TEAL

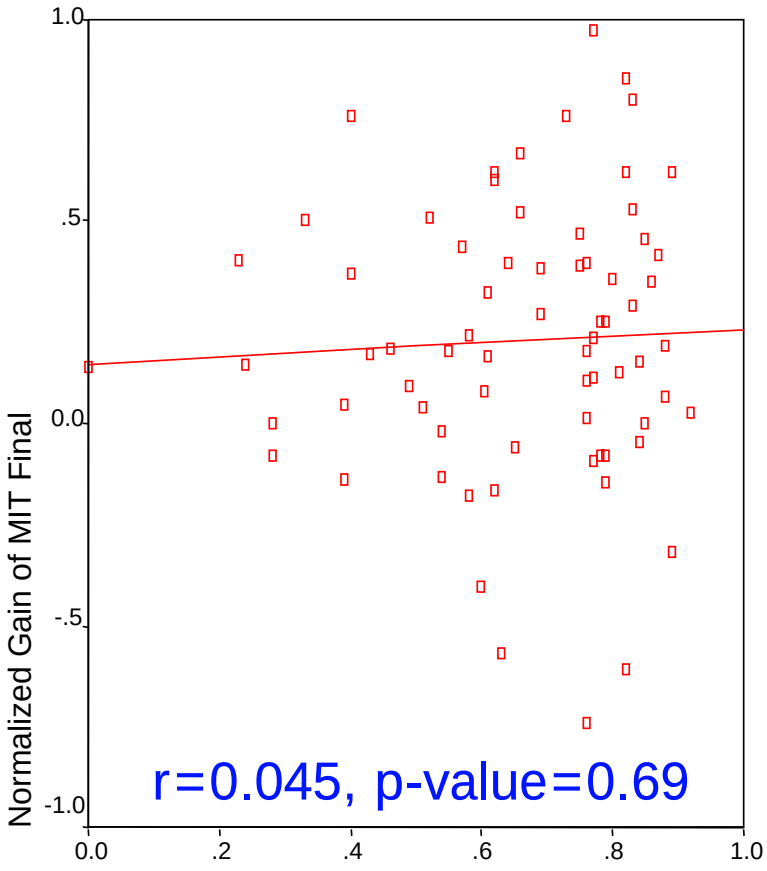
Technology Enhanced **Active** Learning

- Interactive online homework
- Group problem solving
- Personal Response System
- Peer Instruction

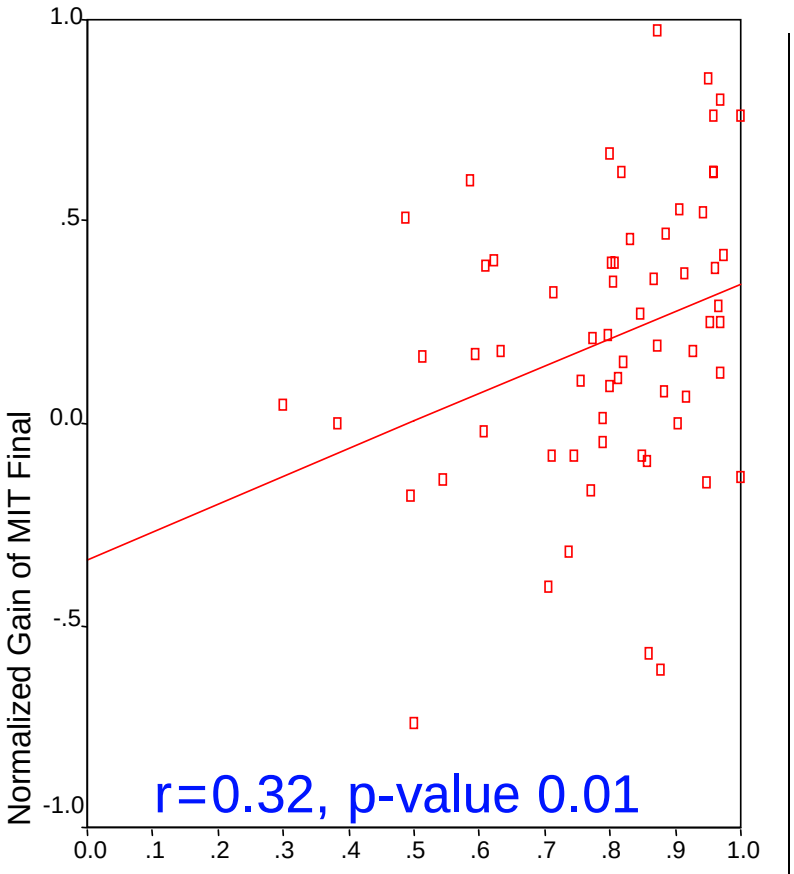
NOT

- Uninterrupted Lectures
- Lecture demonstrations
- Textbook reading to introduce material

Gain on the MIT Final Exam

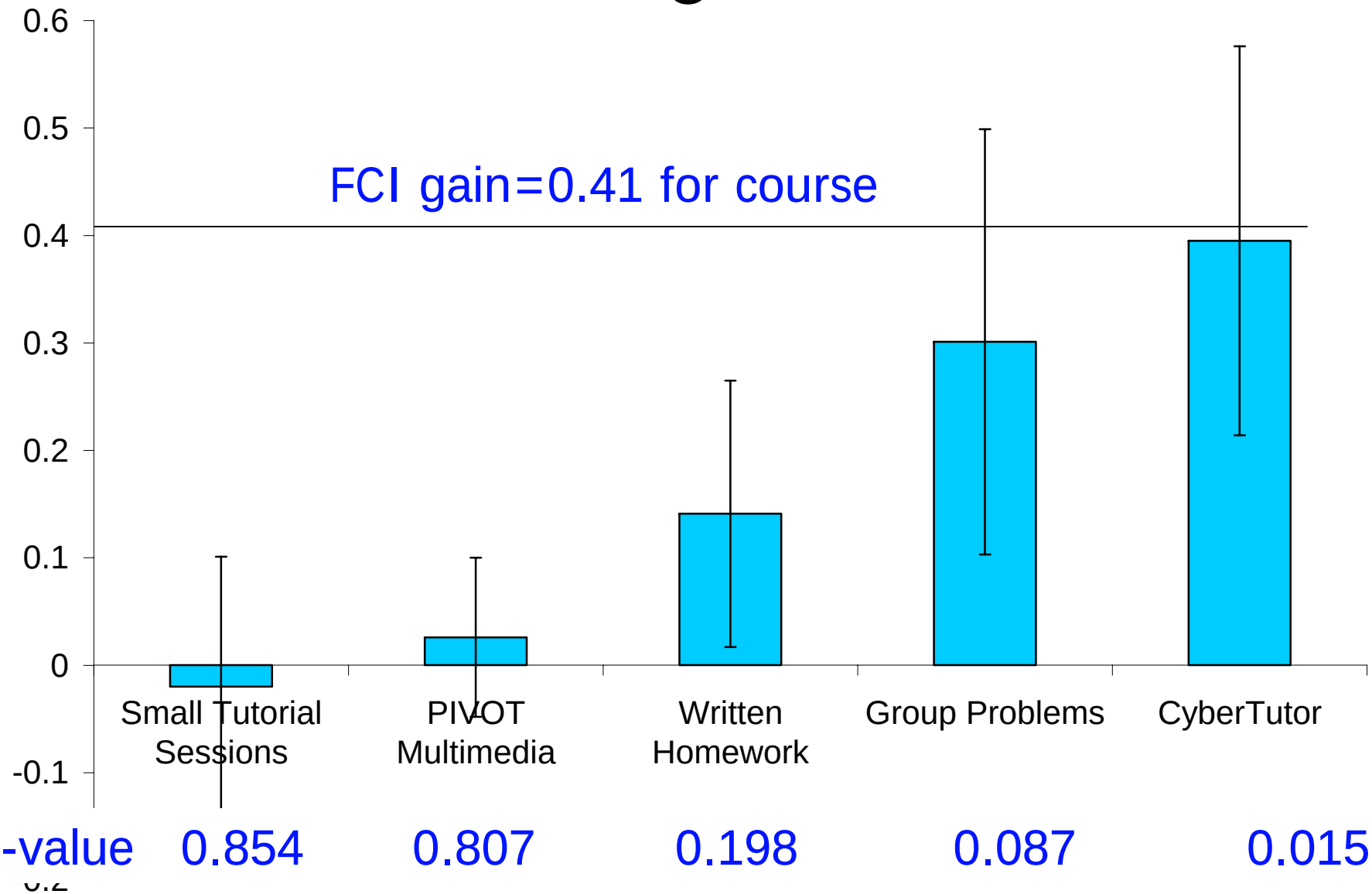


Written Homework



CyberTutor

Gain on Force Concept Inventory - data C. Ogilvie 2000



P-value 0.854 0.807 0.198 0.087 0.015

Overview

- Lecture/presentations
- In-class experiments
- Expert problem solving
- Schedule
- Grading
- WWW page

Lecture/Presentations: Mon./Wed. first hour

- Like lectures, but less formal (discussion, PRS questions, interruption encouraged).
- Notes usually available on server.
- Personal response system (PRS) questions: to stimulate discussion & indicate how concepts are going over.
- In-class problem solving for class/group discussion. There will usually be five people in the room to help out (instructor, grad & two undergrad TAs, and demo-group member).

Experiments: Wed. second hour

- Pre-experiment question part of problem set.
- Carried out by groups of three, in class.
- Laptops with *DataStudio* and other software; most experiments will interface to laptops.
- Conceptual Report due at end of experiment.
- Post-experiment data analysis part of problem set.

Expert Problem Solving

- Mon: In class problem solving session, basics.
- Tues: Problem Set due at 4 pm.
- Thurs: Mastering Physics assignment (due at 10pm) advanced problem solving.
- Fri: In class problem solving session, advanced.
- Sun 1-5 pm : Tutoring.
- Sun: Mastering Physics assignment (due at 10pm) introduction to weekly material.

Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Morning	Hour1 (10-11): Lecture Hour2 (11-12): Problem		Hour1 (10-11): Lecture Hour2 (11-12): Experiment		Hour1 (11-12): Advanced problem solving		
Afternoon		Problem set due by 04:00pm					13:00-17:00
Evening				Mastering Physics due: 22:00 3 tests (19:30-21:30): Sep. 30, Oct. 28 and Nov. 18			Mastering Physics due: 22:00

Grading policy: Weighting scheme

- Tests + Final Exam 45%+20% Individual
- Homework PS 10%
- Mastering Physics 10%
- Experiments 5%
- In class work and PRS 10%

Grading policy: Breakpoints

A+ ≥ 95	A ≥ 90	A- ≥ 85
B+ ≥ 81	B ≥ 77	B- ≥ 73
C+ ≥ 69	C ≥ 66	C- ≥ 63
	D ≥ 60	
	F < 60	

PRS question

A cannonball is shot straight up (not recommended). At the top of its trajectory:

1. It's acceleration is zero, but not its velocity
2. It's velocity is zero as well as its acceleration
3. Neither its velocity nor its acceleration is zero
4. It's velocity is zero, but not its acceleration
5. Both its acceleration and its speed are zero

Pre-Class Diagnostic Test

- 50 minutes for diagnostic test, interrupted by lab tours of 25 min (so 75 min total)

Tours of BEC Experiments

- Students from 3 tables (at a time) will go upstairs to look at Bose-Einstein Condensate experiments at the Center for Ultra Cold Atoms

http://www.rle.mit.edu/cua/default.htm

- Video of Prof. Wolfgang Ketterle Lecture on BEC

http://mitworld.mit.edu/video/77

What is % difference in temperature between summer and winter?

15 % (Kelvin!)

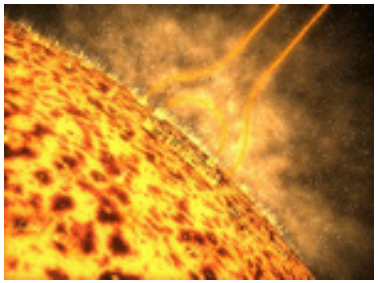
i.e. - not much!

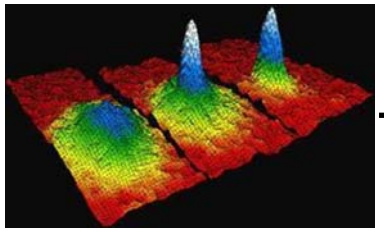
Ratio of hottest to coldest?

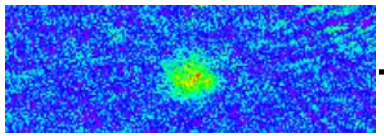
Temperature Scales

laboratory systems | natural systems

laser cooling + evaporative cooling + adiabatic cooling







Kelvin Scale

10^{4} surface of sun

10^{3} room temperature

10^{2}

10 interstellar space

1

10^{-1}

10^{-2} ^{3}He-^{4}He dilution refrigerators — millikelvin regime

10^{-3}

10^{-4} first laser cooled atomic vapors — microkelvin regime

10^{-5}

10^{-6}

10^{-7} first Bose-Einstein condensates (BECs) — nanokelvin regime

10^{-8} old low temperature record

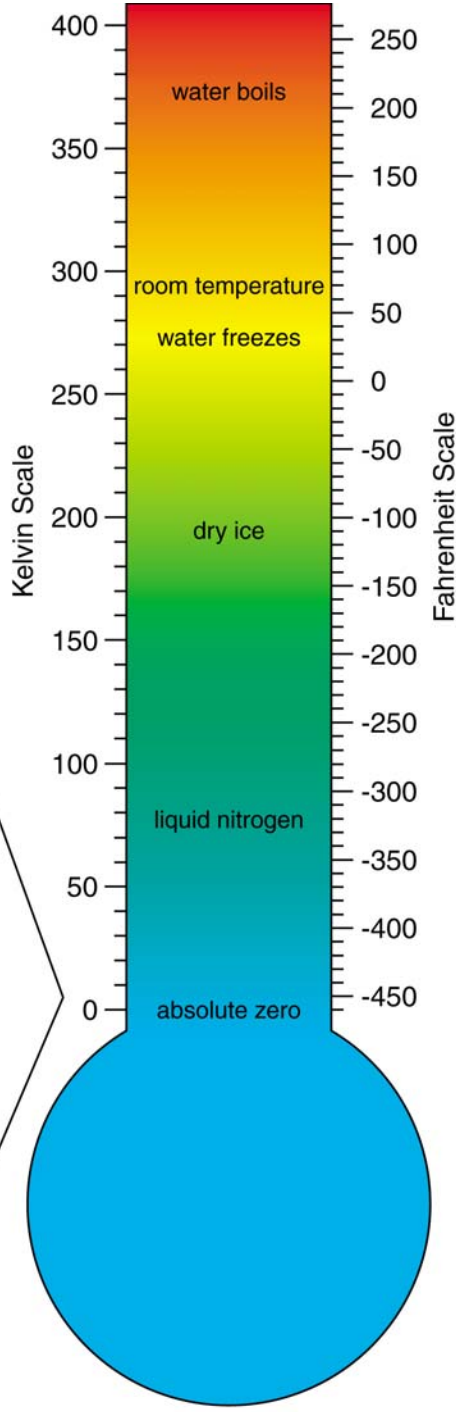
10^{-9} new low temperature record — picokelvin regime

10^{-10}

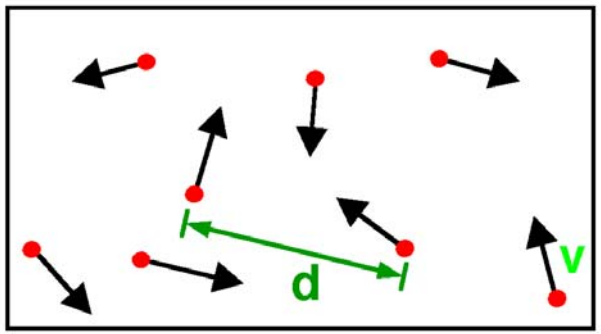
10^{-11}

10^{-12}

laboratory systems | natural systems



What is Bose-Einstein condensation (BEC)?

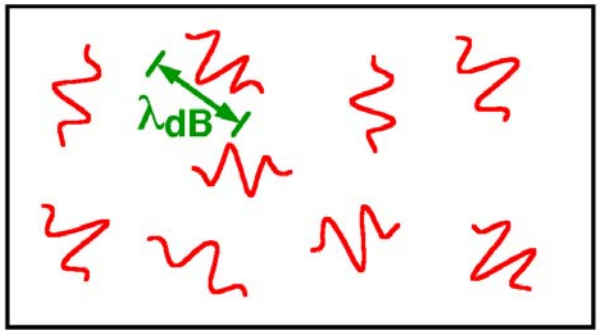


High Temperature T:

thermal velocity v

density d^{-3}

"Billiard balls"

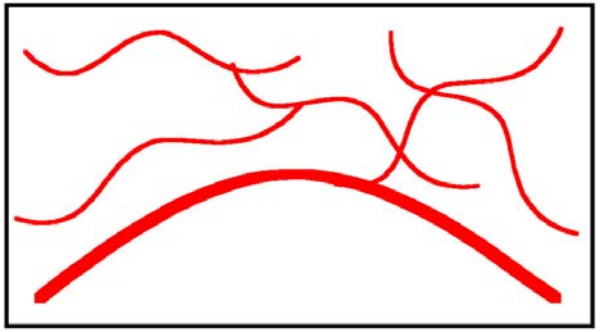


Low Temperature T:

De Broglie wavelength

$\lambda_{dB}=h/mv \propto T^{-1/2}$

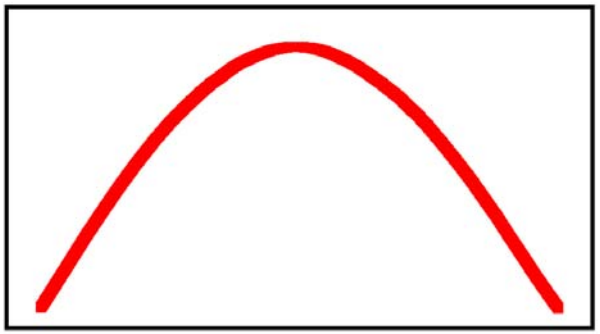
"Wave packets"



$T=T_{crit}$: Bose-Einstein Condensation

$\lambda_{dB} \approx d$

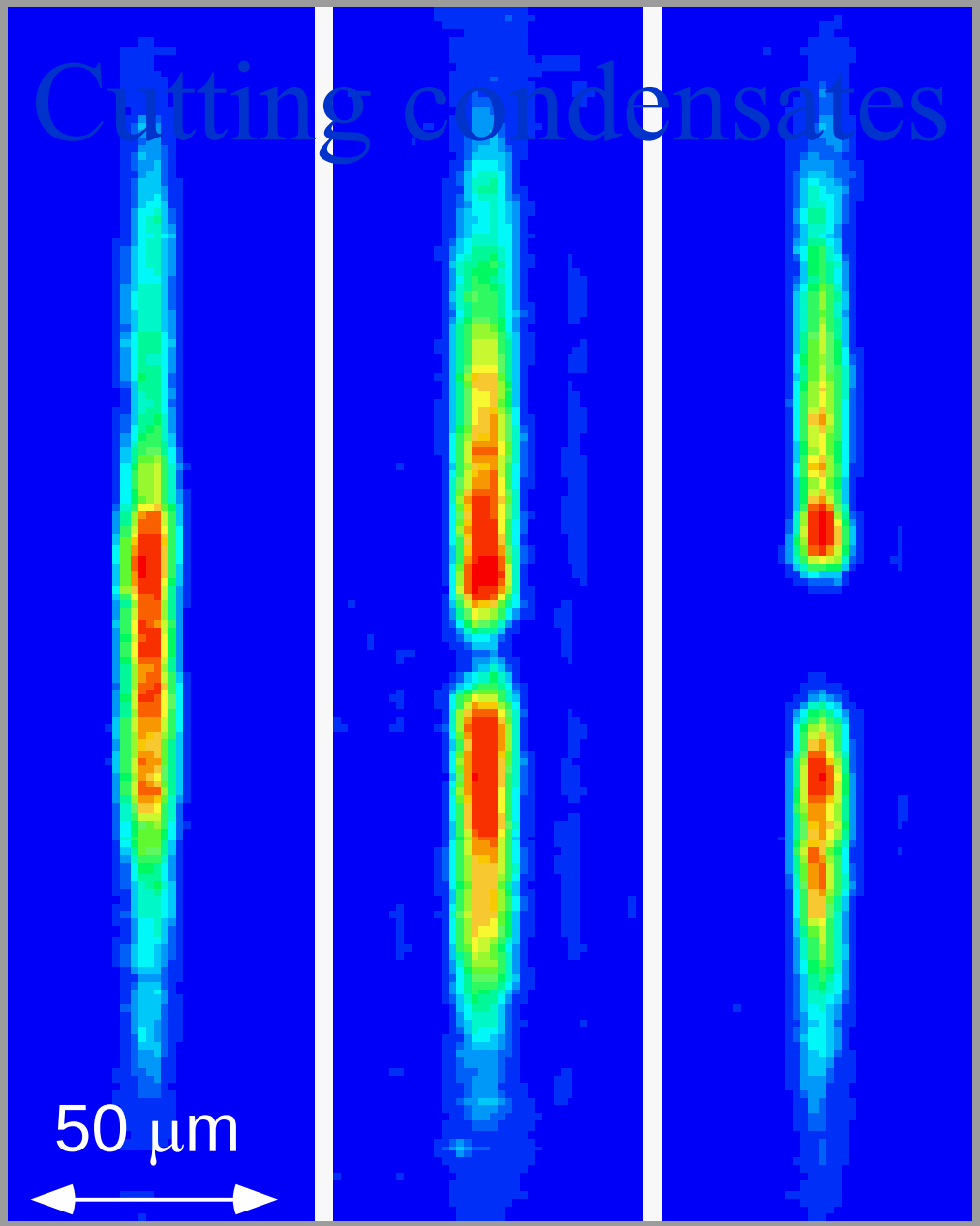
"Matter wave overlap"



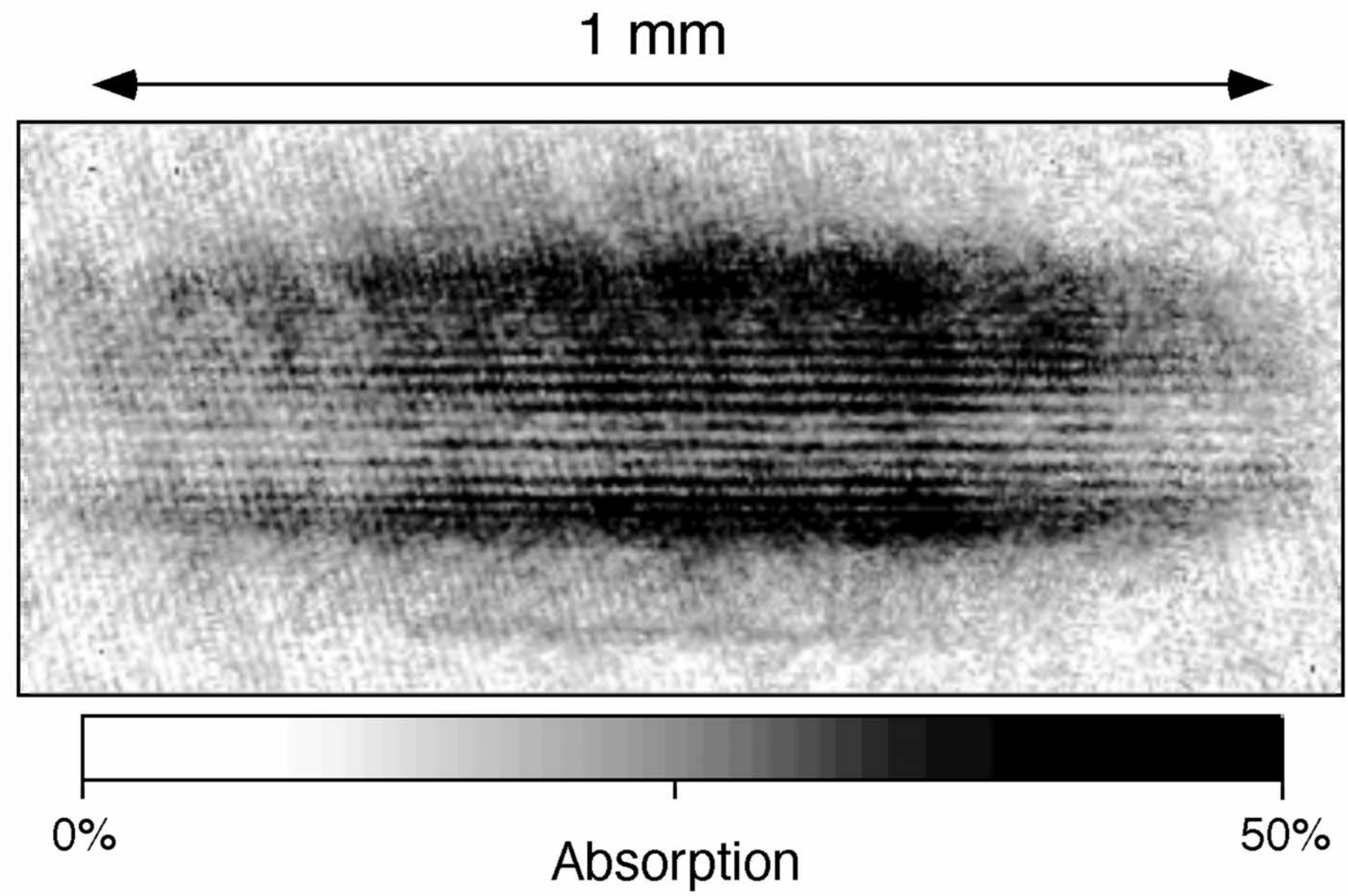
T=0: Pure Bose condensate

"Giant matter wave"

Two condensates ...



Interference of two Bose-Einstein condensates



Andrews, Townsend, Miesner, Durfee, Kurn, Ketterle, Science **275**, 589 (1997)