INTEGRATED QUANTUM SCIENCE AND TECHNOLOGY

University of Stuttgart Germany — ulm university universität uulm — Max Planck Institute for Solid State Research

Second-order correlation function for LED light | 4AGS	Start date: 01.01.2017
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Abstract: An important advantage of a quantum random number generator (QRNG), compared to its classical counterparts, is that quantum mechanics ensures that the generated random numbers are, even in principle, not predictable. However, since QRNG devices are never completely perfect, there is always a classical noise contribution, which in principle allows one to retrieve at least partial information about the generated numbers. Hence, a crucial problem is to quantify how much of the data really originates from the underlying quantum mechanical process. Knowing this quantity, randomness extractors can be used to create true random numbers from the raw numbers. There are already different approaches of how to solve this problem. However, not all of these can be applied to certain designs of QRNGs or have drawbacks regarding their efficiency. One aspect of this work is therefore, to investigate this problem more deeply, and also to take considerations towards special designs of QRNGs. A possible design of a QRNG involves an LED which, possibly in combination with an absorptive filter, produces a very weak light pulse, and two single photon detectors. The parameters of the experiment are chosen such that there is a considerable probability that exactly one detector clicks. This arrangement and the selection of the components ensure that in about 50% of these events, one detector clicks, while in the other ~ 50%, the other one clicks. In this way we generate one random bit. The probability that both detectors located at the positions r_1 and r_2 click at the same time t is related to the second-order correlation function $g^{(2)}(r_1, t_1; r_2, t_2)$ of light for $t=t_1=t_2$. In the case where the second-order correlation function is considerably smaller than one (anti-bunching), the requirement to the parameters of the experiment are fulfilled. The central problem is therefore, to evaluate the full second-order correlation function for LED light. Since this requires the knowledge of the quantum state of the radiation field, a model for the generation of light in such a device has to be developed. Fortunately, such models already exist. In particular, Weng W. Chow (Sandia National Laboratories) has put forward an approach (*Optics Express Vol. **19**, Issue 22, pp. 21818-21831 (2011)*) based on the Heisenberg picture. Applying their model, W.W. Chow et al. (*Light-Sci. Appl. **3** (2014)*) have already found, for the special case of both detectors placed at the same position and clicking at the same time of a Hanbury Brown-Twiss arrangement, a small domain for the injection current where $g^{(2)}(0)$ is smaller than one. However, for the design of a QRNG more detailed studies are necessary. Indeed, a complete model also incorporating the absorptive filter as well as geometric effects such as the arrangement of the detectors relative to the LED has to be addressed.

Recent results:

Recently, the model of an LED by W.W. Chow has been reviewed and used to obtain the relevant equations of motions in the Heisenberg picture. From these, the calculation of the second-order correlation function can be done in a perturbative way. So far, preliminary results up to second-order in perturbation theory have been obtained, while higher-order effects as well as other effects not included in model still need to be considered.
The three partners (WPS, TS and JS) meet on a regular basis to discuss the recent and relevant problems and results.

Publications:

Stochastic model for the QRNG, T. Strohm, (Internal Report, Robert Bosch GmbH, Stuttgart, 2016)