Short visit report on “Quantum communication with bosonic fields”

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The short (3 days) visit was aimed at establishing a collaboration with Marcus Cramer, at Potsdam University's Institut für Physik, on the topic of quantum communication and, more generally, entanglement characterisation in harmonic many-body systems.

The visit was considerably successful, in that clear research objectives to pursue jointly have been singled out and a detailed preliminary analysis of the interesting subjects has been performed. In particular, the collaboration will be focused on the study of the coherent transmission of both quantum information (encoded in infinite dimensional squeezed coherent states) and entanglement in harmonic chains near criticality, taking into account finite temperature effects. Quite remarkably, our preliminary analysis was able to spot an opposite behaviour for the entanglement transmission and generation approaching criticality, depending on the considered coupling (”rotating wave” or ”spring-like”) between the bosonic components of the harmonic chains. While with spring-like interactions the entanglement generation is enhanced close to criticality, the same generation appears to be suppressed with rotating wave interactions. Such an interesting feature deserves further investigation and could bring to shed light about the entanglement characterisation of critical harmonic systems, properly taking into account the role of the specific interaction model adopted. This study will be at first tackled numerically, but analytical statement will be pursued whenever possible, adopting the powerful formalism of covariance matrices and harmonic analysis in phase space.

Another line of research has been selected during the visit, concerning the operational quantification of the entanglement present in many-body systems (say, in their ground state). As shown by J. Eisert and M. Cramer himself [quant-ph/0506250], the entanglement of such systems may be quantified not only, as customary, by asymptotic creation and distillation rates, but also by considering how many singlets can be distilled from a single specimen of the system (”single-copy” entanglement). This interesting theoretical framework leaves open the question of determining optimal (possibly deterministic) protocols to extract such entanglement from a single specimen of the system. Some encouraging preliminary studies in this direction have been already carried out during the visit for harmonic chains, conceiving promising strategies based on non-local interactions between the chain and the system receiving the entanglement (essentially between such system and the - highly non local - normal modes of the chain). The search for optimal strategies based on local interactions (more realistic for actual implementations) has now to be carried out. Notice that this scenario, with local interactions, is again strictly related to the entanglement and information transmission along harmonic chains.

This visit has thus allowed to set a solid base on which this collaboration will be developed, focusing on a precise and relevant research line, with a very likely possibility of dissemination in first class journals (potentially along two lines: entanglement transmission approaching criticality and extraction of single-copy entanglement).