Towards Measurement and Control of Single-Photon Microwave Radiation on Chip

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Real-time detection and generation of single microwave photons would be important in many quantum technology applications. For single-microwave-photon sources, much of the groundwork has been done already within the framework of circuit quantum electrodynamics (cQED) in the frequency range 4 GHz – 8 GHz. However, currently there are no detectors that can reliably resolve single microwave photon events, unlike at optical frequencies. In June 2013, we started a joint research project to develop both microwave detectors and sources working at the single-photon level as a final goal. All devices operate at cryogenic temperatures, most of them below 100 mK. We also aim at improving the performance of other cryoelectronic quantum devices by understanding and eliminating the detrimental effects caused by microwave radiation. The work is done in project MICROPHOTON of the European Metrology Research Programme (EMRP). The goals and status of the project will be described in the presentation.

Photon detectors for frequencies from below 10 GHz up to about 300 GHz are developed especially for microwaves travelling in waveguides. Two variations of superconductor-based Josephson bifurcation amplifier (JBA) have been designed to detect photons at frequencies below 20 GHz. To cover frequencies between about 10 GHz and 80 GHz, thermal detection based on a superconducting coplanar transmission line terminated by a normal-metal resistor is studied. For higher-frequency microwave photons up to about 300 GHz, techniques based on single-electron effects in cryoelectronic nanodevices are investigated.

On-demand single photon sources based on a superconducting quantum bit (qubit) are developed for frequencies up to about 18 GHz. Possibilities of on-demand single-photon generation up to 50 GHz by a so-called Cooper pair box are studied, too. For characterization of detectors up to 300 GHz, continuous radiation microwave sources based on aluminum and niobium Josephson junctions and on thermal black-body radiation are developed. Effects of background microwave radiation on operation of quantum nanodevices in cryogenic environments are studied using a special sample chamber in which the level of microwave filtering and shielding can be varied.