L.079.05802
Quantum Complexity Theory (in English)
Syllabus

Course code: L.079.05802
Course Level: Masters
Instructor: Jun. Prof. Dr. Sevag Gharibian
Office: F2.313
Office hours: 10:30 – 11:30 Tuesdays
Email: sevag.gharibian@upb.de
Classroom: F1.110 (Friday), F0.530 (Monday)
Class website:
http://groups.uni-paderborn.de/fg-qi/courses/UPB_QCOMPLEXITY/2019/UPB_QCOMPLEXITY.html

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1.0 – Major Topics Covered (tentative):

- Review of quantum circuit model and density operator formalism
- BQP and solving linear systems
- Quantum-Classical Merlin Arthur
  - Perfect completeness
  - QCMA-completeness of Ground State Connectivity
- Quantum Merlin Arthur (QMA)
  - Error reduction
  - QMA-completeness of Local Hamiltonian Problem
- One-sided error QMA
  - Efficient Quantum 2-SAT algorithms
  - Quantum Lovász Local Lemma
- QMA(2)
  - NP protocol with short proofs
  - Product state test and QMA(2) = QMA(k)
- Quantum Interactive Proofs
  - Semidefinite programming
  - Matrix Multiplicative Update Weights Method
  - QIP = PSPACE
- Quantum supremacy
  - Boson sampling

    - Random circuit sampling
- As time permits:
    - Approximate simulation and $P^{QMA[log]}$
    - BQP versus the Polynomial-Time Hierarchy
    - Quantum cloud computing (i.e. delegated quantum computation)

2.0 – Class Schedule:

- Lecture: 8:00 – 11:00 Friday in F1.110. Beginning 12.04..2019.
- Tutorial: 14:00-16:00 Monday in F0.530. Beginning 29.04.2019.
- Final Exam (first sitting): TBA
- Final Exam (second sitting): TBA

3.0 – Grading Scheme:

- The full grade for the course is based on the final exam, which will be oral. The grading scheme for the final exam is as follows:

95% - 100% : 1,0
90% - 94% : 1,3
85% - 89% : 1,7
80% - 84% : 2,0
75% - 79% : 2,3
70% - 74% : 2,7
65% - 69% : 3,0
60% - 64% : 3,3
55% - 59% : 3,7
50% - 54% : 4,0
0 – 49% : 5,0

- Update 06.06.2019: There is now a research project option for your final grade, instead of the oral exam. This is completely voluntary; you may choose either option. Please see the research project guidelines on PAUL for details.

- *Homework:* Are graded only for completeness. The bonus points for completing homeworks are as follows. Note the bonus applies only if you pass the final exam.

>= 60% of homeworks completed: 1 step bonus (eg 1,3 to 1,0)

>= 90% of homeworks completed: 2 steps bonus (eg 1,7 to 1,0)

- *Research seminar attendance:* The PhoQS research group at Uni Paderborn organizes a multi-disciplinary quantum seminar series each semester, with details here (note the list of talks may grow as the semester progresses): https://math.uni-paderborn.de/ag/arbeitsgruppe-spektralanalysis/forschung/interdisziplinaeres-oberseminar-quantennetzwerke/

  1 step bonus will be obtained for attending at least 4 seminars in the semester and writing a short summary for each. Each summary should give a few sentences explaining each of the following four points:

  1. The problem studied.
  2. The motivation for studying the problem.
  3. The results obtained.
  4. An intuitive sense of how the the results are obtained.

  While many of these talks are CS-oriented, some are physics-oriented. In such cases, I naturally do not expect you to seriously understand the content, but rather do your best to ask questions and understand as much as you can. Again, I will not grade your summaries for correctness, but rather for completeness.