Fall 2020 QIC 890 / CO 781 Term Project

Goal: Guided self-study on a topic chosen by each individual student.

Scope: Traditionally, most term projects involve reading research paper(s) on a subject related to the course. Students can also submit a research proposal (less common). Either case, students have a month for the studying or research (in parallel with assignments submission).

What has to be done:

• In the first week of Nov, each student writes a short proposal for the term project, explaining the topic, which paper(s) (or parts of papers) are involved, and what will be learnt. This can be a couple of sentences to a fraction of a page.

• Each student should imagine being the author(s) of the research he/she has studied, and prepare to submit the results to QIP with a 3-page abstract. This is due 3 days before the presentation. Here's the instruction from the QIP2021 website:

> This should be 1 to 3 pages in length and contain a non-technical, clear, and insightful description of the results and main ideas, their potential impact, and their importance to quantum information and computation. Extended abstracts should not be a compressed version of a full paper, but instead should facilitate an intuitive understanding of the research results that they represent and help the program committee assess their importance. Extended abstracts should be in PDF format, and typeset in single-column form with reasonable margins and font size at least 11 points. The 3-page maximum does not include references.

• Finally, each student will present the results within 25 min, with 5 min time for questions. Tentatively, presentation can be on Dec 8, 10, 15, 11am-2pm. We can tweak this plan.

• Initial proposal and 3-page abstract should be submitted on Crowdmark (as answers to Q1 and Q2).

Suggestions for topics; students are welcomed to come up with their own:

• Nonlocality without entanglement (9804053,1206.5822)

• Bound entanglement (9604005, 9801069, 9808030, 9908070, 9910026, 0005117)

• Embezzlement of entanglement (0201041, 0804.4118, 1311.6842, 1606.05061, 1811.12575, 1910.11354)

• Lieb-Robinson bound (math-ph/0506030, math-ph/0603064, 1701.00050)

• Limits on the storage of quantum information in a volume of space (1610.06169)

• 4 equivalent additivity conjectures (0305035)

• Holevo information is not additive (0809.3972, 0905.3697, 1003.4925)

• BDSW correspondence (entanglement purification = QECC) (9604024)

• Winter measurement compression and the quantum chernoff bound (0109050)

• Measure concentration, randomized techniques in QI (0307104, 0407049, 1010.3007)

- Proofs of SSA (1210.5190, notes on a talk by Nayak[1])
- Quantum message authentication (0205128, 1610.09434, 1607.07759)
- Locking (0303088, 0404096, 1010.3007, 1011.1612)
- Entanglement assisted zero error capacity (0911.5300, 1009.1195, 1002.2514, 1207.1779)
- Entanglement assisted classical capacity and the reverse Shannon Theorem (0106052)
- Private capacity of quantum channels (0304127, 0306078, 0506189, 0607018, 0903.4308)
- Privacy without coherence (0309110, 0506203, 1312.4989)
- Black holes as mirrors: quantum information in random subsystems (hep-th, arXiv:0708.4025)
- Family of protocols, merging, FQSW, state redistribution (0308044 + 0512015, 0505062, 0606225, 0612050)
- Quantum reverse Shannon theorem (0912.5537, 0912.3805)
- Continuity of entanglement measures and capacities (9908086, 9910002, 0203107, 0312081, 0810.4931)
- Degradable channels (0802.1360)
- Approximate degradable channels and continuity of quantum channel capacities (0810.4931, 1412.0980)
- Finite block length analysis (1109.5417, 1210.4722, 1406.7142)
- Noisy Interactive Quantum Communication (1309.2643, 2001.02818)
- Quantum random access codes (9904093, 0810.2937)
- Quantum bidirectional channels (0205057, 0412126, 0506039, 0511219, 0803.3066)
- Hardness of calculating capacities (0709.2090, 1408.5115)
- Experimental work on quantum communication (Suggestion: Paul Kwiat or Kevin Resch website)

[1] A proof of the quantum data processing inequality with a combinatorial flavour, Ashwin Nayak
The quantum data processing inequality (equivalently, the strong sub-additivity of von Neumann entropy) is a cornerstone of quantum information theory. It has been proven in numerous ways, each proof highlighting different aspects of the property.We present a proof of the data processing inequality based on elementary probability theory and properties of quantum states. In fact, the property follows from a strengthening of the substate theorem [Jain, Radhakrishnan, Sen'02] in the asymptotic setting. We prove, via an explicit construction, that in the limit of large n, the relative entropy of n copies each of two quantum states ρ, σ essentially equals their smooth max-relative entropy. This is analogous to the relationship between Shannon entropy and min-entropy that arises in the context of the noiseless coding theorem.
This is joint work with Shitikanth Kashyap and Michael Saks.