Abstract Title

Dynamical Formulation of Antibunching

Symposium Track

Modeling of Structures and Behaviors at the Nanoscale

Authors' names

Kazuya YUASA

Authors' affiliations

Research Center for Information Security, National Institute of Advanced Industrial Science and Technology (AIST), 1-18-13 Sotokanda, Chiyoda-ku, Tokyo 101-0021, Japan

Abstract body

Antibunching is a direct consequence of the antisymmetry of the wave function of a fermionic system: two fermions in the same spin state are not allowed to occupy the same point in space at the same time, and therefore the probability for their being close together is small. This effect has been explored with electrons for several years [1-5] and has been observed with free neutrons recently [6], which provide evidences for Pauli's principle of antisymmetrization of the wave functions. Understanding antibunching (and bunching of bosons) is important not only for the foundations of quantum mechanics but also for the quantum information technology, since the latter requires a better understanding of the coherence properties of the carriers of quantum information, multi-particle quantum systems.

It is worth mentioning that the interference of two particles (second-order correlation) exhibits a different nature from that of the two amplitudes of a single particle (first-order correlation). Actually, the phase relation between the two amplitudes is important for the latter, but that between the two particles does not play an essential role in the former. Common arguments for the latter can fail to explain the former, and some details concerning the former are not completely understood yet, such as how the temperature of the source, the lateral size of the source, and the resolution of the detectors affect the antibunching.

In order to address these points, we discuss the coincidence experiment depicted in Fig. 1 by treating the whole system, including the reservoir of fermions, as a quantized dynamical system. At the initial time, the reservoir is in the thermal equilibrium state at a finite temperature and the outside is vacuum. We let the total system evolve from the initial state dynamically, just wait until the beam of the emitted particles becomes stationary, and observe the two-particle distribution function (second-order correlation), which exhibits antibunching. The temperature of the reservoir is naturally introduced and the characteristics of the emission site (window of the reservoir) and the detectors are duly taken into account. This setup helps us better understand the characteristics of the antibunching and clarify which features control the interference among particles.

Extending this approach, we also discuss the antibunching in the electron field emission [4,7]. Several years ago, field emission of monochromatic electrons from a superconductor was firstly observed [8]. Now it is worth exploring the antibunching of such electrons, since the presence of the Cooper-pair correlation in the source affects the antibunching and can afford us a new resource of entanglement. The present approach allows us to naturally

introduce the superconductivity of the source, since the source itself is treated explicitly. We clarify the possibility of extracting the Cooper-pair correlation through the field emission.

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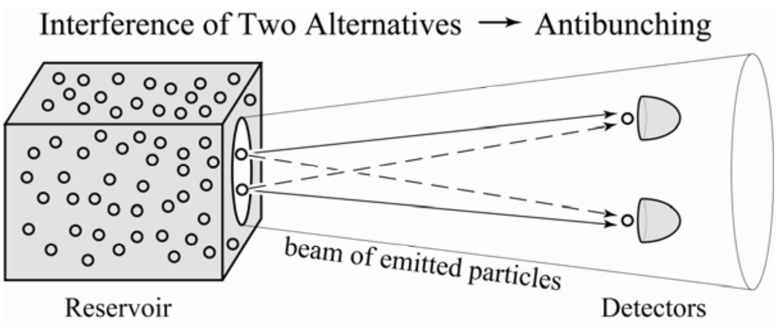

Fig. 1. Coincidence between the two detectors in the beam of the emitted particles.

Keywords

antibunching, multi-particle interference, coherence, field emission, field theory

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Corresponding author contact information

Kazuya YUASA, Research Center for Information Security, National Institute of Advanced Industrial Science and Technology (AIST), 1-18-13 Sotokanda, Chiyoda-ku, Tokyo 101-0021, Japan, Email: kazuya.yuasa@aist.go.jp