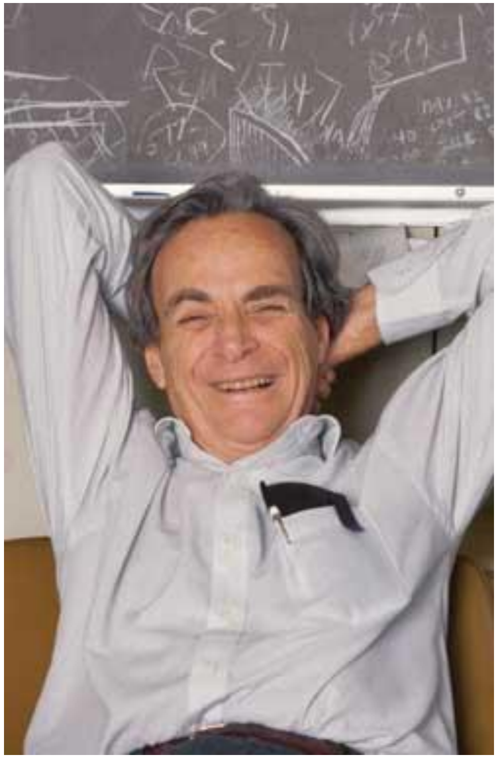
Can we build individual molecules atom by atom?

Lecture 3



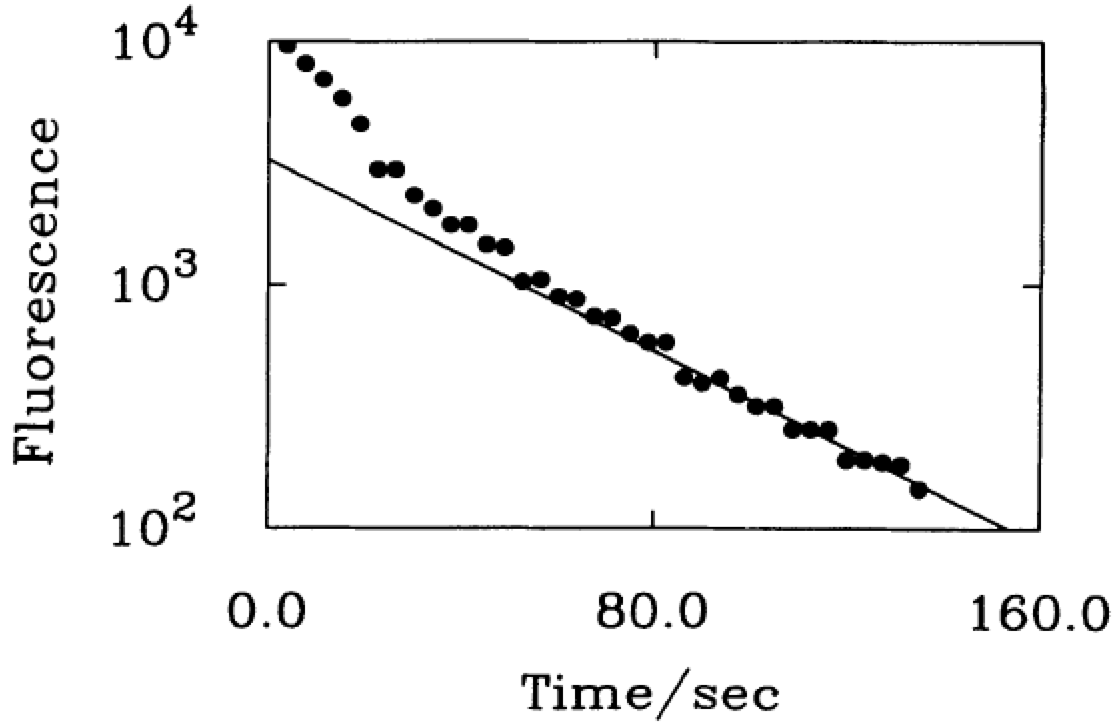
Yesterday we

- Talked about basic molecular physics
- Found that di-atomic molecules are indeed physics
- Talked about the molecular dipole operator

A bit of history

Trapping of Neutral Sodium Atoms with Radiation Pressure

E. L. Raab,[a] M. Prentiss, Alex Cable, Steven Chu,[b] and D. E. Pritchard[a]
AT&T Bell Laboratories, Holmdel, New Jersey 07733
(Received 16 July 1987)



The follow up

Atomic-density-dependent losses in an optical trap

M. Prentiss, A. Cable, J. E. Bjorkholm, and Steven Chu*

AT&T Bell Laboratories, Holmdel, New Jersey 07733

E. L. Raab and D. E. Pritchard

Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Received January 10, 1988; accepted March 10, 1988

We have observed that two-body collisions between cold sodium atoms confined within a magnetic-molasses optical trap lead to significant atomic-density-dependent trap losses. Such losses set an upper limit to the product of atomic density and confinement time that can be achieved in such a trap.

Gallagher-Pritchard

VOLUME 63, NUMBER 9 PHYSICAL REVIEW LETTERS 28 AUGUST 1989

Exoergic Collisions of Cold Na*-Na

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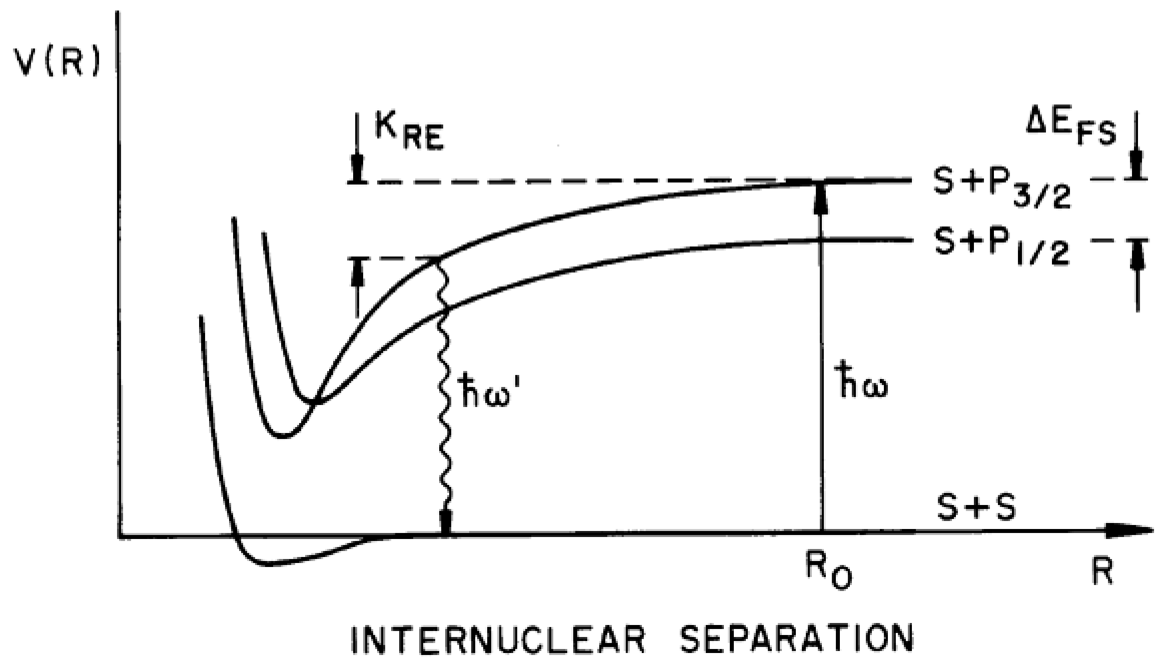
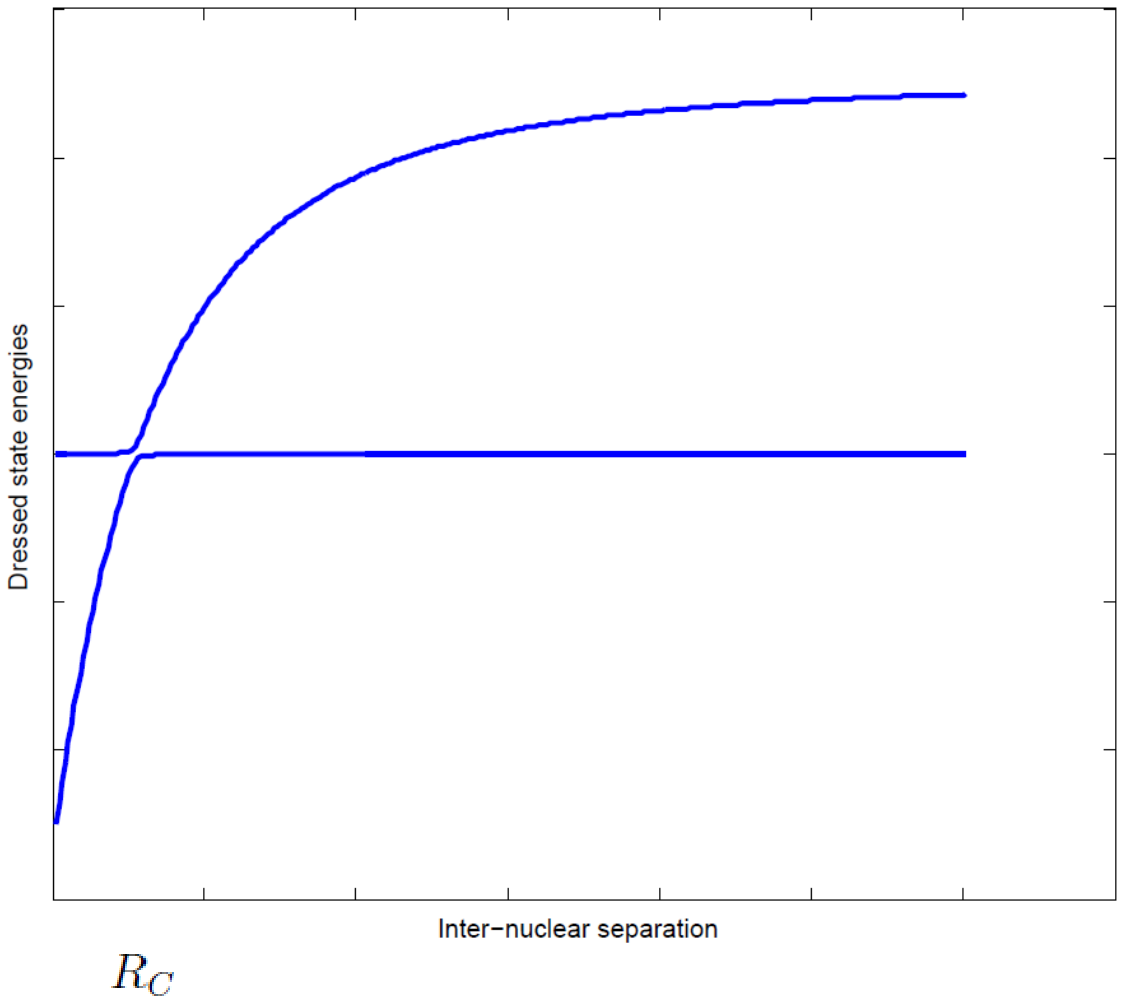
(Received 26 July 1988; revised manuscript received 24 February 1989)

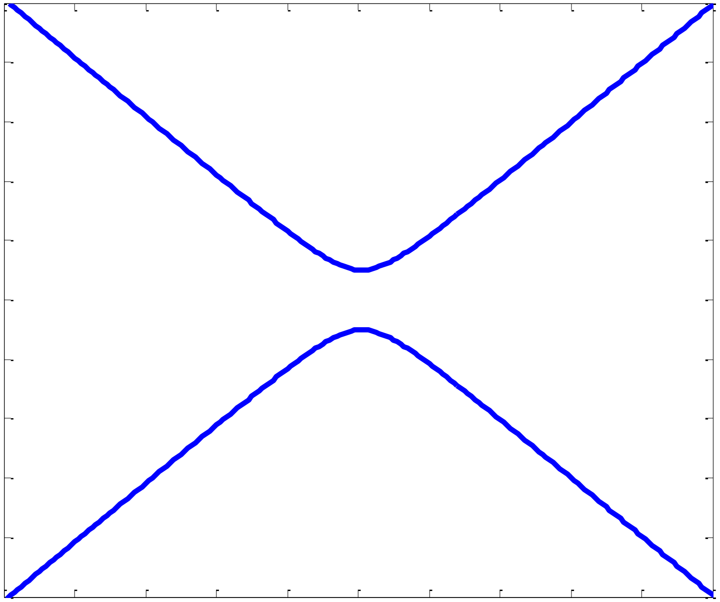


Dressed states



Landau-Zener

$$i\hbar\dot{\mathbf{c}} = \hbar \begin{pmatrix} -at & -\frac{1}{2}\chi \\ -\frac{1}{2}\chi & at \end{pmatrix} \mathbf{c}$$



How to derive

$$\ddot{c}_2 = iac_2 - \left(\frac{1}{4}\chi^2 + (at)^2\right) c_2$$

$$\frac{d^2 f}{dz^2} - \left(\tfrac{1}{4} z^2 + a\right) f = 0$$

Is that Weber the Physicist or Weber the Mathematician

Heinrich F. Weber

Heinrich M. Weber

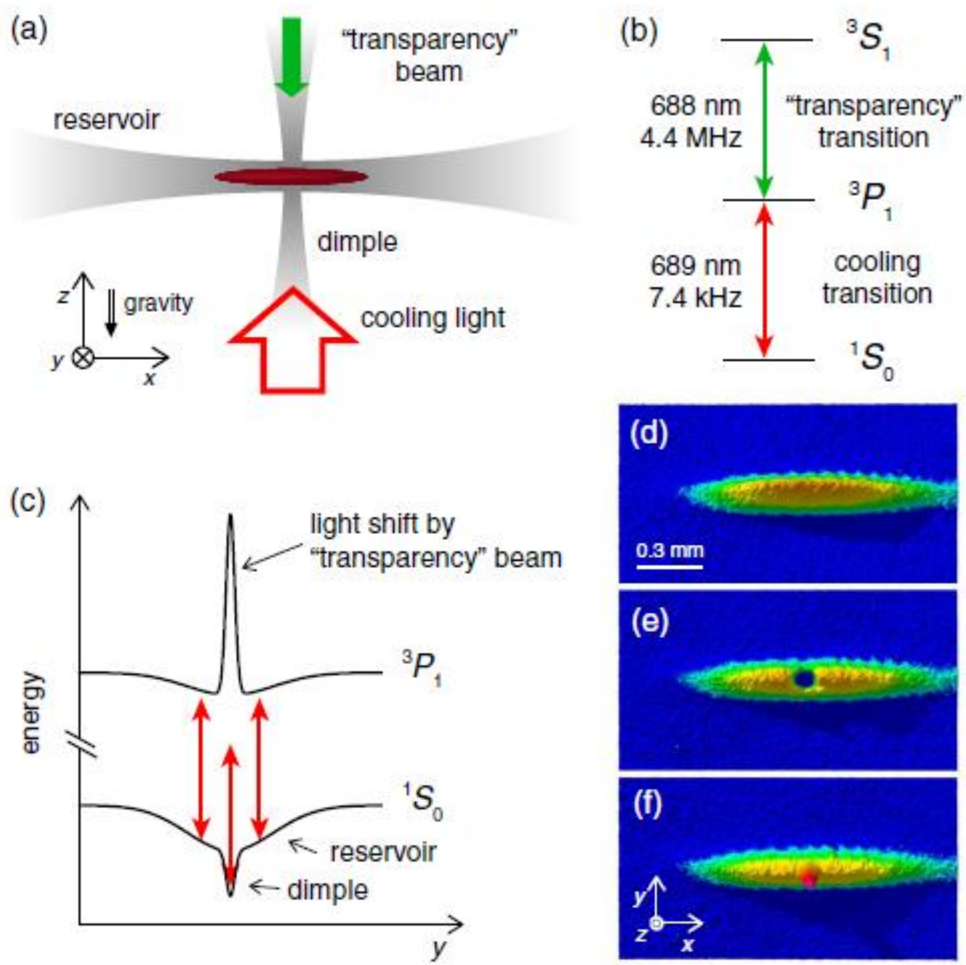
What is H. F. Weber best known for?

Landau-Zener formula

$$P_{LZ} = \exp\left(-\frac{2\pi\hbar\chi^2}{\left|\frac{dU}{dR}\right|_{R_C} v}\right)$$

Laser Cooling to Quantum Degeneracy

Simon Stellmer,[1] Benjamin Pasquiou,[1] Rudolf Grimm,[1,2] and Florian Schreck[1]
[1]Institut für Quantenoptik und Quanteninformation (IQOQI), Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Austria
[2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, 6020 Innsbruck, Austria
(Received 20 January 2013; published 25 June 2013)



It is not a problem it is a feature

VOLUME 82, NUMBER 11 PHYSICAL REVIEW LETTERS 15 MARCH 1999

Unity Occupation of Sites in a 3D Optical Lattice

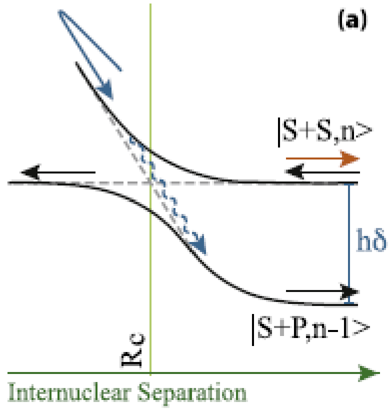
Marshall T. DePue, Colin McCormick, S. Lukman Winoto, Steven Oliver, and David S. Weiss
Department of Physics, University of California at Berkeley, Berkeley, California 94720-7300
(Received 23 October 1998)

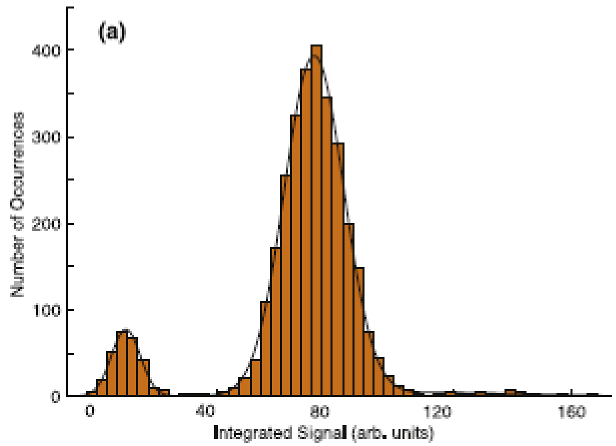
Sub-poissonian loading of single atoms in a microscopic dipole trap

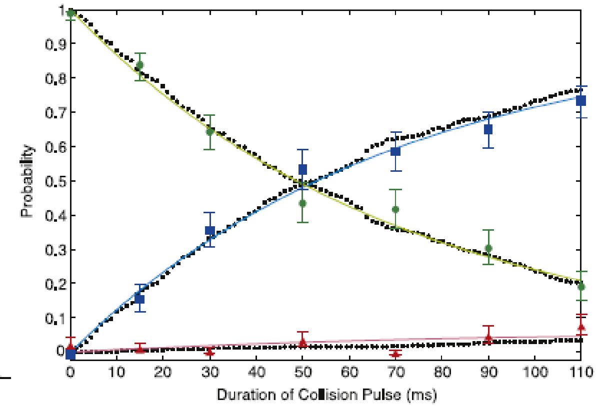
Nicolas Schlosser, Georges Reymond, Igor Protsenko & Philippe Grangier

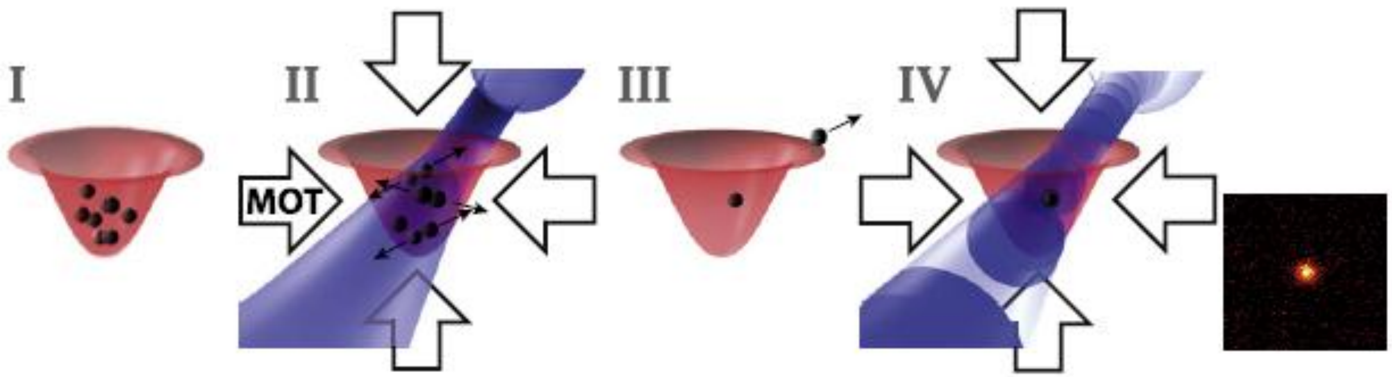
Laboratoire Charles Fabry de l'Institut d'Optique, UMR 8501 du CNRS, BP 147, F91403 Orsay Cedex, France

And even better









Multi-level structure

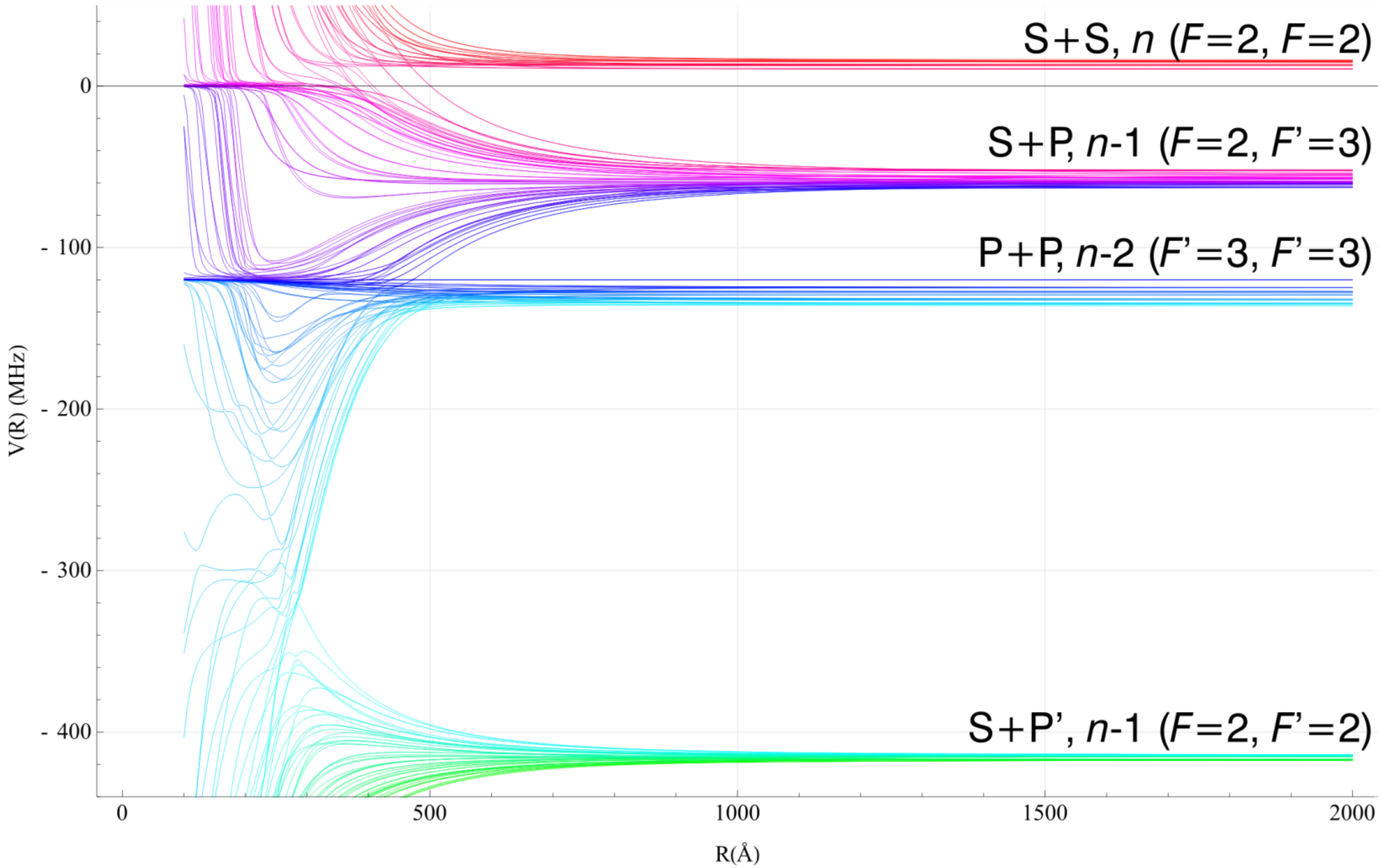
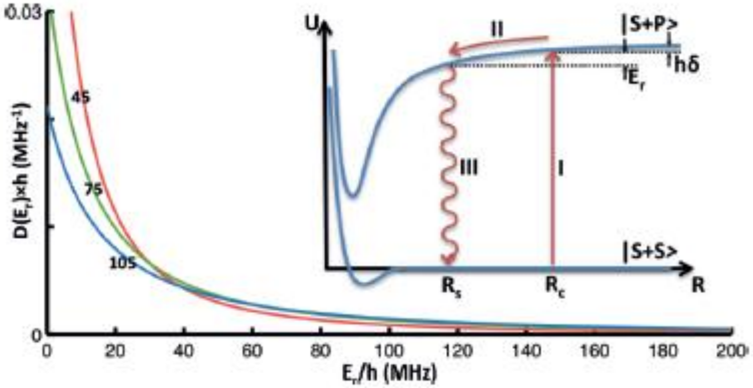
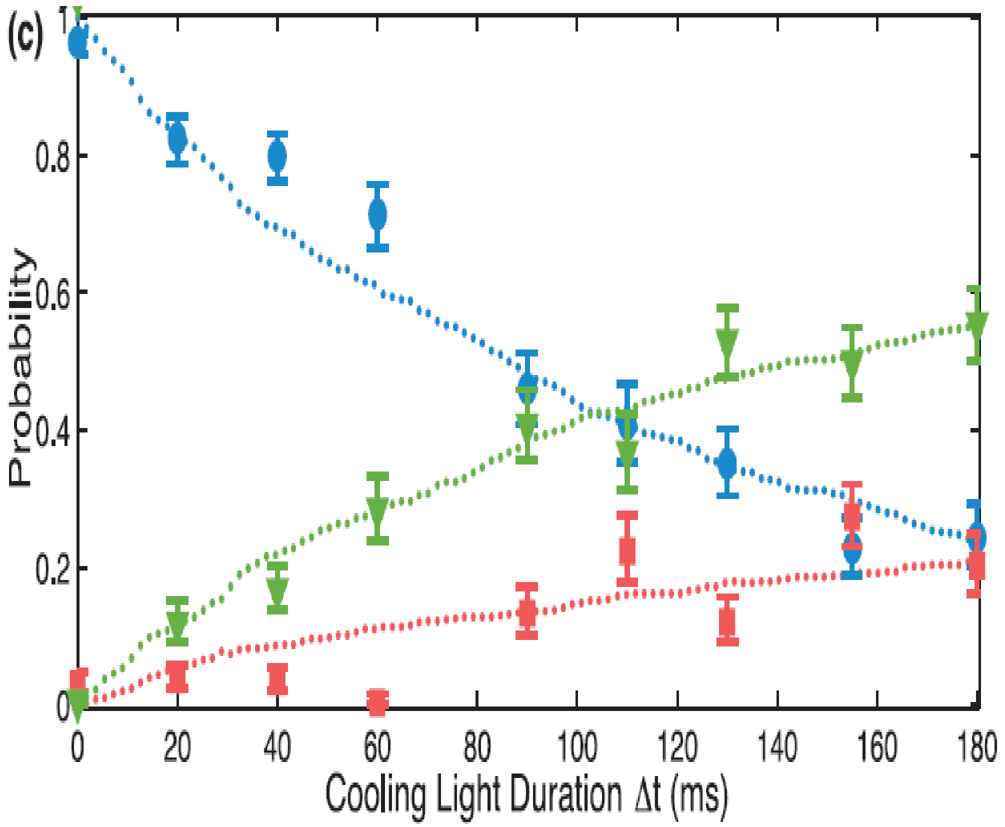


Figure: Thad Walker

Forming individual molecules





A side comment

PHYSICAL REVIEW A **85**, 062708 (2012)

Light-assisted collisions between a few cold atoms in a microscopic dipole trap

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(Received 22 May 2012; published 25 June 2012)

We study light-assisted collisions in an ensemble containing a small number (~3) of cold ^{87}Rb atoms trapped in a microscopic dipole trap. Using our ability to operate with one atom exactly in the trap, we measure the one-body heating rate associated with a near-resonant laser excitation, and we use this measurement to extract the two-body loss rate associated with light-assisted collisions when a few atoms are present in the trap. Our measurements indicate that the two-body loss rate can reach surprisingly large values $\beta > 10^{-8}$ cm^3 s^{-1} and varies rapidly with the trap depth and the parameters of the excitation light.