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35th RQC Colloquium

Learning more about quantum systems via weak interactions and measurements

Prof. Yoon-Ho Kim

Department of Physics, Pohang University of Science and Technology (POSTECH), Korea

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This colloquium will be held in **HYBRID format**.

On-site Venue: Wako C00 HQ 2F Large Meeting Room

Online Venue: Zoom. To receive the link, register in advance at https://krs2.riken.jp/m/rqc_registration_form

Information on the state of a quantum system is obtained through measurement. The projection postulate stipulates that a quantum system is irrecoverably collapsed into one of the eigenstates of the observable, resulting in maximum state disturbance. Such a measurement is known as a projection or von Neumann measurement. A more general quantum measurement based on a weak interaction between the quantum system and the measuring apparatus is known as a weak measurement. In this talk, I will discuss how weak interactions and measurements may be used to learn more about quantum systems than we would with projection measurements.

Unlike projection measurement, weak measurement allows minimum-disturbance measurement, in which maximal information gain is achieved by minimally disturbing a quantum state [1]. Moreover, weak measurement may be reversed through the process of reversal measurement. Such a weak-reversal measurement pair has an interesting application in quantum information, as it can negate the effect of decoherence, even protecting entanglement from highly decoherent noisy channels [2,3]. A sequential application of weak and projection measurements leads to the weak value, which is not bounded by the eigenvalue spectrum of the associated observable. By applying multiple weak interactions sequentially, we can measure the so-called sequential weak value, and the sequential weak value of two incompatible observables is particularly important in quantum information, as it can be used to directly quantify a quantum process [4]. Also, by carefully changing the interaction strengths of the sequential weak interactions, it can be shown that the emergence of a geometric phase in quantum systems is due to quantum measurement back-action; the stronger a quantum measurement, the larger the accumulated geometric phase [5]. Finally, I will introduce a novel concept of the metrological weak value. Unlike the standard weak value, the metrological weak value is valid for arbitrary interaction strengths and, therefore, can be used to measure an arbitrary interaction strength, making it an important tool in quantum metrology [6,7].

[1] H.-T. Lim *et al*., Physical Review Letters 113, 020504 (2014). [2] Y.-S. Kim *et al*., Nature Physics 8, 117 (2012). [3] J.-C. Lee *et al*., Nature Communications 5:4522 (2014). [4] Y. Kim *et al*., Nature Communications 9:192 (2018). [5] Y.-W. Cho *et al*., Nature Physics 15, 665 (2019). [6] Y. Kim, S.-Y. Yoo, and Y.-H. Kim, Physical Review Letters 128, 040503 (2022). [7] S.-Y. Yoo *et al*., Quantum Science and Technology 10, 025054 (2025).