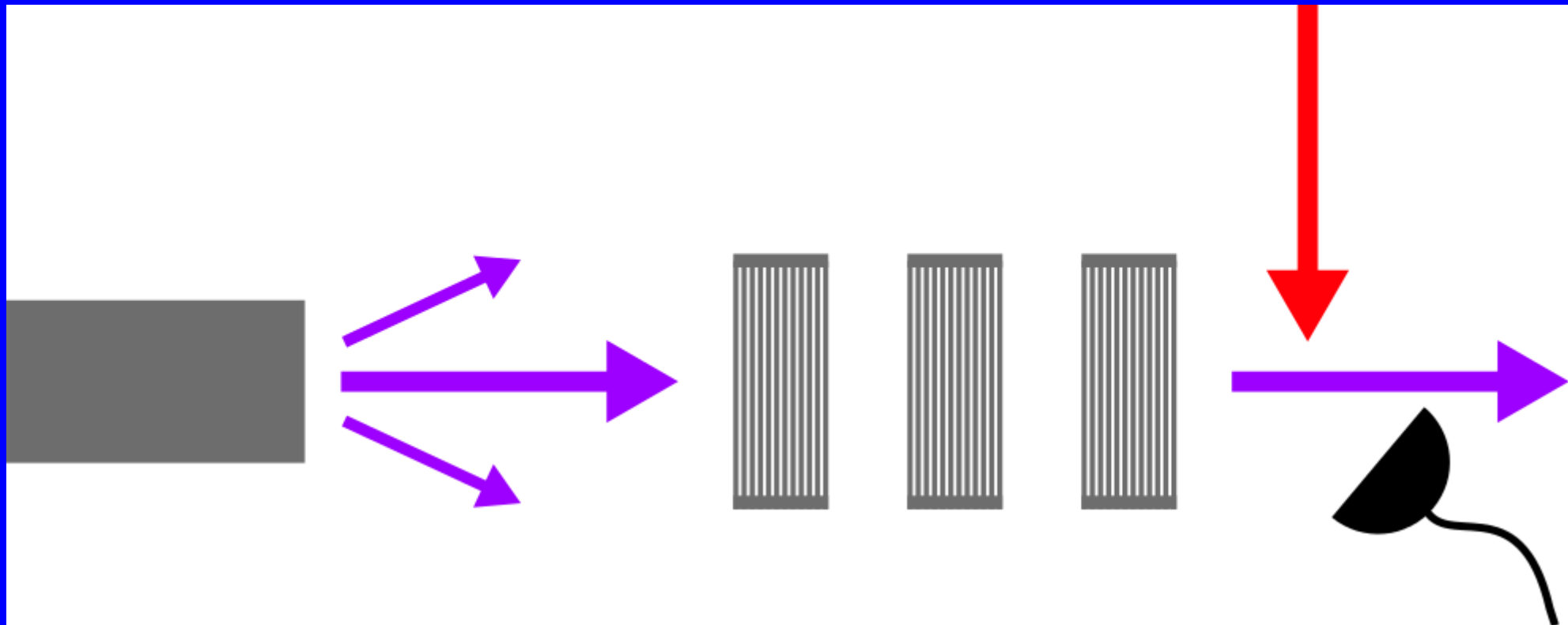


Matterwave interferometry with Rb atoms



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Hasn't this been done already?

Phys. Rev. A 71, 043612 (2005) - Turlapov et al.

Phys. Rev. Lett. 66, 2693 (1991) – Kelth et al.

So what's new?

Coupling of translation motion to spin via inhomogeneous magnetic field.

Some recent work has demonstrated this for nitrogen vacancy centres in optically trapped nanodiamonds: *Physical Review A*, 88 033614 (2013).

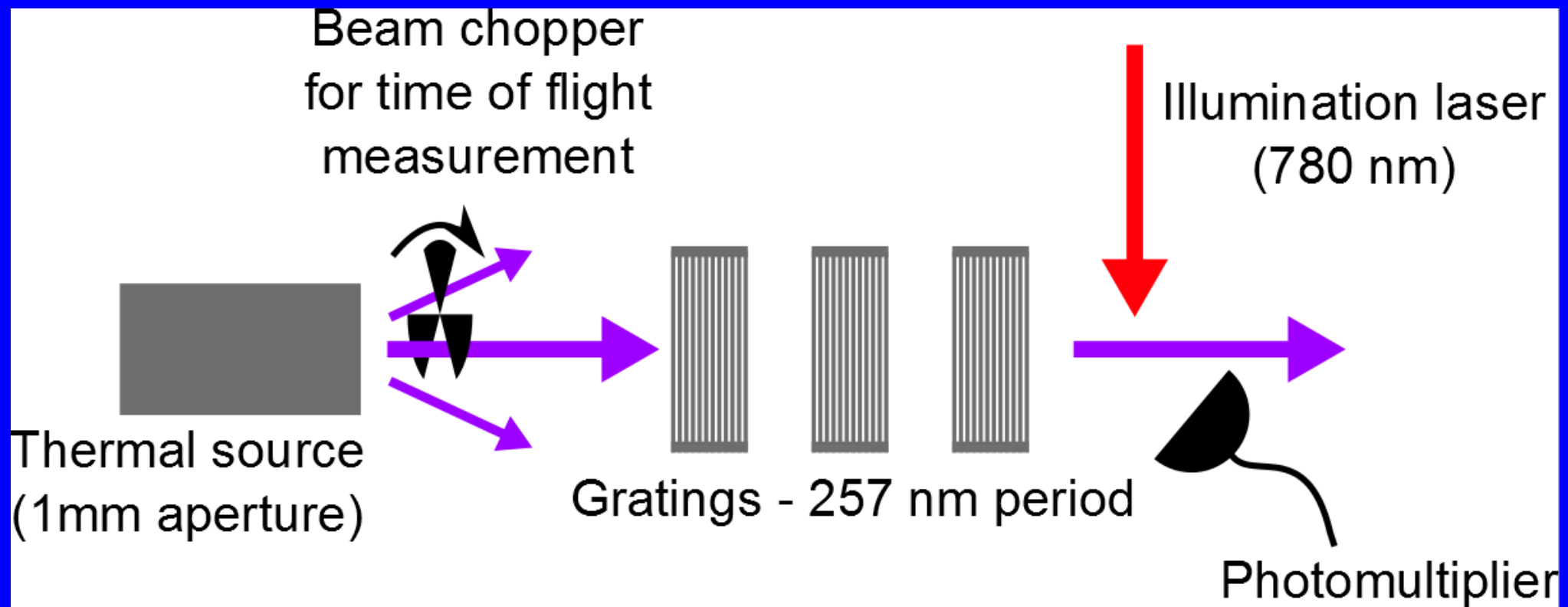
Motivation

Create superposition states of massive objects with large spatial extent:

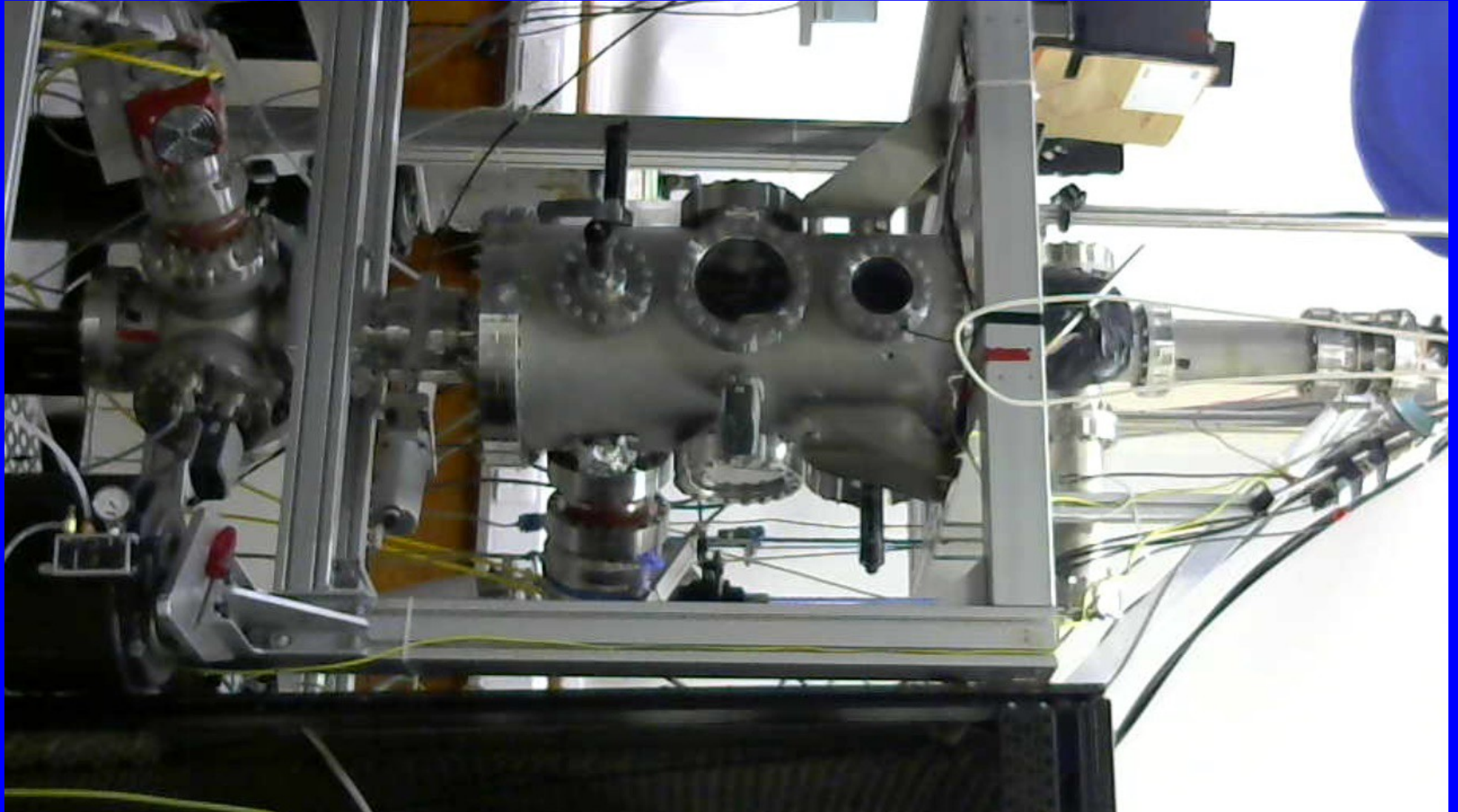
- Tests of fundamental QM
- Sensing
- NMR experiments

...plus the experiment is much easier with Rb!

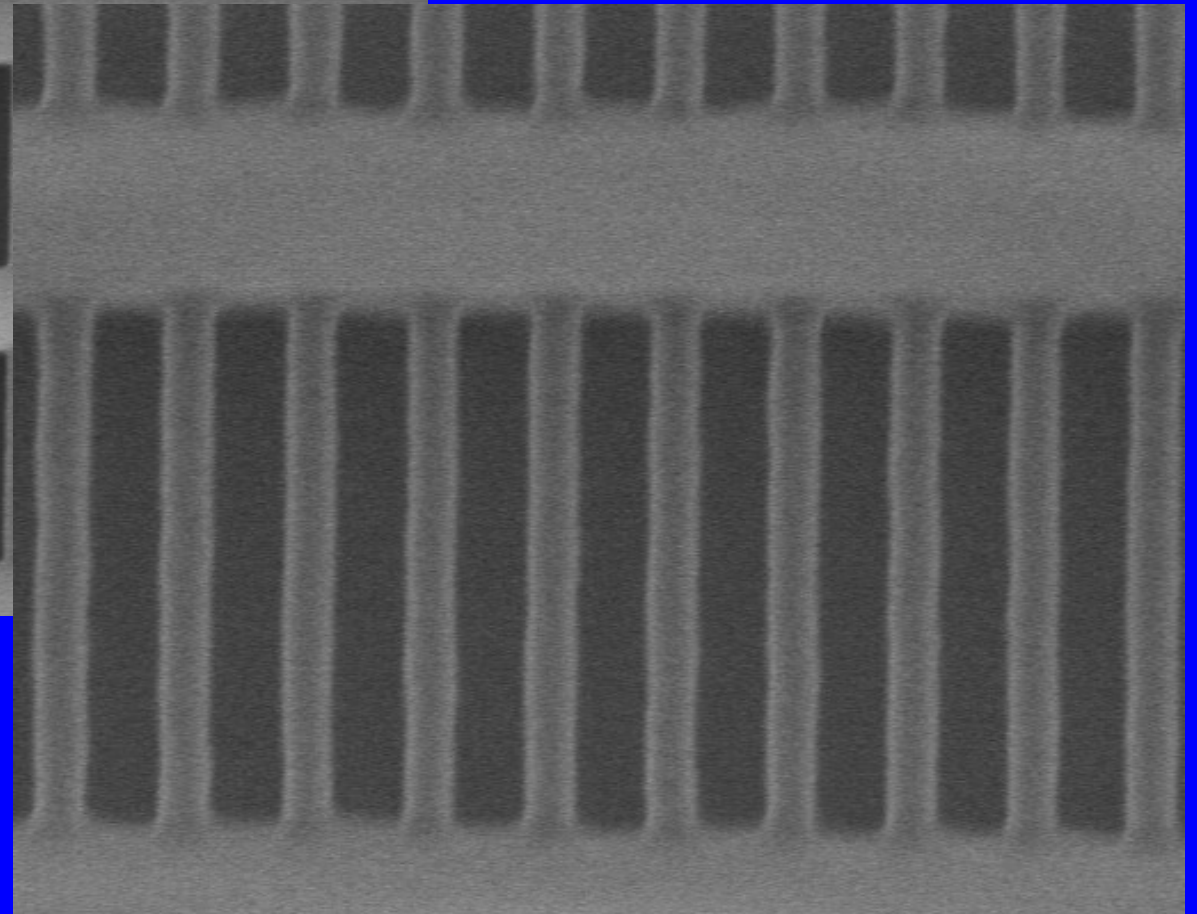
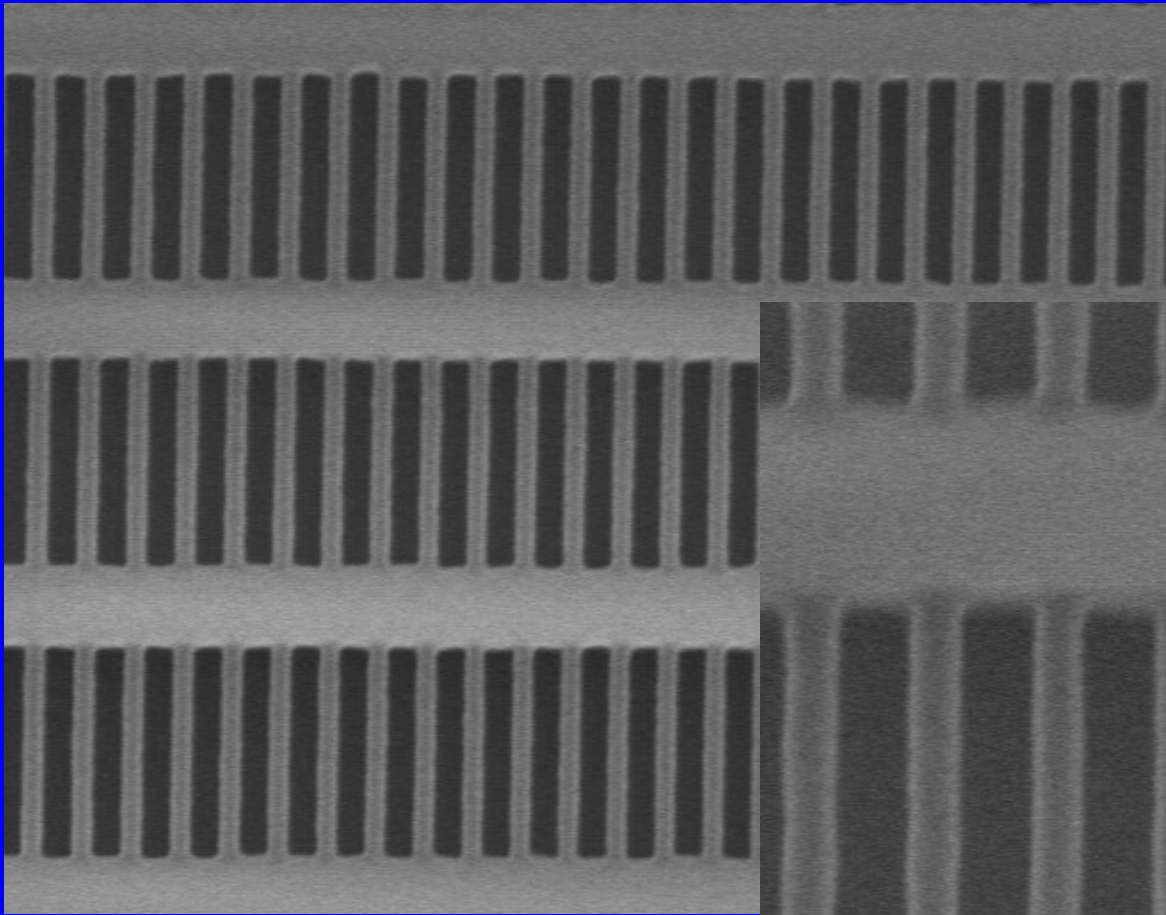
Experimental setup



Experimental setup



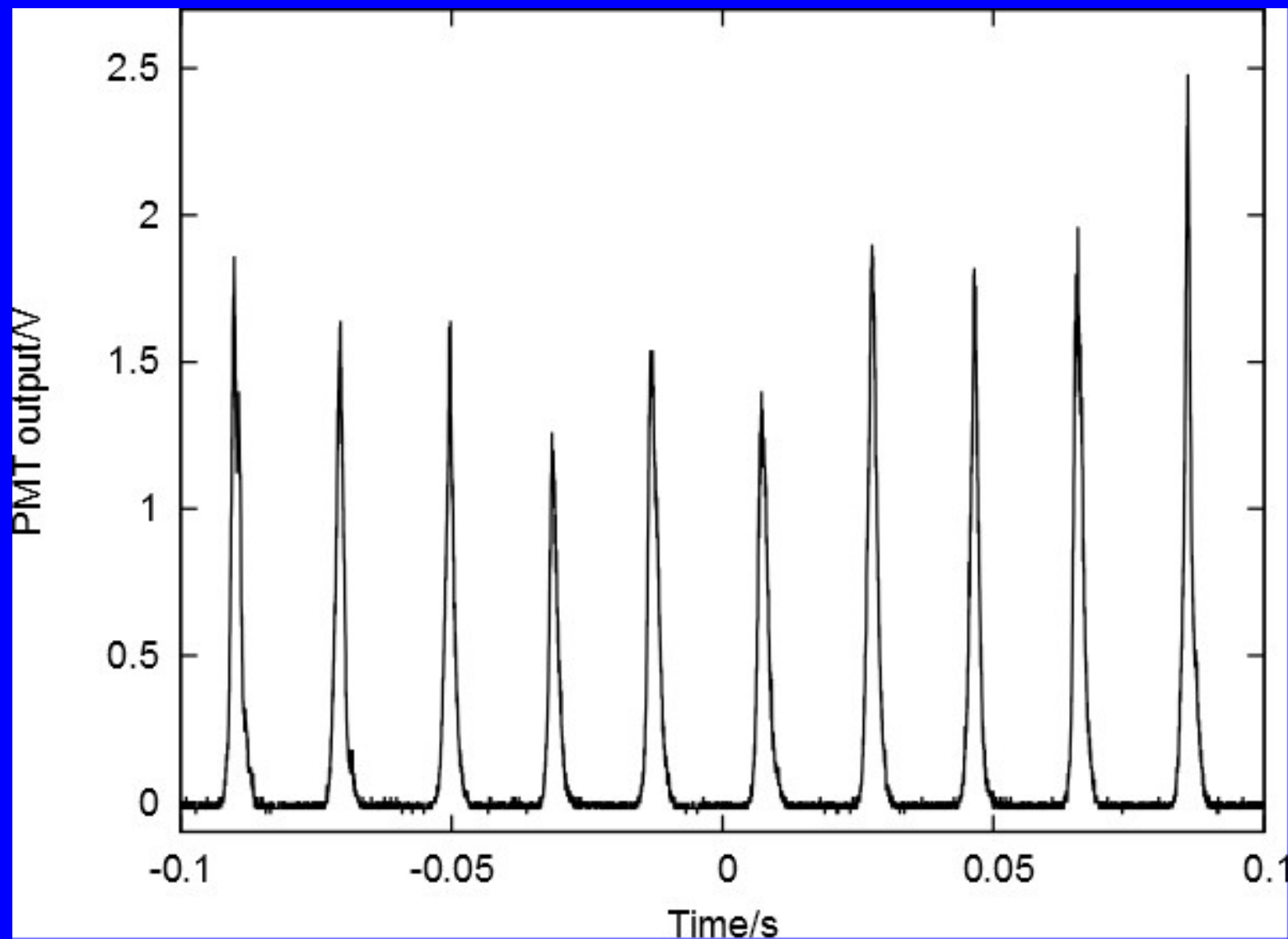
Experimental setup



Experimental progress



Experimental progress



Longer term aims...

NMR experiments

Magnetically mediated interferometry...

...can impart significant momentum via interaction of electron spin with magnetic field gradient.

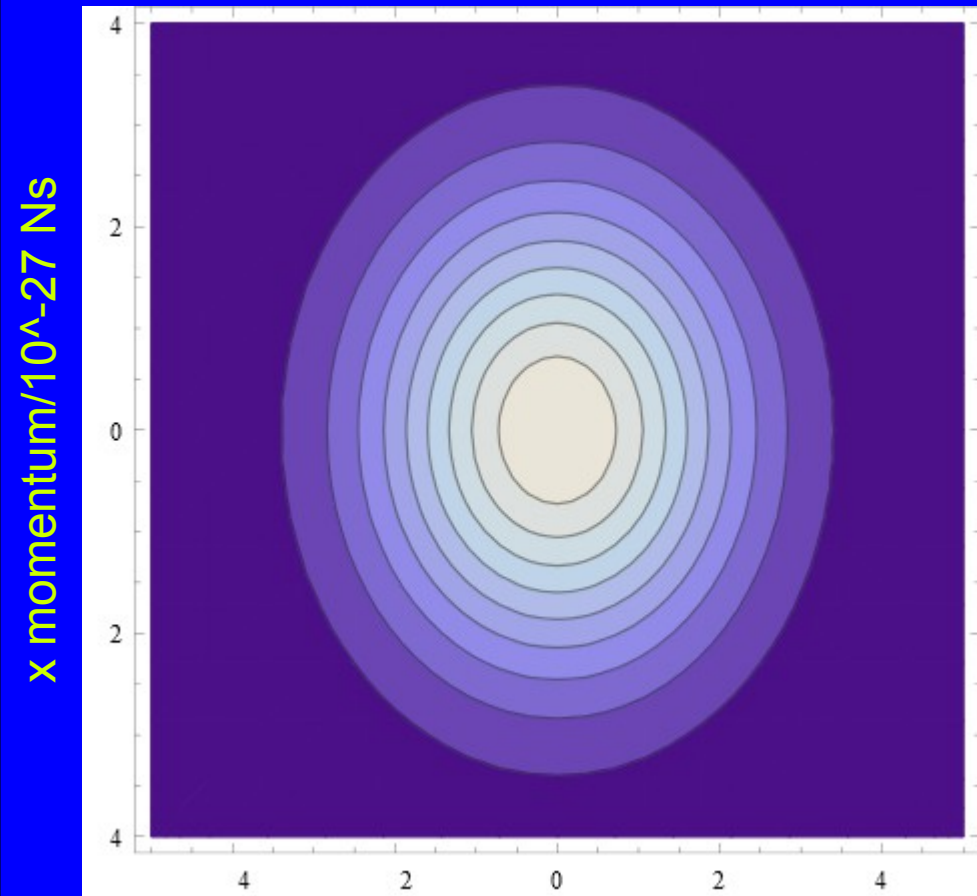
Simulating magnetic interferometry experiments: extended Wigner function approach

$$W(x, p) = \frac{1}{h} \int_0^{\infty} e^{-ips/h} \langle x + s/2 | \hat{\rho} | x - s/2 \rangle ds$$

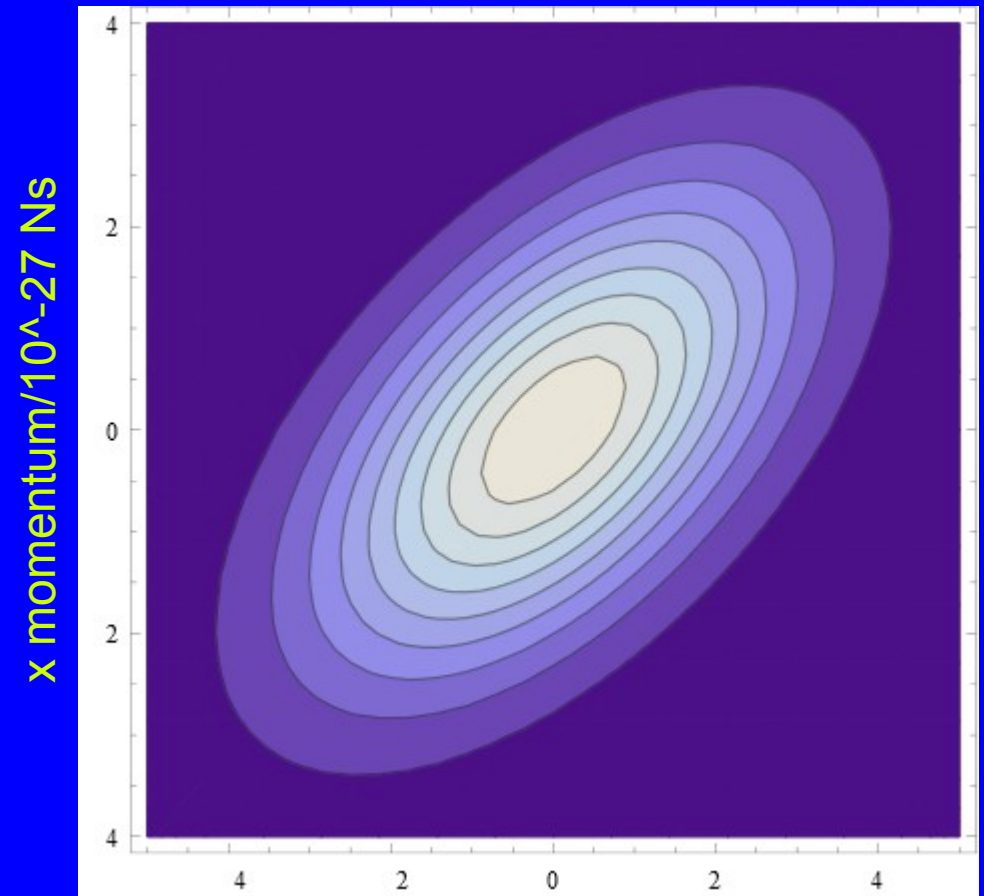
Simulating magnetic interferometry experiments: extended Wigner function approach

$$W_{\eta,\epsilon}(x,p) = \frac{1}{h} \int_0^{\infty} e^{-ips/h} \langle x + s/2, \eta | \hat{\rho} | x - s/2, \epsilon \rangle ds$$

Simulating magnetic interferometry experiments: extended Wigner function approach

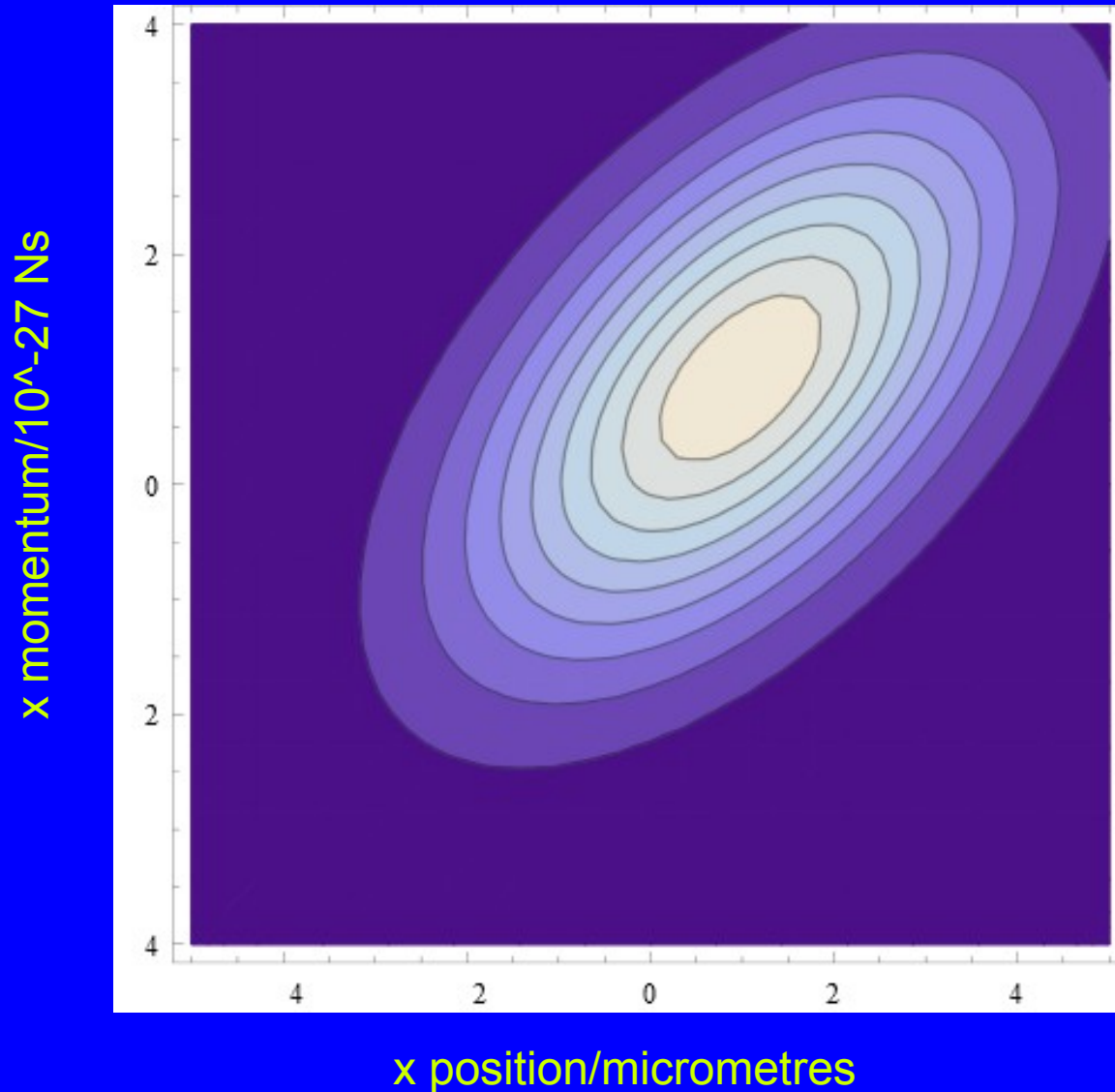


$x \text{ position}/\text{micrometres}$

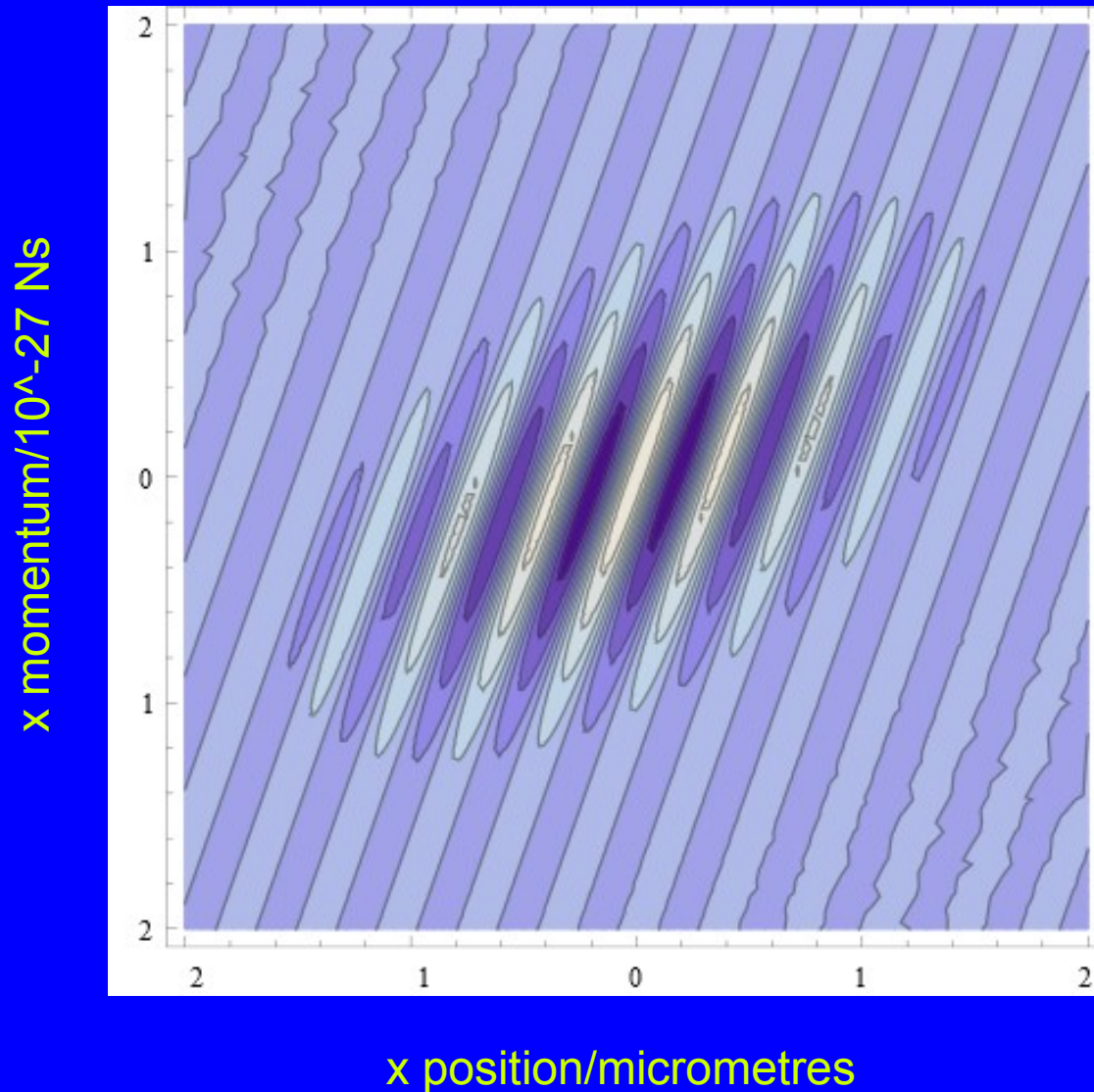


$x \text{ position}/\text{micrometres}$

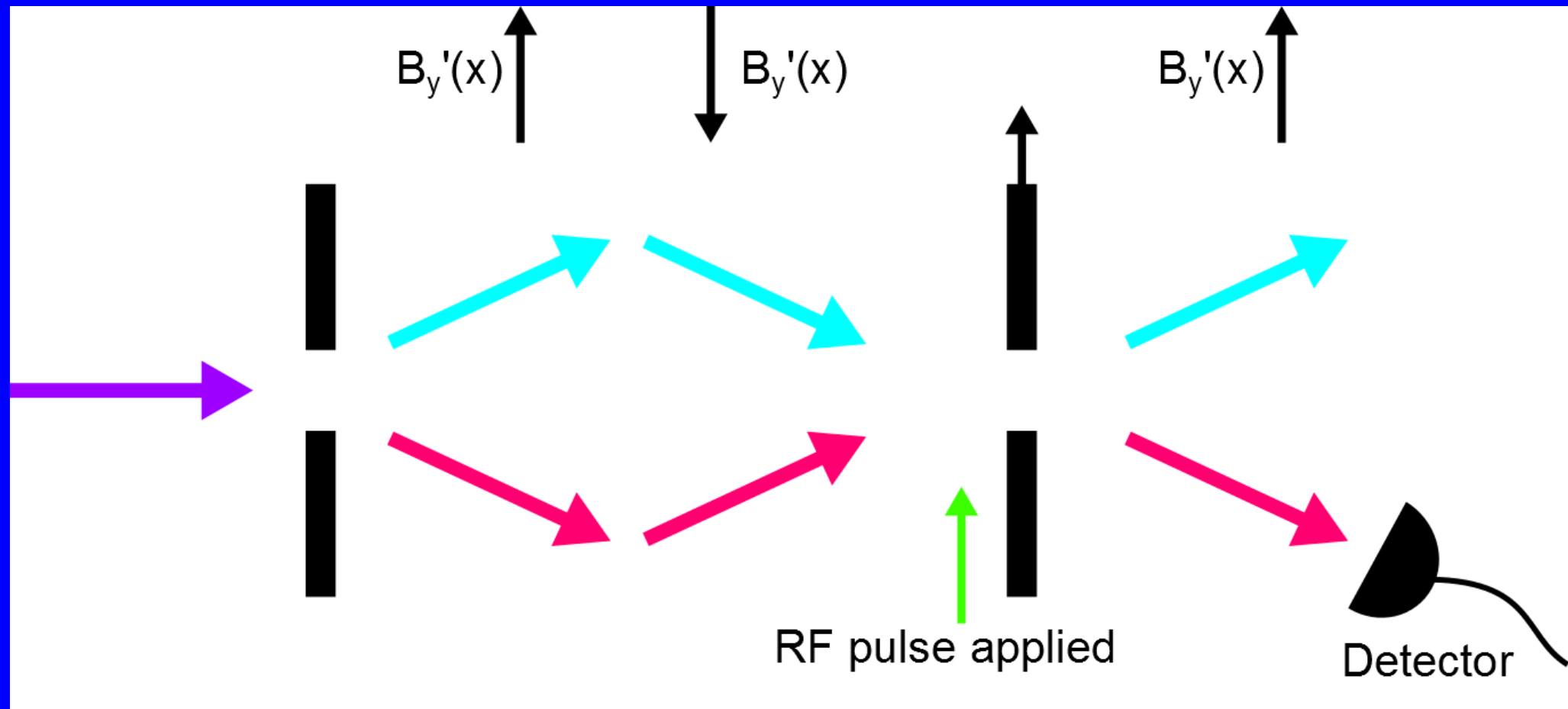
Simulating magnetic interferometry experiments: extended Wigner function approach



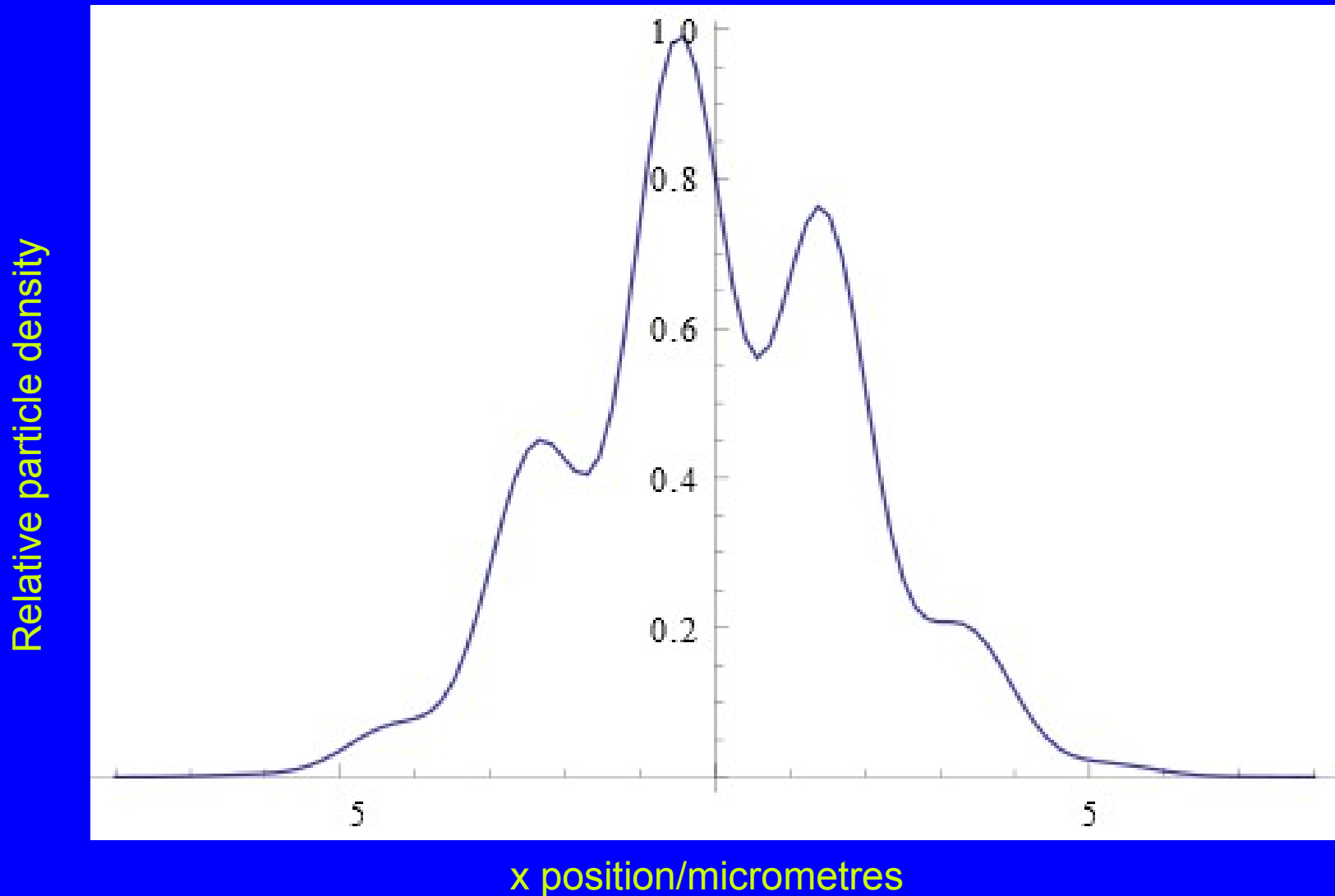
Simulating magnetic interferometry experiments: extended Wigner function approach



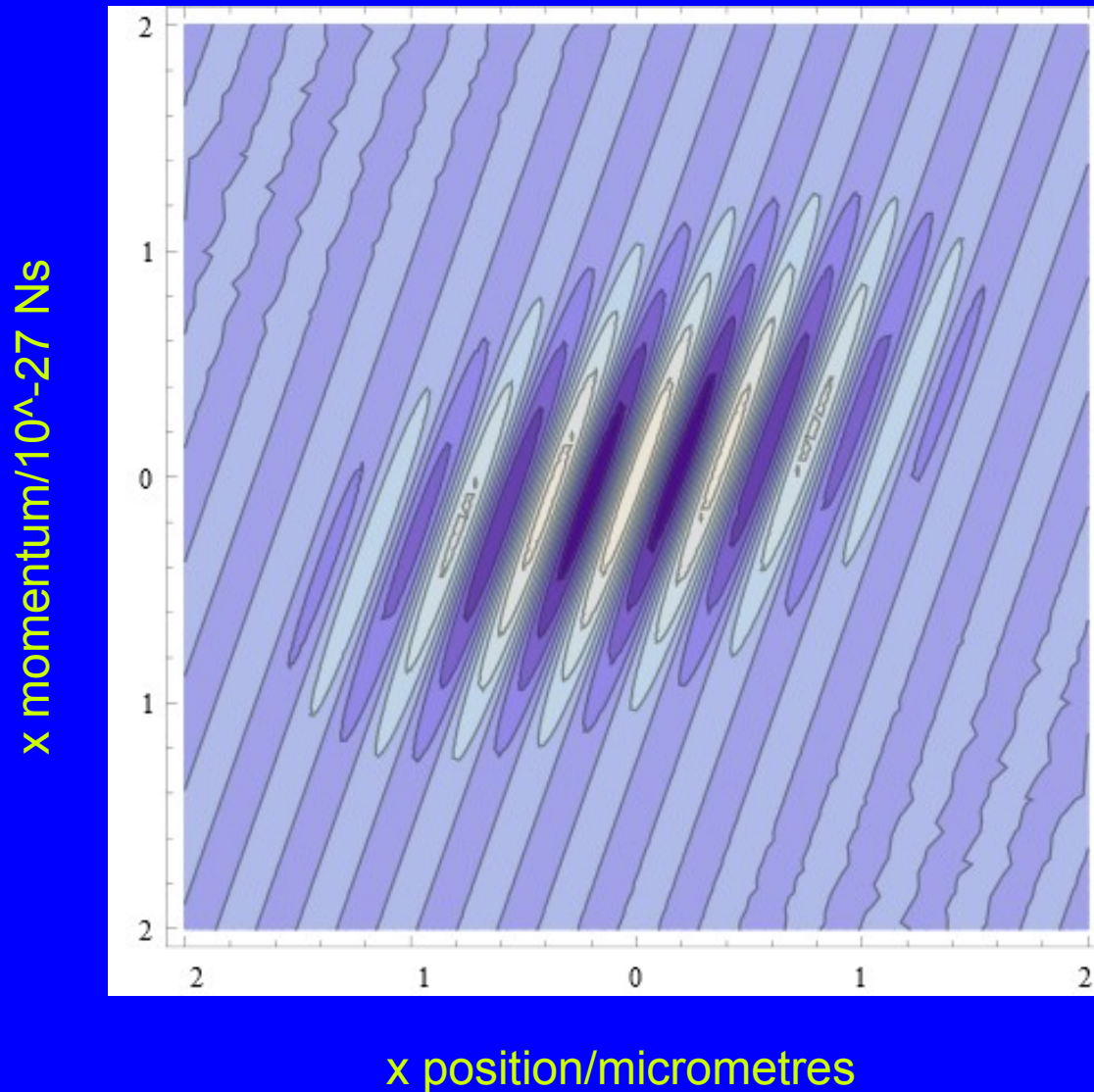
Simulating magnetic interferometry experiments: extended Wigner function approach



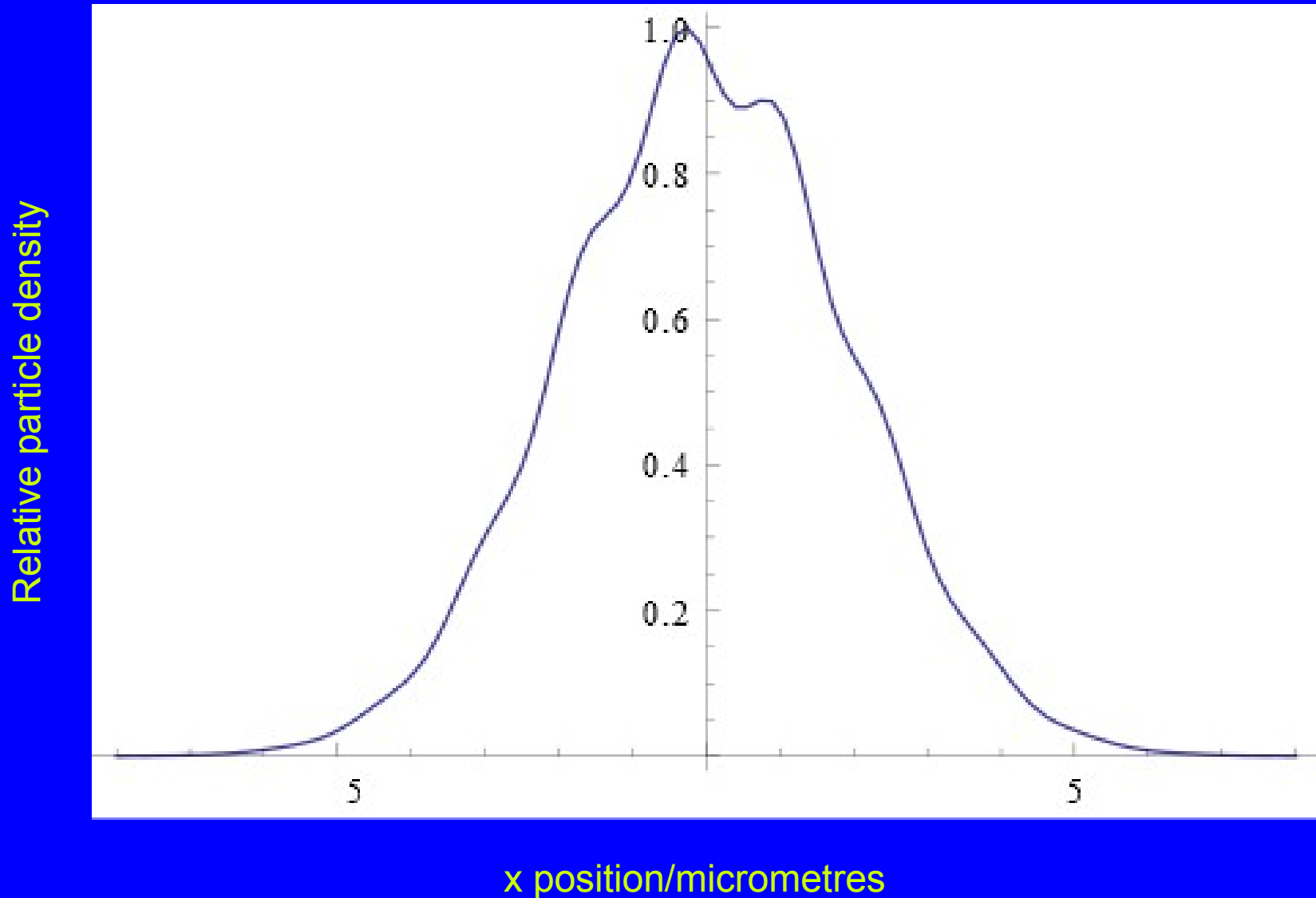
Simulating magnetic interferometry experiments: extended Wigner function approach



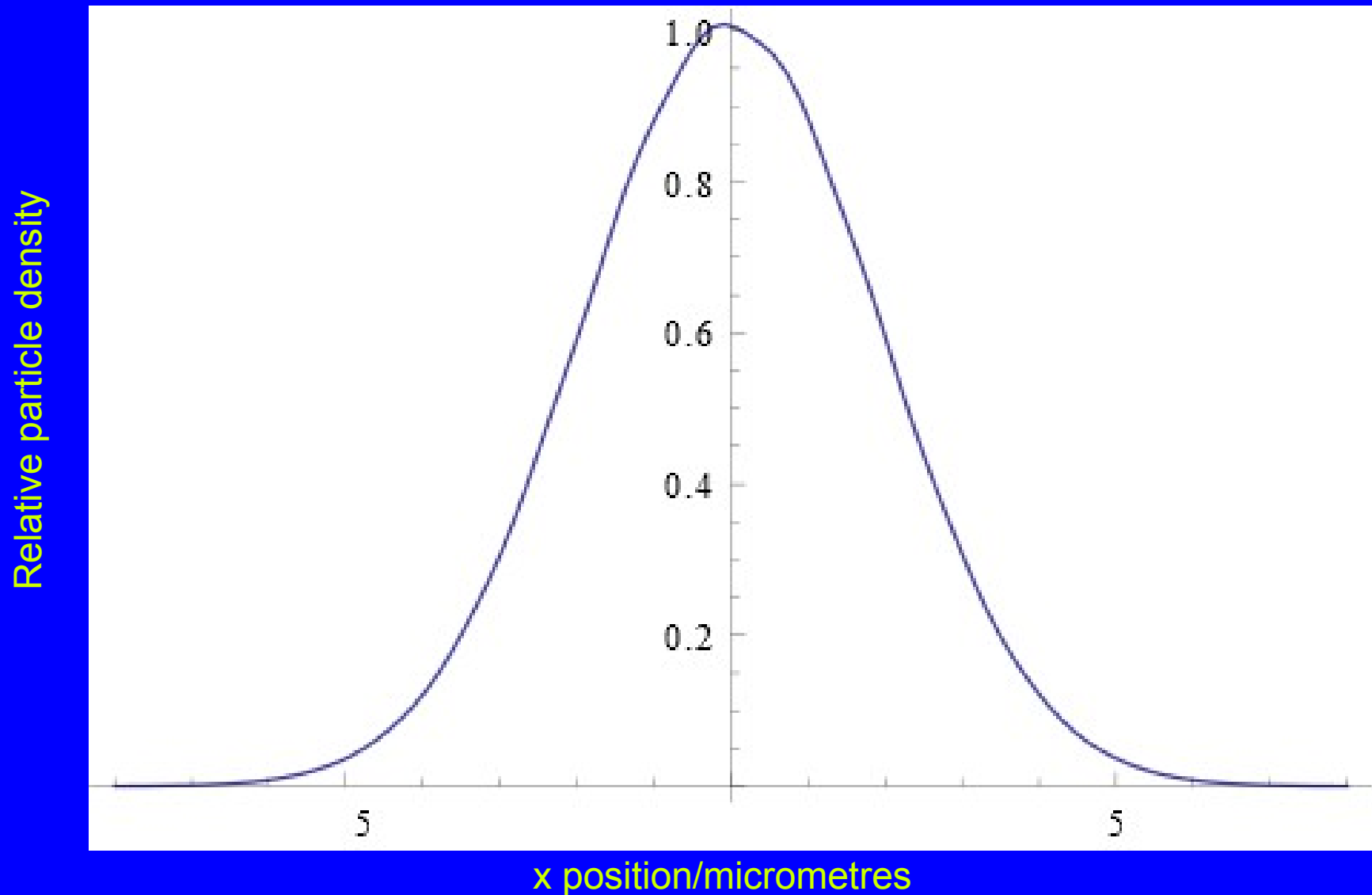
Simulating magnetic interferometry experiments: extended Wigner function approach



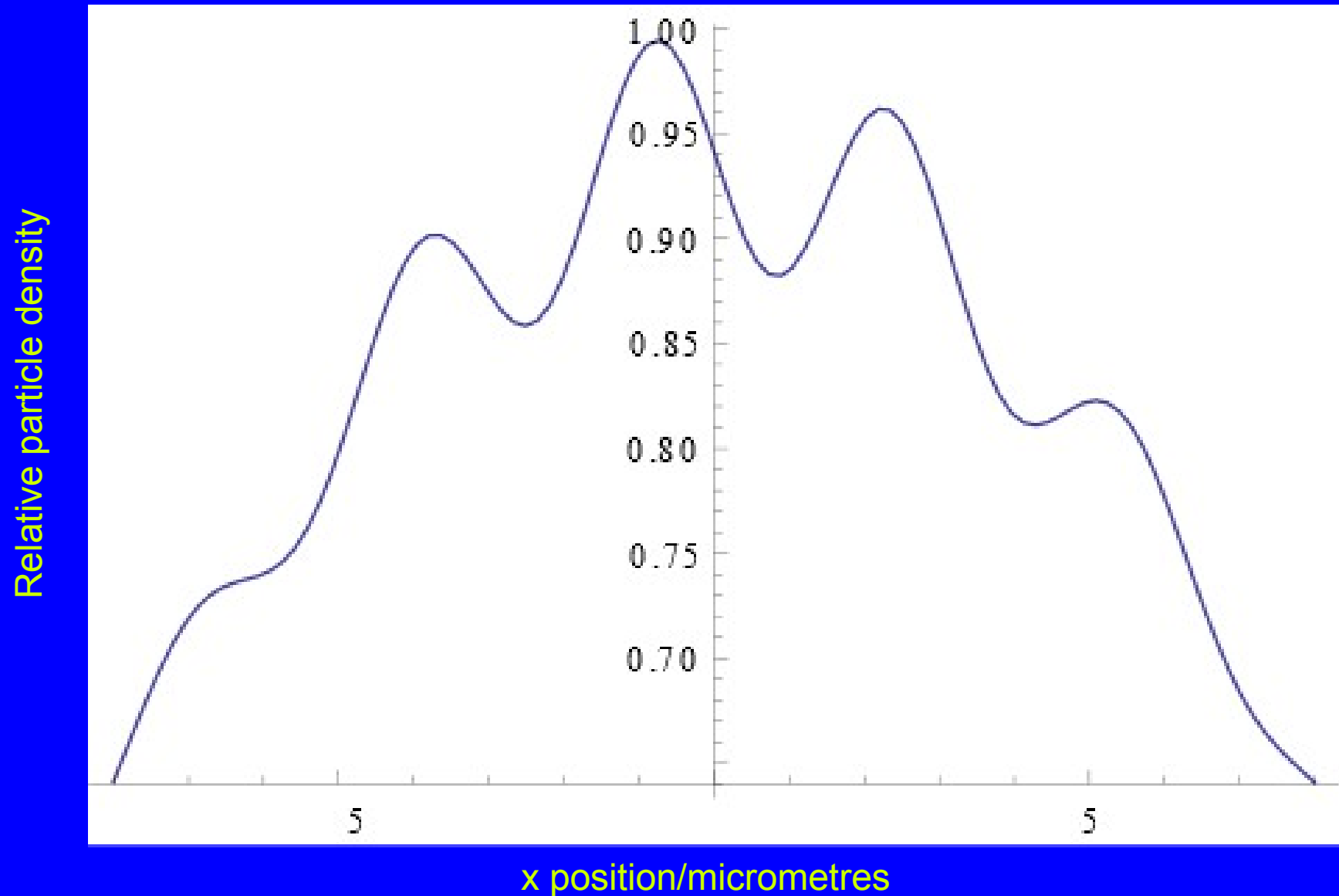
Simulating magnetic interferometry experiments: extended Wigner function approach



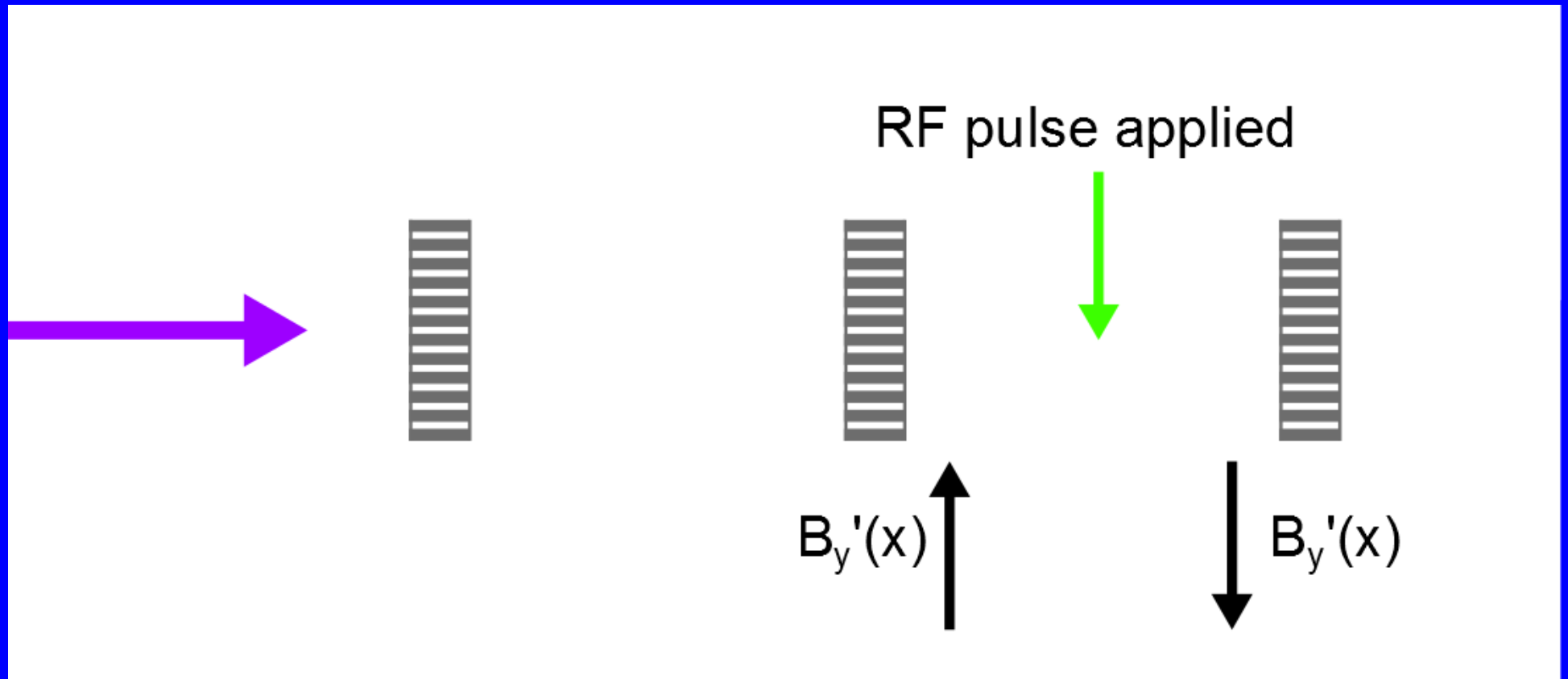
Simulating magnetic interferometry experiments: extended Wigner function approach



Simulating magnetic interferometry experiments: extended Wigner function approach



NMR Experiments



Outlook

- Hope to demonstrate TLI for Rb atoms very soon (weeks not years!).
- Following this, will aim to demonstrate coupling of translational motion to spin state.
- Only major obstacle (that we know about) to magnetically-enhanced nanoparticle interferometry is creating a long-lived embedded spin state.

Thanks

- Hendrik Ulbricht, Malcolm Levitt and Marcel Utz
- The rest of my research group: James Bateman, David Hempston, Paul Clark, Jamie Vovrosh and Muddassar Rashid
- LNF and the conference organisers