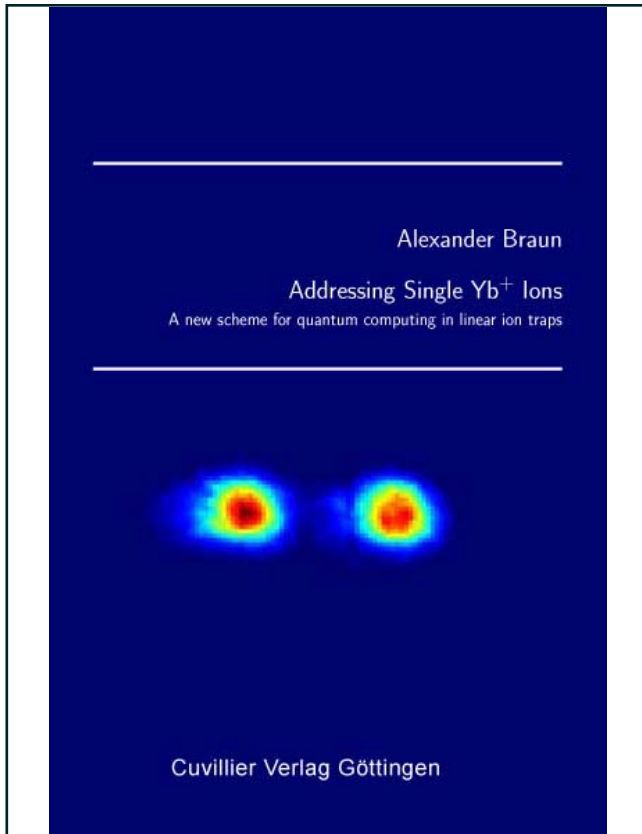




Alexander Braun (Autor)

Addressing Single Yb⁺ Ions

A new scheme for quantum computing in linear ion traps



<https://cuvillier.de/de/shop/publications/1765>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen,
Germany

Telefon: +49 (0)551 54724-0, E-Mail: info@cuvillier.de, Website: <https://cuvillier.de>

Contents

1	Introduction	1
1.1	A brief history of Quantum Computing	1
1.2	Ion trap quantum computing	4
1.3	Magnetic field gradient proposal	6
2	Interaction of ions with em-fields	11
2.1	Interaction with the RF trapping potential	12
2.1.1	Potential and stability diagram	12
2.1.2	Secular and micro-motion	15
2.1.3	Ion crystals	17
2.2	Interaction with laser light	19
2.2.1	Laser cooling	19
2.2.2	Optical pumping	25
2.3	RF radiation: incoherent measurements and coherent interaction	28
2.3.1	Possible qubits	28
2.3.2	Four-level dynamics: Bloch equations	32
2.3.3	Incoherent spectra: Lorentz profiles	35
2.4	Interaction with the magnetic gradient field	38
2.4.1	Ion addressing	38
2.4.2	Coupling internal and external dynamics	41
3	Trapping single Yb⁺ ions	47
3.1	The linear trap	48
3.1.1	Design	48
3.1.2	Ovens	50
3.1.3	Trap drives	53
3.1.4	Secular frequencies	56
3.1.5	Micro-motion	60
3.2	Lasers and optics	63
3.2.1	Diode lasers	63

3.2.2	Laser system at 369 nm	66
3.2.3	Intensity level control and light field switching	67
3.2.4	Laser optics	69
3.3	Detection systems	71
3.3.1	Photo-multiplier	71
3.3.2	Intensified CCD-camera	73
3.4	Static and dynamic magnetic fields	78
3.4.1	Static magnetic field coils	78
3.4.2	RF-excitation coil	81
3.5	Experiment control	83
4	Photo-Ionization	87
4.1	Ionization processes	89
4.2	Atomic excitation spectra	92
4.3	Deterministic number loading of ions	99
5	Addressing single Yb⁺ ions	101
5.1	RF-optical double-resonance spectroscopy of a Yb ⁺ ion	102
5.1.1	Line-width	103
5.1.2	Amplitude	108
5.2	Static magnetic fields	109
5.3	Dynamic magnetic fields	116
5.3.1	Simulation	120
5.3.2	Rabi oscillations	122
5.4	Magnetic gradient field	131
5.4.1	Simulation	131
5.4.2	Gradient alignment	133
5.4.3	Ion addressing	135
6	Conclusion	147
A	Solution of the four level Bloch-equations	153
B	Fluorescence rate: a simple rate equation model	157
C	Ytterbium	161
	Bibliography	165
	Danksagung	175