ENS – IISER Network / BIOSANTEXC Project

Internship Proposal Form
France to India

(Discipline/Field name)

Electrical Engineering and Computer Science

Internship title: Exploration of entanglement of graph state codes usingstabilizer formalism

Keywords related with the subject (minimum 3): graph, algebra, quantum computing

Name of the IISER: IISER Bhopal

Name of the internship supervisor(s): Dr.Ankur Raina

Email(s) of the supervisor(s): ankur@iiserb.ac.in

Prerequisites for the internship Linear Algebra, Basics of Quantum Computing

Requested level: (For IISER Bhopal, it could be French Student M1/M2 level): M1/M2

Foreseen internship dates: May 2025

Internship type (refer to page 1):
■ 3–6-month internship ☐ ~~Research stays~~ ☐ ~~6+6 months internship~~

For 3 to 6 months internships, please indicate the desired duration: 3 months

For 6+6 months internships, please also fill in:

- **Name of the internship co-supervisor:**
- **Name of the co-supervisor's laboratory/entity:**
- **Email of the co-supervisor:**

Internship proposal (description and expected training outcomes / half page min, 1 page max):

Graph states are multipartite quantum states that exhibit richquantum entanglement. Graph states are modeled using graphs consisting of nodes and edges. Nodes represent qubits and edges represent quantum mechanical entangling interactions. To generate a graph state, qubits are initially prepared in the |+> state and these qubits are entangled using Controlled-Z gates. It is also possible to use graph states to create quantum error correcting codes (QECC). When the information of 'k' qubits is encoded into 'n' qubits of a graph state, we get [[n,k]] quantum graph state codes. Graphstate codes have an in-built graph structure that gives them exciting properties suitable for the design of QECC. The performance of QECC is generally measured using coding rate (k/n) and minimum distance 'd'. A code with minimum distance 2d+1 corrects at least d errors.

There exist a class of QECC called the stabilizer codes that can be described by a set of operators forming a group under multiplication. It is easy to study the properties of stabilizer codes using a parity check matrix 'H'. Graph state codes belong to the class of stabilizer codes and thus have an associated parity check matrix H. The minimum distance 'd' isevaluated as the minimum number of linearly independent columns of H. The objective of the project is to study the connections between the minimum distance d of a Quantum Error Correcting code, entanglement, and the graph structure of graph state codes for various coding rates.

Bibliography/References

1. Raina and S. S. Garani, ``Quantum channels over graph states using generalized measurement based quantum computation framework'', Quantum Information Processing, Springer, vol. 19, article 94, March 2020. (doi:10.1007/s11128-020-2597-7)
2. A. Raina, P. J. Nadkarni, and S. S. Garani ``Recovery of quantum information from a node failure in a graph'', Quantum Information Processing, Springer, vol. 19, article 70, Feb. 2020. (doi:10.1007/s11128- 019-2564-3)
3. A. Raina and S. S. Garani, ``Recovery from an eavesdropping attack on a qubit of a graph state'', Quantum Information Processing, Springer, vol. 18, no. 9, article 274, Sep. 2019. (doi: 10.1007/s11128-019-2387-2)
4. P. J. Nadkarni, A. Raina and S. G. Srinivasa, ``Recovery of distributed quantum information from a node failure using graph states,'' in Quantum Communication and Information Technology workshop, IEEE Globecom, Singapore, Dec. 2017. (doi:https://ieeexplore.ieee.org/document/8269075)
5. P. J. Nadkarni, A. Raina and S. S. Garani, ``Modified graph state codes for single node recovery in quantum distributed storage,'' Physical Review A, vol. 102, no. 6, p. 062430, Dec.2020. (doi:10.1103/PhysRevA.102.062430)

Internship conditions:

- monthly stipend of INR 15,000
- Accommodation will be provided on the IISER Bhopal campus
- cultural tour of nearby locations for ENS students during the stay.