Vita

Thad G. Walker
Professor of Physics, University of Wisconsin-Madison

Education

Ph.D., Physics, Princeton University, 1988.
M.A., Physics, Princeton University, 1986.
B.S. (Summa cum Laude), Physics, Abilene Christian University, 1983.

Professional and Research Experience

May 1997-Present: Professor, University of Wisconsin-Madison
May 1993-May1997: Associate Professor, University of Wisconsin-Madison.
Aug. 1990-May 1993: Assistant Professor, University of Wisconsin-Madison.
Sept. 1988-Aug. 1990: Research Associate, JILA.
Jan. 1988-Aug. 1988: Research Associate, Princeton University.

Awards

2000 Vilas Associate Award, University of Wisconsin-Madison
1999 Fellow, American Physical Society, *For pioneering research in spin exchange, optical pumping, ultracold collisions, spin polarized beams and targets, laser cooling, and electron scattering.*
1996 H. I. Romnes Fellowship, University of Wisconsin-Madison
1992 Packard Fellowship in Science and Engineering
1992 National Science Foundation Young Investigator Award
1991 Alfred P. Sloan Fellowship Award
1983 Fred J. Barton Award, Abilene Christian University.

Research Interests:

Spin-exchange optical pumping; Biomagnetometry; Laser cooling and trapping of atoms; Quantum computation with atoms .

Publications

In Refereed Journals: ~ 75.
Review Articles: "Measurements of Collisions Between Laser-Cooled Atoms", *Advances in Atomic, Molecular, and Optical Physics*; "Spin-Exchange Optical Pumping of Noble-Gas Nuclei", *Reviews of Modern Physics.*

Patents

Frequency-Narrowed High Power Diode Laser Array Method and System, co-inventors I. Nelson and B. Chann, U. S. patent #6,584,133
Frequency-Narrowed High Power Diode Laser System with External Cavity, co-inventors I. Nelson and B. Chann, U. S. patent #6,868,099

National Committee Service:

1999-2002: Chair, APS DAMOP Education Committee.

1997-2001: APS DAMOP Executive Committee, Program Committee, Education Committee.

1997 Member, NSF Physics Division Committee of Visitors.

1996-1999: Executive Committee, Gaseous Electronics Conference.

1996-7: Secretary, 50th Gaseous Electronics Conference.

1997-2000: NIST Precision Measurements Grants Committee.

2000-2003: NRC Panel, NIST Physics Division. Chair, Atomic Physics Panel.

2005 Chair, DLS Nomination Committee.

2003-5: DAMOP Program Committee.

2006-7 DAMOP Nomination Committee, Chair.

Advisees

Ph. D.s (10): D. Hoffmann (1996), P. Feng (1996), R. Williamson (1997), R. Nesnidal (1999), S. Kadlecek (1999), I. Nelson (2001), B. Chann (2003), R. Newell (2003), J. Sebby-Strabley (2004), E. Babcock (2005).

Current Students: J. Day, E. Urban, T. Henage, E. Brekke, B. Wyllie, B. Lancor, P. Cook

Postdoctoral Advisees: J. Tobiason, S. Bali, R. S. Schappe, C. Sukenik, S. Kadlecek, P. Kulatunga, D. Yavuz, M. Delaney, Z. Li.

Research Summary

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Laser Trapping and Cooling of Atoms

Beginning in the late 1980's, methods to use laser light to cool and confine atoms at unprecedented temperatures (typically 10 μK and below) have made a dramatic impact on atomic physics, resulting in two Nobel Prizes in the last 10 years. Laser cooled atoms are now used for a wide variety of studies, a few examples being Bose-Einstein condensation, atomic clocks, ultrasensitive isotope detection, ultracold collisions, and quantum information processing. Some of the contributions of Prof. Walker and his group are:

- First atom trap built using diode lasers (Pub. #12)
- Discovery and explanation of light-induced collective phenomena in traps (Pub. #14)
- Invention and demonstration of vortex-force trapping (Pub. #16)
- Invention and demonstration of spin-polarized trapping of atoms. (Pub. #19)
- First quantitative lineshape studies of intensity correlations of light emitted by trapped atoms. (Pub. #34)
- Developed method for quantitatively measuring the depth of laser traps (Pub. #36)
- Demonstration of funnel-loaded trap (Pub. #44)
- First applications of trapped atoms as target for scattering experiments. (Pub. # 30,37)
- New concepts in single atom, single photon sources (Pub. # 62)
- Demonstration of non-destructive spatial heterodyne imaging of trapped atoms (Pub. #52)
- Record trapped-atom densities in Holographic Atom Trap(Pub. # 64,69)
- High fidelity, low cross-talk quantum manipulation of atoms in an array of traps (Pub. #76)

Ultracold Collisions of Laser-Cooled Atoms

Ultracold collisions are uniquely sensitive to long-range interatomic forces, the presence of weak light fields, and interruption of the collision dynamics by spontaneous emission of light. They are also important because they limit the performance of traps. Accomplishments in this area include:

- First demonstration of light-sensitivity of ultracold collisions (Pub. #12)[1]
- Demonstration of importance of hyperfine interactions on the collision dynamics (Pub. # 18,20,24).
- First quantitative confirmation of any aspect of ultracold collision models, and demonstration that hyperfine structure complications can be minimized. (Pub. #25)
- First published experimental evidence for Landau-Zener excitation model for ultracold collisions. (Pub. #34)
- Use of repulsive trap-loss collisions to measure trap depths. (Pub. #36)
- First quantitative studies of two-photon ultracold collision dynamics, including discovery of population depletion. (Pub. #42)
- Quantitative scaling of second-order spin-orbit matrix elements to relate observed spin-relaxation rates at ultracold and high temperatures. (Pub. #43)
- Discovery of light-intensity dependence of spin-exchange collisions. (Pub. #49)
- Major review article on ultracold collisions. (Pub. #29)

[1] Publication numbers refer to the publication list on pages 5–9.

Optical Pumping

Spin-Exchange Optical Pumping is an important method for producing spin polarized samples of atoms and nuclei for magnetic-resonance imaging, polarized ion beams for accelerators, and targets for scattering experiments. Circularly-polarized laser light is absorbed by alkali atoms, and the resulting angular momentum is then transferred to other atoms via collisions. This allows the large amounts of angular momentum present in laser light to be moved to species that do not interact with laser light. In the particular case of He nuclei the angular momentum can be stored for times up to several weeks without significant degradation. The key issues facing this field include: 1) the development of specialized lasers for production of large quantities of high quality laser light; 2) understanding the processes that remove angular momentum from the atoms; 3) integrating spin-exchange devices with applications such as MRI machines, high-energy accelerators, and neutron sources. Major contributions include:

- Origin of spin-rotation interaction in alkali–noble-gas molecules (Pub # 2, 39).
- Reliable estimates of spin-exchange and spin-relaxation rates (Pub. #13).
- Prediction (subsequently experimentally confirmed by groups at Argonne and Erlangen) of nuclear polarization of H and D atoms by spin-exchange at high fields. (Pub. #21)
- Discovery, and partial explanation, of magnetic-field dependence of alkali-alkali spin-relaxation rates due to triplet dimer formation (Pub # 41, 51)
- Invention of new narrow-band high power laser sources (Pub #48, 50, 66).
- Discovery of Xe-Xe molecular spin relaxation (Pub. #58)
- State-of-the-art measurements of spin-relaxation rates. ((Pub. #57), (Pub. #59))
- Hybrid spin-exchange optical pumping. Improves efficiency of spin-exchange by factor of 10. (Pub. #65)
- Discovery of 'X-factor' polarization limits of Rb-^{3}He. (Pub. #75)
- Major review article on spin-exchange optical pumping. (Pub. #38)
- Novel method for atomic magnetometry (Pub. #77)