CITATIONS OF WINNERS

YOUNG SCIENTIST AWARD 2017

Physical, Information & Engineering Sciences Category

Dr Weibo Gao

Nanyang Assistant Professor, Division of Physics and Applied Physics,
School of Physical and Mathematical Sciences, Nanyang Technological University

"For his distinguished research on quantum information and quantum photonics"

Dr Weibo Gao's research interests lie in the fields of quantum information, quantum optics and solid state physics, fields that are generally used in the area of quantum computing wherein researchers aim to solve problems that traditional computers are unable to do.

In quantum computing, qubits are used instead of the bits used in normal computers that can only exist either as a "1" or "0". Qubits can exist as both "0" and "1" at the same time and can also be entangled to each other, meaning that the qubits can be made to relate to each other in such a way that the measurement of one qubit will help us understand the measurement of the other. This makes quantum computers immensely more powerful than traditional computers as they are able to solve complex optimisation problems—something that traditional computers are unable to do on a large scale.

In the early stage of his research career, Dr Gao's focus was mainly on linear quantum optics. He and his colleagues successfully created six-photon and ten-qubit entangled photonic states, which have been the world record for entangled qubit numbers for several years. Based on these entangled states, they demonstrated quantum one-way CNOT gate and teleportation based quantum CNOT logic gate.

CNOT gates determine what position a qubit is in based on a control qubit. If the control qubit is in the "0" position the CNOT gate does nothing, but if the control qubit is in the "1" position, all qubits entangled to the control qubit will then change to their allotted positions. These demonstrations are the basic elements for quantum computation. In addition, they also demonstrated experimental measurement-based quantum computing beyond the cluster-state model.

At a later stage, Dr Gao started working in the field of quantum information based on solid state. He and his colleagues demonstrated the quantum dot spin-photon entanglement[1] and demonstrated quantum teleportation from a propagating photon to a solid-state spin qubit[2]. Their research results have been well-recognised by the

[1] Gao et al., *Nature*, 491, 426 (2012)
[2] Gao et al., *Nature Communications*, 4, 2744 (2013)

scientific community and are summarised in a recent review paper on manipulation, measurement and entanglement of individual solid-state spins using optical fields[3].

More recently, Dr Gao set up the quantum photonics group at Nanyang Technological University (NTU) Singapore. Quantum photonics is a field of quantum physics that deals with the interaction of photons with matter. The group focuses on quantum photonics research based on solid state systems, such as silicon vacancy in diamond, silicon carbide and 2D materials.

Through their research, the group has managed to demonstrate the coherent control of strongly driven silicon vacancies in diamond, silicon carbide and 2D materials[4], and discovered the first room temperature solid state bright single photon source working in the telecom range. This may pave the way for quantum communications with real single photons rather than attenuated lasers, which will provide an even more secure way of communicating and potentially enlarge the secure distance for quantum key distributions. Moreover, they have studied spin-valley-layer locking and exciton lifetimes in 2D heterostructures, which constitute some fundamental principles for the application of 2D materials in quantum information science.

Dr Gao's research in quantum information and quantum photonics has been published in world class journals such as *Nature*, *Nature Physics, Nature Photonics, and Nature Communications*. He was a recipient of the Marie Curie Fellowship in the European Union (2012), the National 100 Excellent Doctoral Dissertation Award in China (2015), and the National Research Foundation Fellowship in Singapore.

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[3] Coherent manipulation, measurement and entanglement of individual solid-state spins using optical fields, Gao et al., *Nature Photonics*, 9, 363 (2015)

[4] Yu et al., *Nature Communications*, 8, 14451 (2017)d