Speaker: **Ilya Karuseichyk**

Title: **Multiparameter Method of Moments for Sources Resolving and Characterization**

Date: **Tuesday, February 18th, 11:00 am (s.t.).**

Place: **Seminar room 915**

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Abstract:

Quantum metrology presents numerous promising prospects, showing the potential for significant enhancing of the measurement precision across various domains, from imaging to gravitational wave detection. However, assessing whether a given measurement scheme effectively extracts all the available information, as predicted by the quantum Cramer-Rao bound, remains challenging in practical scenarios. Additionally, constructing computationally feasible data-processing algorithms that fully exploit the measured data poses another challenge in multiparameter estimation. To address these challenges, this thesis adopts the Method of Moments approach to multiparameter estimation — a data-processing technique leveraging the first statistical moments of measurement results. This method provides straightforward estimators with associated sensitivity bounds, facilitating easy computation and relaxing demands on the detection system. Using this approach, we explore the classical problem of resolving point sources of light and extend its scope to scenarios where bright sources exhibit mutual coherence. Our investigation includes models with diverse statistics and coherence properties, including instances of non-classical statistics or separation-dependent mutual coherence of the sources. By analyzing multiple parameters such as sources' separation, relative and absolute brightness, and phase, we compare the sensitivity of the moment-based spatial mode demultiplexing technique, direct imaging, and the quantum Cramer-Rao bound. Our findings demonstrate a practical estimation approach that often achieves quantum-optimal performance. Furthermore, we apply the moment-based technique to efficiently characterize Gaussian states using homodyne detection data. We devise an optimal unbiased estimator through algebraic transformations of measured data, providing a simpler alternative to traditional optimization-based methods that are computationally intensive.