

Internal Referee's report on the PhD thesis
**«Nonclassicality of Measurement Statistics
of Quantum Electromagnetic Radiation»**
by Vadym KOVTONIUK

The PhD thesis «Nonclassicality of Measurement Statistics of Quantum Electromagnetic Radiation» written by Vadym Kovtoniuk is devoted to the problem of certifying nonclassicality of measurement statistics of quantum electromagnetic radiation under realistic and informationally incomplete experimental conditions.

The boundary between the quantum and classical descriptions of light is formalized through the Glauber-Sudarshan P function: a state is deemed nonclassical if its P function fails to be a valid probability distribution. However, real-world measurements are almost always informationally incomplete, providing only partial access to the properties of quantum states. As a consequence, nonclassicality of a quantum state may remain latent—present at the level of the P function but undetectable in the observed measurement statistics. Mathematically the problem of certifying nonclassicality is considered in convex geometry language: classical statistics form a convex set, while nonclassical statistics lie outside it. This places the problem within convex geometry, where the hyperplane separation theorem and the theory of convex hulls of parametric sets provide natural tools for deriving witness inequalities. A particularly rich structure becomes available when the classical set reduces to a curve whose components form an extended Chebyshev system, in which case the theory of the generalized moment problem applies.

The main new results presented in the thesis include a notion of tight inequalities developed for convex sets beyond the polytope case, with a complete characterization of the tight-witness set as a union of families indexed by coherent amplitudes. When the classical manifold is a curve, whose components form an extended Chebyshev system, the tight witnesses are obtained in closed form, and the optimization over the witness space is reduced to a search of roughly half the dimension. Tight inequalities provide the strongest classicality conditions extractable from a given set of measurement data and remain applicable in practical scenarios that account for experimental imperfections such as optical losses and limited detector resolution. They are shown to outperform traditional variance-based tests in concrete experimentally relevant examples, including super-Poissonian phase-squeezed states.

This result and the other results presented in the thesis are published in five papers in Physical Review A. It independently confirms the high level of the obtained results. Also, the results were presented at international conferences devoted to the subject of the thesis.

As a drawback of the thesis I would like to mention that the thesis is written not in a pedagogical way for specialists outside quantum optics. Also, some notations are not introduced. For example, in Sect 2.4.4 the notation $\phi(t)$ as vector valued function is not defined. However, in this case, it is easy to guess

a correct definition. All these remarks do not diminish the scientific importance and value of the obtained results.

In my opinion, Vadym Kovtoniuk's PhD dissertation "**Nonclassicality of Measurement Statistics of Quantum Electromagnetic Radiation**", meets all the requirements established by the Ministry of Education and Science of Ukraine for doctoral dissertations. **I recommend awarding Doctor of Philosophy degree to Vadym Kovtoniuk.**

June 24, 2026

Head of Laboratory of Integrable Systems,
Bogolyubov Institute for Theoretical Physics,
Kyiv, UKRAINE

Mykola IORGOV