

Scientific report

as requested by the regulations of the ESF “Short Visit Grant” programme, regarding the applicant:

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Host of the short visit:

Prof. German Sierra
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Report:

The purpose of the short visit was to discuss some recent physical developments that I was involved with, in collaboration with Prof. José M.P. Carmelo at the Universidade do Minho, Braga, Portugal, with the host of my short visit, Prof. German Sierra, but also with scientists working in related research areas, such as Prof. Fransisco Guinea and Prof. Gloria Platero (both at the Universidad Autónoma de Madrid) and Prof. Fernando Sols (Universidad Complutense de Madrid). We sought to pinpoint which future research activities would be relevant to engage in, regarding further developments and applications of the theoretical results.

Thus, the scientific interaction of this visit was mainly based on physical results obtained as a part of the PhD-project of Daniel Bozi (DB) under the supervision of Prof. José M.P. Carmelo. In short, these results regard the spectral properties of the one dimensional (1D) Hubbard model, as well as the scattering properties of the quantum objects which diagonalize the 1D Hubbard model hamiltonian. Apart from the references cited below¹⁻⁴, some of these new results make part of manuscripts submitted for publication, as well as constituting several preprints expected to be submitted to physical journals within the next 6 months. Furthermore, they are presented in detail in the recently completed PhD dissertation thesis report, by DB, soon to be uploaded to the cond-mat database.

Some of the research topics discussed during this short visit, included the newly introduced “pseudofermion dynamical theory”⁴ for the 1D Hubbard model. This theory deals with quantum objects dubbed “pseudofermions”. These pseudofermions, eta-spin and spin zero objects, are the scatterers and the scattering centers of the representation of the theory. They have no residual energy interactions. The S-matrix of this representation can be written as a simple phase factor, which involves the phase shifts of the zero energy forward momentum scattering events. The form of the pseudofermion S-matrix constitutes an important new result, and was vividly discussed during my short visit to Madrid.

Beyond the usual low-energy Luttinger liquid theory, the pseudofermion dynamical theory allows us to categorize a separation of the charge and spin degrees of freedom at a finite energy excitation scale. The corresponding charge and spin objects are defined as occupancy configurations of rotated electrons. Such rotated electrons are linked to the electrons by a mere unitary transformation. Our derived expressions are valid for the entire elementary excitation energy bandwidth, and not just the linear regime.

Furthermore, the developed pseudofermion dynamical theory and the application of it to the evaluation of the spectral function in the one-electron removal and one-electron lower Hubbard band addition cases, was used as a basis for the identification of future research activities in this scientific area. The fact that the closed form expressions for the spectral functions, showing explicitly the emergence of the characteristic power-law type behavior of correlation functions of Luttinger liquids, for any value of the on-site effective Coloumb repulsion and electronic density, and in the limit of zero magnetization, enables us to investigate the spectral behavior of other integrable many-body quantum models.

As a product of this short visit, many new ideas were surfaced, and it is most probable that further collaborations in this research field will take place. Some of these new ideas include: application of the same theoretical approach to similar quantum many-body models as well as a further derivation of closed form expressions for many-electron correlation functions. Thus, this short visit was an important stepping-stone for future collaborations in the field of correlated electrons in low dimensional systems, which should lead to several interesting publications in physical journals of mid to high standing.

Complementary to these discussions, the short visit also gave me an opportunity to interact with Prof. Fransisco Guinea, Prof. Gloria Platero and Prof. Fernando Sols (mentioned above), with whom a further collaboration is predicted, a part from already proposed collaboration discussed above. Indeed, having been awarded a 6 months scholarship as a post-doctoral fellow in Madrid, as part of the Madrid node of the RTNNANO MC network, research activity in other research fields are expected to occur as well. Some examples of the "other" research fields include those of Refs. 5-7.

In conclusion, due to the kind financial support of the ESF "Short Visit Grant" programme, several fruitful "informal meetings" were enabled, some of which are sure to lead to further collaborations in the near future.

References

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