite. During my Short Stay visit to Cambridge, we worked out some details of this scheme, based on scaling arguments that can be used because the scattering length is infinite and drops out of the problem.

Previously, scaling arguments had been used for the regime of small polarization. We worked out some details of extrapolating to arbitrary

polarizations. We believe we have some interesting results already which can be useful to the fermionic-atoms community, after we have finalized some more details and performed some example calculations with our extrapolation scheme.

FUTURE COLLABORATION WITH HOST INSTITUTIONS

1. Pomeranchuk instability; Birmingham & Rutherford Lab

I expect to continue work with Prof. Schofield at Birmingham and Dr. Quintanilla at Rutherford Laboratory on the topic of Pomeranchuk instabilities, possibly for several years. There are quite a number of possible followups to our first calculation which is being completed now.

2. Polarized fermions at unitarity, Cambridge

Unfortunately, Dr. M. Parish is leaving for North America in September; so our priority is to write one paper before she leaves. I don't foresee immediate collaboration with anyone else at Cambridge on this topic.

PROJECTED PUBLICATIONS/ARTICLES RESULTING FROM GRANT

1. Pomeranchuk instability

We are hoping to prepare by early July a preprint of our first paper resulting from my collaboration with Birmingham/Rutherford-Lab. A tentative title is *Phase stiffness and fluctuations in two dimensional electronic nematic phase formed via $l = 2$ Pomeranchuk instability*.

2. Polarized fermions at unitarity

We are hoping to have a paper written before Dr. Parish leaves for Princeton in September. We do not have a working title yet.

OTHER COMMENTS

I wish to thank the ESF and in particular the INSTANS program for providing this grant, allowing me to visit my research collaborators.