

**Physics 250**

**Selected Topics  
in Atomic Physics**

**The Reader**

**Berkeley, Spring 2000**

## Preface

The articles in this Reader include reviews (including a number of Nobel lectures) on the topics that will be covered in class, several detailed research papers, and in some cases (e.g. parity nonconservation and Bose-Einstein condensation), also the original "discovery papers." In one case (light-induced drift), we included a paper containing the original proposal for the effect. These papers are intended to give a glimpse of the intellectual excitement that has persisted in our field of experimental atomic physics at least as long as either of us can remember...

The following pages list the contents of the Reader (highlighted), as well as suggestions for additional reading/reference. In some cases, lecture notes precede the reprints for a given topic. These are intended to give a brief "plain language" summary of the principal ideas that are developed in detail in the papers.

Additional references, links to electronic publications and relevant web sites, homework problems, solutions, etc. can be found on the course web site:

<http://phylabs.berkeley.edu/Physics250/> .

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## Contents and Additional References

(Highlighted items are included in the Reader)

### Geonium

1. Hans Dehmelt, "Experiments with an isolated subatomic particle at rest," in *Atomic Physics 12*, J.C. Zorn and R. R. Lewis, Eds., AIP, New York, 1991, pp. 28-46.
2. "Stored Ion Spectroscopy - Three Lectures", Hans Dehmelt, in *Advances in Laser spectroscopy*, F. T. Arecchi, F. Strumia & H. Walther, Eds., Plenum, New York, 1983.
3. H. Dehmelt, "Less is More: Experiments With An Individual Atomic Particle At Rest In Free Space, *Am. J. Phys.* **58**, 17-27 (1990).
4. Van Dyck, Jr., R. S., Schwinberg, P. B. & Dehmelt, H. G., "Electron Magnetic Moment from Geonium Spectra: Early Experiments and Background Concepts" *Phys. Rev. D* **34**, 722-736 (1986).
5. Brown, L.S.; Gabrielse, G., "Geonium theory: physics of a single electron or ion in a Penning trap," *Reviews of Modern Physics*, vol.58, (no.1), Jan. 1986. p.233-313.

### Cooling and trapping

0. Lecture notes: Laser cooling - some very basic ideas.
1. C. N. Cohen-Tannoudji and W. D. Phillips, "New mechanisms for laser cooling," *Physics Today*, October 1990, pp. 33-40.
2. S. Chu, "The manipulation of neutral particles" (Nobel lecture) *Rev. Mod. Phys.* **70**, 685-706 (1998).
3. C. N. Cohen-Tannoudji, "Manipulating atoms with photons" (Nobel lecture), *Rev. Mod. Phys.* **70**, 707-720 (1998).
4. W. D. Phillips, "Laser cooling and trapping of neutral atoms" (Nobel lecture) *Rev. Mod. Phys.* **70**, 721-742 (1998).
5. deCarvalho, R.; Doyle, J.M.; Friedrich, B.; Guillet, T.; Kim, J.; Patterson, D.; Weinstein, J.D. "Buffer-gas loaded magnetic traps for atoms and molecules: a primer." *European Physical Journal D* **7**(3), 289-309, (1999).

### Cooling and trapping videos in the physics library:

1. Chu, Steven. **Laser cooling and trapping**. 1990.
2. Chu, Steven. **Laser cooling, trapping and the applications to atom interferometry, quantum gases & biology**. 1992.
3. Cohen-Tannoudji, Claude. **Ultracold atoms**. 1994.
4. Chu, Steven. **The laser cooling and trapping of atoms and biomolecules**. 1998.
5. Weiss, David S. **Using the atomic photon recoil to measure itself**. 1994.
6. Weiss, David S. **Experiments with atoms in optical lattices**. 1999.
7. Doyle, John. **Magnetic trapping of atoms and neutrons: new techniques, new physics**. 1997.
8. Doyle, John. **Magnetic trapping of molecules**. 1999.

### Bose-Einstein Condensation

1. *Bose-Einstein Condensation*. A. Griffin, D. W. Snoke, and S. Stringari, eds. Cambridge University Press, Cambridge, 1996.

2. M. H. Anderson, J. R. Ensher, M. R. Matthews, C. E. Wieman, and E. A. Cornell, "Observation of Bose-Einstein condensation in a dilute atomic vapor," *Science* **269**, 198-201 (1995).
3. M.R. Andrews et al, "Observation of interference between two Bose condensates," *Science* **275**, pp. 637-641 (1997).
4. D. G. Fried, T. C. Killian, L. Willmann, D. Landhuis, S. C. Moss, D. Kleppner, T. J. Greytak, "Bose-Einstein condensation of atomic hydrogen," *Phys. Rev. Lett.*, **81**(18), p.3811-14 (1998).
5. *Physics Today* **52**(12), 30-42 (1999). Special Focus: W. Ketterle, "Experimental Studies of Bose-Einstein Condensation;" K. Burnett, M. Edwards, and C. W. Clark, "The Theory of Bose-Einstein Condensation of Dilute Gases."
6. <http://amo.phy.gasou.edu/bec.html/> (This page contains online versions of dozens of BEC papers, and complete BEC bibliography).

### **BEC videos in the physics library:**

1. Cornell, Eric. **Bose-Einstein condensation in a dilute atomic gas**. 1995.
2. Cornell, Eric. **Getting to Bose condensation in an atom trap**. 1991.
3. Ketterle, Wolfgang. **When atoms behave as waves Bose-Einstein condensation and the atom laser**. 1997.
4. Rokhsar, Daniel. **Bosons, bosons, bosons condensation, vortices, and superfluidity in confined bose gases**. 1997.
5. Kleppner, Daniel. **Bose-Einstein condensation of atomic hydrogen**. 1999. 1 videocassette (61 min.)

### ***Parity and time reversal invariance violation***

1. D. Budker, "Parity Nonconservation in Atoms," in: *Physics Beyond the Standard Model, proceedings of the Fifth International WEIN Symposium*, P. Herczeg, C. M. Hoffman, and H. V. Klapdor-Kleingrothaus, eds. World Scientific, 1999; pp.418-441.
2. L. M. Barkov and M. S. Zolotarev, "Observation of parity nonconservation in atomic transitions," *Phys. Lett.* **27**(6), 357-361 (1978).
3. R. Conti, P. Bucksbaum, S. Chu, E. D. Commins, and L. Hunter, "Preliminary observation of parity nonconservation in atomic thallium," *Phys. Rev. Lett.* **42**(6), 343-6 (1979).
4. E. D. Commins, S. B. Ross, D. DeMille, and B. C. Regan, "Improved experimental limit on the electric dipole moment of the electron," *Phys. Rev. A* **50**(4), 2960-77 (1994).
5. J. P. Jacobs, W. M. Klipstein, S. K. Lamoreaux, B. R. Heckel, and E. N. Fortson, "Limits on the electric-dipole moment of  $^{199}\text{Hg}$  using synchronous optical pumping," *Phys. Rev. A* **52**(5), 3521-40 (1995).

### **P-, P&T-nonconservation videos in the physics library:**

1. Wu, Chien-shiung. **The discovery of non-conservation of parity in beta-decay**. 1988.
2. Commins, Eugene D. **Search for the electric dipole moment of the electron**. 1990.
3. Wieman, Carl E. **Tev physics on an eV budget measurement of parity nonconservation in atomic cesium**. 1991.
4. Commins, Eugene D. **New results in the search for the electron electric dipole moment**. 1994.

5. Budker, Dmitry. **Parity violation in rare earth atoms**. 1995.
6. Fortson, E. Norval. **Using atoms to probe the particle physics frontier precise measurements of parity violation and tests of time reversal symmetry**. 1996.

### ***Light-induced drift***

0. Lecture notes: Light-induced drift.
1. F. Kh. Gel'mukhanov and A. M. Shalagin, "Light-induced diffusion of gasses," *JETP Lett.* **29**(12), 711 (1979).
2. H. G. C. Werij and J. P. Woerdman, "Light-induced drift of Na atoms," *Phys. Reports* **169**(3), 145 (1988). **For the Reader, need pp. 146-158, 179-189, 206-208.**
3. S. N. Atutov and A. M. Shalagin, "On some possible manifestations of light-induced drift phenomenon in astrophysical objects," in *Spectral Line Shapes v. 5*, J. Szudy, ed. North Holland, Amsterdam, 1988, pp. 777-787.

### ***Coherent population transfer, electromagnetically induced transparency (EIT)***

0. Lecture notes: two-and three-level systems, Rabi oscillations, adiabatic transfer and all that.
1. B.W. Shore, *The theory of coherent atomic excitation*, Wiley, New York, 1990, v.1-2. QC454.A8 S47 1990.
2. R. B. Vrijen et al, "Adiabatic population transfer in multiphoton processes," *Comments At. Mol. Phys.* **33**(2), 66 (1996).
3. K. Bergmann, H. Theuer, and B. W. Shore, "Coherent population transfer among quantum states of atoms and molecules," *Rev. Mod. Phys.* **70**, 1003-1026 (1998).
4. S. E. Harris, "Electromagnetically induced transparency," *Physics Today* **50**(7), 36-42 (1997).
5. A. Kasapi, "Three-dimensional vector model for a three-state system," *J. Opt. Soc. Am. B* **13**(7), 1347-51 (1996).

### ***High resolution spectroscopy, nonlinear magneto-optics***

1. D. Budker, D. J. Orlando, and V. Yashchuk, "Nonlinear Laser Spectroscopy and Magneto-Optics;" *Am. J. Phys.* **67**(7), 584 (1999).

### ***Atomic physics tests of quantum mechanics***

1. J. J. Bollinger, D. J. Heinzen, W. M. Itano, S. L. Gilbert, and D. J. Wineland, in *Atomic Physics 12*, J.C. Zorn and R. R. Lewis, Eds., AIP, New York, 1991, pp. 461-480.
2. S. K. Lamoreaux, "A review of the experimental tests of quantum mechanics." *International Journal of Modern Physics A* **7**(27), pp.6691-762. (1992).
3. S. J. Freedman and J. F. Clauser, "Experimental test of local hidden-variable theories," *Phys. Rev. Lett.* **28**(14), pp. 938-41 (1972).