Cold atoms in microtraps and near surfaces

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Outline

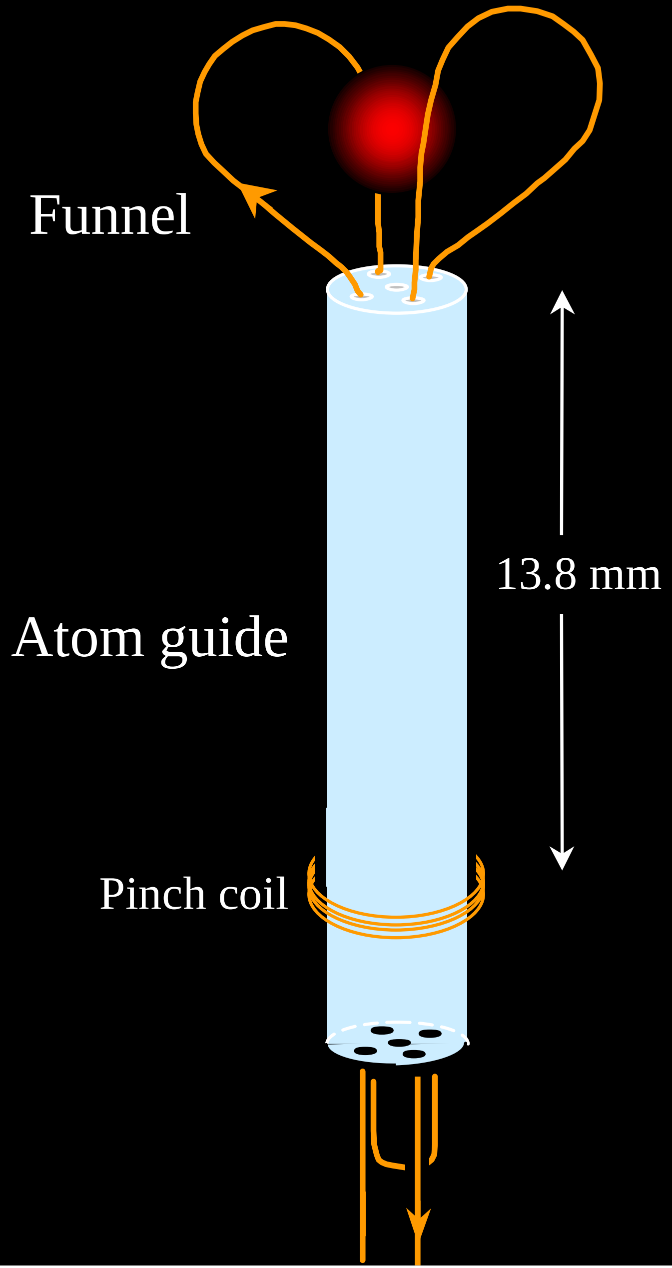
This talk is about
miniaturising atom optics

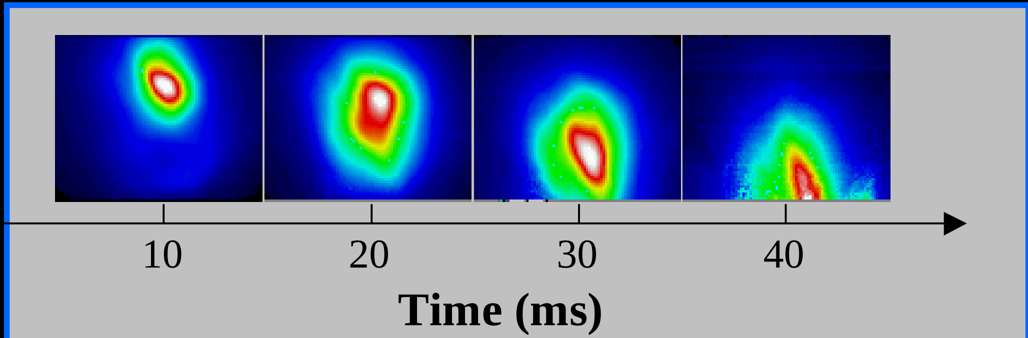
- **2-wire atom waveguide**

- **Videotape atom chip**

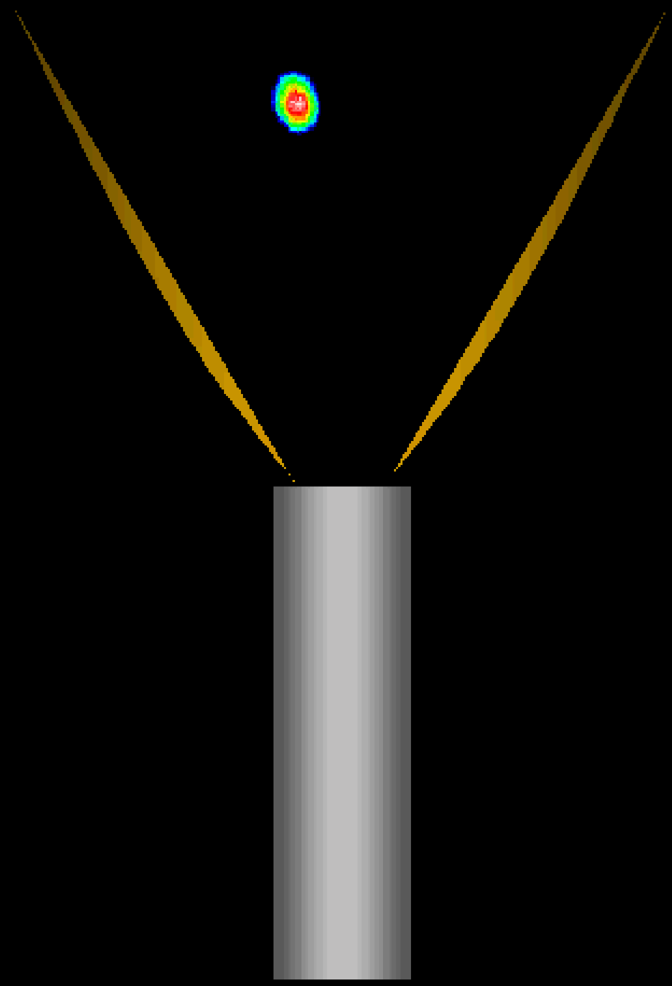
1) The 2-wire atom waveguide

Our first guide had 4 wires in a glass fibre





10^6 Rb atoms falling in the funnel

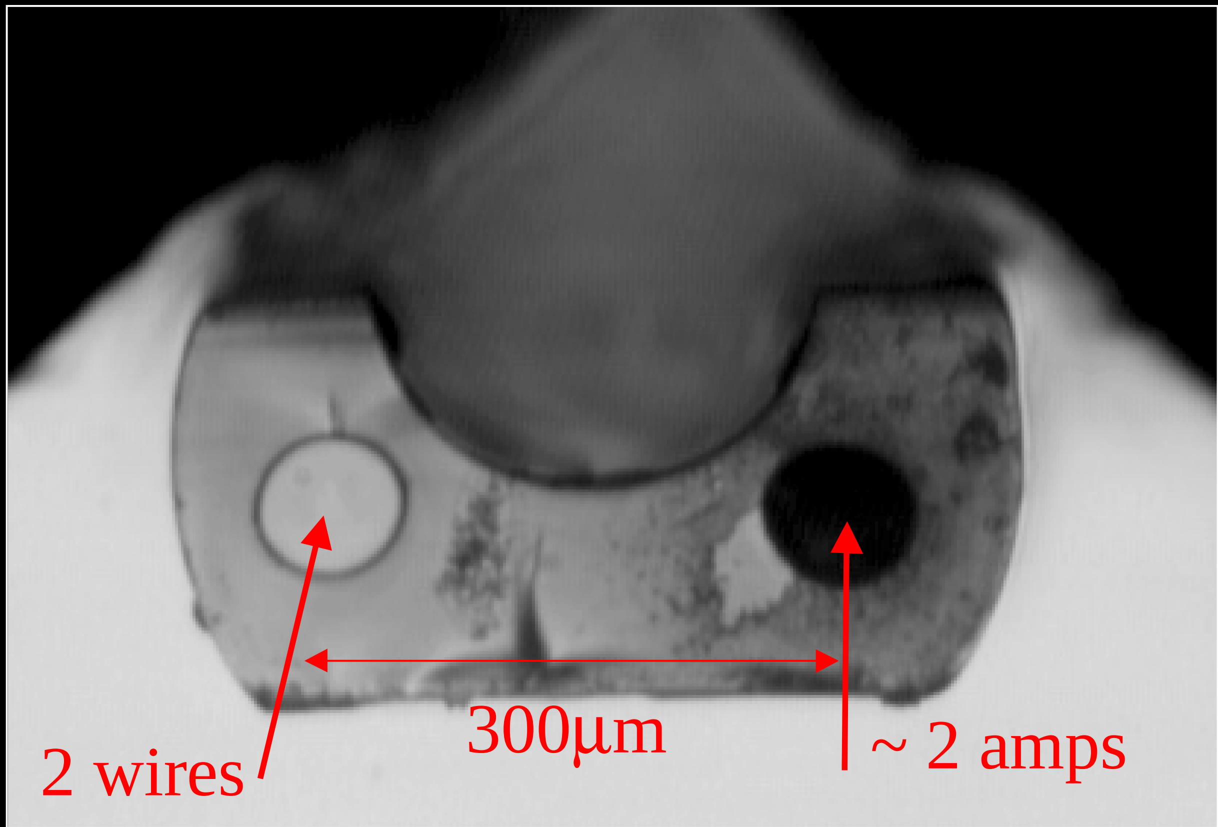


PRL. **84,** 1371 (2000)

The 2-wire atom guide

with Chris Vale and Matt Jones

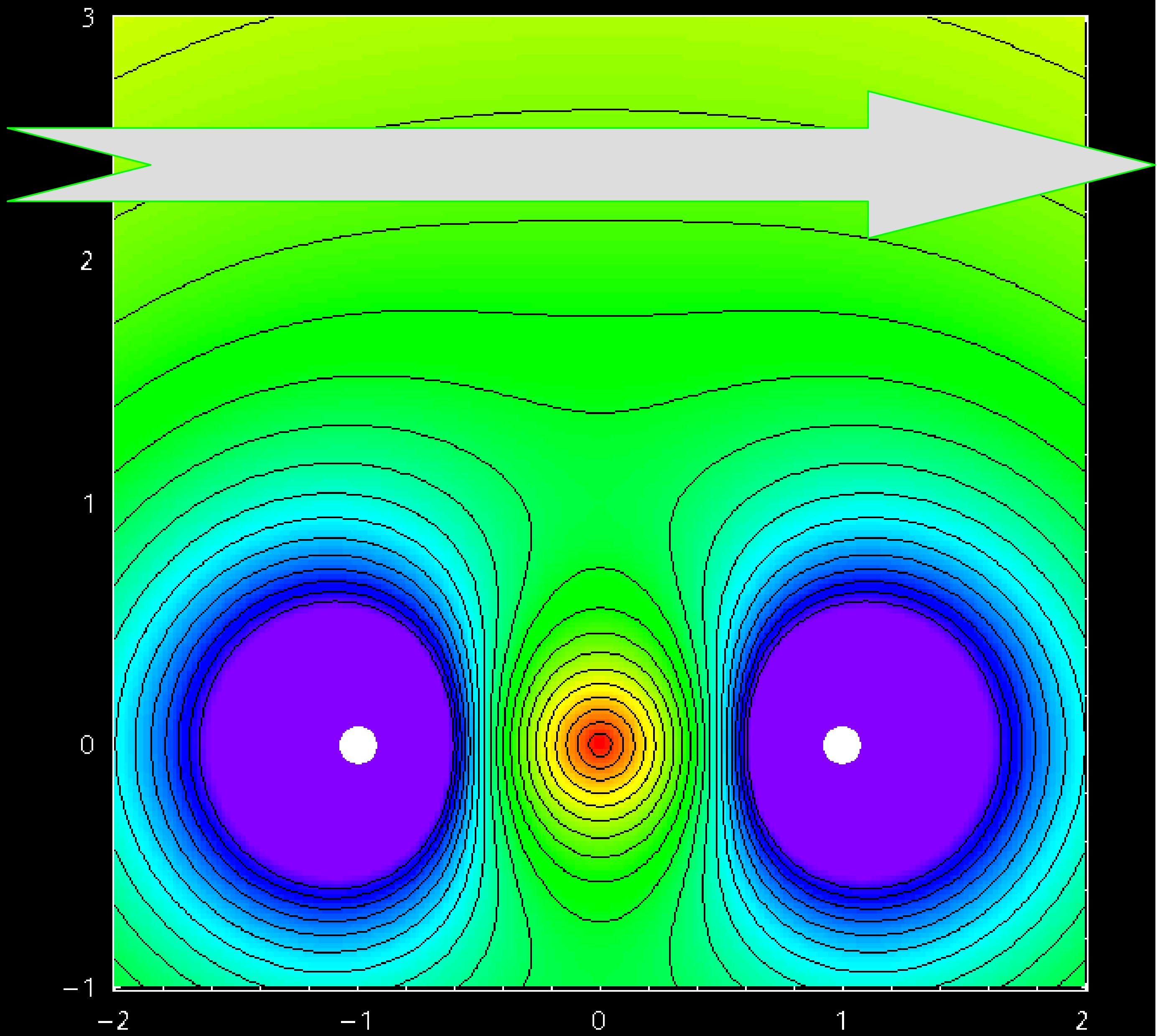
Hollow silica fibre fabricated at the ORC, Southampton University



Basis for a de Broglie wave interferometer

Contours of |**B**|

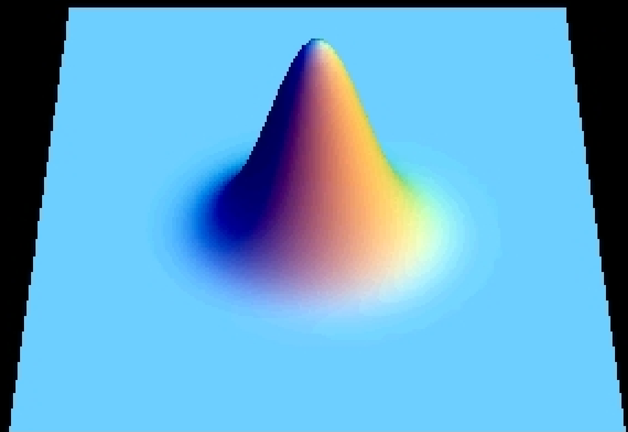
Add a horizontal uniform field



Great potential for coherent splitting

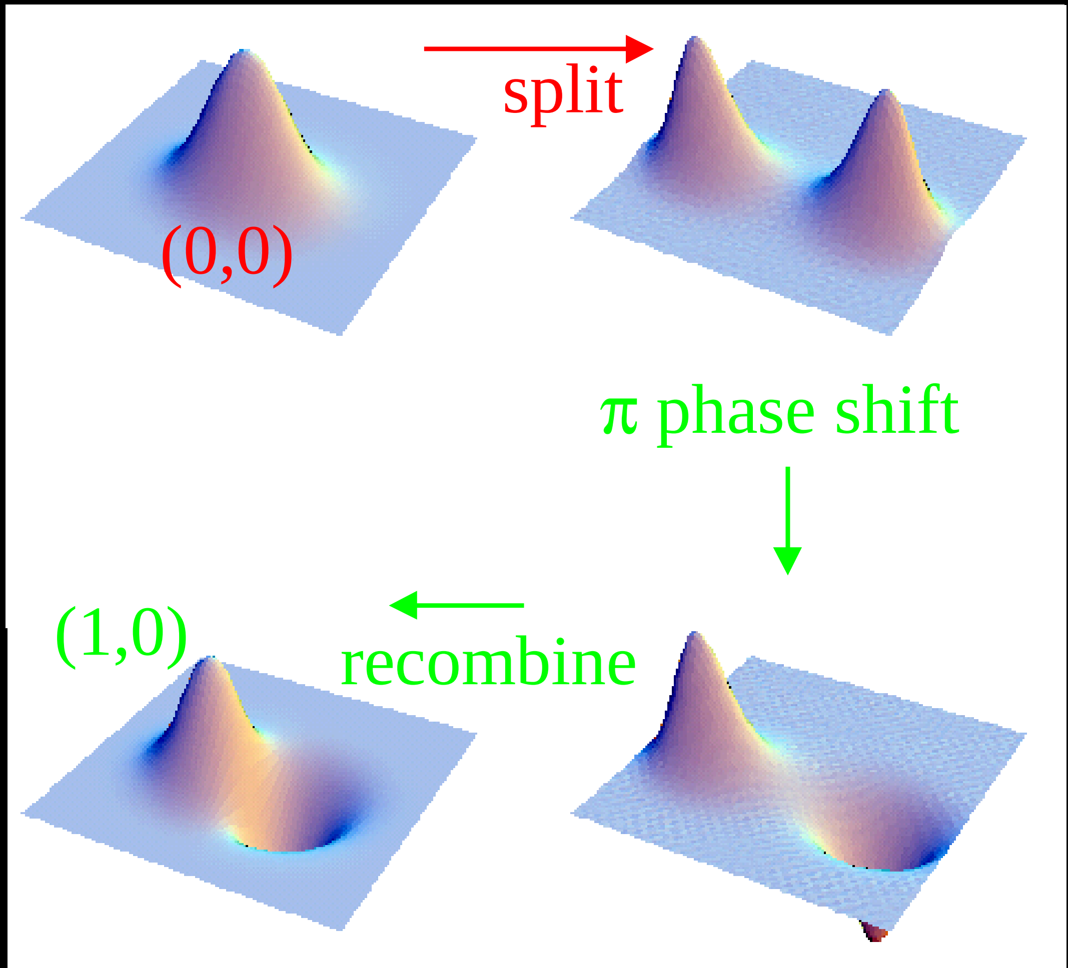
Hinds, Vale, and Boshier
PRL Feb 2001

Splitting the Ground State $\psi(0,0)$



Horizontal bias field increases to make horizontal splitting

Interferometry

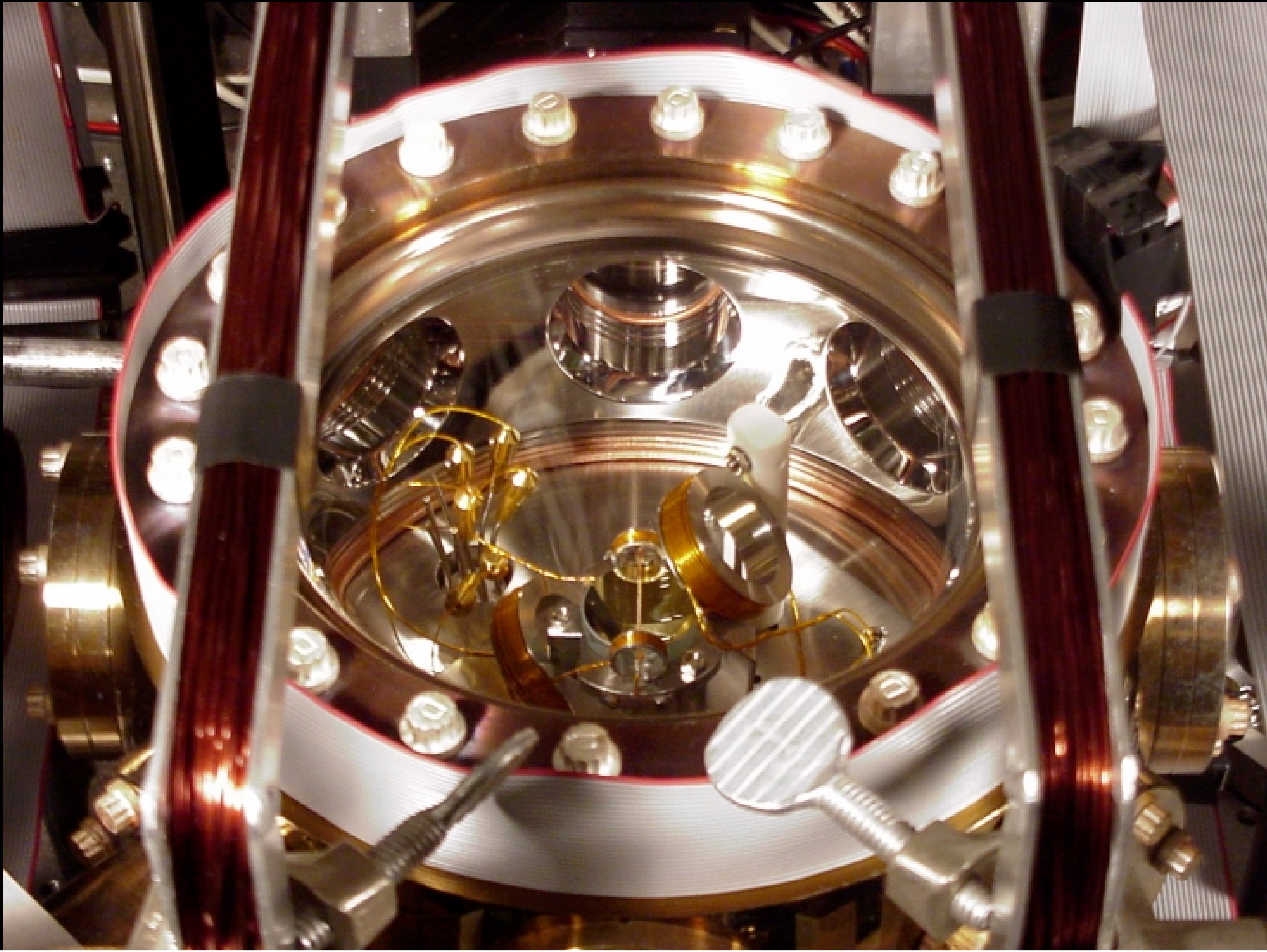


This device may have spectacular sensitivity to

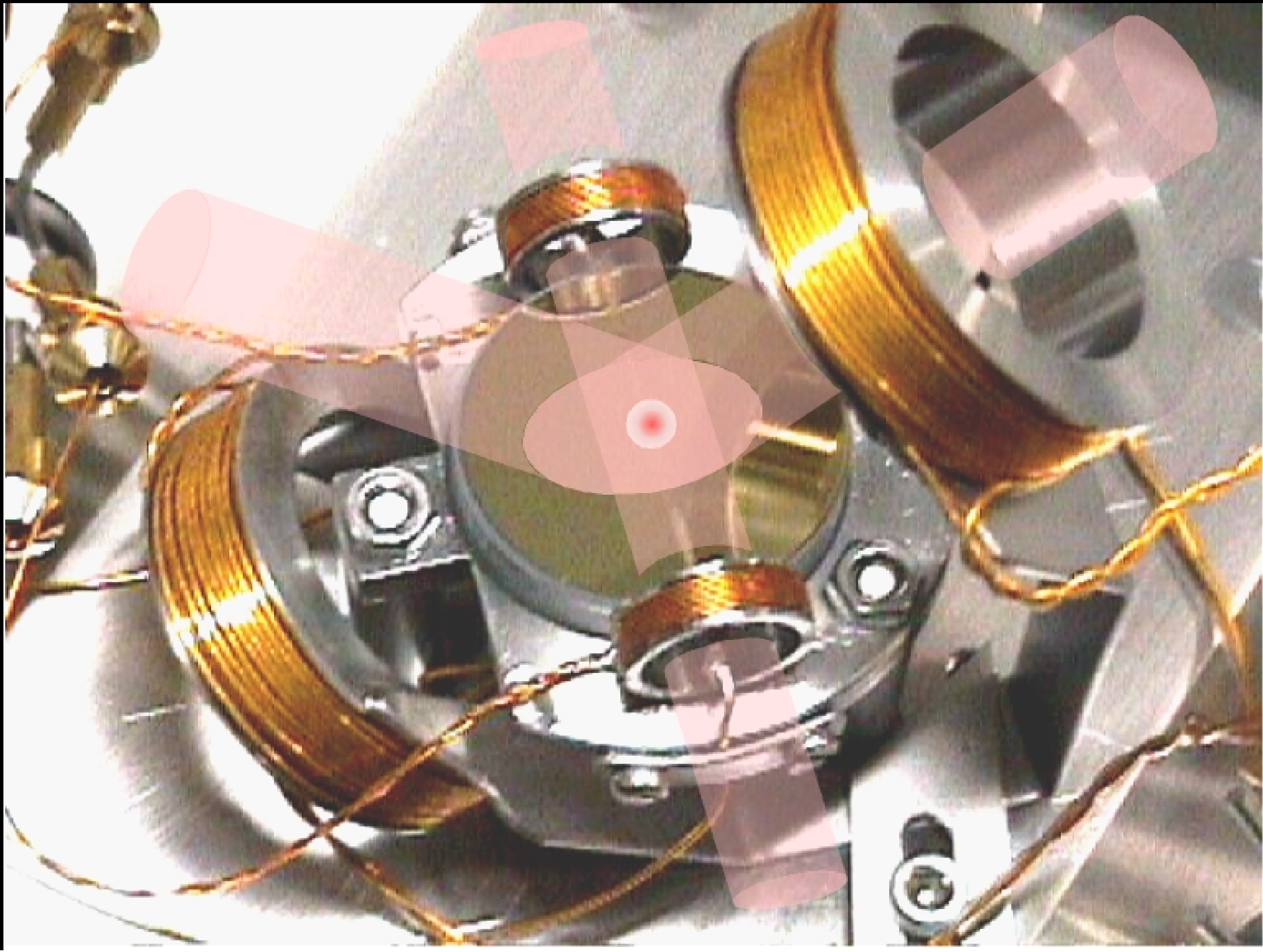
- Gravity
- EM fields
- Other feeble forces

The output ports are the (0,0) and (1,0) vibration states of the guide.

The 2-wire interferometer at SCOAP



The Mirror MOT



Loading the guide

Mirror MOT

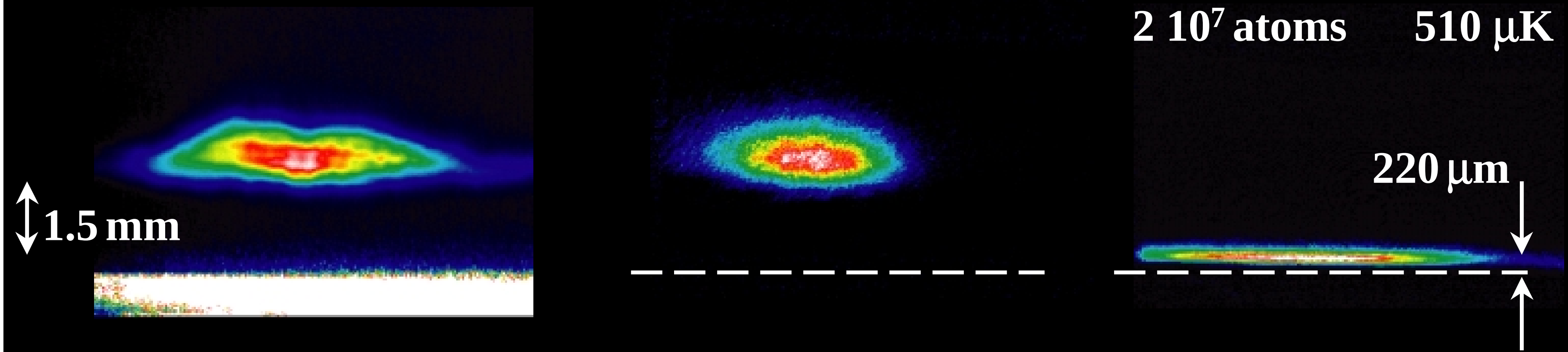
$1\ 10^{8}$ atoms 70 μK

Magnetic trap

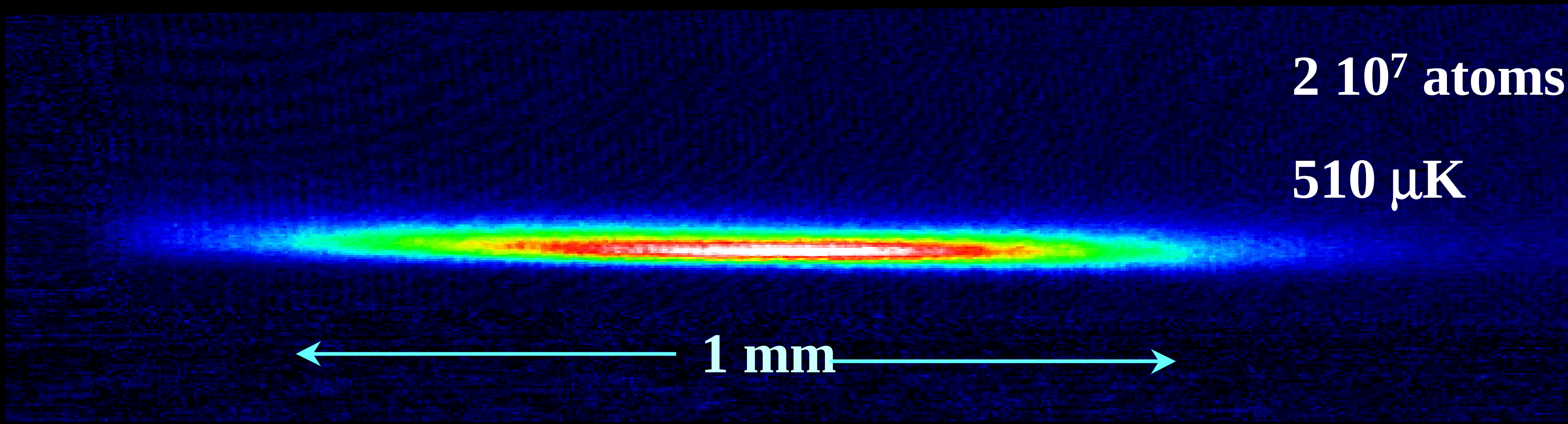
$2\ 10^{7}$ atoms 70 μK

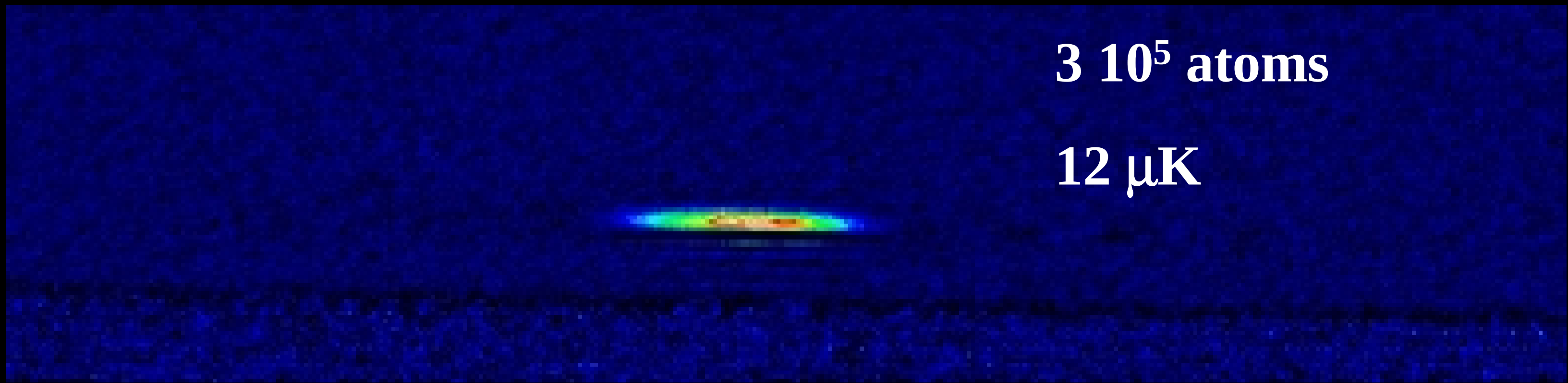
Compressed Magnetic trap

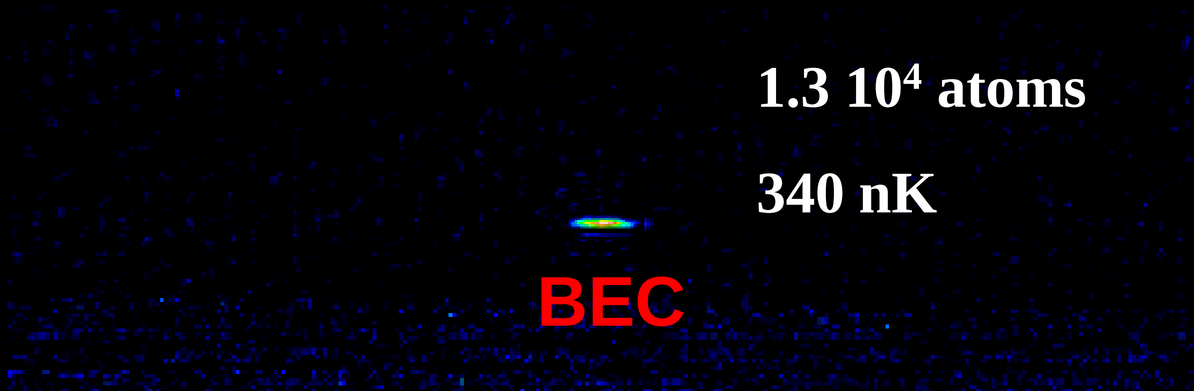
$2\ 10^{7}$ atoms 510 μK



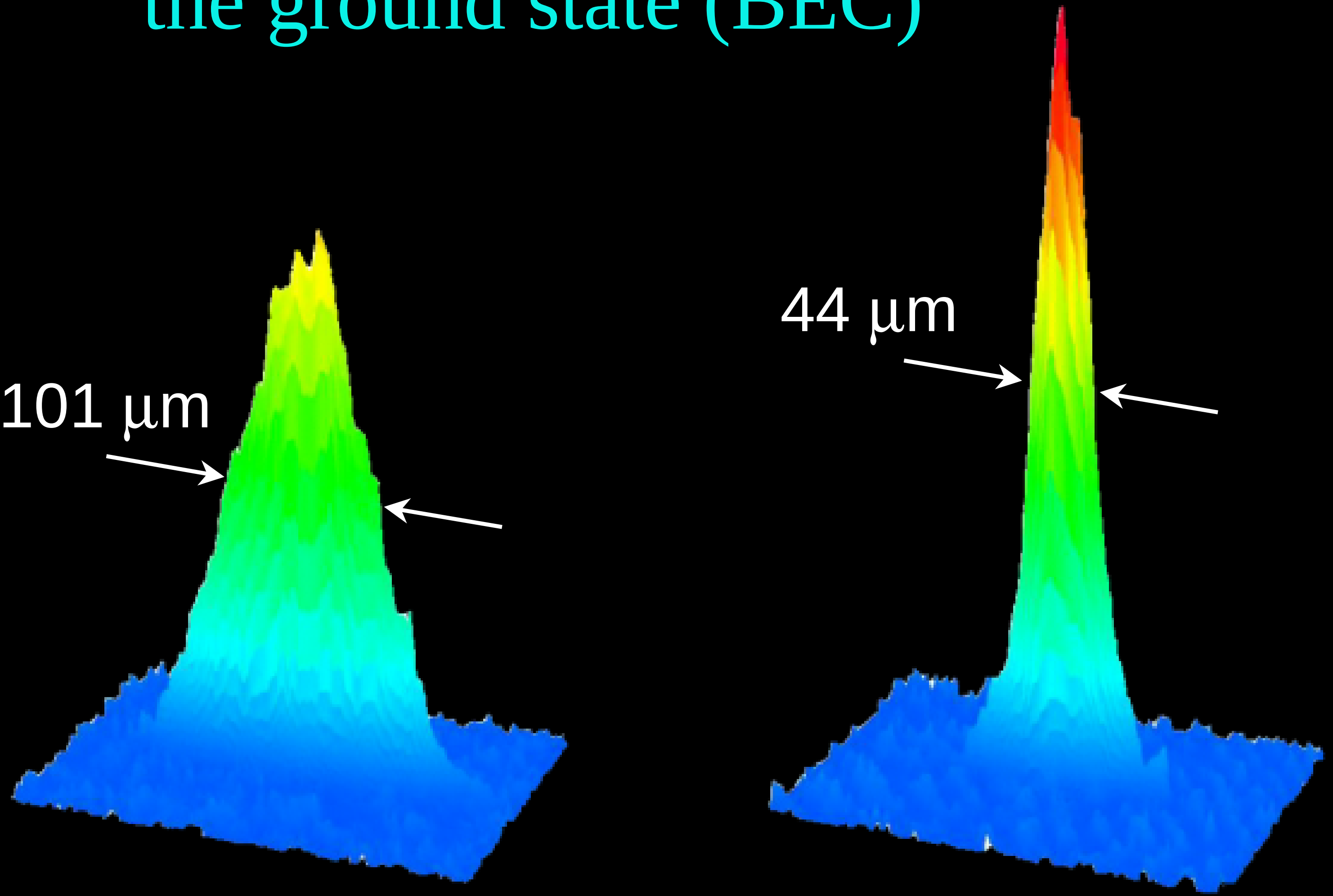
Evaporating to the ground state







At ~350 nK our atoms suddenly go into the ground state (BEC)

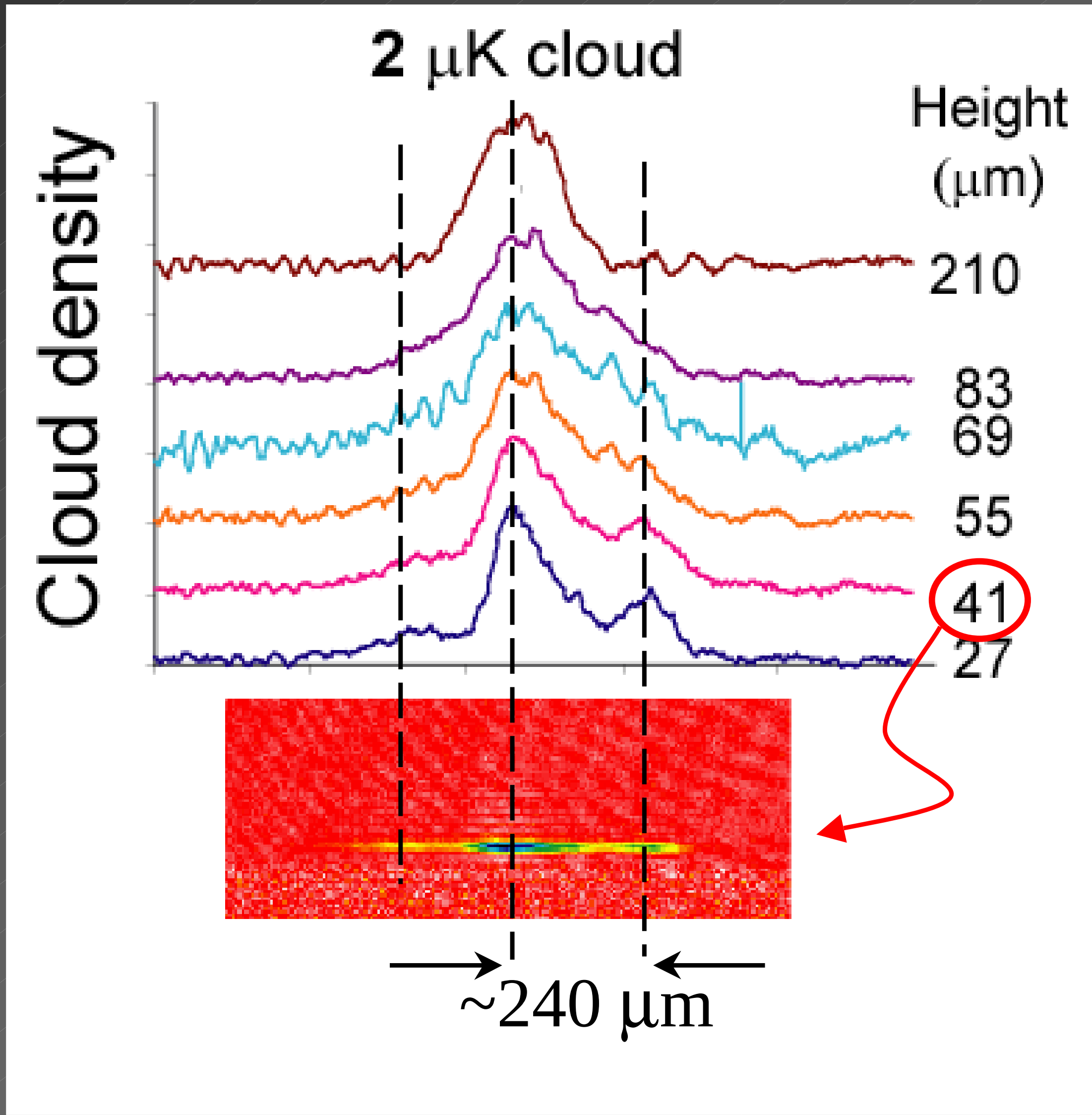


the interferometer should now be ready, however ….

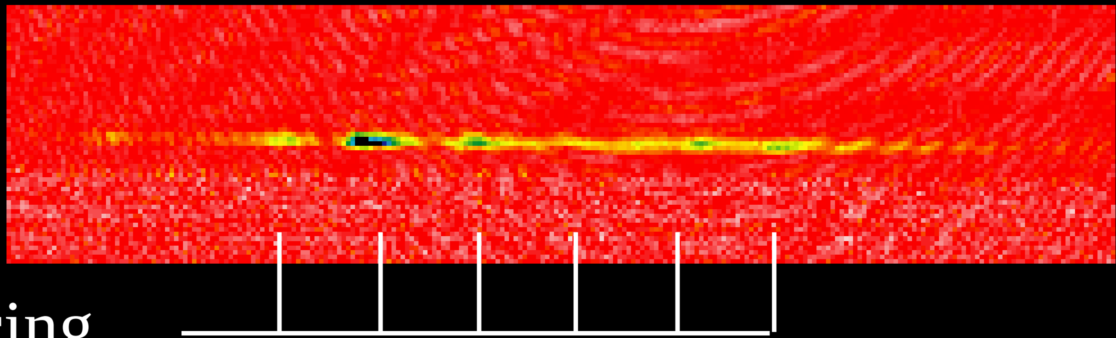
. . . . the atoms interact with the copper wire

the cloud breaks up
when lowered

These wells are ~1μK deep



If the cloud is allowed to expand along the guide,
some atoms are trapped in wells



These have ~ 230 μm spacing

Similar lumps recently seen above Cu wires by

Ketterle group [cond-mat/0203214]

Zimmerman group [cond-mat/0205310]

Zimmerman *et al.* also see a shortening of lifetime

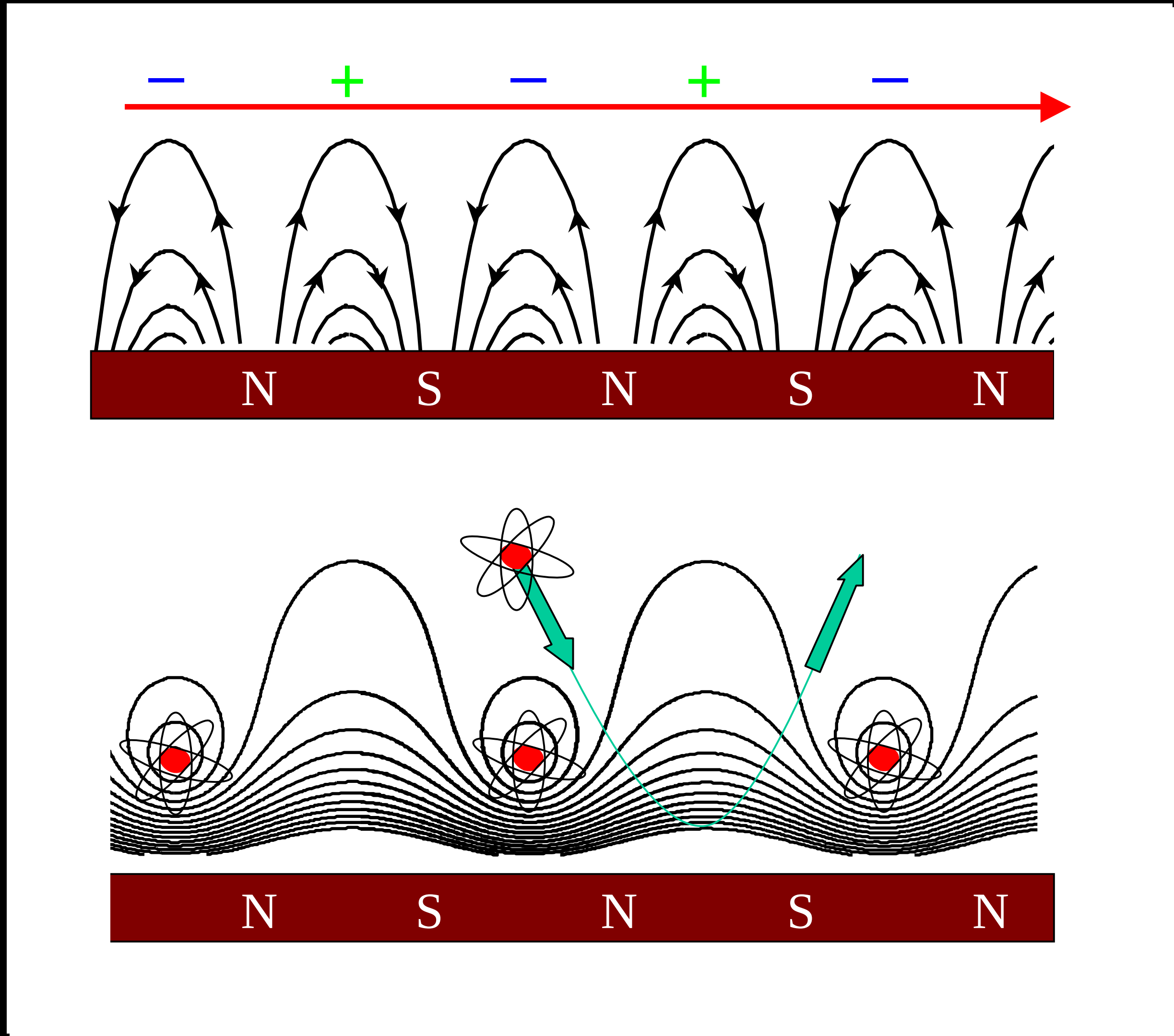
These effects are not yet understood

2) Videotape atom chip

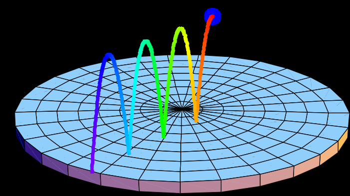
Sinusoidally magnetised videotape makes an atom mirror

A bias field corrugates the mirror

and makes an array of atom guides

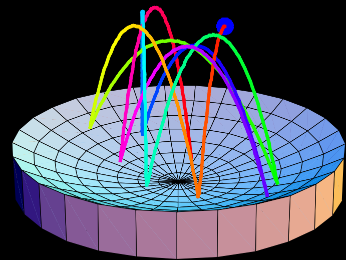


Magnetic Mirror Fabrication



- 1995: flat audio tape mirrors
- 1997: curved floppy disk mirrors

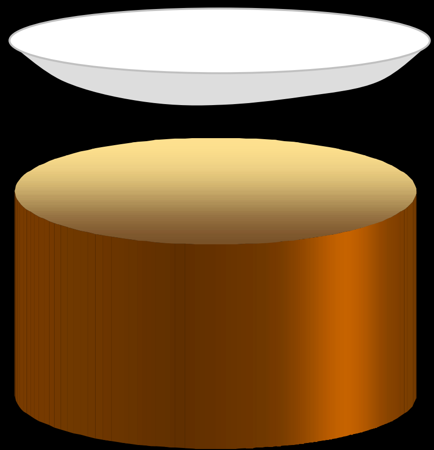
1999: high-quality curved video tape mirrors

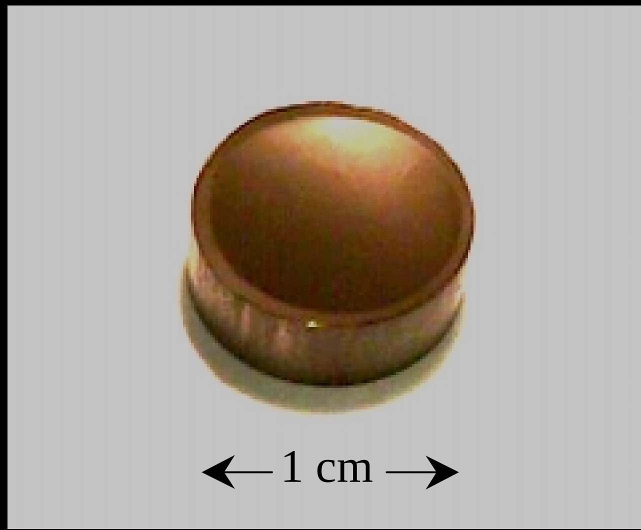


- Single wide track on 12mm camcorder tape
- $\lambda \sim 10\ \mu\text{m}$ and surface field $B_0 \sim 1000$ gauss
- good linearity

Lens to make curvature

Video tape glued to ring



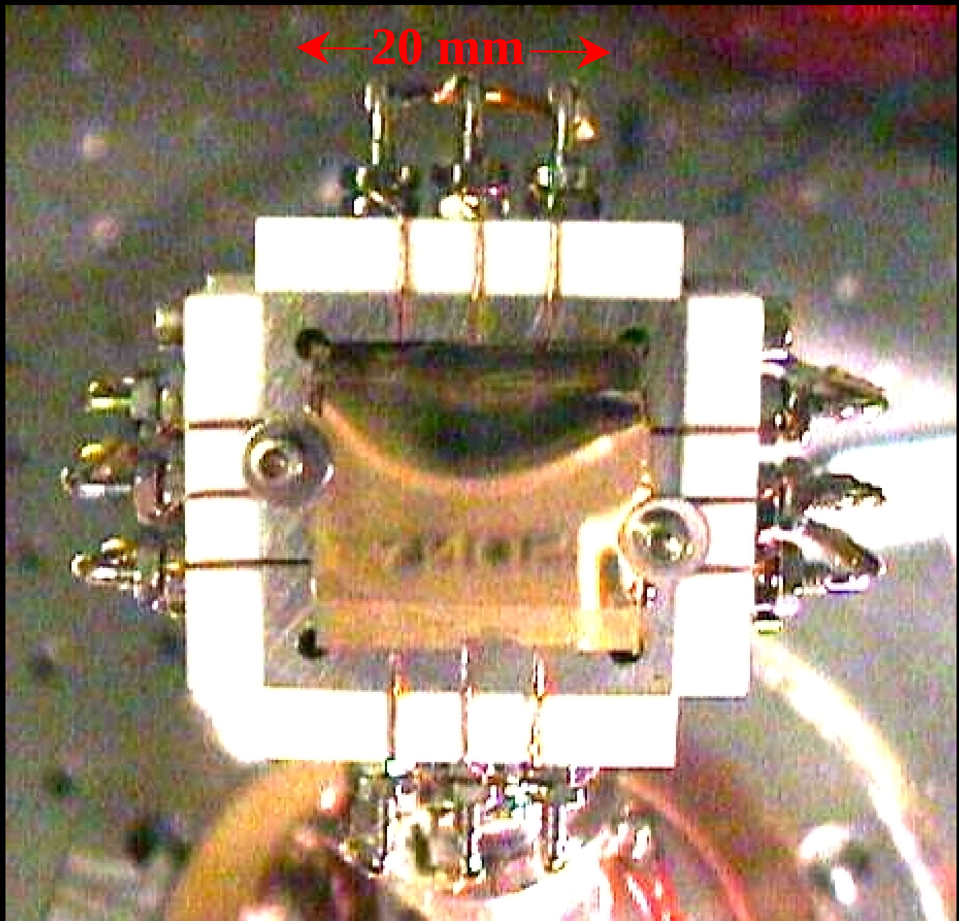


Bouncing atoms on the chip

smooth reflector
(bias field = 0)

corrugated reflector
(bias turned on)

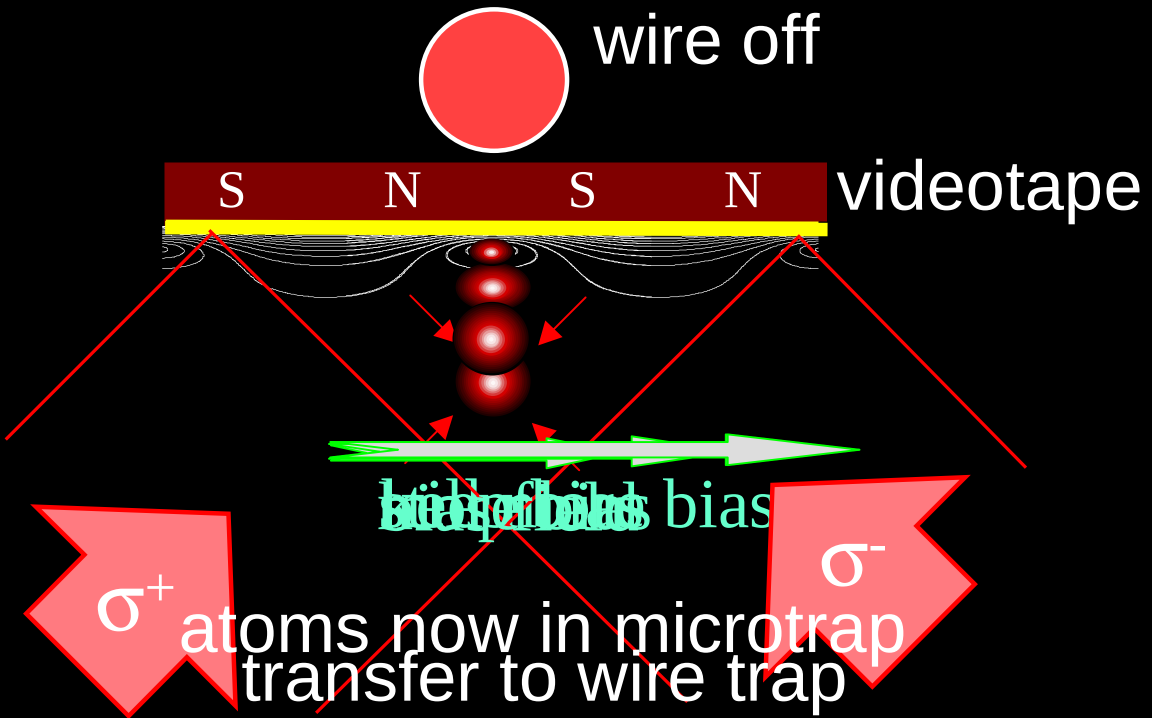
PRA 61 R31404 (2000) with Peter Rosenbusch, Brenton Hall, Ifan Hughes and Carlos Saba and now for microtraps on videotape:



this videotape chip has a 250 microtraps on it

Loading atoms into a videotape microtrap

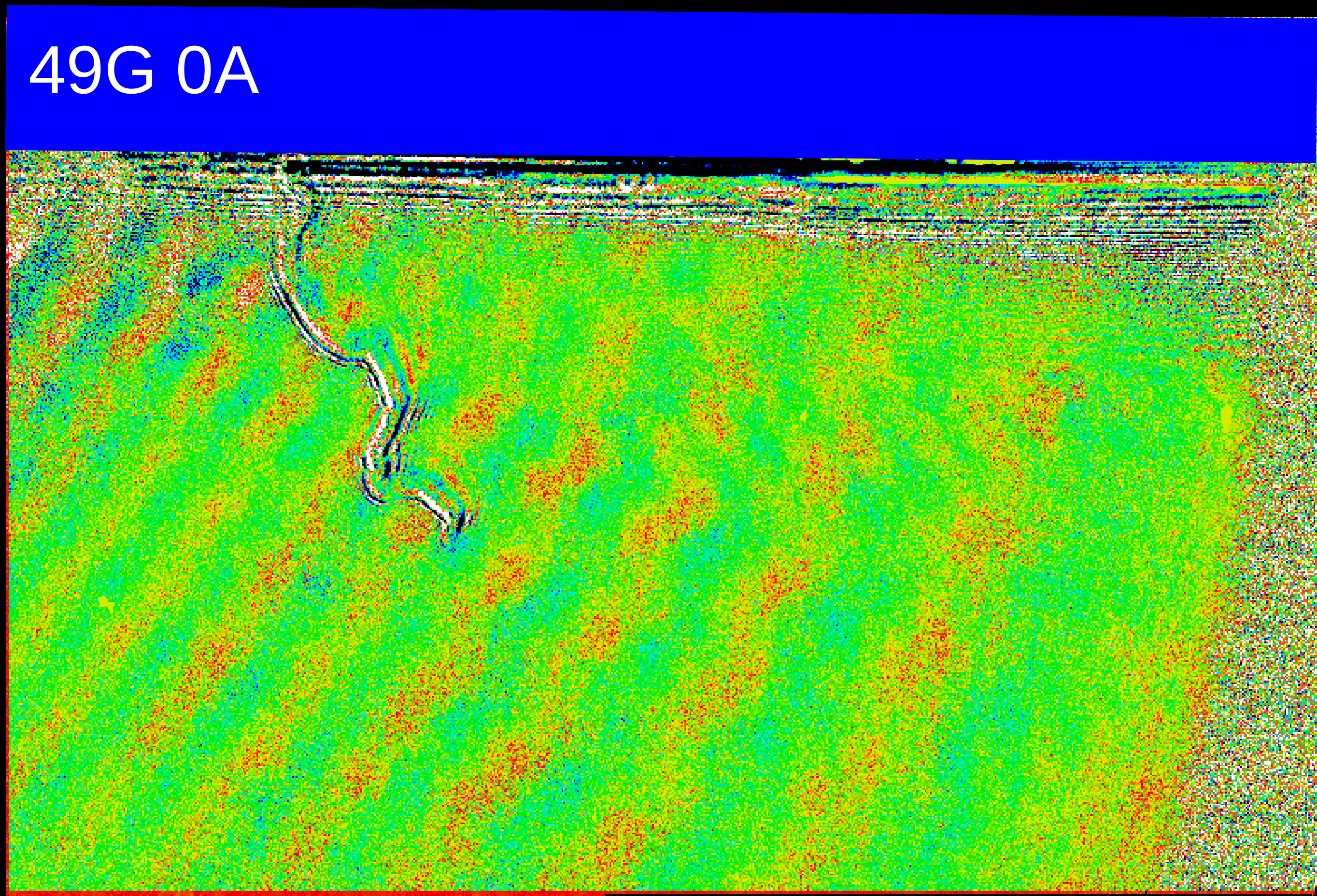
with Brenton Hall and Jocelyn Retter



collect atoms in mirror MOT

Absorption images of loading a microtrap

surface

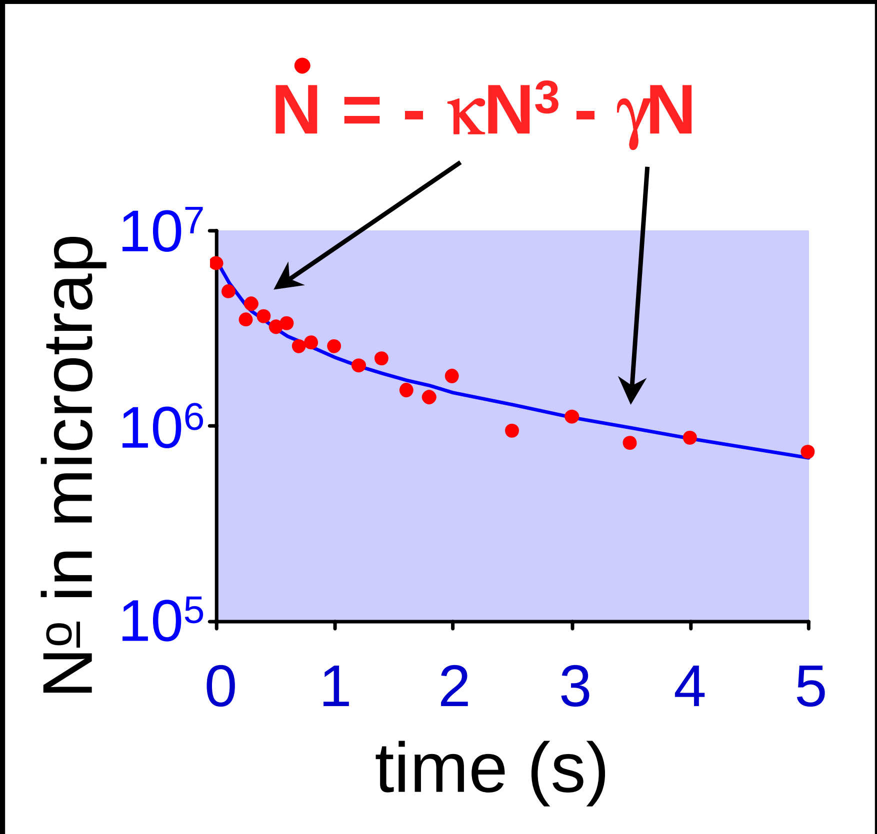


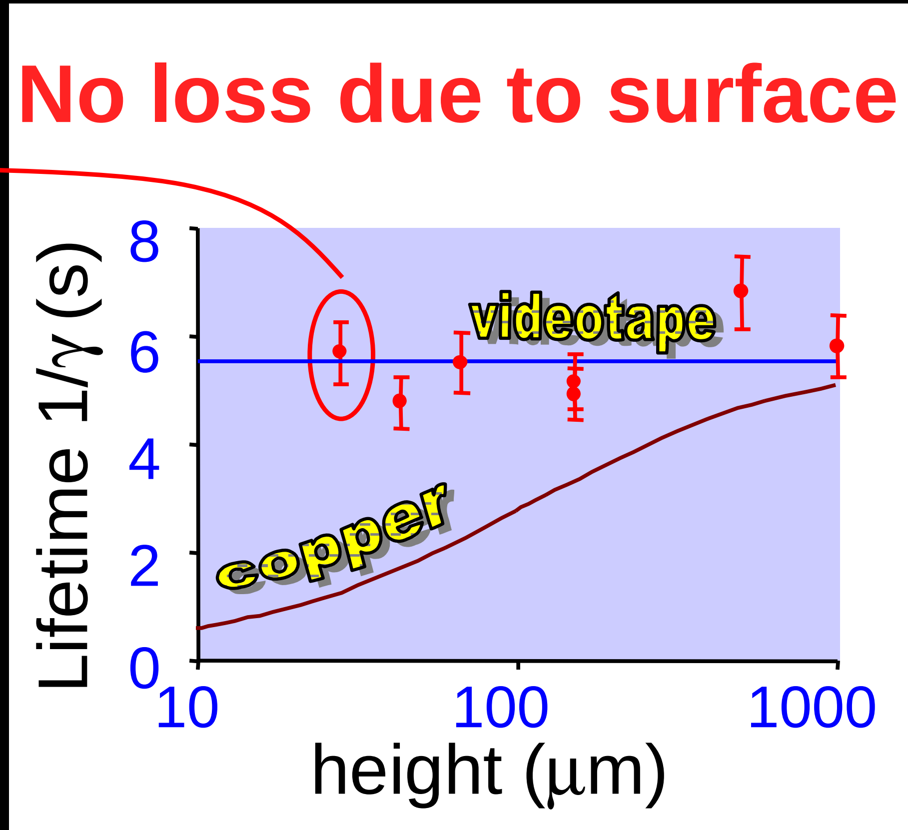
surface

Videotape does not break the cloud into lumps

Atom loss from the microtrap

h = 28μm, $\omega_r = 2\pi \times 31$ kHz





Videotape does not cause atom loss

Summary

BEC can be prepared and manpulated 30μm from a surface.

Microscopic atom interferometer chips seem close, however . . . .

- copper wires

  have a surprise interaction & seem to cause loss

- videotape microtraps

  work really well