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Universiteit Leiden



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Title: Magnetic Resonance Force Microscopy and the spin bath : towards single-spin massive-resonator entanglement and the spoiling influence of the spin bath

Issue Date: 2018-02-20

Stellingen

Behorend bij het proefschrift

*“Magnetic Resonance Force Microscopy and the Spin Bath;
towards single-spin massive-resonator entanglement
and the spoiling influence of the spin bath”*

1. When doing Magnetic Resonance Force Microscopy (MRFM) using the magnet-on-cantilever geometry, it is useless to maximize a commercial cantilever's quality factor, unless the surface of the sample is made sufficiently free of electron spins just before cooling down the experiment.
Chapters 2-4 of this thesis.
2. It is becoming feasible to study the existence of gravitational-induced collapse of the wave function by using a setup where an MRFM-tip interacts with a single Nitrogen-Vacancy center (NV) in diamond.
Chapters 4-5 of this thesis.
3. Now that bonding wires of lead alloys are difficult to obtain, using annealed Nb wire is a possible alternative for creating wire bonds that are superconducting at 4K.
Chapter 6 of this thesis.
4. It is possible to continuously apply milliamps of RF-currents through a micrometer-wide line on the sample, while keeping the RF-line superconducting, the temperature of the sample below 100mK, and a SQUID magnetometer, which is next to the RF-line, stable.
Chapters 4 and 6 of this thesis.
5. The dissipation of resonators as function of temperature has been incorrectly fitted by power laws or hyperbolic tangents.
*M. Imboden and P. Mohanty, “Evidence of universality in the dynamical response of micromechanical diamond resonators at millikelvin temperatures”, Physical Review B, **79**, 125424, (2009).*
*A. Venkatesan, et al., “Dissipation due to tunneling two-level systems in gold nanomechanical resonators”, Physical Review B, **81**, 073410, (2010).*
*A. Bruno, et al., “Reducing intrinsic loss in superconducting resonators by surface treatment and deep etching of silicon substrates” Applied Physics Letters, **106**, 182601, (2015).*

6. The low dissipation of recently developed ladder-shaped cantilevers is only useful for MRFM with micron-sized spherical magnets, if the surface of the sample is completely free of two-level fluctuators.
M. H eritier, et al., "Nanoladder cantilevers made from diamond and silicon", arXiv:1711.11358, (2017).
7. Equipping measurement setups with 'clean grounds' is a form of technological quackery.
8. For most SPM applications that utilize conductive tips, the complicated dihedral approximation for the calculation of the tip-sample capacitance used by Hudlet et al. will not yield better results than the simple ball-and-plane model of Kleinknecht et al.
S. Hudlet, et al., "Evaluation of the capacitive force between an atomic force microscopy tip and a metallic surface", The European Physical Journal B - Condensed Matter and Complex Systems, 2, 5–10, (1998).
H. P. Kleinknecht, et al., "An experimental scanning capacitance Scanning Microscopy", 2, 1839–1844, (1988).
9. Expressing the unit of magnetic field gradient in MT/m is misleading and confusing and T/ μm or mT/nm should be used instead.
10. The simplest way to make yourself an infamous physicist is to openly worry about the measurement problem before you are famous.

Marc de Voogd
Leiden, 20 februari 2018