

University of Groningen

## Laser cooling, trapping and spectroscopy of calcium isotopes

Mollema, Albert Cornelis

**IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.**

*Document Version*

Publisher's PDF, also known as Version of record

*Publication date:*

2008

[Link to publication in University of Groningen/UMCG research database](#)

*Citation for published version (APA):*

Mollema, A. K. (2008). *Laser cooling, trapping and spectroscopy of calcium isotopes*. s.n.

### Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

### Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

# Bibliography

- [1] T. W. Hänsch and A. L. Schawlow, *Optics Communications* **13**, 68 (1975).
- [2] W. D. Phillips and H. Metcalf, *Physical Review Letters* **48**, 596 (1982).
- [3] E. L. Raab, M. Prentiss, A. Cable, S. Chu, and D. E. Pritchard, *Physical Review Letters* **59**, 2631 (1987).
- [4] J. Grünert and A. Hemmerich, *Applied Physics B-Lasers and Optics* **73**, 815 (2001).
- [5] J. Grünert and A. Hemmerich, *Physical Review A* **65**, 041401 (2002).
- [6] S. Knoop, *Electron Dynamics in Ion-Atom Interactions*, Proefschrift Rijksuniversiteit Groningen, 2006.
- [7] J. Weiner, V. S. Bagnato, S. Zilio, and P. S. Julienne, *Reviews of Modern Physics* **71**, 1 (1999).
- [8] T. P. Dinneen, K. R. Vogel, E. Arimondo, J. L. Hall, and A. Gallagher, *Physical Review A* **59**, 1216 (1999).
- [9] Z. T. Lu, C. J. Bowers, S. J. Freedman, B. K. Fujikawa, J. L. Mortara, S. Q. Shang, K. P. Coulter, and L. Young, *Physical Review Letters* **72**, 3791 (1994).
- [10] C. Y. Chen, Y. M. Li, K. Bailey, T. P. O'Connor, L. Young, and Z. T. Lu, *Science* **286**, 1139 (1999).
- [11] S. Hoekstra, A. K. Mollema, R. Morgenstern, H. W. Wilschut, and R. Hoekstra, *Physical Review A* **71**, 023409 (2005).
- [12] K. B. Davis, M. O. Mewes, M. R. Andrews, N. J. v. Druten, D. S. Durfee, D. M. Kurn, and W. Ketterle, *Physical Review Letters* **75**, 3969 (1995).
- [13] M. H. Anderson, J. R. Ensher, M. R. Matthews, C. E. Wieman, and E. A. Cornell, *Science* **269**, 198 (1995).
- [14] C. S. Adams and E. Riis, *Progress in Quantum Electronics* **21**, 1 (1997).

- [15] H. J. Metcalf and P. van der Straten, *Journal of the Optical Society of America B-Optical Physics* **20**, 887 (2003).
- [16] P. D. Lett, W. D. Phillips, S. L. Rolston, C. E. Tanner, R. N. Watts, and C. I. Westbrook, *Journal of the Optical Society of America B-Optical Physics* **6**, 2084 (1989).
- [17] X. Y. Xu, T. H. Loftus, M. J. Smith, J. L. Hall, A. Gallagher, and J. Ye, *Physical Review A* **66**, 011401 (2002).
- [18] X. Y. Xu, T. H. Loftus, J. W. Dunn, C. H. Greene, J. L. Hall, A. Gallagher, and J. Ye, *Physical Review Letters* **90**, 193002 (2003).
- [19] X. Y. Xu, T. H. Loftus, J. L. Hall, A. Gallagher, and J. Ye, *Journal of the Optical Society of America B-Optical Physics* **20**, 968 (2003).
- [20] S. Hoekstra, *Atom Trap Trace Analysis of Calcium Isotopes*, Proefschrift Rijksuniversiteit Groningen, 2005.
- [21] S. Hoekstra, A. K. Mollema, R. Morgenstern, L. Willmann, H. W. Wilschut, and R. Hoekstra, *Hyperfine Interactions* **162**, 167 (2005).
- [22] G. P. A. Berg, P. Dendooven, O. Dermois, M. N. Harakeh, R. Hoekstra, S. Hoekstra, K. Jungmann, S. Kopecky, V. Kravchuk, R. Morgenstern, A. Rogachevskiy, L. Willmann, and H. W. Wilschut, *Nuclear Physics A* **721**, 1107C (2003).
- [23] N. Severijns, M. Beck, and O. Naviliat-Cuncic, *Reviews of Modern Physics* **78**, 991 (2006).
- [24] I. D. Moore, K. Bailey, J. Greene, Z. T. Lu, P. Müller, T. P. O'Connor, C. Geppert, K. D. A. Wendt, and L. Young, *Physical Review Letters* **92**, 153002 (2004).
- [25] K. Nishiizumi, M. W. Caffee, and D. J. DePaolo, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **172**, 399 (2000).
- [26] G. M. Raisbeck and F. Yiou, *Nature* **277**, 42 (1979).
- [27] D. Elmore, M. H. Bhattacharyya, N. Saccogibson, and D. P. Peterson, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **52**, 531 (1990).
- [28] S. P. H. T. Freeman, J. C. King, N. E. Vieira, L. R. Woodhouse, and A. L. Yergey, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **123**, 266 (1997).
- [29] W. Henning, W. A. Bell, P. J. Billquist, B. G. Glagola, W. Kutschera, Z. Liu, H. F. Lucas, M. Paul, K. E. Rehm, and J. L. Yntema, *Science* **236**, 725 (1987).

- [30] Y. Yamaguchi, *Progress of Theoretical Physics* **30**, 567 (1963).
- [31] A. E. Litherland, *Annual Review of Nuclear and Particle Science* **30**, 437 (1980).
- [32] D. Fink, J. Klein, and R. Middleton, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **52**, 572 (1990).
- [33] A. Wallner, A. Arazi, T. Faestermann, K. Knie, G. Korschinek, H. J. Maier, N. Nakamura, W. Ruhm, and G. Rugel, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **223-24**, 759 (2004).
- [34] K. D. A. Wendt, K. Blaum, C. Geppert, R. Horn, G. Passler, N. Trautmann, and B. A. Bushaw, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **204**, 325 (2003).
- [35] Z. T. Lu and K. D. A. Wendt, *Review of Scientific Instruments* **74**, 1169 (2003).
- [36] H. Haken and H. C. Wolf, *The Physics of Atoms and Quanta*, Springer-Verlag, Heidelberg, sixth edition, 2000.
- [37] *CRC Handbook of Chemistry and Physics*, 63 edition, 1983.
- [38] C. van Ditzhuijzen, *Monte Carlo Simulations and Atomic Beam Analysis for the AlCatraz experiment*, Afstudeerverslag Rijksuniversiteit Groningen, 2002.
- [39] W. Nortershauser, N. Trautmann, K. Wendt, and B. A. Bushaw, *Spectrochimica Acta Part B-Atomic Spectroscopy* **53**, 709 (1998).
- [40] H. J. Metcalf and P. van der Straten, *Laser Cooling and Trapping*, Springer Verlag, New York, 1999.
- [41] B. Povh, K. Rith, C. Scholz, and F. Zetsche, *Particles and Nuclei*, Springer-Verlag, Heidelberg, third edition, 2002.
- [42] L. Allen and J. H. Eberly, *Optical Resonance and Two-Level Atoms*, Wiley, New York, 1975.
- [43] D. J. Wineland and W. M. Itano, *Physical Review A* **20**, 1521 (1979).
- [44] P. D. Lett, R. N. Watts, C. I. Westbrook, W. D. Phillips, P. L. Gould, and H. J. Metcalf, *Physical Review Letters* **61**, 169 (1988).
- [45] J. Dalibard and C. Cohen-Tannoudji, *Journal of the Optical Society of America B-Optical Physics* **6**, 2023 (1989).
- [46] P. J. Ungar, D. S. Weiss, E. Riis, and S. Chu, *Journal of the Optical Society of America B-Optical Physics* **6**, 2058 (1989).

- [47] T. Kisters, K. Zeiske, F. Riehle, and J. Helmcke, *Applied Physics B-Lasers and Optics* **59**, 89 (1994).
- [48] C. W. Oates, F. Bondu, R. W. Fox, and L. Hollberg, *European Physical Journal D* **7**, 449 (1999).
- [49] C. Degenhardt, T. Binnewies, G. Wilpers, U. Sterr, F. Riehle, C. Lisdat, and E. Tiemann, *Physical Review A* **67**, 043408 (2003).
- [50] T. Chaneliere, J. L. Meunier, R. Kaiser, C. Miniatura, and D. Wilkowski, *Journal of the Optical Society of America B-Optical Physics* **22**, 1819 (2005).
- [51] S. K. Choi, S. E. Park, J. Chen, and V. G. Minogin, *Physical Review A* **77**, 015405 (2008).
- [52] P. A. Molenaar, P. van der Straten, H. G. M. Heideman, and H. Metcalf, *Physical Review A* **55**, 605 (1997).
- [53] P. A. Molenaar, *Photoassociative Reactions of Laser-Cooled Sodium*, Proefschrift Universiteit Utrecht, 1997.
- [54] S. Chu, L. Hollberg, J. E. Bjorkholm, A. Cable, and A. Ashkin, *Physical Review Letters* **55**, 48 (1985).
- [55] C. F. Fischer and G. Tachiev, *Physical Review A* **68**, 012507 (2003).
- [56] C. G. Townsend, N. H. Edwards, C. J. Cooper, K. P. Zetie, C. J. Foot, A. M. Steane, P. Szriftgiser, H. Perrin, and J. Dalibard, *Physical Review A* **52**, 1423 (1995).
- [57] L. W. Wansbeek and A. Deuzeman, *Private communication*, 2005.
- [58] J. Grünert, *Ultracold metastable calcium atoms in a bichromatic magneto-optical trap*, Dissertation Universität Hamburg, 2002.
- [59] C. W. Gardiner, *Handbook of Stochastic Methods*, Springer-Verlag, Heidelberg, second edition, 1985.
- [60] F. Ruschewitz, D. Bettermann, J. L. Peng, and W. Ertmer, *Europhysics Letters* **34**, 651 (1996).
- [61] P. A. Franken, G. Weinreich, C. W. Peters, and A. E. Hill, *Physical Review Letters* **7**, 118 (1961).
- [62] A. Ashkin, G. D. Boyd, and J. M. Dziedzic, *Ieee Journal of Quantum Electronics* **QE 2**, 109 (1966).
- [63] W. Demtröder, *Laser Spectroscopy*, Springer-Verlag, Heidelberg, third edition, 2003.

- [64] L. Ricci, M. Weidemuller, T. Esslinger, A. Hemmerich, C. Zimmermann, V. Vuletic, W. Konig, and T. W. Hansch, *Optics Communications* **117**, 541 (1995).
- [65] R. V. Pound, *Review of Scientific Instruments* **17**, 490 (1946).
- [66] R. W. P. Drever, J. L. Hall, F. V. Kowalski, J. Hough, G. M. Ford, A. J. Munley, and H. Ward, *Applied Physics B-Photophysics and Laser Chemistry* **31**, 97 (1983).
- [67] A. K. Mollema, L. W. Wansbeek, L. Willmann, K. Jungmann, R. G. E. Timmermans, and R. Hoekstra, *Physical Review A* **77**, 043409 (2008).
- [68] E. A. Donley, T. P. Heavner, F. Levi, M. O. Tataw, and S. R. Jefferts, *Review of Scientific Instruments* **76**, 063112 (2005).
- [69] U. Dammalapati, *Metastable D-state spectroscopy and laser cooling of barium*, Proefschrift Rijksuniversiteit Groningen, 2006.
- [70] C. Kittel and H. Kroemer, *Thermal Physics*, W. H. Freeman and Company, New York, second edition, 1980.
- [71] P. E. Douglas, *Proceedings of the Physical Society of London Section B* **67**, 783 (1954).
- [72] J. Mulder, S. Hoekstra, G. J. Sa, and L. Slatius, in *KVI Annual Report 2002*, 2003.
- [73] W. Alt, *Optik* **113**, 142 (2002).
- [74] R. Grimm and J. Mlynek, *Journal of the Optical Society of America B-Optical Physics* **5**, 1655 (1988).
- [75] R. Grimm and J. Mlynek, *Physical Review Letters* **63**, 232 (1989).
- [76] R. Grimm and J. Mlynek, *Physical Review A* **42**, 2890 (1990).
- [77] F. Minardi, M. Artoni, P. Cancio, M. Inguscio, G. Giusfredi, and I. Carusotto, *Physical Review A* **60**, 4164 (1999).
- [78] M. Artoni, I. Carusotto, and F. Minardi, *Physical Review A* **62**, 023402 (2000).
- [79] A. A. Chernenko and A. V. Shishaev, *Optics Communications* **211**, 249 (2002).
- [80] H. A. J. Meijer, H. P. Vandermeulen, F. Ditewig, C. J. Wisman, and R. Morgenstern, *Journal of Physics E-Scientific Instruments* **20**, 305 (1987).
- [81] K. L. Corwin, Z. T. Lu, C. F. Hand, R. J. Epstein, and C. E. Wieman, *Applied Optics* **37**, 3295 (1998).

- [82] E. D. van Ooijen, G. Katgert, and P. van der Straten, *Applied Physics B-Lasers and Optics* **79**, 57 (2004).
- [83] H. Pauly, in *Atomic and Molecular Beam Methods*, edited by G. Scoles, Oxford University Press, 1988.
- [84] P. T. Greenland, M. A. Lauder, and D. J. H. Wort, *Journal of Physics D-Applied Physics* **18**, 1223 (1985).
- [85] L. W. Wansbeek, *Escape from Al<sup>41</sup> Catraz*, Afstudeerverslag Rijksuniversiteit Groningen, 2006.
- [86] M. D. Hoogerland, J. P. J. Driessen, E. J. D. Vredenburg, H. J. L. Megens, M. P. Schuwer, H. C. W. Beijerinck, and K. A. H. van Leeuwen, *Applied Physics B-Lasers and Optics* **62**, 323 (1996).
- [87] W. Rooijackers, W. Hogervorst, and W. Vassen, *Optics Communications* **123**, 321 (1996).
- [88] I. D. Moore, K. Bailey, Z. T. Lu, P. Müller, T. P. O'Connor, and L. Young, *Nuclear Instruments & Methods in Physics Research Section B-Beam Interactions with Materials and Atoms* **204**, 701 (2003).
- [89] R. L. Cavasso, A. Scalabrin, D. Pereira, and F. C. Cruz, *Physical Review A* **67**, 021402 (2003).
- [90] R. L. Cavasso, W. C. Magno, D. A. Manoel, A. Scalabrin, D. Pereira, and F. C. Cruz, *Journal of the Optical Society of America B-Optical Physics* **20**, 994 (2003).
- [91] R. L. Cavasso, D. A. Manoel, D. R. Ortega, A. Scalabrin, D. Pereira, and F. C. Cruz, *Applied Physics B-Lasers and Optics* **78**, 49 (2004).
- [92] T. Kurosu and F. Shimizu, *Japanese Journal of Applied Physics Part 1-Regular Papers Short Notes & Review Papers* **31**, 908 (1992).
- [93] J. Grünert, G. Quehl, V. Elman, and A. Hemmerich, *Journal of Modern Optics* **47**, 2733 (2000).
- [94] E. Polak, KVI internal report, 2003.
- [95] V. S. Bagnato, L. G. Marcassa, M. Oria, G. I. Surdutovich, R. Vitlina, and S. C. Zilio, *Physical Review A* **48**, 3771 (1993).
- [96] F. D. Nunes, J. F. Silva, S. C. Zilio, and V. S. Bagnato, *Physical Review A* **54**, 2271 (1996).
- [97] A. Hendrickx, *Electron capture in He<sup>2+</sup>-Na collisions*, Afstudeerverslag (master thesis) RuG/KVI Groningen, 2003.

- [98] P. van der Straten and H. Metcalf, in *Interaction in Ultracold Gases*, edited by M. Weidemuller and C. Zimmermann, Wiley-VCH, Germany, 2003, pp. 1–63.
- [99] A. Rogachevskiy, *Production and trapping of Na isotopes for  $\beta$ -decay studies*, Proefschrift Rijksuniversiteit Groningen, 2007.
- [100] S. Chang and V. Minogin, *Physics Reports-Review Section of Physics Letters* **365**, 65 (2002).
- [101] S. Chang, T. Y. Kwon, H. S. Lee, and V. G. Minogin, *Physical Review A* **66** (2002).
- [102] L. P. Maguire, S. Szilagy, and R. E. Scholten, *Review of Scientific Instruments* **75**, 3077 (2004).
- [103] A. Witte, T. Kisters, F. Riehle, and J. Helmcke, *Journal of the Optical Society of America B-Optical Physics* **9**, 1030 (1992).
- [104] A. K. Mollema, *Measurement and analysis of single atom events in the AlCatraz experiment*, Afstudeerverslag Rijksuniversiteit Groningen, 2004.
- [105] H. W. Brandt, K. Heilig, H. Knockel, and A. Steudel, *Zeitschrift fur Physik A-Hadrons and Nuclei* **288**, 241 (1978).
- [106] A. Andl, K. Bekt, S. Goring, A. Hanser, G. Nowicki, H. Rebel, G. Schatz, and R. C. Thompson, *Physical Review C* **26**, 2194 (1982).



