

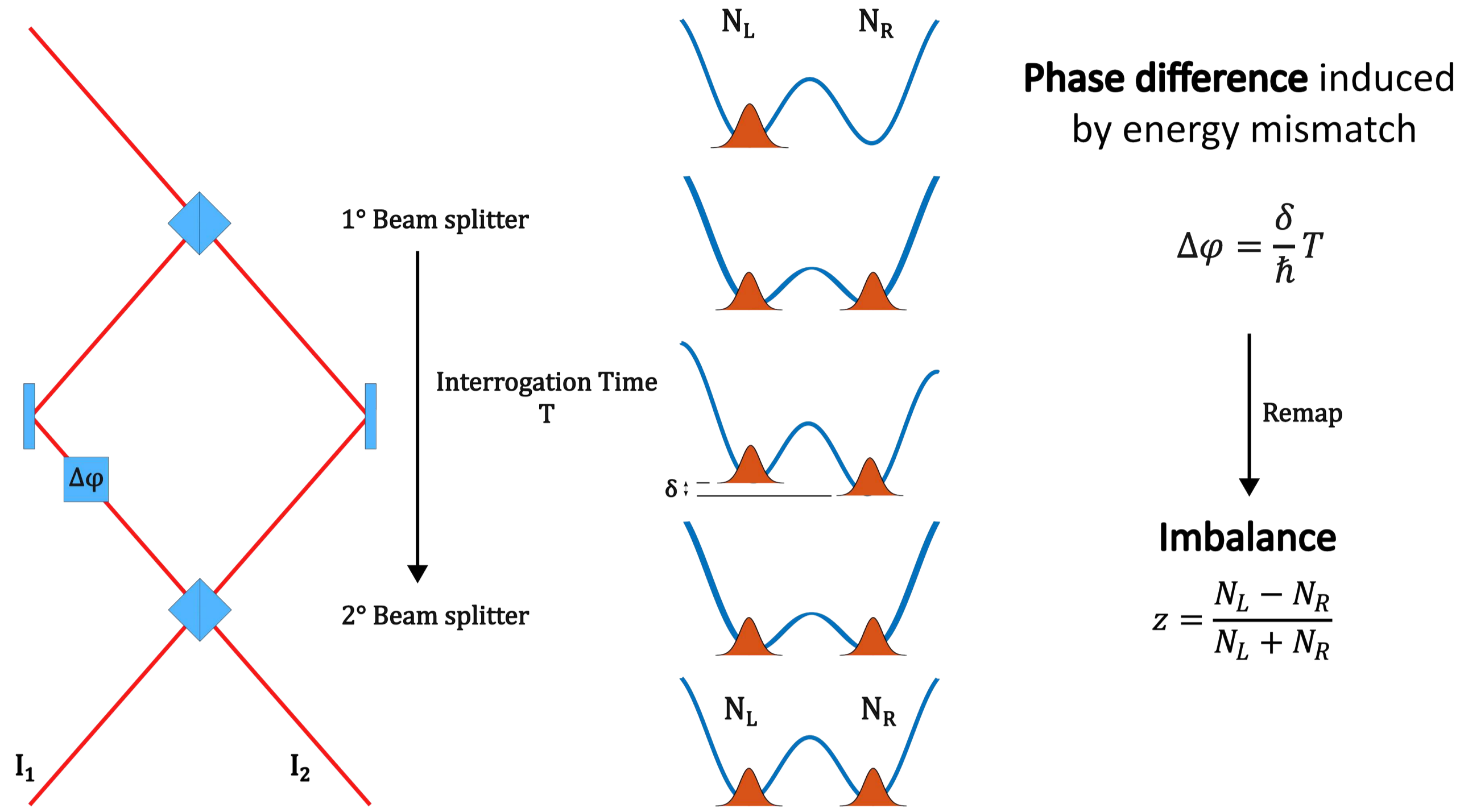
Differential Mach-Zehnder Interferometry With Trapped BECs

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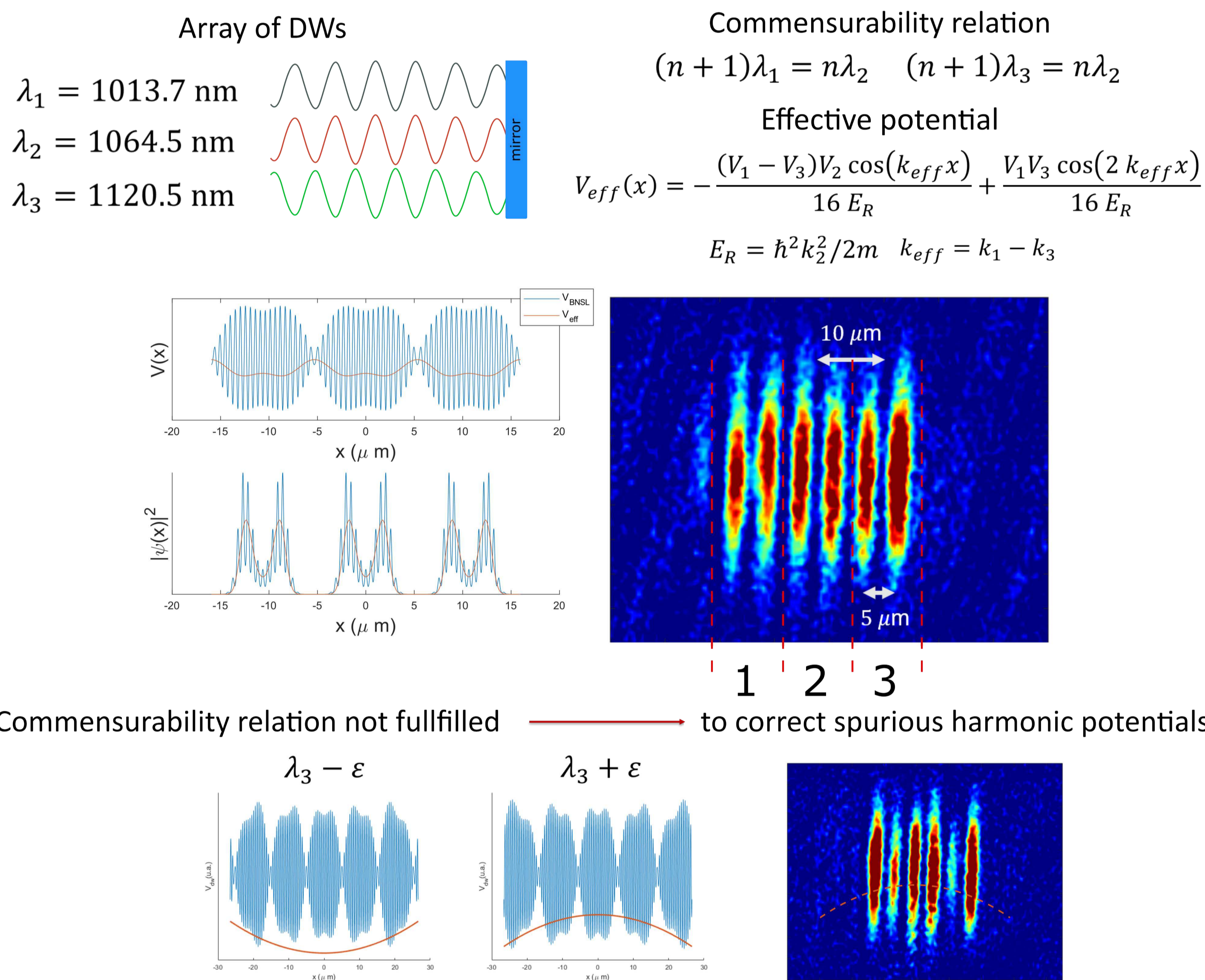
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Our experiment consists of an array of trapped atom double well (DW) interferometers using ³⁹K Bose Einstein condensates. Implementing an optical superlattice potential, we create several interferometers working simultaneously. The novelty of our setup consists in the use of three standard 1D lattices with lasers retroreflected on a common mirror, that realize a new kind of beat note potential [1]. Such configuration is intrinsically very stable because it depends on the stability of the mirror and of the laser frequencies, like in state of the art free falling atom interferometers [2,3]. Cancelling interparticle interactions using a broad magnetic Feshbach resonance we demonstrate the operation of linear Mach-Zehnder interferometers with trapped BECs. By a differential analysis on two interferometers operating in parallel, we demonstrate for the first time a trapped atom gradiometer.

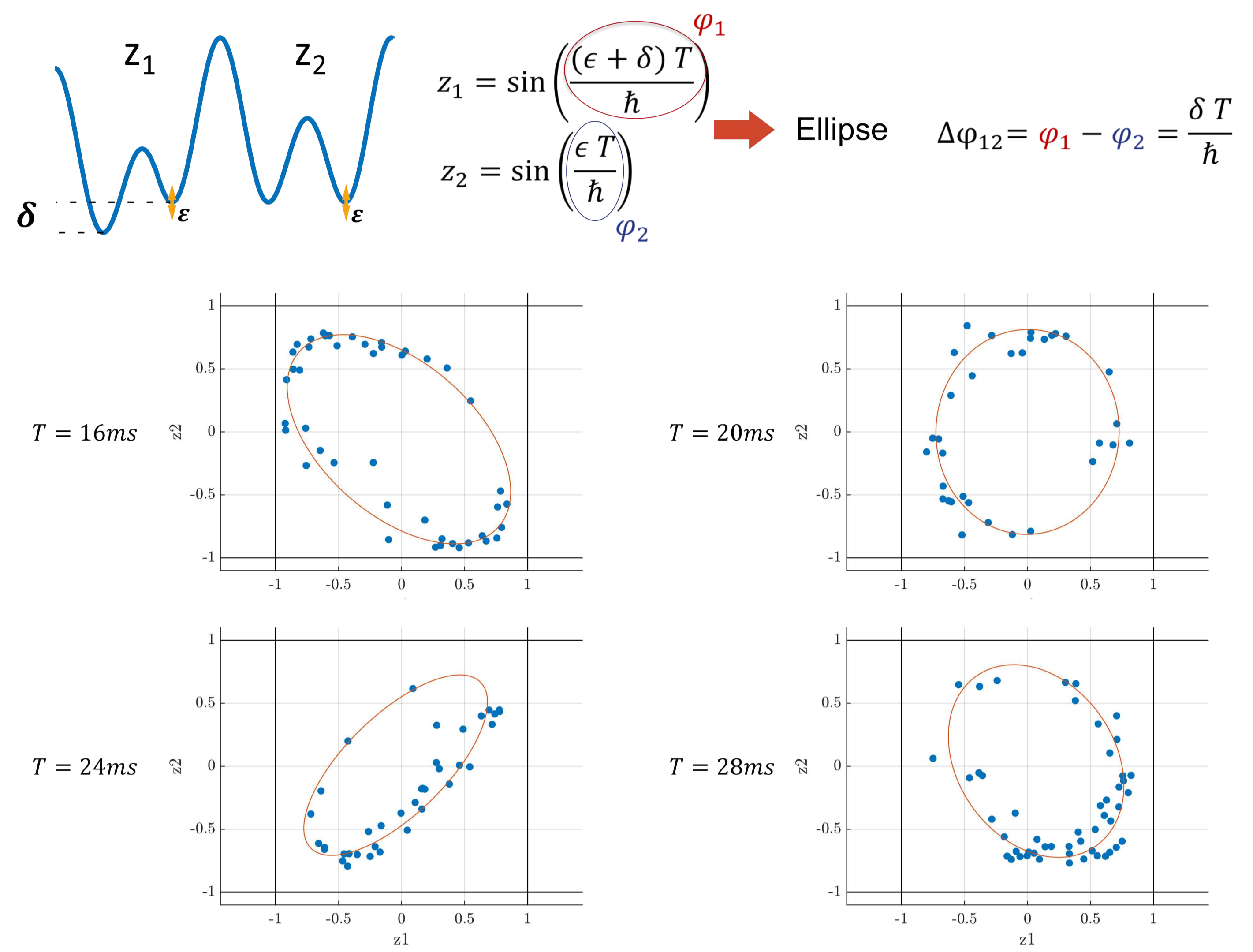
Mach-Zehnder Interferometer with Double-well potential



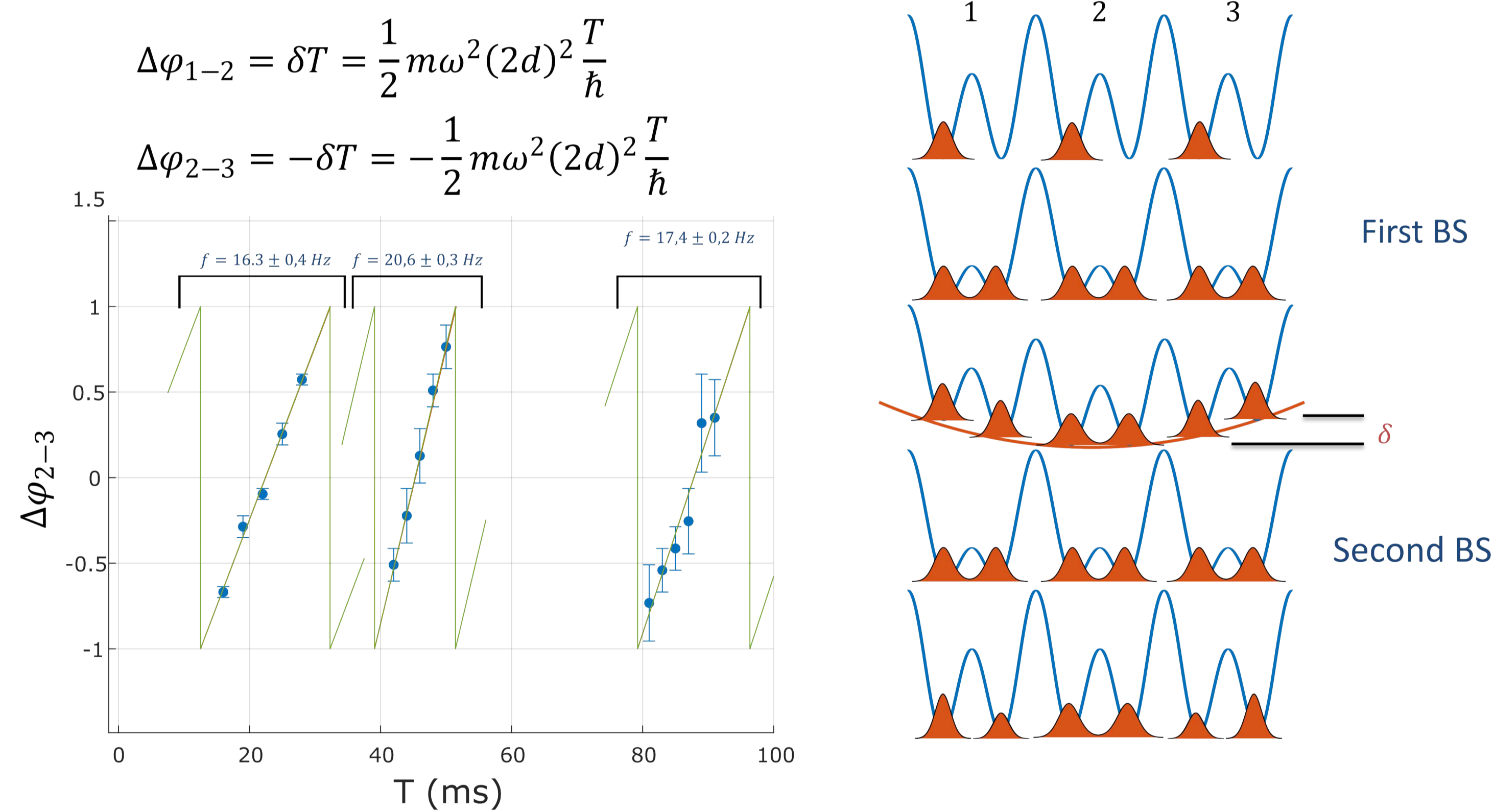
Double-well potential using Beat note lattices



Mach-Zehnder Gradiometer

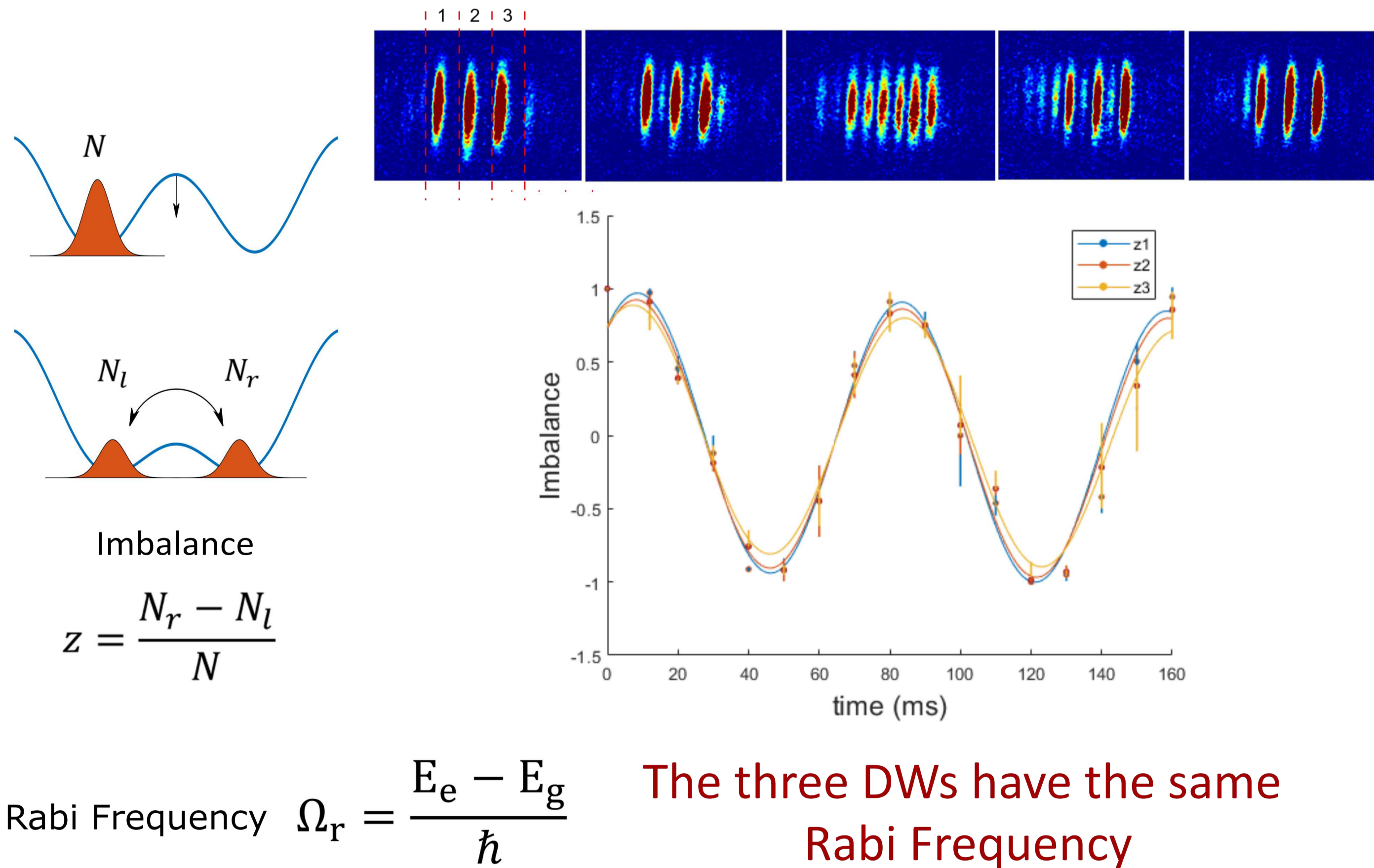


To study the system we add a known harmonic trap



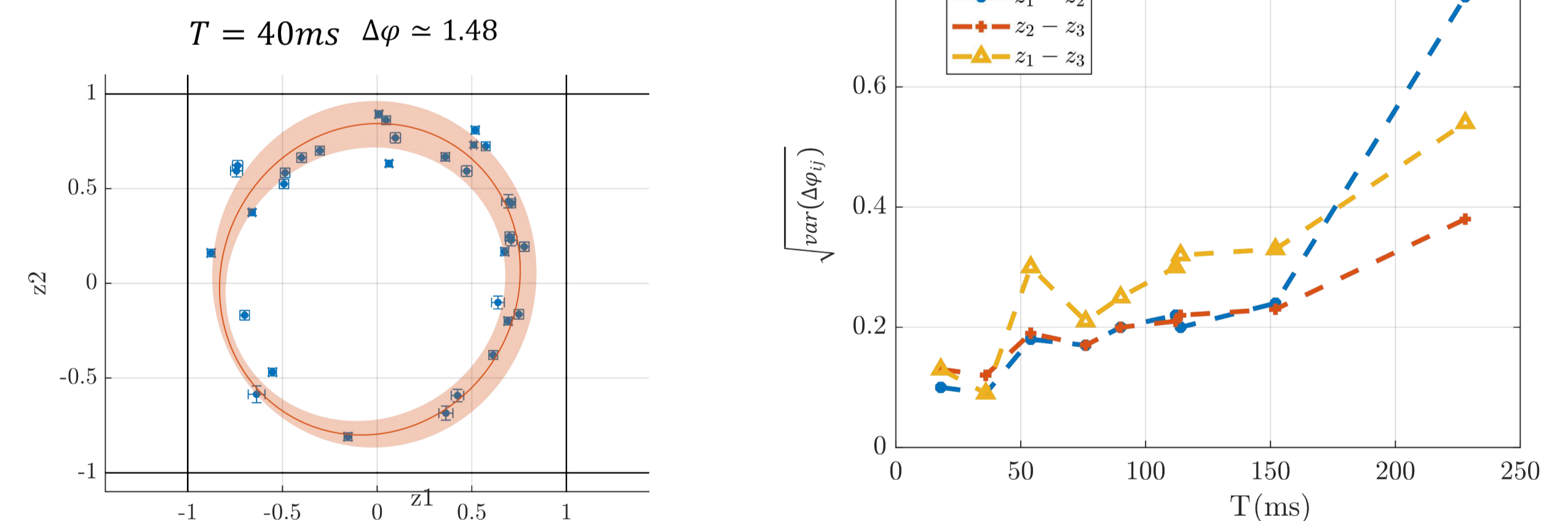
Trapped Atom Gradiometer

Tunneling in the double-well



Coherence

we study $\text{var}(\Delta\phi)$ at different times

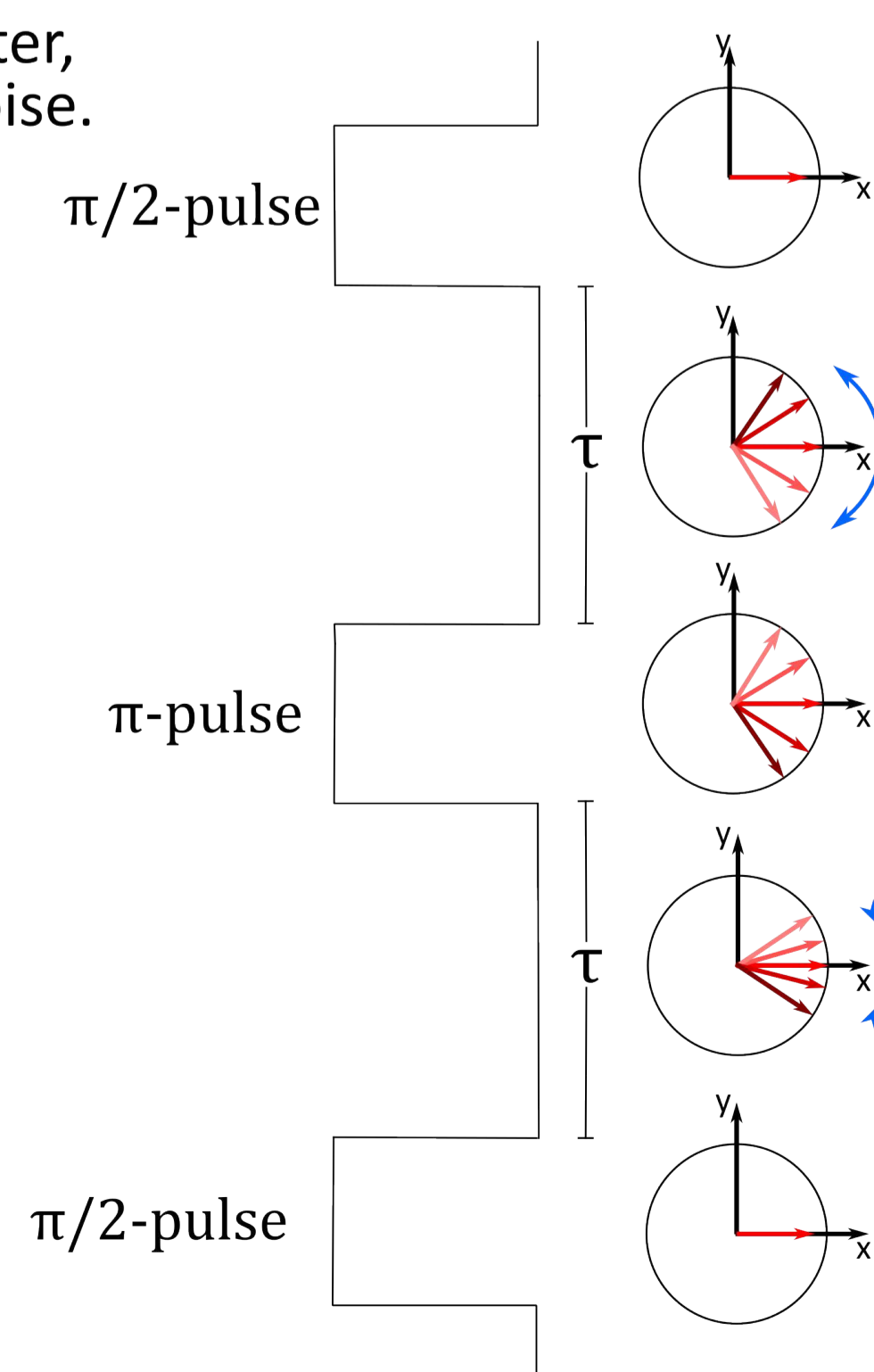
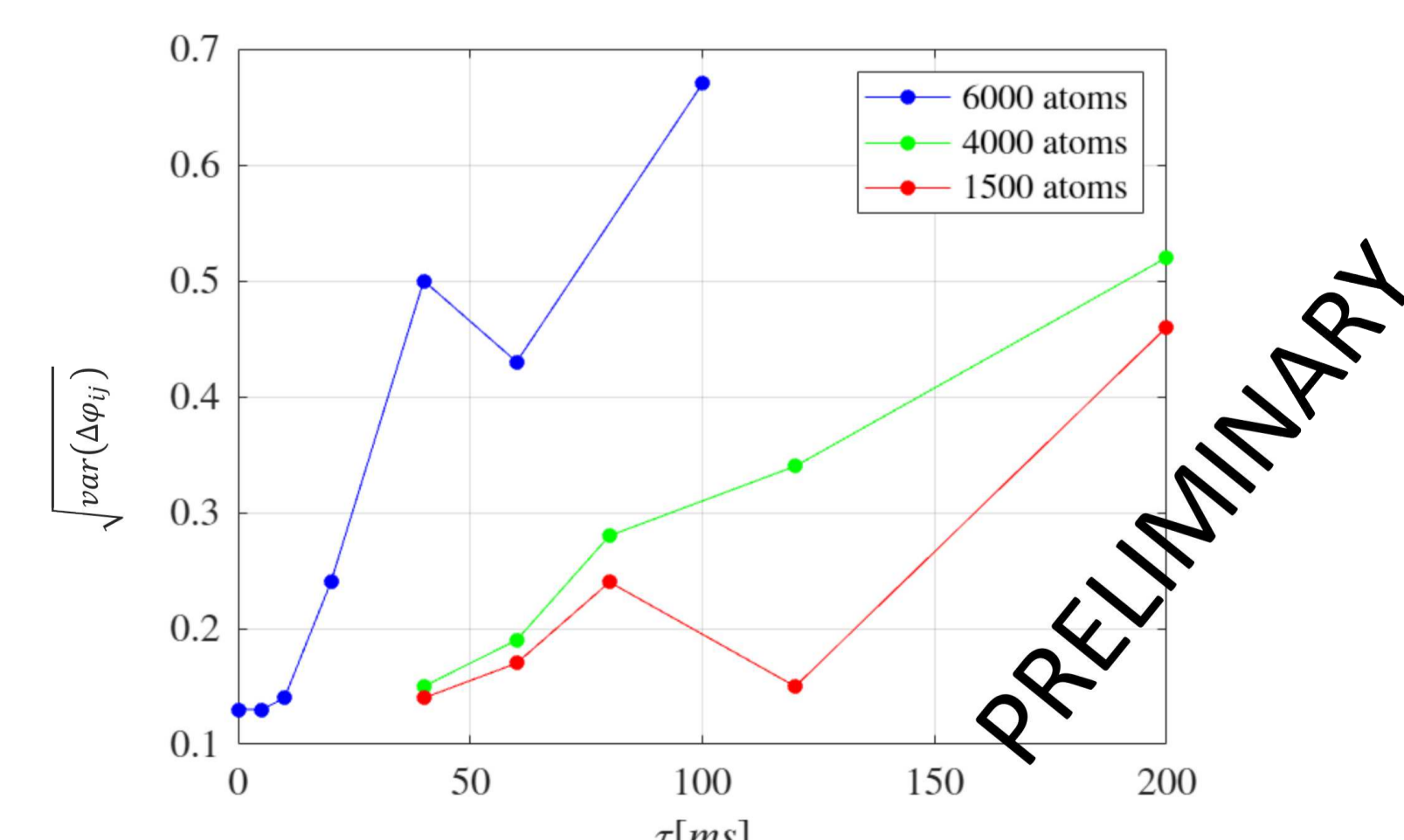


Spin-Echo

Spin echo cancels the low frequency noise in each interferometer, while the differential analysis cancel the common frequency noise.

Spin-echo + gradiometer coherence is affected by:

- 1) Not common AC noise
- 2) Decoherence caused by interactions



Open questions:

- Main sources of decoherence
- Study of residual interactions (three body collisions?)
- Can we cancel extra noise from analysis on three or more interferometers?

References

- [1] Masi, L., et al. "Spatial Bloch Oscillations of a Quantum Gas in a "Beat-Note" Superlattice." Physical Review Letters 127.2 (2021): 020601.
- [2] Peters, Achim, Keng Yeow Chung, and Steven Chu. "Measurement of gravitational acceleration by dropping atoms." Nature 400.6747 (1999): 849-852.
- [3] Shin, Y., et al. "Atom interferometry with Bose-Einstein condensates in a double-well potential." Physical review letters 92.5 (2004): 050405.



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