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Collective neutrino oscillations; evidence for gravitational waves; 54th AAPPS Council Meeting; 2023 Nobel Prize in Physics; Malaysia's Quantum Leap

AAPPS Bulletin[1*]

5 A Build-up Towards Establishing Malaysia's Quantum Science and Technology Initiative by MyQI and Institut Fizik Malaysia (IFM)

Quantum technology makes use of quantum effects such as superposition, interference, or entanglement to outperform conventional computing and information processing carried out using classical bits. Quantum technology has received considerable attention from scientists, engineers, and governments all over the world as it promises, among other things, more powerful computing and secure communication. Major industrial sectors foresee quantum technologies to provide advantages and are exploring its potential applications in areas such as chemistry, drug discovery, and energy harvesting, in addition to its potential use in the automotive, finance, and agricultural realms. Multinational companies that have recognized the potential of quantum computing have begun integrating quantum technologies into their core business activities. Universities have begun offering academic programs in quantum engineering. The profound impact of quantum computing has led to numerous countries launching their own initiatives. Malaysia embarked on the exploration of quantum information as early as 2006 under the 9th Malaysia Plan (2006–2010) and the landscape has evolved into the following core areas: quantum communication and security, quantum information and algorithms, and quantum computing technologies.

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The groundwork started in quantum communication and security. MIMOS, a strategic agency under the Malaysia Ministry of Science, Technology and Innovation (MOSTI) established a research cluster that focused on home-grown quantum communication systems. The research covered a wide range of studies, including quantum key distribution protocols and their security analysis, in-lab experiments, as well as on-site systems testing. In the past decade, these research works gained global recognition. MIMOS had been named among the world's top 10 main players in terms of the number of patent applications. Several patent studies had highlighted the major contribution of MIMOS in the field, including the UK Intellectual Property Office (2014), the *Economist* (2017) magazine, and the European Commission's Joint Research Centre (2019) [14–16]. Through the MIMOS initiative, local and global collaborations have been established with universities and companies like International Islamic University Malaysia; the University of Camerino, Italy; Suez Canal University of Egypt; ID Quantique; and MagiQ Technologies [17]. Malaysia later established its position as a player in the field of quantum cryptography, when it participated in producing the definitive reference for the field in the comprehensive review [18]. These topics are also continued today. The foundation of quantum cryptography is founded on the uncertainty relations for observables. Analogous forms of such relations have been identified for unitary processes, and although they originated from a need for bidirectional quantum cryptography, they connect with various mathematical notions regarding specific structures of unitary bases for the Hilbert space of operators. On a practical side, to take advantage of the growing key rates of quantum cryptographic systems, local quantum information processing nodes such as spin qubits are being connected to optical qubits for reliable quantum communication. The use of optomechanical systems opens new possibilities towards realizing such couplings [19].

Other subfields of quantum information are younger in Malaysia. In recent years, quantum processing platforms have started to be incorporated into artificial intelligence technologies. The aim is to use advanced data processing methods in conjunction with relatively simple physical quantum devices that could be built in the near future, to realize efficiently tasks such as entanglement detection, tomography, state preparation, and computing [20]. These methods also promise a metrological advantage that could be used to test the foundations of physics. Other foundational aspects of gravitation and intense lasers are being developed [21] in parallel with theoretical and computational methods to study the physics of generation, propagation, and interactions of novel photon sources in photonic structures. All of these quantum processors generate quantum entanglement at some point in their evolution and their classification belongs to the mainstream of quantum information in Malaysia [22]. On the algorithmic side, group theoretic methods are addressing the challenges of quantum error correction. It is also hoped that techniques of theoretical physics, such as the supersymmetry of various quantum potentials and algebraic representations of quantum Fourier transforms [23], will ultimately advance quantum computing. Theoretical research related to concrete practical systems cannot miss the study of open quantum systems. General results concerning generators of open system dynamics are actively studied with a focus on the so-called exceptional points they produce [24]. These features are ubiquitous in dissipative systems, such as in driven superconducting qubits, and give rise to improved quantum sensors. Understanding and controlling the effects of decoherence and dissipation on qubits are essential for optimizing their performance and developing robust quantum algorithms in the presence of noise. The performance of a superconducting-based qubit is influenced by the presence of the generalized amplitude noise (GAD) channel, which can be considered the qubit counterpart of the bosonic thermal channel. The GAD serves as a model for lossy processes in low-temperature systems, simulating the effects of background noise. The study of the GAD paves the way for the design and implementation of more efficient and reliable quantum information processing systems in the era of Noisy Intermediate-Scale Quantum (NISQ) devices [25].

The last core area is quantum computing technologies, which involves building quantum computers, i.e., developing the software, middleware, and hardware. The software refers to the programs/libraries that compile quantum algorithms into sets of instructions for the middleware. The middleware is responsible for sending and receiving signals to the quantum hardware, i.e., controlling the qubits in the quantum processor unit. Malaysia aspires to build its own quantum computer and at the moment contributes to developing superconducting quantum computers at the Centre for Quantum Technologies in Singapore [26] and the Center for Quantum Information and Quantum Biology at Osaka University.

At the institutional level, Malaysian universities are increasing their efforts to enhance quantum information research activities. A noteworthy example of this commitment is the establishment of dedicated research centers of excellence within the universities this year: the IIUM Photonics Quantum Centre (iPQC) and Universiti of Malaya Quantum Information Science and Technology (UM QIST). iPQC is focused on being a self-sustaining high-impact research center with a team of experienced researchers in the field of fiber lasers and quantum information and cryptography. UM QIST is pushing key long-term initiatives in quantum communication using telecom-wavelength optical fibers for dual classical-quantum communication, a quantum machine learning for computational chemistry problems, and a single-photon source using carbon quantum dots. At the individual level, researchers are uniting. After the COVID-19 pandemic, the first online meeting of the Malaysian quantum information community was held in August 2022 and culminated in the Quantum Information Meetup 2023 at Xiamen University Malaysia. Representatives of all major institutions working on quantum information in Malaysia took part in the gathering, with many specialists meeting each other for the first time. It was a short and informal event, where everyone had the opportunity to introduce their research, intertwined with panels on prospective future directions in the context of Malaysia and coordinated efforts for research support. Some of the topics reported in this news article were thoroughly discussed.

[Participants of the Quantum Information Meetup 2023, hosted by Xiamen University Malaysia.]

At present, the quantum information research community in Malaysia is relatively small. Nevertheless, the allure of quantum computing has attracted researchers from diverse scientific backgrounds to explore the potential of incorporating quantum algorithms or quantum communications into their research endeavors. As they come together and capitalize on each other's strengths, Malaysia steadily prepares for a quantum information era.

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Declarations

Competing interests

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