

**VITA****Leo W. Hollberg****Oct. 2012****PERSONAL DATA**

Born November 6, 1952; Denver Colorado

**EDUCATION**

University of Colorado, Boulder, CO, Ph.D. in Physics - 1984

Stanford University, Stanford CA, B.S. in Physics - 1976

**EXPERIENCE**

9/2011- Present

Professor (research), Dept. of Physics, Stanford University

5/2009 – 8/101

Chief Technical Officer, AOSense, Sunnyvale CA

10/2008 – 4/2009

Technical consulting

11/85-9/2008

Staff scientist and Group Leader

National Institute of Standards and Technology,

Time and Frequency Division, Boulder, Colorado

9/88-Present

Lecturer University of Colorado, Department of Physics

4/84-11/85

Postdoctoral position at A.T.&amp;T. Bell Labs, Holmdel, NJ

with S. Chu and R. Slusher

1/84-4/84

Postdoctoral position at the Joint Institute for Laboratory

Astrophysics with J.L. Hall

1977-1984

Research assistant with J. L. Hall at the Joint Institute for

Laboratory Astrophysics (JILA), doing thesis work in high-resolution laser spectroscopy, atomic physics and nonlinear optics.

1973-1990

Business experience with family greenhouse business including aspects

part-time

of management and general business operation

1976-1977

Research assistant with the petro-physics and remote sensing division of

part-time

the United States Geological Survey. Working on Fourier transform and classical infrared spectroscopy for remote sensing applications

1975

Teaching assistant, undergraduates Dept. Physics, Stanford University

**PROFESSIONAL ASSOCIATIONS**

American Physical Society (APS), Optical Society of America (OSA), International IEEE

**AWARDS and RECOGNITION**

Department of Commerce Gold Medal Award,

“For revolutionizing the way frequency is measured (2001).

Fellow, Optical Society of America, (2003).

Fellow, American Physical Society, (2003).

Department of Commerce, Silver Medal Award.

“For design and development of ultra-miniature atomic clocks and magnetometers,” (2005).

I.I. Rabi award of the IEEE-UFFC, International Frequency Control Symposium,

“For seminal contribution to optical frequency metrology with the development of stable optical frequency standards and related femtosecond clockwork,” shared w/ P. Gill, NPL-UK. (2007).

William F. Meggers Award, of the Optical Society of America,

“For seminal contributions to the development of diode lasers as powerful spectroscopic tools, development of femtosecond combs, and demonstration of unique quantum effects in the interaction between light and atoms,” ( 2009).

**Awarded a Rank Prize** for optoelectronics in 2013, from the Rank Prize Funds, for:  
“For the creation and demonstration of the first chip scale atomic clock”, award shared with my previous colleagues J. Kitching and S. Knappe.

**Professional activities Sept. 2012 – Aug. 2013, between yellow highlights**

**Conference presentations and invited lectures:**

- Invited lecture, Stanford UniverPhotonics Research Center, 2013. 2011

**University committee and administrative duties:**

- Deputy director Stanford Center for Position Navigation and Time, SCPNT
- Member, Physics Dept. graduate admissions committee

**Outside Service:**

- NASA review committee on Cold Atom Laboratory for space, 2013.



**PATENTS**

Ma Lang-sheng, Leo Hollberg, Jon H. Shirley and John L. Hall, "Modulation Transfer Spectroscopy for Stabilizing Lasers," (1986), U. S. Pat. Num. 4,590,597.

B. Dahmani and L.W. Hollberg, "Optical Feedback Locking of Semiconductor Lasers," (1990), U. S. Pat. Num. 4,907,237.

J. Kitching, L. Hollberg, R. Wynands, S. Knappe, “Method of minimizing the short-term frequency instability of laser-pumped atomic clocks,” patent application serial no. 10/175,324 applied for June (2002).

J. Kitching and L. Hollberg, “Miniature frequency standard based on all-optical containment vessel,” U.S patent application serial no. 10/175,498, approved April (2004).

J. Kitching, L. Hollberg, L-A. Liew, S. Knappe, J. Moreland, V.L. Velichansky, H.G. Robinson, “Micromachined alkali-atom vapor cells and method of microfabrication,” patent application serial no. 10/821,236 . (2004).

Two additional patent applications in submission process.

**PUBLICATIONS – L. Hollberg**

(Note: publications while at NIST accessible as pdf’s at <http://tf.nist.gov> ,publications link)

**PEER REVIEWED**

J.L. Hall, L. Hollberg, T. Baer, and H.G. Robinson, "Optical Heterodyne Saturation Spectroscopy," Appl. Phys. Lett., 39, 680-682 (1981).

J.L. Hall, L. Hollberg, Ma Long-sheng, T. Baer and H.G. Robinson, "Progress Toward Phase-stable Optical Frequency Standards," Journal de Physique, Colloque C8 42, C8-59-C8-71 (1981).

L. Hollberg and J.L. Hall, "Measurement of the Shift of Rydberg Energy Levels Induced by Blackbody Radiation," *Phys. Rev. Lett.*, 53, 230-233 (1984).

J. Hough, D. Hils, M.D. Rayman, Ma L.-S., L. Hollberg and J.L. Hall, "Dye-Laser Frequency Stabilization Using Optical Resonators," *Appl. Phys. B*, 33, 179-185 (1984).

R.E. Slusher, L. Hollberg, B. Yurke, J.C. Mertz and J.F. Valley, "Squeezed States in Optical Cavities: A Spontaneous-Emission-Noise Limit," *Phys. Rev. A*, 31, 3512-3515 (1985).

Steven Chu, L. Hollberg, J.E. Bjorkholm, Alex Cable and A. Ashkin, "Three Dimensional Viscous Confinement and Cooling of Atoms by Resonance Radiation Pressure," *Phys. Rev. Lett.*, 55, 48-51 (1985).

R.E. Slusher, L.W. Hollberg, B. Yurke, J.C. Mertz, and J.F. Valley, "Observation of Squeezed States Generated by Four-Wave Mixing in an Optical Cavity," *Phys. Rev. Lett.*, 55, 2409-2412 (1985).

S. Chu, J.E. Bjorkholm, A. Ashkin, J.P. Gordon and L. Hollberg, "Proposal for Optically Cooling Atoms to Temperatures of the Order of  $10^{-6}$  K," *Opt. Lett.*, 11, 73-75 (1986).

B. Dahmani, L. Hollberg, and R.E. Drullinger, Frequency Stabilization of Semiconductor Lasers by Resonant Optical Feedback, *Opt. Lett.*, 12, 876-878, 1987.

L. Hollberg and M. Ohtsu, Modulatable Narrow-Linewidth Semiconductor Lasers, *Appl. Phys. Lett.*, 53, 944-946, 1988.

R. Drullinger, L. Hollberg, S. Ohshima, Y. Ikegami, and Y. Koga, Characteristics of an Optically Pumped Cs Frequency Standard at the NRLM, *IEEE Trans. Instrumen. Meas.* 38, 533-536, 1989.

G.M. Tino, L. Hollberg, A. Sasso, M. Inguscio, and M. Barsanti, Hyperfine Structure of the Metastable  $^5S_2$  State of  $^{17}O$  Using an AlGaAs Diode Laser at 777 nm, *Phys. Rev. Lett.*, 64, 2999-3002, 1990.

C. Weiman and L. Hollberg, Using Diode Lasers for Atomic Physics, *Rev. Sci. Instrum.*, 62, 1-20, 1991.

N. Vansteenkiste, C. Gerz, R. Kaiser, L. Hollberg, C. Salomon and A. Aspect, A Frequency-Stabilized LNA Laser at 1.083  $\mu\text{m}$ : Application to the Manipulation of Helium 4 Atoms, *J. Phys. II France*, 1, 1407-1428, 1991.

R.W. Fox, S.L. Gilbert, L. Hollberg, J.H. Marquardt, and H.G. Robinson, Optical Probing of Cold Trapped Atoms, *Opt. Lett.* 18, 1456, 1993.

R.W. Fox, C. Weimer, L. Hollberg, and G.C. Turk, The Diode Laser as a Spectroscopic Tool, *Spectrochimica Acta Reviews*, 15, 291, 1993.

R. Ellingsen, A.S. Zibrov, R.W. Fox, V.L. Velichansky, C. Weimer, G.M. Tino, and L. Hollberg, High-Resolution Diode Laser Spectroscopy of Calcium, *Appl. Phys. B*, 59, 327-331 (1994).

D.A. Van Baak and L. Hollberg, A Proposed Sum-and-Difference Method for Optical Frequency Measurement in the Near Infrared, *Opt. Lett.* (1994).

U. Simon, S. Waltman, I. Loa, F.K. Tittel, and L. Hollberg, External Cavity Difference-Frequency Source in the Mid-Infrared based on AgGaS<sub>2</sub> and Diode Lasers, *J. Opt. Soc. Am. B*, 12, 323-327 (1995).

A. Dax, J.S. Wells, L. Hollberg, A.G. Maki, and W. Urban, Sub-Doppler Frequency Measurements on OCS at 87 THz (3.4  $\mu\text{m}$ ) with the CO Overtone Laser, *J. Mol. Spect.*, 168, 416-428 (1994).

J.S. Wells, A.Dax, L. Hollberg, and A.G. Maki, Sub-Doppler Frequency Measurements on OCS near 1689 and 1885  $\text{cm}^{-1}$ , *J. Mol. Spec.*, 170, 75-81 (1995).

A.S. Zibrov, M.D. Lukin, D.E. Nikonov, L. Hollberg, M.O. Scully, V.L. Velichansky, and H.G. Robinson, Experimental Demonstration of Laser Oscillation Without Population Inversion via Quantum Interference in Rb, *Phys. Rev. Lett.*, 75 1499 (1995).

K.P. Petrov, S. Waltman, U. Simon, R.F. Curl, F.K. Tittel, E.J. Dlugokencky, and L. Hollberg, Detection of Methane in Air Using Diode-Laser-Pumped Difference-Frequency Generation near 3.2  $\mu\text{m}$ , *J. Opt. Soc. Am. B*, 61, 553-558 (1995).

A.S. Zibrov, M.D. Lukin, L. Hollberg, D.E. Nikonov, M.O. Scully, H.G. Robinson, and V.L. Velichansky, Experimental Demonstration of Enhanced Index of Refraction via Quantum Coherence in Rb, *Phys. Rev. Lett.* 76, 3935 (1996).

J.H. Marquardt, H.G. Robinson, and L. Hollberg, Lineshapes of Cascade Two-Photon Transitions in a Cesium Magneto-Optic Trap, *J. Opt. Soc. Am. B* 13, 1384-1393 (1996).

O. Pfister, M. Mürtz, Joseph S. Wells and L. Hollberg, Division by Three of Optical Frequencies Using Difference Frequency Generation in Non-Critically Phase-Matched RTA, *Opt. Lett.* 21, 1387 (1996).

V.V. Vasiliev, V.L. Velichianskii, M.L. Gorodetskii, V.S. Ilchenko, L. Hollberg, A.V. Yarovitskii, High-coherence diode laser with optical feedback via a microcavity with whispering gallery modes, *Quantum Electronics* 26, 657-658 (1996).

K.P. Petrov, S. Waltman, E.J. Dlugokencky, M. Arbore, M.M. Fejer, F.K. Tittel, L. Hollberg, Precise measurement of methane in air using diode-pumped 3.4 $\mu\text{m}$  difference-frequency generation in PPLN, *Appl. Phys. B* 64, 567-572 (1997).

O. Pfister, J.S. Wells, L. Hollberg, L. Zink, D.A. Van Baak, M.D. Levenson, and W.R. Bosenberg, CW Frequency Tripling and Quadrupling by Simultaneous Three-wave mixings in Periodically Poled Crystals, Application to a Two-step 1.19-10.71  $\mu\text{m}$  Frequency Bridge, *Optics Lett.* 22, 1211 (1997).

M.D. Lukin, M. Fleischauer, A.S. Zibrov, H.G. Robinson, V.L. Velichansky, L. Hollberg, and M.O. Scully, Spectroscopy in Dense Coherent Media: Line Narrowing and Interference Effects, *Phys. Rev. Lett.* 29, 2959 (1997).

M. Mürtz, J.S. Wells, L. Hollberg, T. Zibrova, N. Mackie, Extended-Cavity Grating-Tuned Operation of Mid-Infrared InAsSb Diode Lasers, *Appl. Phys. B*, 66, 277 (1998).

V.V. Vasiliev, V.L. Velichansky, V.S. Ilchenko, M.L. Gorodetsky, L. Hollberg, A.V. Yarovitsky, Narrow-line-width diode laser with a high-Q microsphere resonator, *Opt. Comm.* 158, 305-312 (1998).

J. Franzke, R.W. Fox, and L. Hollberg, Tunable UV generation at 283 nm by frequency doubling and sum frequency mixing of two semiconductor lasers for the detection of Pb, *Spectrochimica ACTA*, part B, **53**, 1951-1955 (1998).

M.M. Kash, V.A. Sautenkov, A.S. Zibrov, L. Hollberg, G.R. Welch, M.D. Lukin, Y. Rostovtsev, E.S. Fry, and M.O. Scully, Ultraslow Group Velocity and Enhanced Nonlinear Optical Effects in a Coherently Driven Hot Atomic Gas, *Phys. Rev. Lett.*, **82**, 5229-5232 (1999).

J. Kitching and L. Hollberg, Interference-Induced Optical Gain Without Population Inversion in Cold, Trapped Atoms, *Phys. Rev. A*, **59**, 4685-4689 (1999).

L. Gianfrani, R.W. Fox, and L. Hollberg, Cavity-Enhanced Absorption Spectroscopy of Molecular Oxygen, *J. Opt. Soc. Am. B*, 2247-2254 (1999).

C.W. Oates, F. Bondu, R.W. Fox and L. Hollberg, A Diode-Laser Optical Frequency Standard Based on Laser-Cooled Ca Atoms: Sub-kilohertz Spectroscopy by Optical Shelving Detection, *Eur. Phys. J., D* **7**, 449-460 (1999).

B. Frech, J.S. Wells, C.W. Oates, J. Mitchell, Yu-Ping Lan, T. Kurosu, L. Zink, L. Hollberg, T. Zibrova, B.C. Young, and J.C. Bergquist, Sub-Systems for Optical Frequency Measurements: Application to the 282 nm  $^{199}\text{Hg}^+$  Transition and the 657 nm Ca Line, *IEEE Trans. Ultrason., Ferroelect., Freq. Contr.*, **47**, 2 (2000).

N. Vukicevic, A.S. Zibrov, L. Hollberg, F.L. Walls, J. Kitching and H.G. Robinson, Compact Diode-Laser Based Rubidium Frequency Reference, *IEEE Trans. Ultrason. Ferroelect. and Freq. Control*, **47**, 1122-1126 (2000).

S. Römisch, J. Kitching, E. Ferrè-Pikal, L. Hollberg and F.L. Walls, Performance Evaluation of an Optoelectronic Oscillator, *IEEE Trans. Ultrason. Ferroelect. and Freq. Control*, **47**, 1159-1165, (2000).

D. Mazzotti, P. De Natale, G. Giusfredi, C. Fort, J.A. Mitchell, L.W. Hollberg, Difference-frequency generation in PPLN at 4.25  $\mu\text{m}$ : an analysis of sensitivity limits for DFG spectrometers, *Applied Phys. B*, **70**, 747-750 (2000).

C.W. Oates, E.A. Curtis, and L. Hollberg, Improved Short-Term Stability of Optical Frequency Standards: Approaching 1 Hz in 1 Second with the Ca Standard at 657 nm., *Optics Lett.* **25**, 1603-1605 (2000).

J. Kitching, S. Knappe, N. Vukičević, L. Hollberg, R. Wynands and W. Weidemann, "A microwave frequency reference based on VCSEL-driven dark line resonances in Cs vapor", *IEEE Trans. Inst. and Meas.*, **49**, 1313-1317 (2000).

K.R. Vogel, S.A. Diddams, C.W. Oates, E. A. Curtis, R.J. Rafac, W.M. Itano, J.C. Bergquist, R.W. Fox, W.D. Lee, J.S. Wells and L. Hollberg, "Direct comparison between two cold-atom-based optical frequency standards using a femtosecond-laser comb" *Optics Lett.*, **26**, 102-104 (2001).

Th. Udem, S.A. Diddams, K.R. Vogel, C.W. Oates, E.A. Curtis, W.D. Lee, W.M. Itano, R.E. Drullinger, J.C. Bergquist and L. Hollberg, "Absolute Frequency Measurements of the  $\text{Hg}^+$  and Ca Optical Clock Transitions with a Femtosecond Laser," *Phys. Rev. Lett.*, **86**, 4996-4999 (2001).

- S. Knappe, R. Wynands, J. Kitching, H.G. Robinson and L. Hollberg, "Characterization of coherent population-trapping resonances as atomic frequency references," *J. Opt. Soc. Am.* **B**, *18*, 1545-1553 (2001).
- J. Kitching, H.G. Robinson, L. Hollberg, S. Knappe and R. Wynands, "Optical Pumping Noise in Laser-Pumped All-Optical Microwave Frequency References," *J. Opt. Soc. Am.* **B**, *18*, 1676-1683 (2001).
- S.A. Diddams, Th. Udem, J.C. Bergquist, E.A. Curtis, R.E. Drullinger, L. Hollberg, W.M. Itano, W.D. Lee, C.W. Oates, K.R. Vogel, and D.J. Wineland, "An Optical Clock Based on a Single Trapped  $^{199}\text{Hg}^+$  Ion, *Science*, **293**, 825-828 (2001).
- E.A. Curtis, C.W. Oates and L. Hollberg, "Quenched narrow-line laser cooling of  $^{40}\text{Ca}$  to near the photon recoil limit," *Phys. Rev. A*, **64** 031403(R), (2001).
- J. Kitching, L. Hollberg, S. Knappe and R. Wynands, "Frequency-dependent optical pumping in atomic  $\Lambda$ -systems," *Optics Letts.*, **26**, 1507-1509 (2001).
- L. Hollberg, C.W. Oates, E. A. Curtis, E. N. Ivanov, S.A. Diddams, T. Udem, H.G. Robinson, J.C. Bergquist, R.J. Rafac, W.M. Itano, R.E. Drullinger, and D.J. Wineland, "Optical Frequency Standards and Measurements," *IEEE J. Quantum Electronics*, **37**, 1502-1513 (2001).
- J. Kitching, L. Hollberg, S. Knappe and R. Wynands, "A Compact Atomic Clock based on Coherent Population Trapping," *Electronics Lett.*, **37**, 1449-1451 (2001).
- A.S. Zibrov, A.B. Matsko, L. Hollberg and V.L. Velichansky, "Resonant enhancement of refractive index in a cascade scheme," *J. of Mod. Optics*, **49**, 359-365 (2002).
- Scott A. Diddams, L. Hollberg, Long-Sheng Ma and Lennart Robertsson, Femtosecond—laser-based optical clockwork with instability  $< 6.3 \times 10^{-16}$  in 1 s," *Optics Letts.*, **17**, 58-60 (2002).
- S. Knappe, J. Kitching, L. Hollberg, and R. Wynands, "Temperature Dependence of Coherent Population Trapping Resonances," *Appl. Phys.* **B**, *74*, 217-222 (2002).
- A.S. Zibrov, M.D. Lukin, L. Hollberg and M.O. Scully, "Efficient frequency up-conversion in resonant coherent media," *Phys. Rev. A*, **65**, 051801(R), pgs. 4, (2002).
- J. Kitching, S. Knappe and L. Hollberg, "Miniature Vapor-Cell Atomic-Frequency References," *Applied Phys. Letts.*, **81**, 553-555 (2002).
- M. Stahler, R. Wynands, S. Knappe, J. Kitching and L. Hollberg, A. Taichenachev and V. Yudin, "Coherent Population Trapping Resonances in Thermal  $^{85}\text{Rb}$  Vapor:  $D_1$  versus  $D_2$  Line Excitation", *Optics Letts.*, **27**, 1472-1474 (2002).
- T. Dennis, E. A. Curtis, C. W. Oates, S. Gilbert, and L. Hollberg, "Wavelength references for 1300-nm wavelength-division multiplexing", *J. of Lightwave Technology* **20**, 776 (2002).
- W. Fox and L. Hollberg, "The Role of Spurious Reflections in Ring-Down Spectroscopy," *Optics Letters*, Vol. **27**. 1833- (2002).

T.M. Ramond, S.A. Diddams, L. Hollberg, and A Bartels, "Phase-coherent link from optical to microwave frequencies by means of the broadband continuum from a 1-GHz Ti:sapphire femtosecond oscillator," *Optics Letts.* **27**, 1842-1844 (2002).

U. Tanaka, J.C. Bergquist, S. Bize, S.A. Diddams, R.E. Drullinger, L. Hollberg, W.M. Itano, C.E. Tanner, and D.J. Wineland, "Optical Frequency Standards Based on the  $^{199}\text{Hg}^+$  Ion," Special Issue on CPEM 2002, *IEEE Trans. Instrumen.Meas.*, **52**, 245-249 (2002).

E. A. Curtis, C. W. Oates, and L. Hollberg, "Quenched narrow-line second- and third-stage cooling of  $^{40}\text{Ca}$ ," *J. Opt. Soc. Am.* **B**, **20**, Special Issue on Laser Cooling, 977 (2003).

S. Knappe, V. Velichansky, H.G. Robinson, J. Kitching, and L. Hollberg, compact atomic vapor cells fabricated by laser-induced heating of hollow-core glass fibers," *Rev. Sci. Instr.* **74**, 3142-3145 (2003).

Isabell Thomann, Leo Hollberg, Scott A. Diddams, Randy Equall, "Chromium-Doped Forsterite: Dispersion Measurement with White-Light Interferometry" *Applied Optics-LP*, Vol. **42**, 1661- (2003).

S. Bize, S.A. Diddams, U. Tanaka, E.E. Tanner, W.H. Oskay, R.E. Drullinger, T.E. Parker, T.P. Heavner, S.R. Jefferts, L. Hollberg, W.M. Itano, and J.C. Bergquist, "Testing the Stability of Fundamental Constants with the  $^{199}\text{Hg}$  Single-ion Optical Clock," *Phys. Rev. Lett.*, 150802 (2003).

A. Bartels, S. A. Diddams, T. M. Ramond, L. Hollberg, "Mode-locked laser pulse trains with sub-femtosecond timing jitter synchronized to an optical reference oscillator," *Optics Letters*, vol. **28**, 663- (2003).

I. Thomann, A. Bartels, K.L. Corwin, N.R. Newbury, L. Hollberg, S.A. Diddams, "A 420 MHz Cr:Forsterite Femtosecond Ring Laser and Continuum Generation in the 1-2  $\mu\text{m}$  Range," *Optics Letts.*, vol. **28**, 1368-1370 (2003).

H. Schnatz, L. Hollberg, and J. Ye, "Optical Frequency Combs: From Frequency Metrology to Optical Phase Control," *IEEE J. of Special Topics in Quant. Elect.*, vol. **9**. 1041-1058 (2003).

E. N. Ivanov, Scott A. Diddams and L. Hollberg, Analysis of Noise Mechanisms Limiting the Frequency Stability of Microwave Signals Generated with a Femtosecond Laser, *IEEE J. Special Topics in Quantum Electronics*, vol. **9**, 1059-1065 (2003).

S.A. Diddams, A. Bartels, T.M. Ramond, C.W. Oates, S. Bize, E.A. Curtis, J.C. Bergquist and L. Hollberg, "Design and Control of Femtosecond Lasers for Optical Clocks and the Synthesis of Low Noise Optical and Microwave Signals," *IEEE J. Special Topics in Quantum Electronics*, vol. **9**, 1072-1080 (2003).

Jun Ye, Jin-Long Peng, R. Jason Jones, Kevin W. Holman, John L. Hall, David J. Jones, Scott A. Diddams, John Kitching, Sebastien Bize, James C. Bergquist, Leo W. Hollberg, Lennart Robertsson, Long-Sheng Ma, "Delivery of high-stability optical and microwave frequency standards over an optical fiber network," *JOSA B*, **20** 1459- (2003).

A.V. Taichenachev, A.M. Tumaikin, V.I. Yudin, M. Stahler, R. Wynands, J. Kitching, and L. Hollberg, "Non-linear-resonance line shapes: Dependence on the transverse intensity distribution of a light beam,"

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L. Liew, S. Knappe, J. Moreland, H.G. Robinson, L. Hollberg, and J. Kitching, "Microfabricated alkali atom vapor cells," Appl. Phys. Lett. **84**, 2694-2696 (2004).

A. Bartels, N.R. Newbury, I. Thomann, L. Hollberg, and S.A. Diddams, "Broadband phase-coherent optical frequency synthesis with actively linked Ti:sapphire and Cr:forsterite femtosecond lasers," Opt. Lett. **29**, 403-405 (2004).

S. Knappe, J. Kitching, and L. Hollberg Dark-line atomic resonances in submillimeter structures Opt. Lett., vol. **29**, 388-390 (2004).

A. Bartels, C.W. Oates, L. Hollberg, and S.A. Diddams "Stabilization of femtosecond laser frequency combs with subhertz residual linewidths," Opt. Lett. **29**, 1081-1083 (2004).

K.L. Corwin, I. Thomann, A. Bartels, T. Dennis, R.W. Fox, W.C. Swann, E.A. Curtis, C.W. Oates, G. Wilpers, S.L. Gilbert, L. Hollberg, N.R. Newbury, S.A. Diddams, J. Nicholson, and M.F. Yan, "Absolute-frequency measurements with a stabilized near-infrared optical frequency comb from a Cr:forsterite laser," Opt. Lett., **29**, 397-399 (2004).

L-S Ma, Z. Bi, A. Bartels, L. Robertsson, M. Zucco, R.S. Windeler, G. Wilpers, C.W. Oates, L. Hollberg, and S.A. Diddams, "Optical frequency synthesis and comparison at the  $10^{-19}$  level," Science, **303** 1843-1845 (2004).

S. Knappe, V. Shah, P.D. Schwindt, L. Hollberg, J. Kitching, L. Liew, and J. Moreland A microfabricated atomic clock Appl. Phys. Lett., **85**, 1460-1462 30-AUG-04

S. Kargapol'tsev, J. Kitching, L. Hollberg, A.V. Taichenachev, V.L. Velichanski, and V.I. Yudin, "High-contrast dark resonances in  $\sigma^+$  -  $\sigma^-$  optical field", Laser Phys. Lett., **1**, 495-499 01-OCT-04

V. Gerginov, C.E. Tanner, S.A. Diddams, A. Bartels, and L. Hollberg Optical frequency measurements of  $^{68}\text{S}_{1/2}$  -  $^{69}\text{P}_{3/2}$  transition in  $^{133}\text{Cs}$  Atomic beam using a femtosecond laser frequency comb, Phys. Rev. A., **70**, 042505(8) 20-OCT-04

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P. Schwindt, S. Knappe, V. Shah, L. Hollberg, J. Kitching, L. Liew and J. Moreland Chip-scale atomic magnetometers, Appl. Phys. Lett., **85**, 6409-6411 27-DEC-04

R.W. Fox, S.A. Diddams, A. Bartels, and L. Hollberg Optical frequency measurements with the global positioning system: tests with iodine-stabilized HeNe-laser, Appl. Opt., **44** 113-120 01-JAN-05

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A. Bartels, S.A. Diddams, C.W. Oates, G. Wilpers, J.C. Bergquist, W.H. Oskay, and L. Hollberg Femtosecond-laser-based synthesis of ultrastable microwave signals from optical frequency references, *Opt. Lett.*, **30** 667-669, 2005.

S. Knappe, P. Schwindt, V. Shah, L. Hollberg, J. Kitching, L. Liew, and J. Moreland A chip-scale atomic clock based on  $^{87}\text{Rb}$  with improved frequency stability *Opt. Express.* 13 1249-1253 21-FEB-05

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