# IV SWEDISH—UKRAINIAN SEMINAR
# in THEORETICAL PHYSICS

***September 10, 2024***

**Mixed on-line/off-line regime***

## Program**

10.00–10.05 – Opening

10.05–10.45 – **Ingemar Bengtsson** (Stockholm University, Sweden) **“Two unsolved problems from quantum information theory”**

10.45–11.25 – **Andriy Sotnikov** (Department of Statistical Physics and Quantum Field Theory, Akhiezer Institute for Theoretical Physics, NSC Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine) **“A need for quantum computing for strongly-correlated many-body systems.”**

11.25–11.40 – Coffee break

11.40–12.20 – **Eugene Stolyarov** (Bogolyubov Institute For Theoretical Physics, NAS of Ukraine, Kyiv, Ukraine) **“Photon counting in microwave superconducting circuits”**

12.20–13.00 – **Göran Johansson** (Chalmers University, Sweden) **“Scattering from one and more atoms in waveguide QED”**

*** Join Zoom Meeting**

https://kth-se.zoom.us/j/68315431943

****EE Time, CE Time is one hour earlier**

# Two unsolved problems from quantum information theory

Ingemar Bengtsson

*Stockholm University, Sweden*

Quantum information theory is largely concerned with finite dimensional Hilbert spaces. For various reasons it would be convenient to have a complete set of Mutually Unbiased Bases, or a Symmetric Informationally Complete POVM. Do such objects exist in all dimensions? These two problems are unsolved, but one of them is moving quickly. I will try to explain the status of both problems from scratch.

# A need for quantum computing for strongly-correlated many-body systems

Andriy Sotnikov

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## Photon counting in microwave superconducting circuits

Eugene Stolyarov
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Superconducting circuit quantum electrodynamics (QED) is a versatile and well-developed hardware platform for building scalable quantum information processing devices [1, 2]. It harnesses the nonlinear properties of Josephson junctions to create atom-like systems that interact with microwave photons [3, 4]. Fast and efficient detection of microwave quanta in superconducting circuit QED systems is essential for many applications such as quantum state engineering and qubit readout. One of the promising approaches for detecting microwave photons is using a Josephson photomultiplier (JPM) [5, 6]. This device is essentially a phase qubit acting as a narrowband absorbing single-photon detector. First, I will outline two designs of JPMs and discuss their operating principle. Then, I will discuss the approach to counting photons in a resonator mode via repetitive measurement by the JPM [7]. Finally, I will briefly outline a feasible approach for building a JPM-based detector of photon pairs.

[1] G. Wendin, Quantum information processing with superconducting circuits: A review, Rep. Prog. Phys. **80**, 106001 (2017).
[2] A. Blais, A. L. Grimsmo, S. M. Girvin, and A. Wallraff, Circuit quantum electrodynamics, Rev. Mod. Phys. **93**, 025005 (2021).
[3] G. Wendin and V. S. Shumeiko, Quantum bits with Josephson junctions (review article), Low Temp. Phys. **33**, 724 (2007).
[4] J. Clarke and F. K. Wilhelm, Superconducting quantum bits, Nature (London) **453**, 1031 (2008).
[5] Y.-F. Chen *et al.*, Microwave photon counter based on Josephson junctions, Phys. Rev. Lett. **107**, 217401 (2011).
[6] A. Opremcak *et al.*, Measurement of a superconducting qubit with a microwave photon counter, Science **361**, 1239 (2018).
*[7] E. V. Stolyarov, O. V. Kliushnichenko, V. S. Kovtoniuk, and A. A. Semenov, Photon-number resolution with microwave Josephson photomultipliers, Phys. Rev. A* ***108****, 063710 (2023).*

# TBA

Göran Johansson

*Chalmers University, Sweden*

In this talk, I'll review some earlier results on measuring the field scattered from one and more atoms in a one-dimensional waveguide, i.e. Waveguide QED.

Then I will discuss some new analytical results on the quantum properties of the transmitted field for two and more atoms in the waveguide