***Associateship Scheme***

*(5/4/2012****)***

**VISITING ASSOCIATE REPORT - FORM B**

**Please complete this form carefully at the end of your visit and return it to the Associateship Office.**

**This information is vital for the continuation of the Scheme.**

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**Address:**

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**Electronic mail address:**

**Country: Zip code:**

**Temporary address valid until:**

**Date of Arrival at ICTP:** 20/7/2016 **Date of Departure from ICTP:** 18/9/2016

**Period/s spent outside ICTP in connection with present Associateship visit:**

**Institute/Town/Country:**

**Reason for visit:**

**Field of Research:**

**Kindly specify below (using a maximum of 150 characters) your current main resesarch topics:**

Quantum information theory promises many future engineering applications such as quantum cryptography and quantum computation and also provides tools to investigate new paradigms for fundamental physics such as topological states of matter.  This field brings together two of the greatest discoveries of 20th century: quantum physics and information theory. Now, it is commonly accepted that quantum information science will a broad impact on fundamental science and subsequently on the technology exploiting the entanglement which constitutes  a basic resource for several quantum tasks such as quantum computing, quantum key distribution.  In this sense, it is necessary to establish a system approach to quantify, characterize and classify entanglement between multipartite systems.  Despite the considerable efforts deployed by the quantum information community, our understating remains limited. The complexity in investigating entanglement grows exponentially with the number of particles. In this context, with my collaborators , during the last years, we are interested in investigating the  quantum correlations using different measures Introduced by different authors from different perspectives and for specific purpose. Each one has its advantages and drawbacks and might be useful for some appropriate task.  In particular the quantum correlations in multipartite quantum systems prepared in coherent states.  These measures can be entropic or geometric to quantify the distance between a quantum state and another one without the required property. Probably the most familiar among entropic measures is the quantum discord which goes beyond the entanglement of formation. It is given by the difference of total and classical correlations existing in a bipartite system. Now, it is well understood that almost all quantum states, including un-entangled (separable) ones, possess quantum correlations. In particular the notion of quantum uncertainty offers a reliable and computable measure to determine analytically the amount of non classical correlations in a given multipartite system.

**Give a brief description of the research work carried out during your visit.**

**Quantum interferometric power and the role of nonclassical correlations in quantum metrology for a special class of two-qubit states**

We analyze the effects of quantum correlations on the parameter precision in an interferometric configuration. As probe states, we consider a class of two-qubit states for which the analytical expression of the quantum interferometric power, quantifying the quantum correlations, is explicitly derived. Also, we give and analyze the local quantum Fisher information, which evaluates the sensitivity of the probe state to the phase shift, for some relevant local Hamiltonians. The discord-like quantum correlations based on the notion of quantum interferometric power is compared with the original quantum discord based on von Neumann entropy. We also examine the significance of quantum correlations in enhancing the precision of the phase estimation. Our study corroborates the recent series of investigations focusing on the role of quantum correlations other than entanglement on the efficiency of quantum metrology protocols.

**Quantum correlations for two-qubit $X$ states through the local quantum uncertainty**

 Local quantum uncertainty is defined as the minimum amount of uncertainty in measuring a local observable for a bipartite state.

It provides a well-defined measure of pairwise quantum correlations in quantum systems and has operational significance in quantum metrology. In this work, we analytically derive the expression of local quantum uncertainty for two-qubit $X$ states which are of paramount importance in various fields of quantum information. As an illustration, we consider two-qubit states extracted from even and odd spin coherent states.

**Dynamics of Local quantum uncertainty under decoherence process**

A special emphasis is devoted to the concept of local quantum uncertainty as an indicator of quantum correlations. We study quantum discord for a class of two-qubit states parameterized by two parameters. Quantum discord based on local quantum uncertainty, von Neumann entropy and trace distance (Schatten 1-norm) are explicitly derived and compared. The behavior of quantum correlations, quantified via local quantum uncertainty, under decoherence effects is investigated. We show that the discord-like local quantum uncertainty exhibits the possibility of freezing behavior during its evolution.

**Graph states from phase states for multi-qudit entangled systems**

The description of qudits in a formalism based on a generalized variant of Weyl-Heisenberg algebras is discussed. The unitary

phase operators for a multi-qudit system and the corresponding phase states (the eigenstates of the phase operator) are constructed. We discuss the dynamics of multi-qudit phase states governed by a specific Hamiltonian involving one and two-body interaction which offers a remarkable connection between phase states and generalized graph states which are of paramount importance in quantum information. Another important facet of this work concerns the construction of mutually unbiased bases from phase states. Finally, entanglement aspects of some special class of phase states are examined.

**Give details of lectures and seminars given at ICTP and/or elsewhere during your visit.**

**List scientific activities attended at ICTP and/or elsewhere during your visit and the benefits obtained from such activities.**

During my visit, I have attended to the following activity:

1. WORKSHOP ON GEOMETRIC CORRESPONDENCE OF GAUGE THEORIES (12-16/09/2016)

2. WORKSHOP ON THEORY AND PRACTICE OF ADIABATIC QUANTUM COMPUTERS AND QUANTUM SIMULATION (22-26/08/2016)

3. CONFERENCE ON INTERACTIONS AND TOPOLOGY IN DIRAC SYSTEMS (03-09/08/2016)

4. CONFERENCE ON ENTANGLEMENT AND NON-EQUILIBRIUM PHYSICS OF PURE AND DISORDERED SYSTEMS (25-27/07/2016)

**List titles of papers/preprints submitted for publication during your visit.**

1. Quantum interferometric power and the role of non-classical correlations in quantum metrology for a special class of two-qubit states

2. Quantum correlations for two-qubit X states through the local quantum uncertainty

3. Dynamics of Local quantum uncertainty under decoherence process

4. Graph states from phase states for multi-qudit entangled systems

**Give details of scientific collaborations/contacts made during your visit.**

I discussed with many scientists, visiting ICTP or/and attending some activities, the main of their research topics especially

with scientists working on subjects related to quantum information.

**Which research facilities at ICTP have you found most useful to your work?**

Online access to journals.

Computing facilities.

The permanent help of the ICTP staff (scientists as well as others)..

**To what extent have you accomplished the scientific programme you planned for during your visit?**

During two months visit, I realized almost 80% of my previously planned program.

**Comment on the relevance and impact of your scientific activity at the ICTP to your scientific work in your country.**

My regular visits to AS-ICTP are of great importance for my research activities and have also an important impact on my career.

In the other hand, visiting ICTP allows me to attend to high quality conferences, seminars organized by ICTP.

**VERY IMPORTANT:**

This is my second visit as associate member. I visited several times the centre before. Thanks to the different schemes support (federation, visiting program …), I benefited from the ICTP facilities and this helped me in many respects.

**- NUMBER OF REFEREED INTERNATIONAL JOURNALS/PROCEEDINGS AT START OF ICTP visits 10**

**- NUMBER OF REFEREED INTERNATIONAL JOURNALS/PROCEEDINGS PRODUCED SINCE THEN 85**

**TOTAL NUMBER TODATE 95**

**Please suggest ways in which the ICTP could be of greater assistance to your future research work.**

**Other comments and suggestions.**

I would like to thank all the AS-ICTP members and especially the condensed matter section and the associate office team.

***Signature: Date: 16/09/2016***