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Single Photon Counter at 14 and 26 GHz for searching Galactic Axions within the QUAX and ORGAN projects

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Axions appear in extensions of the Standard Model of particle physics and may be the solution of the Dark Matter in our Universe. Several new experiments are foreseen in the next decade searching them in a wide range of the parameter space. In the mass region from few to several tens of microelectronvolt, detector sensitivity will be limited by the Standard Quantum Limit of linear amplifiers and a new class of single microwave-photon detectors is needed.
We have developed a single photon counter (SPC) at 14 GHz, based on the voltage switching of a Josephson junction coupled to a coplanar waveguide for QUAX project. By measuring the switching voltage, we can register single photons at 14 GHz with the rate less than 1 photon per 3000 sec.
We fabricated Al-AlOx-Al Josephson junctions for single photon detecting. Switching rate was measured at different temperatures and for different positions of bias current relatively to critical current. First measurements have shown an optimistic situation with a lifetime over 1000 sec at 100mK, limited by external interferences. After using additional filters, we were able to increase the time of false triggering of the detector prototype on Al SIS to 5000-6000 sec.
We have made RF tests by measuring switching probability in dependence on attenuation of the signal for different values of a bias current relatively to the critical current. These curves show that the detection probability decreases with the decrease of the power with different exponent rates proportional to one, two and three. This behavior demonstrate the single-photon, two-photon and three-photon detection mechanisms.
We are starting development of SPC based on Al-Al Josephson junction for 26 GHz receiving system of the ORGAN project.
In general, we can develop SPC based on Al-Al Josephson junction for the range of frequencies from 3 to 50 GHz.

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[1] L.Kuzmin, A.Sobolev, C.Gatti, D.Gioacchino, N.Crescini, A.Gordeeva, E.Il'ichev, Single Photon Counter based on a Josephson Junction at 14 GHz for searching Galactic Axions, IEEE TAS, Vol.8, pp.1-5(2018).

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