

PRESIDENT'S SCIENCE AWARD 2023

Dr Qiu Cheng-Wei

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“For his trailblazing contributions to topological thermal materials and diffusion physics, pioneering the fundamental framework in structured thermal metamaterials, quantum heat transport, advanced cooling technologies, and nonreciprocal thermal photonics.”

Over the past 15 years, Dr Qiu Cheng-Wei's groundbreaking research has laid the foundation for topological thermal diffusion and quantum heat transport. His works established new frontiers in classical fields of thermal diffusion, which circumvent intrinsic limitations of conventional heat transfer laws and yield unprecedented opportunities in ultra-high thermal conductivity, non-reciprocal heat transfer, thermal metamaterials, thermal harvesting and management, advanced cooling technologies, and energy sustainability.

Heat transfer can occur anytime and anywhere. Its fundamentals have been well established for centuries, such as Fourier's law on diffusive thermal conduction, and the Stefan-Boltzmann law on thermal radiation. However, traditional knowledge about thermal diffusion is insufficient to address emerging challenges in the contemporary era, such as global warming, energy crisis, heat waste, and the self-heating of integrated microelectronic chips. These problems largely arise from the limitations of thermal conductivities of natural bulk materials in meeting the demand for rapid heat dissipation and diffusion. As such issues are intrinsic for macroscopic thermal transport and diffusion, both the scientific community and policymakers are urgently calling for game-changing scientific solutions to resolve these fundamental barriers.

Instead of adopting traditional roadmaps, Dr Qiu's discovery of quantum and topological behaviour in thermal diffusion has drastically changed the landscape of thermal science. Dr Qiu has pioneered the fields of quantum thermal diffusion and topological thermal materials, both of which have long been perceived as non-existence in the field of dissipative heat transfer. Some of his groundbreaking discoveries include the quantum anti-parity-time mechanics in heat transfer, thermal zero-index material, phase-transition thermal diffusion, non-reciprocal heat transfer, spatiotemporal thermal lattice, diffusive Fizeau drag, diffusive non-Hermitian Weyl rings, passive ultra-conductive materials, thermal Willis couplings and chiral diffusion.

These notable scientific achievements herald a fresh perspective of controlling the heat transfer and diffusion process, enabled by quantum mechanics and topological physics. Dr Qiu has demonstrated technical capabilities in tailoring thermal energy and overcoming the bottleneck issues in thermal dissipation, conduction and radiation. His research has unlocked new possibilities for applications that exploit ultra-high thermal conductivity, edge-state heat transfer, as well as thermal locking and cooling, among others.

Beyond advancing the boundaries of science, Dr Qiu firmly believes that his technological breakthroughs should also benefit the society and create value for the industry. Indeed, his work has an enormous influence in areas such as microelectronics, chip technologies, thermal imaging, and carbon neutrality.

Thermal camouflaging and cloaking technologies developed by Dr Qiu have profound impacts on infrared monitoring, night vision and infrared deception. His work on sensitive thermography significantly enhances thermal imaging resolution and contrast, and brings about radical disruptions in electronics diagnostics, healthcare monitoring, thermal imaging, and construction defect detection. He has also pioneered a series of innovations in topological thermal diffusion, which constitutes a pool of ready solutions to overcome the rising challenges of heat dissipation, over-heating issues, and low-grade heat upcycling in integrated chips, computing servers for IoTs and other related industries.

Dr Qiu's outstanding contributions extend beyond the pursuit of academic excellence. Under his dedicated mentorship, nearly 30 former members of his lab became CEOs and CTOs of high-tech companies, or held positions as Nanyang Assistant Professor, chair professors, college deans and vice deans. Many of the scientists supervised by Dr Qiu went on to receive prestigious accolades.

Dr Qiu has published over 480 papers with more than 39,000 citations to date. He is a Fellow of ASEAN Academy of Engineering and Technology. He is also a Fellow of esteemed professional societies including Optica (US), SPIE (US) and The Electromagnetics Academy (US). For his achievements, Dr Qiu has received numerous awards, such as the URSI Young Scientist Award (2008), NUS Young Investigator Award (2011), MIT TR35@Singapore Award (2012), Young Scientist Award by Singapore National Academy of Science (2013), Faculty Young Researcher Award in NUS (2013), SPIE Rising Researcher Award (2018), Young Engineering Research Award (2018) and Engineering Researcher Award in NUS (2021), and World Scientific Medal by Institute of Physics, Singapore (2021). He was named by Clarivate as one of the Highly Cited Researchers from 2019 to 2023. He was most recently conferred the Achievement in Asia Award 2023 by the International Organization of Chinese Physicists and Astronomers, US.