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Curriculum Vitae

Jelmer Renema was born on the 4th of July 1986 in Hoogeveen. He graduated from Groene Hart Lyceum secondary school in 2003 with a specialization in science and technology and went on to study physics at Leiden University. Jelmer obtained a BSc from that university; the final project was *Surface plasmon spectroscopy*. He then went on to do an MSc at Leiden University, with two projects: *Two-photon interference on Young's double slit* and *Magnetometry and entanglement with room-temperature caesium atoms*. After a year at the Niels Bohr Institute working on cold atomic ensembles he returned to Leiden to work on superconducting single-photon detectors in the group of Dirk Bouwmeester.

List of Publications

1. W.H. Peeters, J.J. Renema, M.P. van Exter *Engineering of two-photon spatial quantum correlations behind a double slit* Phys. Rev. A **79** (4), 043817 (2009)
2. W. Wasilewski, K. Jensen, H. Krauter, J.J. Renema, M.V. Balabas, E.S. Polzik *Quantum noise limited and entanglement-assisted magnetometry* Phys. Rev. Lett. **104** (13), 133601 (2010)
3. A. Louchet-Chauvet, J. Appel, J.J. Renema, D. Oblak, N. Kjaergaard, E.S. Polzik *Entanglement-assisted atomic clock beyond the projection noise limit* New J. Phys. **12** (6), 065032 (2010)
4. J.J. Renema, G. Frucci, Z. Zhou, F. Mattioli, A. Gaggero, R. Leoni, M.J.A. de Dood, A. Fiore, M.P. van Exter *Modified detector tomography technique applied to a superconducting multiphoton nanodetector* Opt. Exp. **20** (3), 2806-2813 (2012) (Chapter 2 of this thesis)
5. A.J.H. van der Torren, S.C. Yorulmaz, J.J. Renema, M.P. van Exter, M.J.A. de Dood *Spatially entangled four-photon states from a periodically poled potassium-titanyl-phosphate crystal* Phys. Rev. A **85** (4), 043837 (2012)
6. J.J. Renema, G. Frucci, M.J.A. de Dood, R. Gill, A. Fiore, M.P. van Exter *Tomography and state reconstruction with superconducting single-photon detectors* Phys. Rev. A **86** (6), 062113 (2013)
7. J.J. Renema, G. Frucci, Z. Zhou, F. Mattioli, A. Gaggero, R. Leoni, M.J.A. de Dood, A. Fiore, M.P. van Exter *Universal response curve for nanowire superconducting single-photon detectors* Phys. Rev. B **87** (17), 174526 (2013) (Chapter 3 of this thesis)
8. J.J. Renema, R. Gaudio, Q. Wang, Z. Zhou, A. Gaggero, F. Mattioli, R. Leoni, D. Sahin, M.J.A. de Dood, A. Fiore, M.P. van Exter *Experimental Test of Theories of the Detection Mechanism in a Nanowire Superconducting Single-Photon Detector* Phys. Rev. Lett. **112** (11), 117604 (2014) (Chapter 4 of this thesis)

9. J.J. Renema, R.J. Rengelink, I. Komen, Q. Wang, R. Gaudio, K.P.M. op 't Hoog, Z. Zhou, D. Sahin, A. Fiore, P. Kes, J. Aarts, M.P. van Exter, M.J.A. de Dood, and E.F.C. Driessen, *The Magnetic Field Response of Nanowire Superconducting Single-Photon Detectors* Submitted to Applied Physics Letters (Chapter 6 of this thesis)

List of Symbols and Material Parameters

Symbol	Name	Value/expression	Reference
$A(x)$	Local absorption probability	-	-
B	Magnetic field	-	-
B_0	Field scale	350 mT	-
B_Γ	Usadel field scale	$\sqrt{6}\hbar/ew\xi = 2.7$ T	^a
χ^2	Goodness of fit	$\chi^2 = \sum_i \frac{(y_{i,exp} - y_{i,fit})^2}{\sigma_i^2}$	-
c	Speed of light	$3.00 * 10^8$ m/s	-
C	Photon count rate	-	-
C_e	Hot electron density	-	-
C_{qp}	Quasiparticle density	-	-
c_i	Expansion coefficient	$c_i = e^{-N} \frac{N^i}{i!}$	^b
d	Thickness	4.9 nm	-
D	Diffusion constant	0.4 cm ² /s	-
Δ	Superconducting gap	1.9 meV @ 1.5 K	-
ε_0	Vortex entry energy	$\Phi^2/2\pi\mu_0\Lambda_\perp = 67.6$ meV	[25]
ϵ	Dielectric constant	-	-
E	Excitation energy	-	-
Φ_0	Elementary flux quantum	$h/2e = 2.067$ fWb	-
γ	Energy-current interchange	2.9 μ A/eV	^a
$\gamma'(x)$	Local value of γ	-	-
Γ	Intrinsic pair breaker	≈ 100 μ eV	-
η	Linear optical efficiency	-	-
h	Planck's constant	4.14 feV s	-

^aFor a 150 nm wide detector

^bFor coherent states

Symbol	Name	Value/expression	Reference
I_b	Bias current	-	-
I_c	Critical current	28 μA	^a
I_0	Reference current	$I_0 \approx 0.8I_c$	^b
I_{th}	Threshold current	$I_{th} = I_c - \gamma E$	-
I_Γ	Usadel current scale	$\sqrt{2\Delta}/eR(\xi) = 180 \mu\text{A}$	^a
j	Current density	-	-
j_c	Critical current density	40 GA/m^2	-
j^*	Rolloff current density	0.9 GA/m^2	-
k_b	Boltzman constant	$8.6 * 10^{-5} \text{eV}/\text{K}$	-
λ	Penetration length	430 nm, 500 nm	[28, 21]
λ	Optical wavelength	-	-
λ_c	Cutoff wavelength	-	-
Λ_\perp	Effective penetration length	50 μm	-
L	Wire length	-	-
l_{taper}	Taper effective length	74 nm	-
μ_0	Magnetic permeability of vacuum	$4\pi * 10^{-7} \text{N}/\text{A}^2$	-
n_{max}	Model selection cutoff	-	-
n_{se}	Density of supercond. electrons	-	-
N_0	Density of states	51 nm^3/eV	[28]
N	Mean photon number	-	-
ν_h	Reduced vortex entry energy	3-8, 40-110	[25, 26] ^c
ν	Vortex entry energy	$\varepsilon_0/k_bT = 250$	[25]
ν	Photon energy	-	-
p_n	Internal detection probability	-	-
$P(x)$	Local detection probability	-	-
ς	QP conversion efficiency	0.25	[28]
R	Detection probability per pulse	-	-
R_\square	Sheet resistance	600 Ω	-
s	Hotspot size	22 nm	-
t	Reduced temperature	T/T_c	-
T	Temperature	-	-
T_c	Critical temperature	9.5 K	-
τ	Timescale for QP multiplication	1.6 ps	[28]
v_s	Supercond. velocity	-	-
v_c	Critical velocity	-	-
V	Visibility	-	-
w	Wire width	-	-
ξ	Coherence length	3.9 nm	-

^aFor a 150 nm wide detector^bFor low threshold values^cFor photon counts and dark counts, respectively

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