

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Spin Dynamics — Quasiclassical Description</b>	<b>5</b>
<b>3</b>	<b>Spin Dynamics — Quantum Description</b>	<b>15</b>
<b>4</b>	<b>Mechanical Vibrations of the Cantilever</b>	<b>25</b>
<b>5</b>	<b>Single-Spin Detection in Magnetic Force Microscopy (MFM)</b>	<b>33</b>
5.1	Static displacement of the cantilever tip (CT) . . . . .	33
5.2	Decoherence time . . . . .	38
<b>6</b>	<b>Transient Process in MFM — The Exact Solution of the Master Equation</b>	<b>41</b>
6.1	Hamiltonian and master equation for the spin-CT system . . .	41
6.2	Solution for spin diagonal matrix elements . . . . .	47
6.3	Solution for spin off-diagonal matrix elements . . . . .	54
<b>7</b>	<b>Periodic Spin Reversals in Magnetic Resonance Force Microscopy (MRFM) Driven by <math>\pi</math>-Pulses</b>	<b>59</b>
<b>8</b>	<b>Oscillating Adiabatic Spin Reversals Driven by the Frequency Modulated <math>rf</math> Field</b>	<b>65</b>
8.1	Schrödinger dynamics of the CT-spin system . . . . .	66
8.2	Decoherence and thermal diffusion for the CT . . . . .	79

<b>9 Oscillating Cantilever-Driven Adiabatic Reversals (OSCAR) Technique in MRFM</b>	<b>85</b>
9.1 CT-spin dynamics: discussion and estimates . . . . .	87
9.2 Experimental detection of a single spin . . . . .	94
<b>10 CT-Spin Dynamics in the OSCAR Technique</b>	<b>97</b>
10.1 Quasiclassical theory: simple geometry . . . . .	97
10.2 Quantum theory of the OSCAR MRFM . . . . .	106
10.3 OSCAR frequency shift for a realistic setup . . . . .	114
<b>11 Magnetic Noise and Spin Relaxation in OSCAR MRFM</b>	<b>127</b>
11.1 OSCAR relaxation in a spin ensemble . . . . .	128
11.2 Reduction of magnetic noise . . . . .	145
11.3 Simple model for quantum jumps . . . . .	153
11.4 Reduction of the frequency shift due to the CT-spin entanglement . . . . .	158
<b>12 MRFM Applications: Measurement of an Entangled State and Quantum Computation</b>	<b>163</b>
12.1 MRFM measurement of an entangled spin state . . . . .	163
12.2 MRFM based spin quantum computer . . . . .	169
<b>13 MRFM Techniques and Spin Diffusion</b>	<b>183</b>
13.1 Spin diffusion in the presence of a nonuniform magnetic field .	184
13.2 Suppression of the spin diffusion in a spin quantum computer	193
<b>14 Conclusion</b>	<b>207</b>
14.1 Abbreviations . . . . .	209
14.2 Prefixes . . . . .	210
14.3 Notations . . . . .	211
Bibliography . . . . .	217
Index . . . . .	223