SIS junction as single microwave photon counter for axion search

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Principle of operation

SIS tunnel junction is a type of Josephson junction with low damping, having hysteretic current-voltage characteristic. It is used as threshold detector – the single photon counter.
Laboratory of Superconducting Nanoelectronics
Sample photos
Lifetime (dark count time) for large SIS junctions

\[ \gamma = \frac{I_T}{I_C} \quad I_T [\mu\text{A}] = 0.042T [\text{K}] \]

\[ \tau = \frac{f(\alpha) \exp(\Delta u / \gamma)}{\sqrt{1 - i^2}} \]

Graph showing the relationship between current, voltage, and lifetime for different temperatures (50mK, 100mK, 200mK, 300mK, 600mK).
Small SIS junctions, 10$^{\text{th}}$ nA critical current

For small junctions critical current is suppressed due to MQT

Resonant response drives sensitivity of Josephson Escape Detector
Does Kramers’ formula $\tau \sim \exp(\Delta u/\gamma)$ still work??

Lifetime can be increased by orders of magnitude due to the phase diffusion regime

Kramers’ formula $\tau \sim \exp(\Delta u/\gamma_{\text{eff}})$, but $\gamma_{\text{eff}} \ll \gamma$

Lifetime can be increased by orders of magnitude due to the phase diffusion regime
Calibration of signal power by PAT steps

Problem: absence of microwave single photon sources on-demand
Supplying strongly attenuated harmonic signal

(testing, 11-Nov-2018)
Counting photons by large statistics in IR range

Detection of 140 THz photons at 4 K

$N$-photon response to 9 GHz signal at 50 mK

Supplying strongly attenuated harmonic signal giving Poisson distribution of photons

Lifetime (dark count time) with and without cavity
Lifetime (dark count time) with and without cavity

SPC without Cavity

Efficiency = 0.08

Theory for 50 mK

14 GHz

9 mK
50 mK
100 mK
20 mK SIS44_1
50 mK SIS44_1
100 mK SIS44_1
Thank you for attention!

Please, send your questions to: alp@ipmras.ru

Here ALP stands for Andrey L. Pankratov