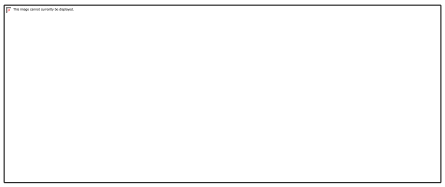

PHOTONICS - EUROPHOTONICS MASTER COURSE

MASTER THESIS PROPOSAL

Course 2014 –2015

Laboratory : ICFO

City, Country : Castelldefels (Barcelona), Spain

Title of the master thesis : Efficiency of nonlocality detection with two-body Bell inequalities

Name and affiliation of the tutor of the master thesis : Remigiusz Augusiak and Antonio Acín

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Summary of the subject (maximum 1 page):

Local measurements on entangled composite quantum systems may lead to correlations that cannot be simulated by any local deterministic strategy assisted by shared randomness. This phenomenon is known as nonlocality. Apart from its fundamental interest, non-locality has also turned into a key resource for certain information-theoretic tasks, such as key distribution or certified quantum randomness generation. Hence, revealing the nonlocality of a given composite quantum state is one of the central problems of quantum information theory.

The most popular tool to detect nonlocality in quantum systems are Bell inequalities— linear inequalities constructed from expectation values of tensor products of measurements performed by the local obsevers. Violation of such inequalities by some quantum state implies that this state is nonlocal. Althought many constructions of multipartite Bell inequalities have been provided, most of them involve correlations between all the parties. Such inequalities are, however, hard to test experimentally in quantum systems consisting of many parties. Recently, it has been shown that detection of nonlocality in multipartite systems is possible with Bell inequalities involving only one- and two-body expectation values (let us call such inequalities two-body Bell inequalities), opening the possibility of experimental nonlocality detection in large quantum systems.

It is nevertheless uncertain how efficient these new inequalities are. In other words, how much of all multipartite nonlocal states they are capable to detect. The role of the applicant would be to address this question in multipartite quantum systems for which all two-body Bell inequalities can be determined using computer algorithms, that is, systems consisting of three, four and five parties. The aims of the project are:

(i) determine all two-body Bell inequalities for three, four and five parties; use of symmetries can be taken into account if this problem is too difficult computationally. Then, for systems consisting of four and five parties, determine also three-body and three- and four-body Bell inequalities, respectively (here by three-body Bell inequalities we undrstand Bell inequalities involving three, two and single body expectation values),

(ii) write a program generating randomly multipartite pure states consisting of three, four and five qubits; higher-dimensional systems and some mixed states can also be taken into account if they are not too expensive computationally,

(iii) write a program checking if a randomly generated state violates one of the Bell inequalities from the above lists,

(iv) determine what is the amount of pure states with respect to some measure violating two-, three- and four-body Bell inequalities and compare them.

Keywords : nonlocality, Bell inequalities, multipartite quantum systems, Haar measure

Additional information :

* Amount of the monthly allowance (if it is the case):

* Required skills: knowledge of Mathematica, Matlab and/or programing languages

* Miscellaneous: