

Prof. Rainer Blatt

Realizowane kluczowe projekty:

- 2006-2009 ARO (US) project: *Scalable quantum information processing with trapped $^{43}\text{Ca}^+$ ions*,
- 2006-2009 EU STREP project MICROTRAP: *Development of pan-European technology*,
- 2005-2009 EU IP project SCALA: *Scalable quantum computing with light and atoms*,
- 2006-2009 EU NoE QUROPE: QIPC NoE,
- 2003-2007 ARO (US) project: *Quantum information processing with trapped $^{43}\text{Ca}^+$ ions*,
- 2005-2006 Accion Integrada: *Quantum feedback with single ions*,
- 2005-2007 EU ERA-pilot QIST: *Structuring European Research Area within QI Science*,
- 2004-2007 EU network CONQUEST: *Controlled Coherence and Entanglement in sets*,
- 2003-2005 EU network QGATES: *Quantum gates and elementary scalable processors*,
- 2000-2004 EU network QUEST: *Quantum entangled states of trapped particles*,
- 2000-2002 EU network QUBITS: *Quantum based information processing*,
- since 2000 funding through Institut für Quanteninformation G.m.b.H., Tirol, Austria,
- 1999-2003 EU network QIPC NoE: *Quantum information processing and communications NoE*,
- 1996-2000 EU TMR network QI: *The physics of quantum information*,
- Funded projects:
 - *Strings of Calcium ions – a tool for quantum information* (1999-2005)
 - *Cavity QED with single trapped ions* (1999-2008)
 - *Quantum optics with few ultra-cold atoms in a tightly confining trap* (1999-2005)
 - *Strings of Calcium ions* (2005-2008)
 - *Single-atom single-photon interaction* (2005-2008)
- since 1999 continuous funding within FWF SFB project F15:
Control and measurement of coherent quantum systems
- 1996-1999 FWF project: *Quantum Optics with ultra-cold (Rb) atoms*
- 1995-1998 FWF project: *Quantum information processing with trapped Ca^+ ions*
- 1996-1998 FWF project: *Quantum optics with a single trapped (Ba^+) ion*
- 1994-1995 DFG project: *Quantum information processing with trapped Ca^+ ions*
- 1994-1995 DFG project: *Quantum optics with trapped Ba^+ ions*
- 1989-1994 DFG project: $^{171}\text{Yb}^+$ ion for frequency standards,
- 1989-1994 DFG Heisenberg fellowship
- 1982-1983 DFG research fellowship

Funkcja promotora prac doktorskich:

- **Felicity Splatt** - *Development and operation of miniaturised segmented ion traps for scalable quantum computation* (2009)
- **Michael Chwalla** - *Precision spectroscopy with $^{40}\text{Ca}^+$ ions in a Paul trap* (2009)
- **Carlos Russo** - *Photon statistics of a single ion coupled to a high-finesse cavity* (2008)
- **Jan Benhelm** - *Precision spectroscopy and quantum information processing with trapped calcium ions* (2008)

- **Daniel Rotter** - *Quantum feedback and quantum correlation measurements with a single Barium ion* (2008)
- **Herbert Crepaz** - *Trapping and cooling rubidium atoms for quantum information processing* (2007)
- **Mark Riebe** - *Preparation of entangled states and quantum teleportation with atomic qubits* (2005)
- **Axel Kreuter** - *Spontaneous emission of a single trapped Ca^+ ion* (2004)
- **Pavel Bushev** - *Interference experiments with a single barium ion: from QED towards quantum feedback* (2004)
- **Andreas Mundt** - *Cavity QED with single trapped $^{40}\text{Ca}^+$ -ions* (2003)
- **Stephan Gulde** - *Experimental realization of quantum gates and the Deutsch-Jozsa algorithm with trapped $^{40}\text{Ca}^+$ -ions* (2003)
- **Matthias Schulz** - *Tightly confined atoms in optical dipole traps* (2002)
- **Christoph Raab** - *Interference experiments with the fluorescence light of Ba^+ ions* (2001)
- **Harald Rohde** - *Experimente zur Quanteninformationsverarbeitung in einer linearen Ionenfalle* (2001)
- **Christian Roos** - *Controlling the quantum state of trapped ions* (2000)
- **Hanns-Christoph Nägerl** - *Ion Strings for Quantum Computing* (1998)

Wybrane kluczowe artykuły z dziedziny informatyki kwantowej i prac nad kwantowym procesorem:

1. G. Kirchmair, F. Zähringer, R. Gerritsma, M. Kleinmann, O. Gühne, A. Cabello, **R. Blatt**, C. F. Roos,
State-independent experimental test of quantum contextuality,
Nature 460, 494 (2009)
2. G. Kirchmair, J. Benhelm, F. Zähringer, R. Gerritsma, C. F. Roos, **R. Blatt**,
High-fidelity entanglement of ions of $^{43}\text{Ca}^+$ hyperfine clock states,
Phys. Rev. A 79, 020304 (2009)
3. G. Kirchmair, J. Benhelm, F. Zähringer, R. Gerritsma, C. F. Roos, **R. Blatt**,
Deterministic entanglement of ions in thermal states of motion,
New J. Phys. 11, 023002 (2009)
4. T. Monz, K. Kim, W. Hänsel, M. Riebe, A. S. Villar, P. Schindler, M. Chwalla, M. Hennrich,
R. Blatt,
Realization of the quantum Toffoli gate with trapped ions,
Phys. Rev. Lett. 102, 040501 (2009)
5. J. Benhelm, G. Kirchmair, C. F. Roos, **R. Blatt**,
Experimental quantum information processing with $^{43}\text{Ca}^+$ ions,
Phys. Rev. A 77, 062306 (2008)
6. J. Benhelm, G. Kirchmair, C. F. Roos, **R. Blatt**,
Towards fault-tolerant quantum computing with trapped ions,
Nature Physics 4, 463 (2008)
7. **R. Blatt**, D. J. Wineland,
Entangled states of trapped atomic ions,
Nature 453, 1008 (2008)

8. H. Häffner, C. F. Roos, **R. Blatt**,
Quantum computing with trapped ions,
Physics Reports 469, 155-203 (2008)
9. K. Kim, C. F. Roos, L. Aolita, H. Häffner, V. Nebendahl, **R. Blatt**,
Geometric phase gate on an optical transition for ion trap quantum computation,
Phys. Rev. A 77, 050303(R) (2008)
10. M. Riebe, T. Monz, A. S. Villar, P. Schindler, M. Chwalla, M. Hennrich, **R. Blatt**,
Deterministic entanglement swapping with an ion trap quantum computer,
Nature Physics 4, 839 (2008)
11. M. Riebe, M. Chwalla, J. Benhelm, H. Häffner, W. Hänsel, C. F. Roos, **R. Blatt**,
Quantum teleportation with atoms: quantum process tomography,
New J. Phys. 9, 211 (2007)
12. M. Riebe, K. Kim, P. Schindler, T. Monz, P. O. Schmidt, T. Körber, W. Hänsel, H. Häffner,
C. F. Roos, **R. Blatt**,
Process tomography of ion trap quantum gates,
Phys. Rev. Lett. 97, 220407 (2006)
13. P. Zoller, T. Beth, D. Binosi, **R. Blatt**, H. J. Briegel, D. Bruss, T. Calarco, J. I. Cirac, D. Deutsch, J. Eisert, A. Ekert, C. Fabre, N. Gisin, P. Grangiere, M. Grassl, S. Haroche, A. Imamoglu, A. Karlson, J. Kempe, L. Louwenhofen, S. Kröll, G. Leuchs, M. Lewenstein, D. Loss, N. Lütkenhaus, S. Massar, J.E. Mooij, M. B. Plenio, E. S. Polzik, S. Popescu, G. Rempe, A. Sergienko, D. Suter, J. Twamley, G. Wendin, R. Werner, A. Winter, J. Wrachtrup, A. Zeilinger,
Quantum information processing and communication,
Eur. Phys. J. D 36/2, 203 (2005)
14. **R. Blatt**,
Ionen in Reih und Glied,
Physik Journal 4, Nr. 11, 37 (2005)
15. H. Häffner, W. Hänsel, C. F. Roos, J. Benhelm, D. Chek-al-kar, M. Chwalla, T. Körber, U. D. Rapol, M. Riebe, P. O. Schmidt, C. Becher, O. Gühne, W. Dür, **R. Blatt**,
Scalable multi-particle entanglement of trapped ions,
Nature 438, 643 (2005)
16. **R. Blatt**, H. Häffner, C. F. Roos, C. Becher, F. Schmidt-Kaler,
Ion Trap Quantum Computing with Ca⁺ Ions,
Quant. Inf. Proc. 3, 1 (2004)
17. S. Gulde, M. Riebe, G.P.T. Lancaster, C. Becher, J. Eschner, H. Häffner, F. Schmidt-Kaler,
R. Blatt,
Quantized AC-Stark shifts and their use for multiparticle entanglement and quantum gates,
Europhys. Lett. 65, 587 (2004)
18. C. F. Roos, G. Lancaster, M. Riebe, H. Häffner, W. Hänsel, S. Gulde, C. Becher, J. Eschner, F. Schmidt-Kaler, **R. Blatt**,
Bell States of Atoms with Ultralong Lifetimes and Their Tomographic State Analysis,
Phys. Rev. Lett. 92, 220402 (2004)
19. **Blatt**,
Deterministic quantum teleportation with atoms,
Nature 429, 734 (2004)
20. S. Gulde, H. Häffner, M. Riebe, G. P.T. Lancaster, C. Becher, J. Eschner, F. Schmidt-Kaler, I. L. Chuang, **R. Blatt**,
Quantum information Processing with Trapped Ca⁺ ions,
Phil. Trans. R. Soc. Lond. A 361, 1-12 (2003)

21. S. Gulde, M. Riebe, G. Lancaster, C. Becher, J. Eschner, H. Häffner, F. Schmidt-Kaler, I. L. Chuang, **R. Blatt**,
Implementing the Deutsch-Jozsa algorithm on an ion-trap quantum computer,
Nature 421, 48 (2003)
22. F. Schmidt-Kaler, H. Häffner, S. Gulde, M. Riebe, G.P.T. Lancaster, T. Deuschle, C. Becher,
W. Hänsel, J. Eschner, C. F. Roos, **R. Blatt**,
How to realize a universal quantum gate with trapped ions,
Appl. Phys. B: Lasers and Optics 77, 789 (2003)
23. F. Schmidt-Kaler, H. Häffner, M. Riebe, S. Gulde, G. Lancaster, T. Deuschle, C. Becher,
C. F. Roos, J. Eschner, **R. Blatt**,
Realization of the Cirac-Zoller controlled-NOT quantum gate,
Nature 422, 408 (2003)
24. A. B. Mundt, A. Kreuter, C. Becher, D. Leibfried, J. Eschner, F. Schmidt-Kaler, **R. Blatt**,
Coupling a single atomic quantum bit to a high finesse optical cavity,
Phys. Rev. Lett. 89, 103001 (2002)
25. **R. Blatt**,
Delicate information,
Nature 412, 773 (2001)
26. **R. Blatt**,
Push-button entanglement,
Nature 404, 231 (2000)
27. H.-C. Nägerl, C. F. Roos, D. Leibfried, H. Rohde, G. Thalhammer, J. Eschner, F. Schmidt-Kaler,
R. Blatt,
Investigating a qubit candidate: Spectroscopy on the $S_{1/2}$ to $D_{5/2}$ transition of a trapped calcium ion in a linear Paul trap,
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28. A. Steane, C. F. Roos, D. Stevens, A. B. Mundt, D. Leibfried, F. Schmidt-Kaler, **R. Blatt**,
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29. H.-C. Nägerl, W. Bechter, J. Eschner, F. Schmidt-Kaler, **R. Blatt**,
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30. **R. Blatt**,
Quantum tricks in ion traps,
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Wybrane kluczowe artykuły z dziedziny inżynierii stanów kwantowych uwięzionych jonów:

31. H. G. Barros, A. Stute, T. E. Northup, C. Russo, P. O. Schmidt, **R. Blatt**,
Deterministic single-photon source from a single ion,
New J. Phys. 11, 103004 (2009)
32. S. Gerber, D. Rotter, L. Slodicka, J. Eschner, H. J. Carmichael, and **R. Blatt**,
Intensity-Field Correlation of Single-Atom Resonance Fluorescence
Phys. Rev. Lett. 102, 183601 (2009).
33. C. F. Roos, T. Monz, K. Kim, M. Riebe, H. Häffner, D. F.V. James, **R. Blatt**,
Nonlinear coupling of continuous variables at the single quantum level,
Phys. Rev. A 77, 040302(R) (2008)

34. F. Dubin, D. Rotter, M. Mukherjee, S. Gerber, **R. Blatt**,
Single-ion two-photon source,
Phys. Rev. Lett. 99, 183001 (2007)
35. F. Dubin, D. Rotter, M. Mukherjee, C. Russo, J. Eschner, **R. Blatt**,
Photon Correlation versus Interference of Single-Atom Fluorescence in a Half-Cavity,
Phys. Rev. Lett. 98, 183003 (2007)
36. P. Bushev, D. Rotter, A. Wilson, F. Dubin, C. Becher, J. Eschner, **R. Blatt**, V. Steixner,
P. Rabl,
P. Zoller,
Feedback cooling of a single trapped ion,
Phys. Rev. Lett. 96, 043003 (2006)
37. J. Korbicz, O. Gühne, M. Lewenstein, H. Häffner, C. F. Roos, **R. Blatt**,
Generalized spin-squeezing inequalities in N-qubit systems,
Phys. Rev. A 74, 052319 (2006)
38. P. Bushev, M. Wilson, J. Eschner, C. Raab, F. Schmidt-Kaler, C. Becher, **R. Blatt**,
Forces between a Single Atom and Its Distant Mirror Image,
Phys. Rev. Lett. 92, 223602 (2004)
39. A. Kreuter, C. Becher, G. Lancaster, A. B. Mundt, C. Russo, H. Häffner, C. F. Roos, J.
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F. Schmidt-Kaler, **R. Blatt**,
Spontaneous Emission Lifetime of a Single Trapped Ca^+ Ion in a High Finesse Cavity,
Phys. Rev. Lett. 92, 203002 (2004)
40. M. Riebe, H. Häffner, C. F. Roos, W. Hänsel, J. Benhelm, G. Lancaster, T. W. Körber, C.
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F. Schmidt-Kaler, D. James, **R. H. Rohde**, J. Eschner, F. Schmidt-Kaler, **R. Blatt**,
Optical decay from a Fabry-Perot cavity faster than the decay time,
J. Opt. Soc. Am. B 19, 1425 (2002)
41. J. Eschner, G. Morigi, F. Schmidt-Kaler, **R. Blatt**,
Laser cooling of trapped ions,
J. Opt. Soc. Am. B 20, 1003 (2003)
42. D. Leibfried, **R. Blatt**, C. Monroe, D. J. Wineland,
Quantum dynamics of single trapped ions,
Rev. Mod. Phys. 75, 281 (2003)
43. A. B. Mundt, A. Kreuter, C. Russo, C. Becher, D. Leibfried, J. Eschner, F. Schmidt-Kaler,
R. Blatt,
Coherent coupling of a single Ca^+ ion to a high-finesse optical cavity,
Applied Physics B: Lasers and Optics 76, 117 (2003)
44. F. Schmidt-Kaler, S. Gulde, M. Riebe, T. Deuschle, A. Kreuter, G.P.T. Lancaster, C.
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J. Eschner, H. Häffner, **R. Blatt**,
Coherence of qubits based on single Ca^+ ions,
J. Phys. B: At. Mol. Opt. Phys. 36, 623 (2003)
45. J. Eschner, C. Raab, F. Schmidt-Kaler, **R. Blatt**,
Light interference from single atoms and their mirror images,
Nature 413, 495 (2001)
46. H. Rohde, S. Gulde, C. F. Roos, P. A. Barton, D. Leibfried, J. Eschner, F. Schmidt-Kaler,
R. Blatt,
Sympathetic ground state cooling and coherent manipulation with two-ion-crystals,
J. Opt. B: Quantum Semiclass. Opt. 3, 34 (2001)
47. C. F. Roos, D. Leibfried, A. B. Mundt, F. Schmidt-Kaler, J. Eschner, **R. Blatt**,
Experimental demonstration of ground state laser cooling with electromagnetically

- induced transparency*,
Phys. Rev. Lett. 85, 5547 (2000)
48. H.-C. Nägerl, D. Leibfried, H. Rohde, G. Thalhammer, J. Eschner, F. Schmidt-Kaler, **R. Blatt**,
Laser addressing of individual ions in a linear ion trap,
Phys. Rev. A 60, 145 (1999)
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Quantum state engineering on an optical transition and decoherence in a Paul trap,
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Trapped ions in the strong excitation regime: ion interferometry and non-classical states,
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 53. **R. Blatt**, J. I. Cirac, A. S. Parkins, P. Zoller,
Quantum motion of trapped ions,
Physica Scripta T59, 294 (1995)
 54. **R. Blatt**, J. I. Cirac, P. Zoller,
Trapping states of motion with cold ions,
Phys. Rev. A 52 1, 518–524 (1995)
 55. J. I. Cirac, **R. Blatt**, P. Zoller,
Nonclassical states of motion in a three-dimensional ion trap by adiabatic passage,
Phys. Rev. A 49, R3174 (1994)
 56. I. Marzoli, J. I. Cirac, **R. Blatt**, P. Zoller,
Laser cooling of trapped three-level ions: Designing two-level systems for sideband cooling,
Phys. Rev. A 49, 2771 (1994)
 57. J. I. Cirac, **R. Blatt**, A. S. Parkins, P. Zoller,
Quantum collapse and revival in the motion of a single trapped ion,
Phys. Rev. A 49, 1202 (1994)
 58. J. I. Cirac, L. J. Garay, **R. Blatt**, A. S. Parkins, P. Zoller,
Laser cooling of trapped ions: The influence of micromotion,
Phys. Rev. A 49, 421 (1994)
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Ion storage in the rf-octupole trap,
Phys. Rev. A 50, 4122 (1994)
 60. J. I. Cirac, **R. Blatt**, A. S. Parkins, P. Zoller,
Spectrum of resonance fluorescence from a single trapped ion,
Phys. Rev. A 48, 2169 (1993)
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Laser cooling of trapped ions with polarization gradients,
Phys. Rev. A 48, 1434–1445 (1993)
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Phys. Rev. Lett. 70, 556 (1993)
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J. Mod. Opt. 39, 325 (1992)
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Laser cooling of trapped ions in a standing wave,
Phys. Rev. A 46, 2668 (1992)
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Current Perspectives on The Physics of Trapped Ions,
J. Mod. Opt. 39, 193 (1992)
68. M. Schubert, I. Siemers, **R. Blatt**, W. Neuhauser, P. E. Toschek,
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Phys. Rev. Lett. 68, 3016 (1992)
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Kinetic energy and spatial width of ion clouds in Paul traps,
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Population Trapping in Excited Yb^+ Ions,
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Spatially Localized Optical Pumping in Paul Traps,
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Cooling in traps,
Physica Scripta T22, 216 (1988)
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Ordered Structures and Statistical Properties of Ion Clouds in Paul Traps,
Appl. Phys. B 45, 175 (1988)
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Wybrane kluczowe artykuły z dziedziny metrologii kwantowej i ultra precyzyjnej spektroskopii laserowej:

78. M. Chwalla, J. Benhelm, K. Kim, G. Kirchmair, T. Monz, M. Riebe, P. Schindler, A. S. Villar,

- W. Hänsel, C. F. Roos, **R. Blatt**, M. Abgrall, G. Santarelli, G. D. Rovera, Ph. Laurent, *Absolute frequency measurement of the $^{40}\text{Ca}^+ 4s^2S_{1/2} - 3d^2D_{5/2}$ clock transition*, Phys. Rev. Lett. 102, 023002 (2009)
79. R. Gerritsma, G. Kirchmair, F. Zähringer, J. Benhelm, **R. Blatt**, C. F. Roos, *Precision measurement of the branching fractions of the $4p^2P_{3/2}$ decay of Ca II*, Eur. Phys. J. D 50, 13 (2008)
80. J. Benhelm, G. Kirchmair, U. D. Rapol, T. Körber, C. F. Roos, R. Blatt, *Measurement of the hyperfine structure of the $S_{1/2}$ - $D_{5/2}$ transition in $^{43}\text{Ca}^+$* , Phys. Rev. A 75, 032506 (2007)
81. M. Chwalla, K. Kim, T. Monz, P. Schindler, M. Riebe, C. F. Roos, R. Blatt, *Precision spectroscopy with two correlated atoms*, Appl. Phys. B 89, 483 (2007)
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89. W. Vogel, **R. Blatt**, *Resonance fluorescence from three-level atoms: Atomic coherences and squeezed light*, Phys. Rev. A 45, 3319 (1992)
90. R. Casdorff, V. Enders, **R. Blatt**, W. Neuhauser, P. E. Toschek, *A 12-GHz Standard Clock on Trapped Ytterbium Ions*, Ann. Physik (Leipzig) 48, 41 (1991)
91. H. Harde, J. Hattendorf-Ledwoch, H. Lehmitz, **R. Blatt**, *Self-induced Zeeman coherences in trapped Yb^+ ions*, Appl. Phys. B 53, 131 (1991)
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93. W. Ertmer, **R. Blatt**, J. L. Hall, M. Zhu, *Laser Manipulation of Atomic Beam Velocities: Demonstration of Stopped Atoms and*

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94. **R. Blatt**, W. Ertmer, J. L. Hall,
Cooling of an Atomic Beam with Frequency Sweep Techniques,
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 95. W. Ertmer, **R. Blatt**, J. L. Hall,
*Candidate Atoms and Ions for Frequency Standards Research Using Laser Radiative
Cooling Techniques,*
Progr. Quant. Electr. 8, 249 (1984)
 96. **R. Blatt**, H. Schnatz, G. Werth,
Determination of the $^{171}\text{Yb}^+$ Ground-State Hyperfine Separation,
Z. Phys. A 312, 143 (1983)
 97. **R. Blatt**, H. Schnatz, G. Werth,
Ultrahigh Resolution Microwave Spectroscopy on Trapped $^{171}\text{Yb}^+$ Ions,
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*Precision Determination of the Ground-State Hyperfine Splitting in $^{137}\text{Ba}^+$ Using the Ion
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Phys. Rev. A 25, 1476 (1982)
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