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**Degrees:**

Ph. D., 1994, University of California at Berkeley;  
M. Sc., 1991, University of Chicago;  
B. Sc., 1987, University of Science and Technology of China.

**Appointments:**

2007 – Present, Senior Scientist, Argonne National Laboratory;  
2004 – Present, Professor (part-time), University of Chicago;  
2000 – 2007, Scientist, Argonne National Laboratory;  
1997 – 2000, Assistant Scientist, Argonne National Laboratory;  
1994 – 1997, Research Associate, JILA, University of Colorado.

**Research Interests:**

Low-energy search for physics beyond the Standard Model;  
Ultrasensitive trace-isotope analysis;  
Laser spectroscopy of exotic atoms.

**Honors:**

Fellow, American Physical Society (2006);  
Guest Professor, University of Science and Technology of China (2005-2008);  
U. S. Presidential Early Career Award for Scientists and Engineers (2000);  
U. S. DOE Office of Science Early Career Scientist and Engineer Award (2000).

**Professional Service and Association:**

Co-chair, Local Organizing Committee of the 2007 Town Meetings for NSAC Long Range Plan;  
Member and Councilor-at-large, Overseas Chinese Physics Association, 2007;  
Member, Committee on Membership, American Physical Society, 2005 - 2007;  
Member, American Physical Society, 1990 – Present.

## Research Projects:

### Testing time-reversal symmetry in atoms and nuclei

We are searching for a permanent electric-dipole moment (EDM) of the  $^{225}\text{Ra}$  ( $t_{1/2} = 15$  d) atom. A positive finding would signify the violation of time-reversal symmetry (T) and the charge-parity symmetry (CP). While the CKM mechanism in the Standard Model gives rise to a negligible EDM, extensions to the Standard Model such as supersymmetry (SUSY) generally predict a relatively large EDM within the reach of this experiment. Therefore, this experiment provides an outstanding opportunity to search for new physics beyond the Standard Model. The  $^{225}\text{Ra}$  nucleus is an especially good case because it has the characteristics of octupole deformation, which leads to large enhancements of the T-violating Schiff moment. The overall scheme is to cool and trap  $^{225}\text{Ra}$  atoms in a magneto-optical trap, transfer the trapped  $^{225}\text{Ra}$  atoms to an optical dipole trap, and perform EDM measurements. We have succeeded in realizing laser trapping and cooling of radium atoms (both  $^{226}\text{Ra}$  and  $^{225}\text{Ra}$ ) for the first time. At present, we are developing the techniques and apparatus needed for the EDM measurements with cold  $^{225}\text{Ra}$  atoms.

- J.R. Guest *et al.*, Phys. Rev. Lett. **98**, 093001 (2007);
- AIP Physics News Update, [Number 812](#) (2007).

### Radio-krypton dating

The Atom Trap Trace Analysis (ATTA) method developed by our group has revolutionized our ability to measure radiokrypton isotopes,  $^{81}\text{Kr}$  ( $t_{1/2} = 2.3 \times 10^5$  years, isotopic abundance  $\sim 1 \times 10^{-12}$ ) and  $^{85}\text{Kr}$  ( $t_{1/2} = 10.8$  yr, I.A.  $\sim 10^{-11}$ ), in samples of natural material. This in turn opens the door to a wide range of new applications in the Earth sciences.  $^{81}\text{Kr}$  measurements of groundwater samples from the Nubian Aquifer in the Western Desert of Egypt showed residence times approaching one million years. At present, we are developing the next-generation instrument, ATTA-3, with a much higher efficiency. In collaboration with geologists, we plan to apply ATTA-3 to a wide range of studies in groundwater and glacial ice.

- N. C. Sturchio *et al.*, Geophys. Res. Lett. **31**, L05503 (2004);
- C.Y. Chen *et al.*, Science **286**, 1139 (1999);
- AIP Physics News Update, [Number 679](#) (2004).

### Studying exotic nuclear structure

Helium-8 ( $^8\text{He}$ ) is the most neutron-rich matter that can be synthesized on earth: it consists of two protons and six neutrons, and remains stable for an average of 0.2 seconds. Because of its intriguing properties,  $^8\text{He}$  has the potential to reveal new aspects of the fundamental forces among the constituent nucleons. We have recently succeeded in laser trapping and cooling this exotic helium isotope and have performed precision laser spectroscopy on individual trapped atoms. Based on atomic frequency differences measured along the isotope chain  $^3\text{He} - ^4\text{He} - ^6\text{He} - ^8\text{He}$ , the nuclear charge radius of  $^8\text{He}$  has been determined for the first time. The result can now be compared with the values predicted by a number of nuclear structure calculations and is testing their ability to characterize this loosely-bound halo nucleus.

- P. Mueller *et al.*, Phys. Rev. Lett. **99**, 252501 (2007);
- L.-B. Wang *et al.*, Phys. Rev. Lett. **93**, 142501 (2004);
- AIP Physics News Update, [Number 851](#) (2007).

### Invited Publications:

Atom Trap, krypton-81, and the groundwater underneath the Sahara Desert

X. Du and Z.-T. Lu

Physics (a magazine published by the Chinese Physical Society), Vol. **34**, 408 (2005)

Searches for stable strangelets in ordinary matter: overview and a recent example

Z.-T. Lu, R. J. Holt, P. Müller, T. P. O'Connor, J. P. Schiffer, L.-B. Wang

Nuclear Physics **A754**, 361c (2005)

Tracing Noble Gas Radionuclides in the Environment

P. Collon, W. Kutschera and Z.-T. Lu

Annual Review of Nuclear and Particle Science, Vol. **54**, 39 (2004)

Laser-Based Methods for Ultrasensitive Trace-Isotope Analyses (*Feature review article*)

Z.-T. Lu and K.D.A. Wendt

Review of Scientific Instruments **74**, 1169 (2003)

Atom Trap Trace Analysis

Z.-T. Lu

*McGraw-Hill 2002 Yearbook of Science and Technologies* (2002)

Atom Trap Trace Analysis

Z.-T. Lu, K. Bailey, C.Y. Chen, X. Du, Y.-M. Li, T.P. O'Connor, L. Young

*Atomic Physics 17*, edited by E. Arimondo, P. DeNatale and M. Inguscio (AIP, 2001)

### Contributed Publications:

Nuclear charge radius of  $^8\text{He}$

P. Mueller, I.A. Sulai, A.C.C. Villari, J.A. Alcantara-Nunez, R. Alves-Conde, K. Bailey, G.W.F. Drake, M. Dubois, C. Eleon, G. Gaubert, R.J. Holt, R.V.F. Janssens, N. Lecesne, Z.-T. Lu, T.P. O'Connor, M.-G. Saint-Laurent, J.-C. Thomas, L.-B. Wang

Physical Review Letters **99**, 252501 (2007)

Laser-trapping of Ra-225 and Ra-226 with repumping by room-temperature blackbody radiation

J.R. Guest, N.D. Scielzo, I. Ahmad, K. Bailey, J. P. Greene, R.J. Holt, Z.-T. Lu, T.P. O'Connor, and D.H. Potterveld

Physical Review Letters **98**, 093001 (2007)

A thermal beam of metastable krypton atoms produced by optical excitation

Y. Ding, S.-M. Hu, K. Bailey, A. M. Davis, R. W. Dunford, Z.-T. Lu, T. P. O'Connor, L. Young

Review of Scientific Instruments **78**, 023103 (2007)

Fine structure of the  $1s3p\ ^3P_j$  level in atomic  $^4\text{He}$ : theory and experiment

P. Mueller, L.-B. Wang, G.W.F. Drake, K. Bailey, Z.-T. Lu, T.P. O'Connor

Physical Review Letters **94**, 133001 (2005)

Laser spectroscopic determination of the  $^6\text{He}$  nuclear charge radius

L.-B. Wang, P. Mueller, K. Bailey, G.W.F. Drake, J.P. Greene, D. Henderson, R.J. Holt, R.V.F. Janssens, C.L. Jiang, Z.-T. Lu, T.P. O'Connor, R.C. Pardo, K.E. Rehm, J.P. Schiffer, and X.D. Tang

Physical Review Letters **93**, 142501 (2004)

One million year old groundwater in the Sahara revealed by krypton-81 and chlorine-36

N. C. Sturchio, X. Du, R. Purtschert, B. E. Lehmann, M. Sultan, L. J. Patterson, Z.-T. Lu, P. Mueller, K. Bailey, T. P. O'Connor, L. Young, R. Lorenzo, B. M. Kennedy, M. van Soest, Z. El Alfy, B. El Kaliouby, Y. Dawood, and A. M. A. Abdallah

Geophysical Research Letters **31**, L05503 (2004)

Counting individual  $^{41}\text{Ca}$  atoms with a Magneto-Optical Trap

I. D. Moore, K. Bailey, J. Greene, Z.-T. Lu, P. Mueller, T. P. O'Connor, Ch. Geppert, K. D. A. Wendt, L. Young

Physical Review Letters **92**, 153002 (2004)

Search for anomalously heavy isotopes of helium in the Earth's atmosphere

P. Mueller, L.-B. Wang, R. J. Holt, Z.-T. Lu, T. P. O'Connor, and J. P. Schiffer

Physical Review Letters **92**, 022501 (2004)

A new method of measuring  $^{81}\text{Kr}$  and  $^{85}\text{Kr}$  abundances in environmental samples

X. Du, R. Purtschert, K. Bailey, B. E. Lehmann, R. Lorenzo, Z.-T. Lu, P. Mueller, T. P. O'Connor, N.C. Sturchio, and L. Young

Geophysical Research Letters **30**, 2068 (2003).

Ultrasensitive isotope trace analyses with a magneto-optical trap

C.Y. Chen, Y.M. Li, K. Bailey, T.P. O'Connor, L. Young, Z.-T. Lu

Science **286**, 1139 (1999)

Efficient collection of  $^{221}\text{Fr}$  atoms into a vapor cell magneto-optical trap

Z.-T. Lu, K.L. Corwin, K.R. Vogel, C.E. Wieman, T.P. Dinneen, J. Maddi and H. Gould

Physical Review Letters, **79**, 994 (1997)

Low-velocity intense source of atoms from a magneto-optical trap

Z.-T. Lu, K.L. Corwin, M.J. Renn, M.H. Anderson, E.A. Cornell, and C.E. Wieman

Physical Review Letters, **77**, 3331 (1996)

Laser trapping of short-lived radioactive isotopes

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**, 3792 (1994)

## Invited Talks, Seminars, Colloquia

**2008**

*Simple atom, Extreme Nucleus: Laser Trapping and Probing of Helium-8*

Physics Department Colloquium, University of Chicago, February 2008.

**2007**

*Atom Trap, Krypton-81, and Saharan Water*

Physics Department Colloquium, University of Connecticut, January 2007;

American Physical Society Spring Meeting, Jacksonville, FL, April 2007;

Atomic Physics Division Seminar, NIST, Gaithersburg, September 2007;

Physics Department Colloquium, University of Tennessee, November 2007.

*Laser trapping and probing of exotic helium atoms*

TUNL Seminar, Duke University, April 2007;

APS Fall Meeting of the Division of Nuclear Physics, Newport News, VA, October 2007;

Institute of Nuclear Theory Workshop, University of Washington, May 2007;  
Physics Division Seminar, Oak Ridge National Laboratory, November 2007;  
Nuclear Physics Seminar, University of Notre Dame, November 2007.

*Search for the Nuclear Schiff Moment of Radium-225*

Gordon Research Conference on Nuclear Physics, July 2007;

*Rare-Isotope Cold Atom Physics*

Summer School of National Science Foundation of China, Shanghai, August 2007.

**2006**

*Atom Trap, Krypton-81, and Saharan Water*

Physics Department Colloquium, University of Kentucky, January 2006;  
Physics Department Colloquium, Michigan State University, September 2006;  
Seminar, GANIL, Caen, France, November 2006;

*Laser trapping of radium-225 atoms and progress towards an electric dipole moment measurement*

The 5<sup>th</sup> joint meeting of Chinese physicists worldwide (OCPA5), Taipei, Taiwan, June 2006;  
The 2<sup>nd</sup> International Symposium on Cold Atom Physics (ISCAP-2), Qindaohu, China, July 2006;  
Seminar, University of Mainz, Germany, November 2006;

*Laser trapping and probing of exotic helium atoms*

High Energy Physics Seminar, University of Chicago, March 2005;

*Helium: probing the exotic and search for the strange*

Schiffer Symposium, Argonne National Laboratory, September 2006;

*Time reversal, halo nuclei, and Saharan water – many uses of cold, radioactive atoms*

Kolloquium, GSI, Darmstadt, Germany, November 2006.

**2005**

*Atom Trap, Krypton-81, and Saharan Water*

Physics Department Colloquium, University of California at Berkeley, February 2005;  
Seminar, Indiana University Cyclotron Facility, April 2005;  
Seminar, National Laboratory for Physical Science at Micro-Scale, Univ of Science and Technology of China, Hefei, China, July 2005;  
Colloquium, Fermi Lab, August 2005;  
Seminar, University of Florence, Italy, September 2005;  
Physics Colloquium, Kansas State University, September 2005;  
Atomic Physics Seminar, University of Michigan, September 2005;  
Physics Colloquium, University of Maryland, October 2005;  
Physics Colloquium, University of New Brunswick, October 2005.

<sup>81</sup>*Kr-Dating: From dream to practice*

The 15th Annual Goldschmidt Conference, Moscow, Idaho, May 2005;  
Nuclear Physics Divisional Meeting of the European Physical Society, Pavia, Italy, September 2005;

*Laser trapping and probing of exotic helium atoms*

Nuclear Science Division Colloquium, Lawrence Berkeley National Laboratory, February 2005;  
Gordon Research Conference on Nuclear Structure, New London, NH, June 2005;  
Physics Lab Seminar, National Institute of Standards and Technology, Gaithersburg, October 2005.