

# ATOMIC PHYSICS 20

XX International Conference on Atomic Physics

ICAP 2006

*Innsbruck, Austria      16 – 21 July 2006*

*EDITORS*

Christian Roos  
Hartmut Häffner  
Rainer Blatt

*Institute for Quantum Optics and Quantum Information  
Innsbruck, Austria  
and the  
University of Innsbruck, Innsbruck, Austria*

## **SPONSORING ORGANIZATIONS**

International Union of Pure and Applied Physics (IUPAP)  
bm:bwk Austria  
FWF Austria (Austrian Science Fund)  
University of Innsbruck  
Institute for Quantum Optics and Quantum Information  
Institute for Quantum Information Ges.m.bH (Austria)  
European Science Foundation  
National Institute of Standards and Technology (U.S.A.)  
Army Research Office (U.S.A.)  
LINOS  
Sacher Lasertechnik  
Journal of Physics B  
Coherent  
ELS  
Oxford University Press  
Radant Dyes Laser  
Thorlabs  
Toptica  
Nufem  
MenloSystems  
Schöffer+Kirchhoff

**AIP**  
*75 Years of Service*

Melville, New York, 2006

**AIP CONFERENCE PROCEEDINGS ■ VOLUME 869**

## CONTENTS

Preface.....	ix
Programme Committee.....	xi
Advisory Committee.....	xiii

### PERSPECTIVES OF ATOMIC PHYSICS

A Beginner's Guide to ICAP.....	3
D. Kleppner	
Speculating on the Future of Atomic Physics.....	13
N. F. Ramsey	

### SCIENCE EDUCATION

Science Education for the 21st Century; A Scientific Approach to Science Education.....	19
C. Wieman	

### ATOMIC TESTS OF FUNDAMENTAL PHYSICS

Variation of Fundamental Constants.....	29
V. V. Flambaum	
Precision Spectroscopy of H <sub>2</sub> and a Possible Variation of $m_p/m_e$ over Cosmological Time.....	37
W. Ubachs	
Probing the Electron EDM with Cold Molecules.....	44
B. E. Sauer, H. T. Ashworth, J. J. Hudson, M. R. Tarbutt, and E. A. Hinds	
Quantum Electrodynamics of Heavy Ions and Atoms.....	52
V. M. Shabaev, A. N. Artemyev, D. A. Glazov, I. I. Tupitsyn, A. V. Volotka, and V. A. Yerokhin	
Precision Experiments with Stored and Cooled Highly Charged Ions.....	60
H.-J. Kluge	
New Measurement of the Electron Magnetic Moment and the Fine Structure Constant.....	68
G. Gabrielse and D. Hanneke	

### ATOMIC CLOCKS AND PRECISION MEASUREMENTS

Fundamental Physics and Precision Measurements ( <i>Abstract Only</i> ).....	79
T. W. Hänsch	

<b>Precision Measurement Based on Ultracold Atoms and Cold Molecules .....</b>	<b>80</b>
J. Ye, S. Blatt, M. M. Boyd, S. M. Foreman, E. R. Hudson, T. Ido, B. Lev, A. D. Ludlow, B. C. Sawyer, B. Stuhl, and T. Zelevinsky	
<b>Trapped Ion Optical Clocks at NPL .....</b>	<b>92</b>
H. S. Margolis, G. P. Barwood, K. Hosaka, G. Huang, H. A. Klein, S. N. Lea, A. Stannard, B. R. Walton, S. A. Webster, and P. Gill	

## QUANTUM INFORMATION AND QUANTUM OPTICS

<b>Trapped Atomic Ions and Quantum Information Processing.....</b>	<b>103</b>
D. J. Wineland, D. Leibfried, J. C. Bergquist, R. B. Blakestad, J. J. Bollinger, J. Britton, J. Chiaverini, R. J. Epstein, D. B. Hume, W. M. Itano, J. D. Jost, M. Knill, J. C. J. Koelemeij, C. Langer, R. Ozeri, R. Reichle, T. Rosenband, T. Schaetz, P. O. Schmidt, S. Seidelin, N. Shiga, and J. H. Wesenberg	
<b>Precision Spectroscopy with Entangled States: Measurement of Electric Quadrupole Moments .....</b>	<b>111</b>
C. F. Roos, M. Chwalla, K. Kim, M. Riebe, and R. Blatt	
<b>Quantum Control of Electron and Nuclear Spin Qubits in the Solid State .....</b>	<b>119</b>
M. V. Gurudev Dutt, L. Childress, E. Togan, J. M. Taylor, L. Jiang, A. S. Zibrov, P. R. Hemmer, F. Jelezko, J. Wrachtrup, and M. D. Lukin	
<b>Hybrid Quantum Information Processing with Polar Molecules.....</b>	<b>128</b>
A. André, D. DeMille, J. M. Doyle, M. D. Lukin, S. E. Maxwell, P. Rabl, R. J. Schoelkopf, and P. Zoller	
<b>Light Forces in Cavity QED .....</b>	<b>136</b>
G. Rempe and K. Murr	
<b>Quantum Optics with Atomic Ensembles and Single Atoms in Cavities.....</b>	<b>144</b>
T. E. Northup and H. J. Kimble	

## BOSE GASES

<b>The Atomic Bose Gas in Flatland.....</b>	<b>155</b>
Z. Hadzibabic, P. Krüger, M. Cheneau, B. Battelier, and J. Dalibard	
<b>Symmetry Breaking in Bose-Einstein Condensates .....</b>	<b>165</b>
M. Ueda, Y. Kawaguchi, H. Saito, R. Kanamoto, and T. Nakajima	
<b>How to Study Correlation Functions in Fluctuating Bose Liquids Using Interference Experiments .....</b>	<b>173</b>
V. Gritsev, E. Altman, A. Polkovnikov, and E. Demler	
<b>Producing and Detecting Correlated Atoms .....</b>	<b>181</b>
C. I. Westbrook, M. Schellekens, A. Perrin, V. Krachmalnicoff, J. Viana Gomes, J.-B. Trebbia, J. Estève, H. Chang, I. Bouchoule, D. Boiron, A. Aspect, T. Jelte, J. McNamara, W. Hogervorst, and W. Vassen	

## ATOMS IN OPTICAL LATTICES

.....80	
.....92	<b>Strongly Correlated Quantum Matter in Optical Lattices</b> .....191 I. Bloch, S. Fölling, A. Widera, T. Müller, T. Rom, Th. Best, D. van Oosten, U. Schneider, B. Paredes, and F. Gerbier
	<b>Travelling to Exotic Places with Ultracold Atoms</b> .....201 M. Lewenstein, A. Kubasiak, J. Larson, C. Menotti, G. Morigi, K. Osterloh, and A. Sanpera
.....103	<b>Repulsively Bound Atom Pairs: Overview, Simulations and Links</b> .....212 A. J. Daley, A. Kantian, H. P. Büchler, P. Zoller, K. Winkler, G. Thalhammer, F. Lang, R. Grimm, and J. Hecker Denschlag
	<b>Fermi-Bose Mixtures in Three-dimensional Optical Lattices</b> .....219 C. Ospelkaus, S. Ospelkaus, P. Ernst, O. Wille, M. Succo, L. Humbert, K. Sengstock, and K. Bongs
.....111	<b>Insulating Phases of Ultracold Bosons in a Disordered Optical Lattice: From a Mott Insulator to a Bose Glass</b> .....229 V. Guarrera, L. Fallani, J. E. Lye, C. Fort, and M. Inguscio

## FERMI GASES

.....119	
.....128	<b>Dual-Species Quantum Degeneracy of <math>^{40}\text{K}</math> and <math>^{87}\text{Rb}</math> on an Atom Chip</b> .....241 M. H. T. Extavour, L. J. LeBlanc, T. Schumm, B. Cieslak, S. Myrskog, A. Stummer, S. Aubin, and J. H. Thywissen
.....136	<b>Quantum Monte Carlo Study of the Ground-state Properties of a Fermi Gas in the BCS-BEC Crossover</b> .....250 S. Giorgini, G. E. Astrakharchik, J. Boronat, and J. Casulleras

## COLD MOLECULES AND ATOM-ATOM INTERACTIONS

.....144	
.....155	<b>Simple Theoretical Models for Resonant Cold Atom Interactions</b> .....261 P. S. Julienne and B. Gao
.....165	<b>Experimental Evidence for Efimov Quantum States</b> .....269 H.-C. Nägerl, T. Kraemer, M. Mark, P. Waldburger, J. G. Danzl, B. Engeser, A. D. Lange, K. Pilch, A. Jaakkola, C. Chin, and R. Grimm
.....173	<b>A Mott-like State of Molecules</b> .....278 S. Dürr, T. Volz, N. Syassen, D. M. Bauer, E. Hansis, and G. Rempe
.....181	<b>Optical Production of Ultracold Polar Molecules</b> .....284 D. DeMille, J. M. Sage, S. Sainis, and T. Bergeman
	<b>Designing Interactions in Polar Molecules: Towards Novel Quantum Phases</b> .....292 H. P. Büchler, G. Pupillo, A. Micheli, M. Lukin, E. Demler, N. Prokof'ev, and P. Zoller

## ATTOSECOND PHYSICS

<b>Probing Attosecond Dynamics by Laser Driven Electron Recollisions .....</b>	<b>303</b>
J. P. Marangos, S. Baker, J. S. Robinson, C. A. Haworth, C. C. Chirila, M. Lein, L. Chipperfield, and J. W. G. Tisch	
<b>Author Index .....</b>	<b>313</b>