【Research Activity Report 2015】

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■Publications

1) Antonella De Pasquale, Paolo Facchi, Giuseppe Florio, Vittorio Giovannetti, Koji Matsuoka, and Kazuya Yuasa, "Two-Mode Bosonic Quantum Metrology with Number Fluctuations," Physical Review A **92**, 042115 (2015).

2) Daniel Burgarth, Vittorio Giovannetti, Airi N. Kato, and Kazuya Yuasa, "Quantum Estimation via Sequential Measurements," New Journal of Physics **17**, 113055 (2015).

3) Davide Orsucci, Daniel Burgarth, Paolo Facchi, Hiromichi Nakazato, Saverio Pascazio, Kazuya Yuasa, and Vittorio Giovannetti, "Hamiltonian Purification," Journal of Mathematical Physics **56**, 122104 (2015).

4) Hiromichi Nakazato, Saverio Pascazio, Magdalena Stobińska, and Kazuya Yuasa, "Photon Distribution at the Output of a Beam Splitter for Imbalanced Input States," Physical Review A **93**, 023845 (2016).

■Presentations

1) Kazuya Yuasa, Daniel Burgarth, Paolo Facchi, Vittorio Giovannetti, Hiromichi Nakazato, Davide Orsucci, and Saverio Pascazio, "Exponential Rise of Dynamical Complexity in Quantum Computing through Projections," 8th Italian Quantum Information Science Conference (IQIS 2015) (Monopoli, Italy, September 10-12, 2015).

2) Giuseppe Florio, Antonella De Pasquale, Paolo Facchi, Vittorio Giovannetti, Koji Matsuoka, and Kazuya Yuasa, "Two-Mode Bosonic Quantum Metrology with Number Fluctuations," 8th Italian Quantum Information Science Conference (IQIS 2015) (Monopoli, Italy, September 10-12, 2015).

3) 門内隆明・湯浅一哉, 「ミクロカノニカル状態における KMS 条件と熱力学極限」, 日本物理学会 2015 年秋季大会 (関西大学, 2015 年 9 月 17 日).

■Summary of Research Achievements

1) We are working at several issues on "**quantum parameter estimation**." In the standard strategy, we estimate a target parameter through the data collected by performing many identical experiments independently. The data collected in this way are independent and identically distributed (i.i.d.). In contrast, we are studying a scheme in which we collect data for parameter estimation via measurements sequentially performed without resetting the system every after the measurement. The data collected in this way are not i.i.d. anymore. We have shown that under a certain condition on the

estimation process the central limit theorem holds for some functionals of the data, such as the average, from which we are allowed to estimate the target parameter. In addition, by making use of the correlations among the data, which are absent in the i.i.d. data, we are able to enhance the precision of the estimation.

2) We are pursuing “**quantum metrology**” as a possible future quantum technology, which allows us to beat the classical estimation precision limit. In particular, we have investigated an optical estimation scheme, which exploits multiparticle quantum interference arising due to the indistinguishability of photons. We have clarified the ultimate precision bound allowed by quantum mechanics for a generic two-mode passive linear optical circuit.

3) We are studying “**quantum control**.” In particular, we are interested in control strategies which make use of quantum measurement as a tool for quantum control. We have shown that quantum measurement can exponentially enhance the complexity of quantum dynamics, and thus enhance the controllability over a given quantum system. We have also shown that its converse is true: any complicated quantum dynamics with noncommutative Hamiltonians can be viewed as a projected dynamics of a simple dynamics induced by commutative Hamiltonians in an extended Hilbert space.

4) We are discussing issues on the foundations of statistical mechanics, focusing on the “**quantum typicality**” of the quantum states of large quantum systems. We have shown that the output distributions of the photons from a balanced beam splitter with many photons injected from the two input ports are typically the same for a relatively wide range of imbalanced inputs.