Atul Singh Arora

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Research

2021-*present* | PostDoc, California Institute of Technology, United States
Advisor: Prof. Thomas Vidick

Showed oracle separations of hybrid quantum-classical circuits and recovered previous results (original proofs had errors).[1]

Constructed a more robust proof of quantumness, based on computational assumptions. It uses only 2 rounds and does not require the adaptive hardcore bit property (e.g. the Rabin cryptosystem suffices).[2]

Motivated by contextuality, demonstrated self-testing of a single quantum system (includes both theory and experiment).[3]

Introduced methods to improve the security of device-independent weak coin flipping protocols, resulting in an improvement after a decade.[4]

Collected all our previous results on the topic into a journal version—Solutions to Quantum Weak Coin Flipping.[5]

[1] ASA, A. Gheorghiu, U. Singh. arXiv:2201.01904 (submitted; web)
[2] K. Bharti, S. Hung, ASA, et. al. (in preparation; overleaf)
[3] X. Hu, Y. Xie, ASA, M. Ai, K. Bharti, et. al. arXiv:2203.09003 (submitting)
[4] ASA, J. Sikora, T Van Himbeeck (submitting; overleaf, web)
[5] ASA, J. Roland, C. Vlachou, S. Weis. (submitted; overleaf)

2016-20 | PhD Thesis, Université libre de Bruxelles (ULB), Belgium
Quantum Weak Coin Flipping
Advisor: Prof. Jérémie Roland

Primarily working on quantum weak coin flipping, a cryptographic primitive. Its figure of merit is called the bias, ϵ. The best known had $\epsilon \to 1/6$ by C. Mochon in 2005.

End 2017: Protocols with $\epsilon \to 1/10$ were found[1].

End 2018: An algorithm to numerically find protocols with $\epsilon \to 0$ was given[1].

End 2019: An exact (geometric) solution to the problem was found[2].

Mid 2020: A simpler, exact (algebraic) solution to the problem was found[3].

On the side, investigated foundational aspects of quantum mechanics[4].

[1] ASA, J. Roland, S. Weis. arXiv:1811.02984 (QIP '19 STOC '19 web)
[2] ASA, J. Roland, C. Vlachou. arXiv:1911.13283v1 (web)
[3] ASA, J. Roland, C. Vlachou. arXiv:1911.13283v2 (QCrypt '20 QIP '21 SODA '21 web)
[4] K. Bharti, A.S.A, L. C. Kwek, J. Roland. arXiv:1811.05294 (Phys. Rev. Res. 2, 033010)

2015-16 | Master's Thesis, Indian Institute of Science Education and Research (IISER), Mohali, India
Contextuality in a Deterministic Quantum Theory
Advisor: Prof. Arvind

Concluded that contextuality is not a necessary feature of quantum mechanics and proposed an alternative, non functional-consistency, bolstered by an explicit construction.

ASA, K. Bharti, Arvind. arXiv:1607.03498; Physics Letters A. (Nov 2018)

Summer 2015 — Internship University of Siegen, Germany
Towards a macroscopic test of local realism
Advisor: Prof. Otfried Gühne
Constructed a Bell inequality using observables bounded in phase space to probe local realism using macroscopic variables.
ASA, A. Asadian. arXiv:1508.04588; Phys. Rev. A 92, 061207

2011-14 — Internships
IISER Mohali, India. Quantum simulation (theory). Advisor: Prof Arvind.
National Physical Laboratory (NPL), New Delhi, India. Set up an experiment to study the dynamics of a dipole lattice. Advisor: Dr Ravi Mehrotra.
Indian Institute of Technology (IIT), Bombay, India. Yarn defect recognition using OpenCV. Advisor: Prof Anirban Guha.

Education

Sep 2020 – Oct 2016 — Doctorat en Sciences de l'ingénieur et technologie,
Université libre de Bruxelles (ULB), Belgium.

July 2016 – July 2011 — Bachelor and Master of Science with Physics major,
Indian Institute of Science Education and Research (IISER), Mohali, India.
CPI: **9.4** /10. Graduated with *rank two*. | Details at the end

Conferences

2022 **Poster**. *Oracle separations of hybrid quantum-classical circuits*
Quantum Information Processing (QIP). Caltech, USA

2022 **Poster**. *Improving the security of device independent weak coin flipping protocols.*
Quantum Information Processing (QIP). Caltech, USA

2021 **Talk**. *Analytic quantum weak coin flipping protocols with arbitrarily small bias.*
ACM-SIAM Symposium on Discrete Algorithms (SODA). Virtual.

2021 **Talk**. *Analytic quantum weak coin flipping protocols . . ..*
Quantum Information Processing (QIP). Virtual/Munich, Germany.

2020 **Talk**. *Analytic quantum weak coin flipping protocols . . ..*
QCrypt. Virtual/Amsterdam, Netherlands.

2019 **Participant**.
QuantAlgo Workshop. CWI, Amsterdam, Netherlands.

2019 **Participant**.
(Physics) Lindau Nobel Laureate Meeting (LINo). Lindau, Germany.

2019 **Talk**. *Quantum Weak Coin Flipping.*
Symposium on Theory of Computing (STOC). Phoenix, Arizona, USA.

2019 **Talk**. *Quantum Weak Coin Flipping.*
Quantum Information Processing (QIP). University of Colorado, USA.

2018 **Talk**. *Quantum Weak Coin Flipping beyond bias 1/6.*
QuantAlgo Workshop. Université Paris-Diderot, Paris, France.

2018 **Poster**. *Quantum Weak Coin Flipping with bias 1/10.*
Quantum Information Processing (QIP). TU Delft, Netherlands.

2017 **Participant**.

Theory of Quantum Computation, Communication and Cryptography (TQC). Paris, France.

Recognition

2019 Granted financial support for attending the *(Physics) Lindau Nobel Laureate Meeting, 2019*.

2018 Renewed. Two year research fellowship from the Belgian *Fonds National Recherche de Science (FNRS)*, through the FRIA grant.

2016 Awarded. Two year research fellowship from the Belgian *Fonds National Recherche de Science (FNRS)*, through the FRIA grant.

2016 Top 5% in the physics stream of the *Graduate Aptitude Test in Engineering (GATE)*, India.
Obtained a 92.3 percentile in the national graduate physics exam, *Joint Entrance Screening Test (JEST)*, India.

2015 Awarded the *Junior Research Fellowship (JRF-NET)* from the Council of Scientific and Industrial Research, India.
Awarded the *DAAD WISE* fellowship for a summer internship by and in Germany.

2013-16 Awarded the Certificate of Merit for the best academic performance in a semester, twice by IISER. Was among the highest scorers four other times.

2012 Awarded the *KVPY* fellowship for my work on Stepper Motor Control, by DST, India.

2010 Granted financial support for attending the Bright Green Youth climate summit, Denmark.

Teaching

2019 Teaching Assistant. Information Quantique (graduate). ULB, Brussels.

2016 Teaching Assistant. Thermodynamics (undergraduate). IISER, Mohali.

2015 Teaching Assistant. Classical Mechanics (undergraduate). IISER, Mohali.

Languages

English: Fluent
French: Basic
Hindi: Fluent
Punjabi: Intermediate

Interests & Extracurricular

Technology, Open-Source, Programming;
Philosophy, Reading;
Fitness; Piano, Guitar, Violin.

Bachelor and Master of Science with a major in Physics

Semester*	Subjects	Score
1	Mechanics, Chemistry of elements and chemical transformations, Cellular basis of life, Symmetry, Language skills B (English), Introduction to computers, Physics lab I, Chemistry lab I, Biology lab I	8.5/10
2	Electromagnetism, Atoms molecules and symmetry, Gene expression and development, Analysis in one variable, Hands-on electronics, History of science, Physics lab II, Chemistry lab II, Biology lab II	8.6/10
3	Waves and optics, Spectroscopic and other physical methods, Genetics and evolution, Curves and surfaces, Introduction to astrophysics, Workshop training, Physics lab III, Chemistry lab III, Biology lab III	8.8/10
4	Thermodynamics and statistical physics, Energetics and dynamics of chemical reactions, Behaviour and ecology, Probability and statistics, Introduction to quantum physics, Philosophy of science, Physics lab IV, Chemistry lab IV, Biology lab IV	9.7/10
5†	Classical mechanics, Quantum mechanics, Electrodynamics, Advanced optics lab, Reason and rationality	10/10
6	Statistical mechanics, Atomic and molecular physics, Quantum computation, Advanced electronics and instrumentation lab, Quantum field theory	9.6/10
7	Solid state physics, Nuclear and particle physics, Nuclear physics lab, Physics of fluids, Quantum principles and quantum optics, Radiative effects and renormalisation group in relativistic quantum field theory	9.4/10
8	Nonlinear dynamics, Chaos and complex systems, Condensed matter physics lab, computational methods in physics, Standard model and beyond, Selected topics in classical and quantum mechanics	9.5/10
9	Ethics, MS Thesis—Research project I	10/10
10	Cosmology and galaxy formation, MS Thesis—Research project II	10/10
	Cumulative Performance Index (CPI)	**9.4** /10

∗ Note that the credits associated with each semester are not exactly the same.

† Physics major henceforth.