Optical Dimple Traps and BEC

Ultracold wave machines and other games.

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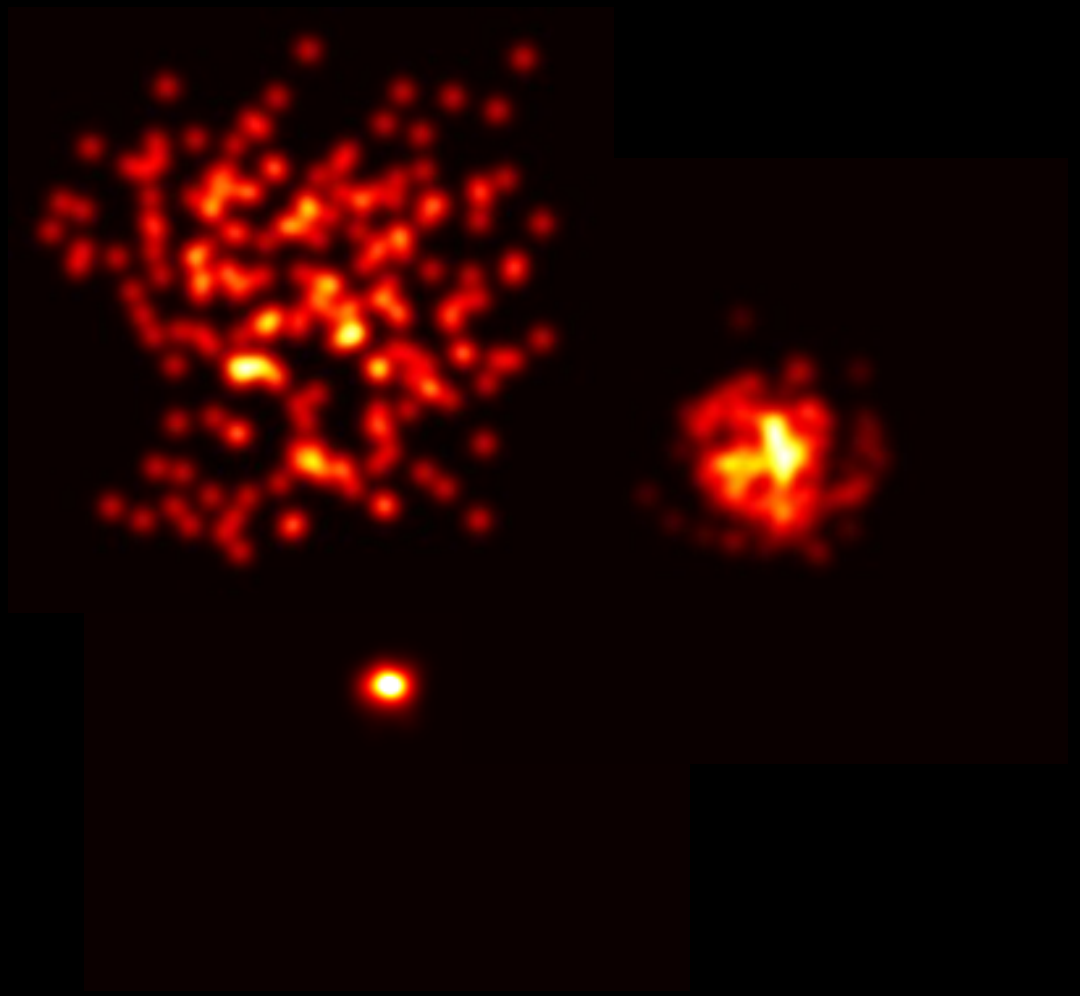


Dimple Traps

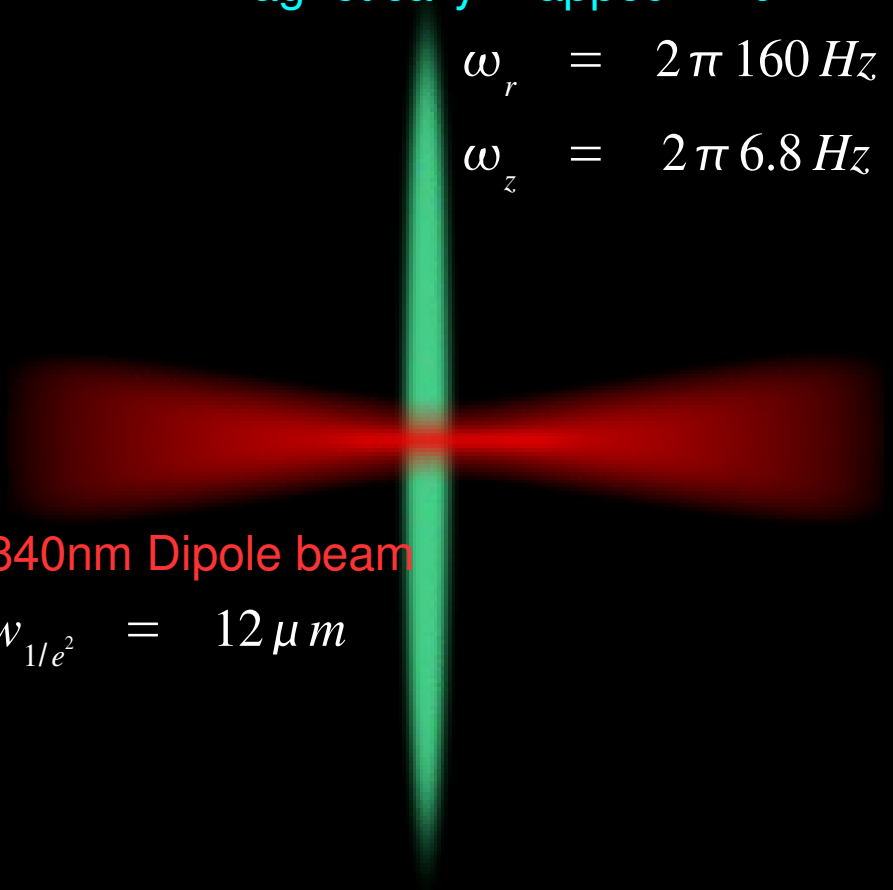
- Most ultra cold physics is in optical lattices and/or harmonic traps.
- Combining a harmonic trap with a Gaussian “dimple” opens other possibilities.
  - Condensate formation by compression.
  - Pulse generation for shock waves.

Apparatus

Magnetically Trapped ^{87}Rb

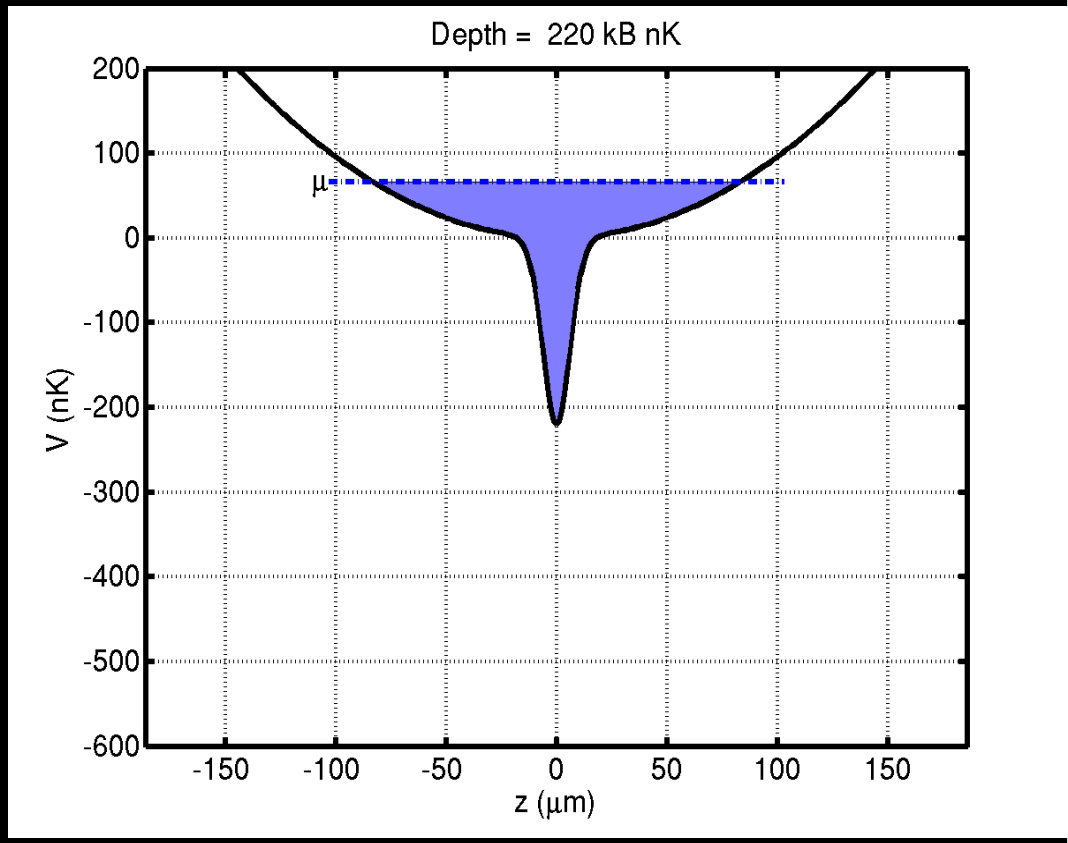
$$\omega_r = 2\pi\, 160\, Hz$$

$$\omega_z = 2\pi\, 6.8\, Hz$$



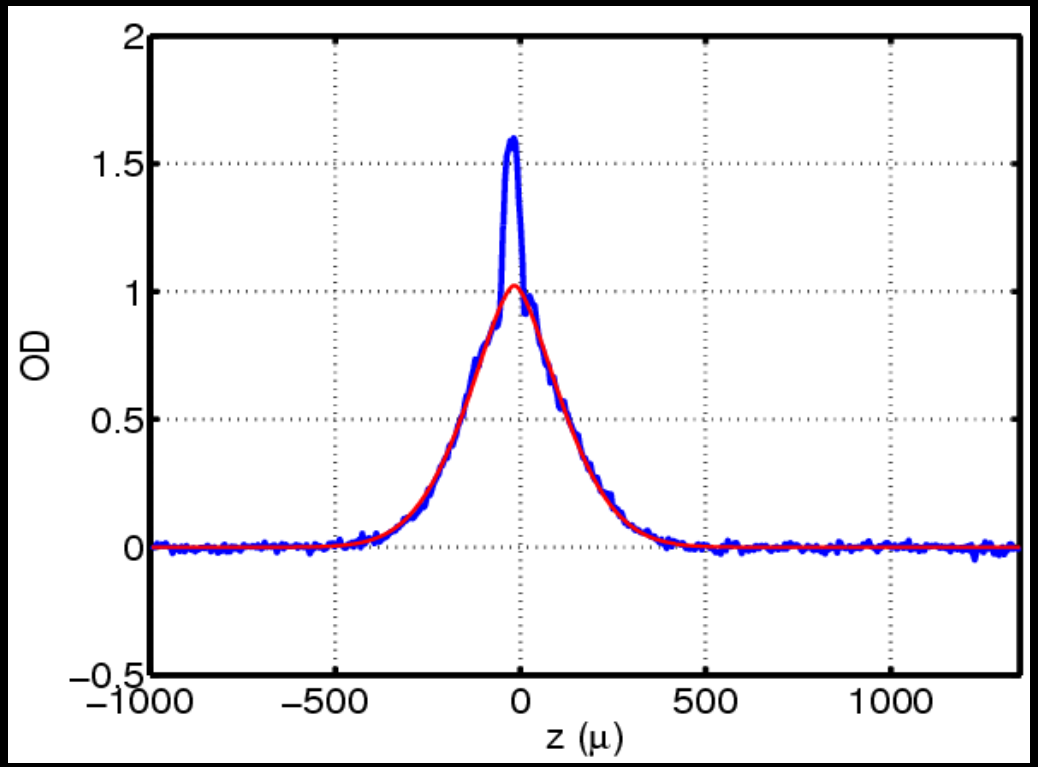
840nm Dipole beam

$$w_{1/e^2} = 12\,\mu m$$



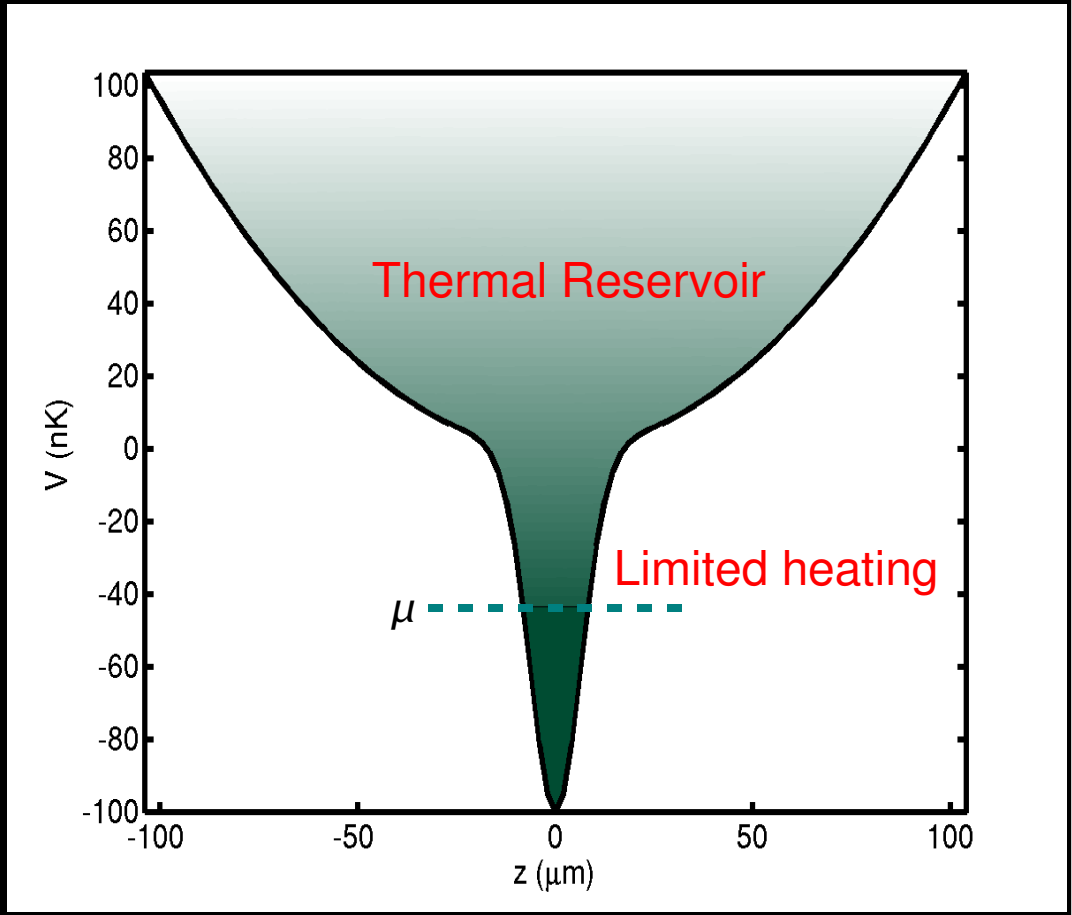
Condensate Formation

- Condensates can also be formed by *compression* (e.g. Ketterle *et al*, 1998)
  - This process is reversible.
  - But it can not be done with conventional traps.



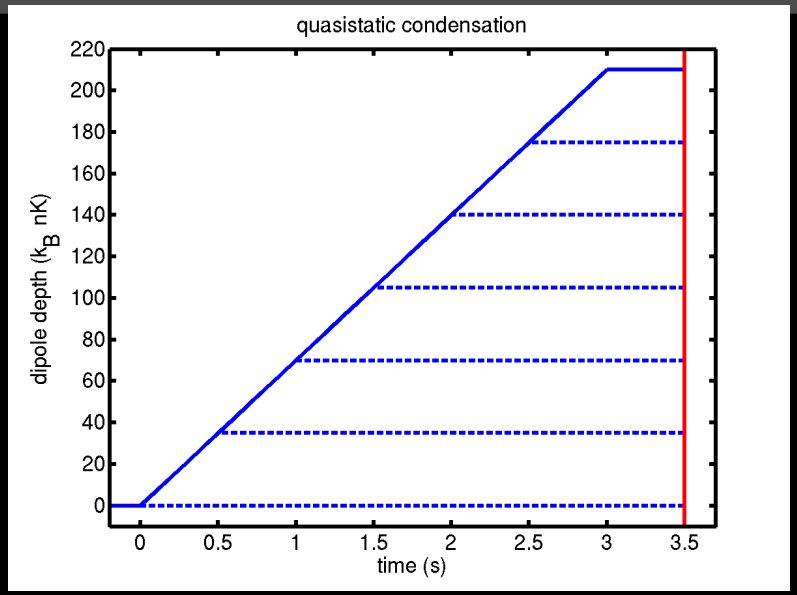
Dimple traps don't conserve PSD.

- Heating conserves PSD in harmonic traps.
- Atoms can remain *outside* a dimple.
- This reservoir stabilises intensive parameters.
- Trap “punches through” the chemical potential.

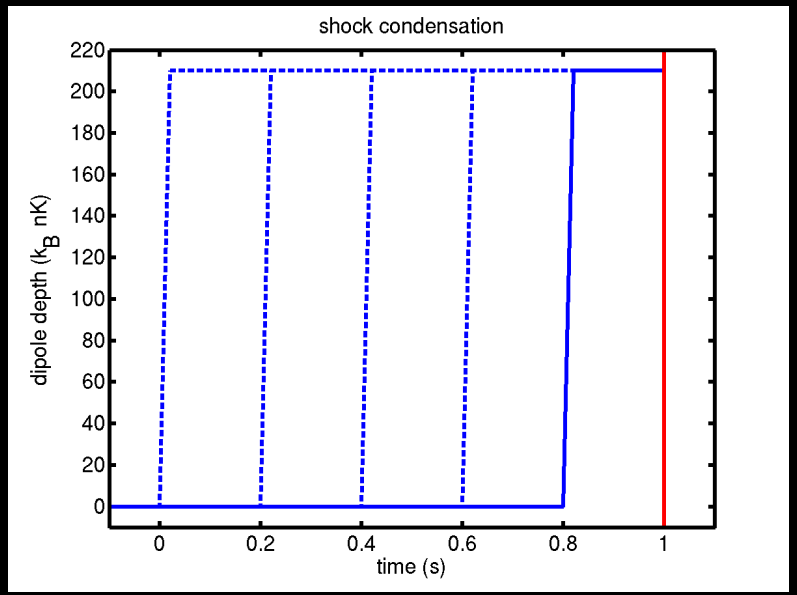


Two Options

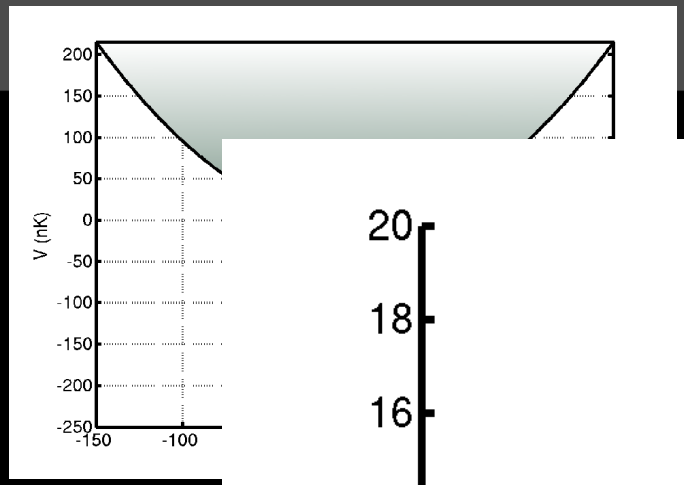
- Quasistatic Condensation

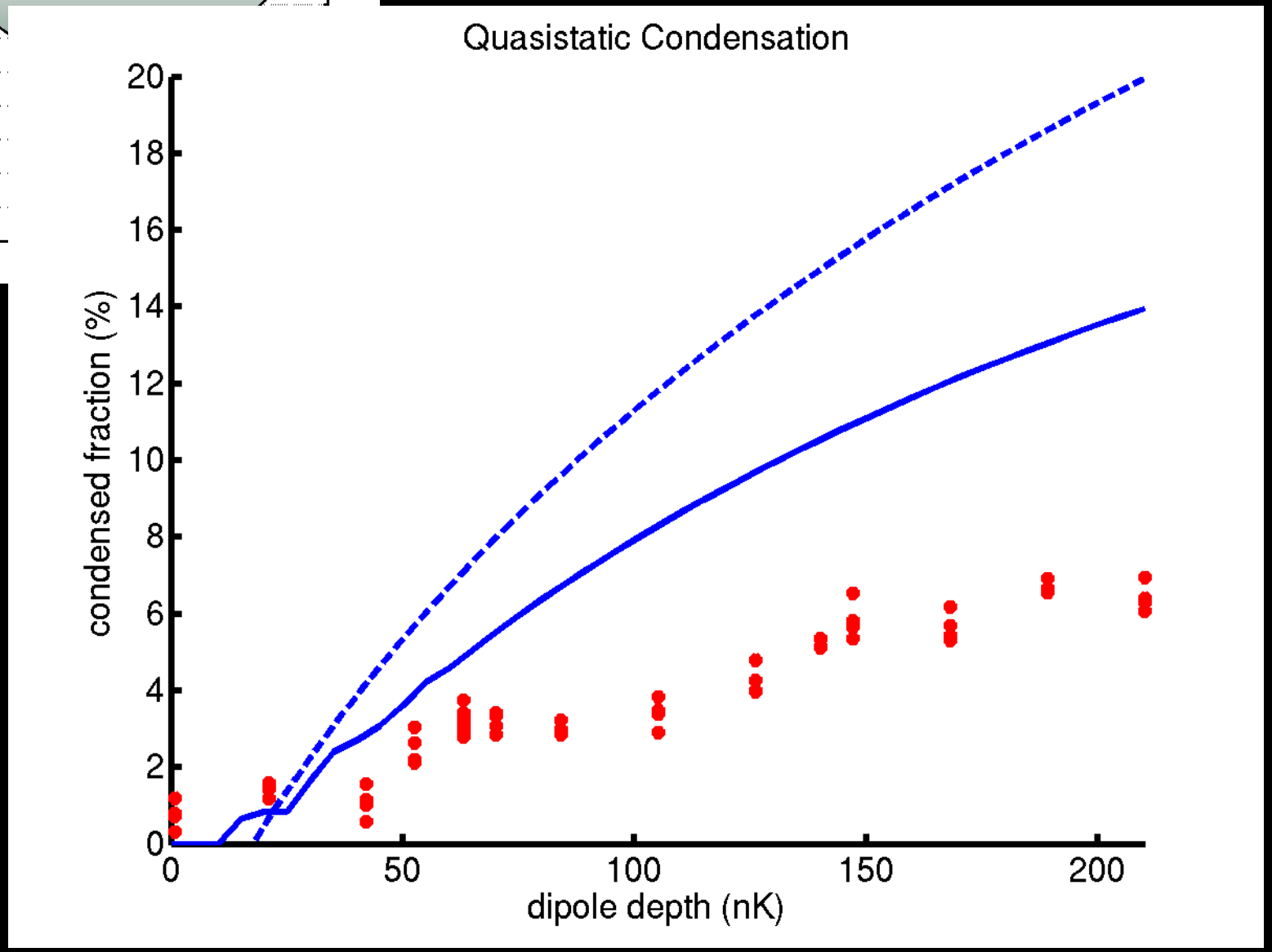


- Shock Condensation

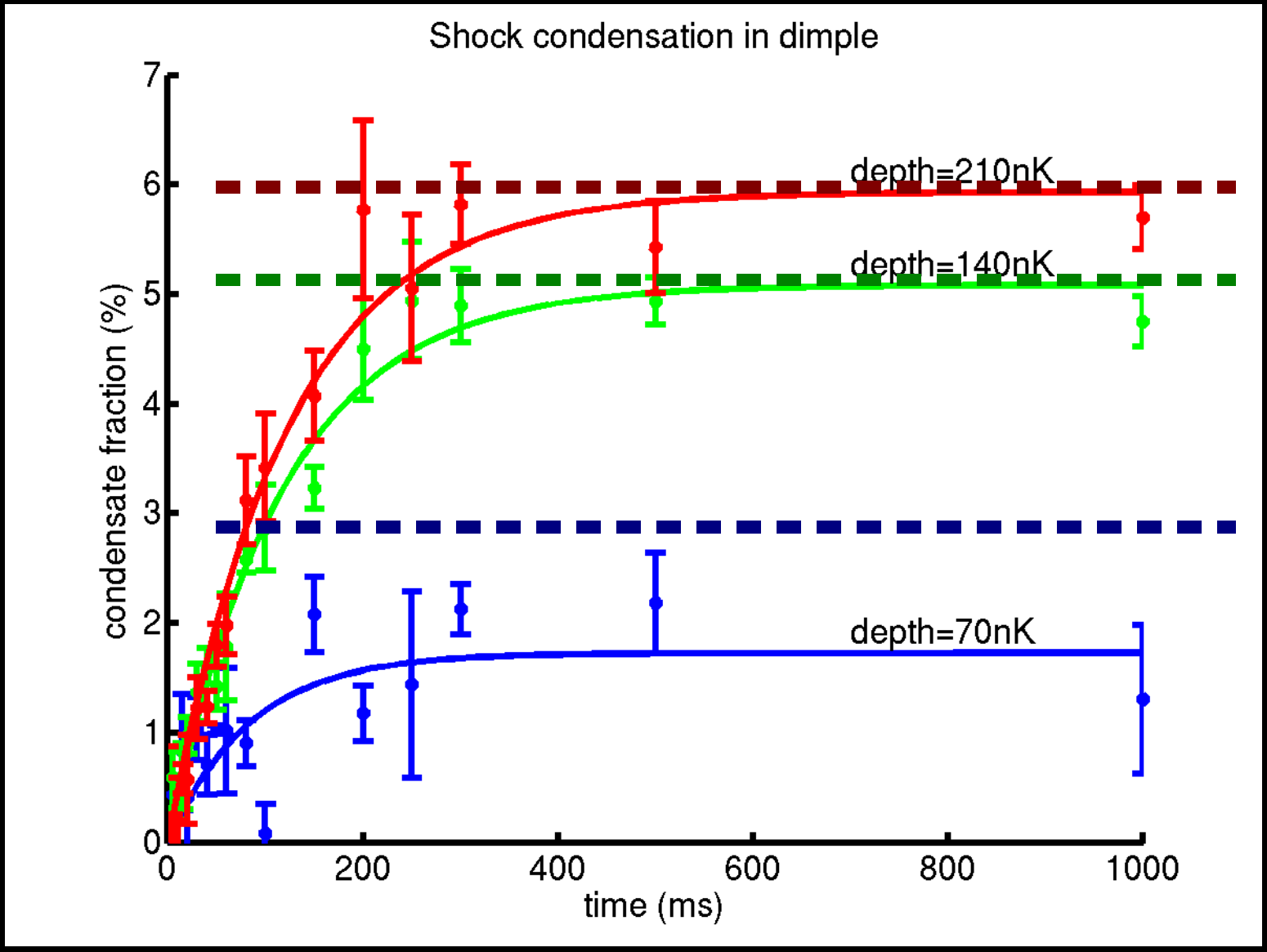


Quasistatic Condensation





Shock Condensation



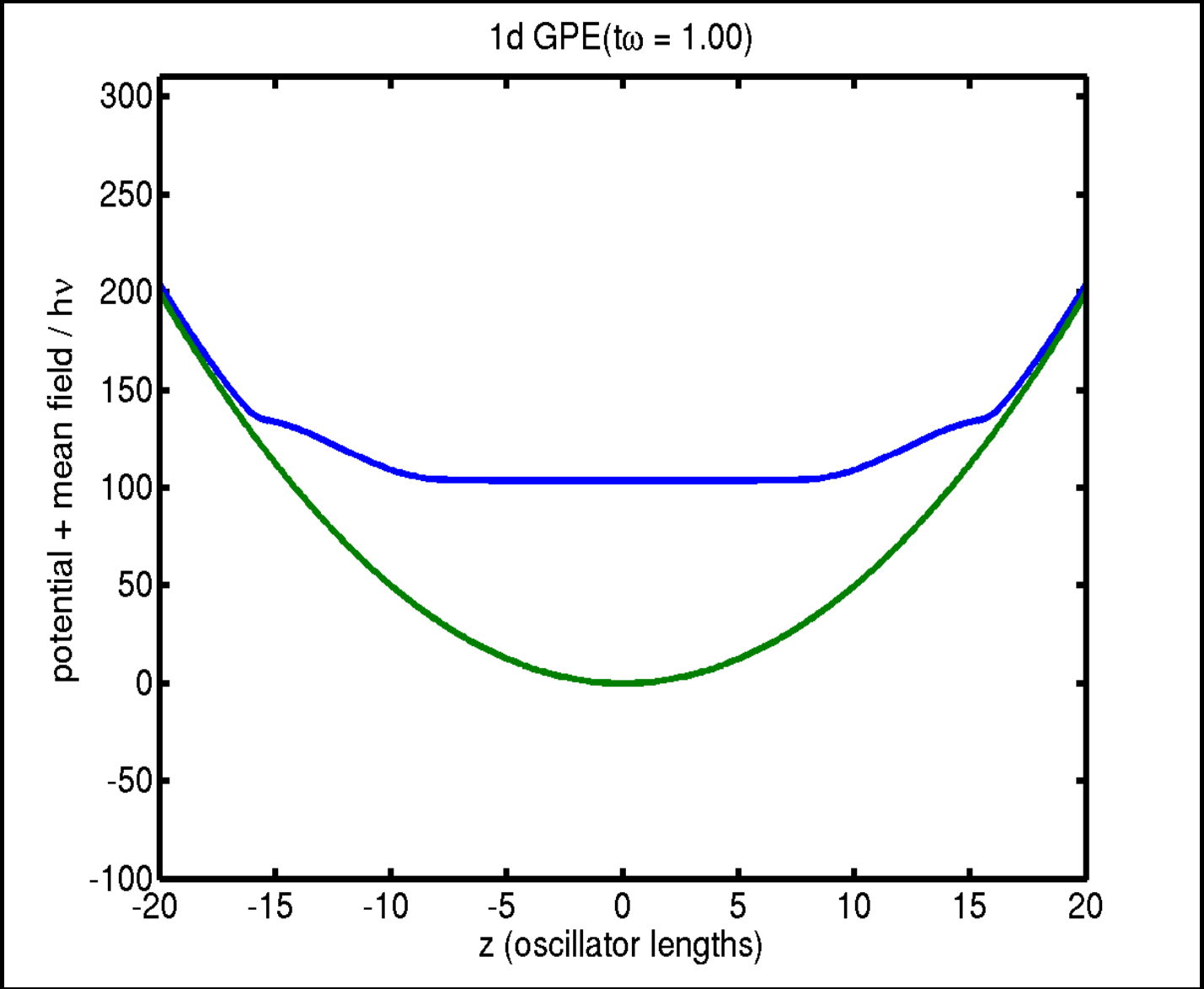
Outlook

- Explain observed dynamic behaviour.
- Mean-Field Theory.
- Quantify the difference between fast and slow condensation.

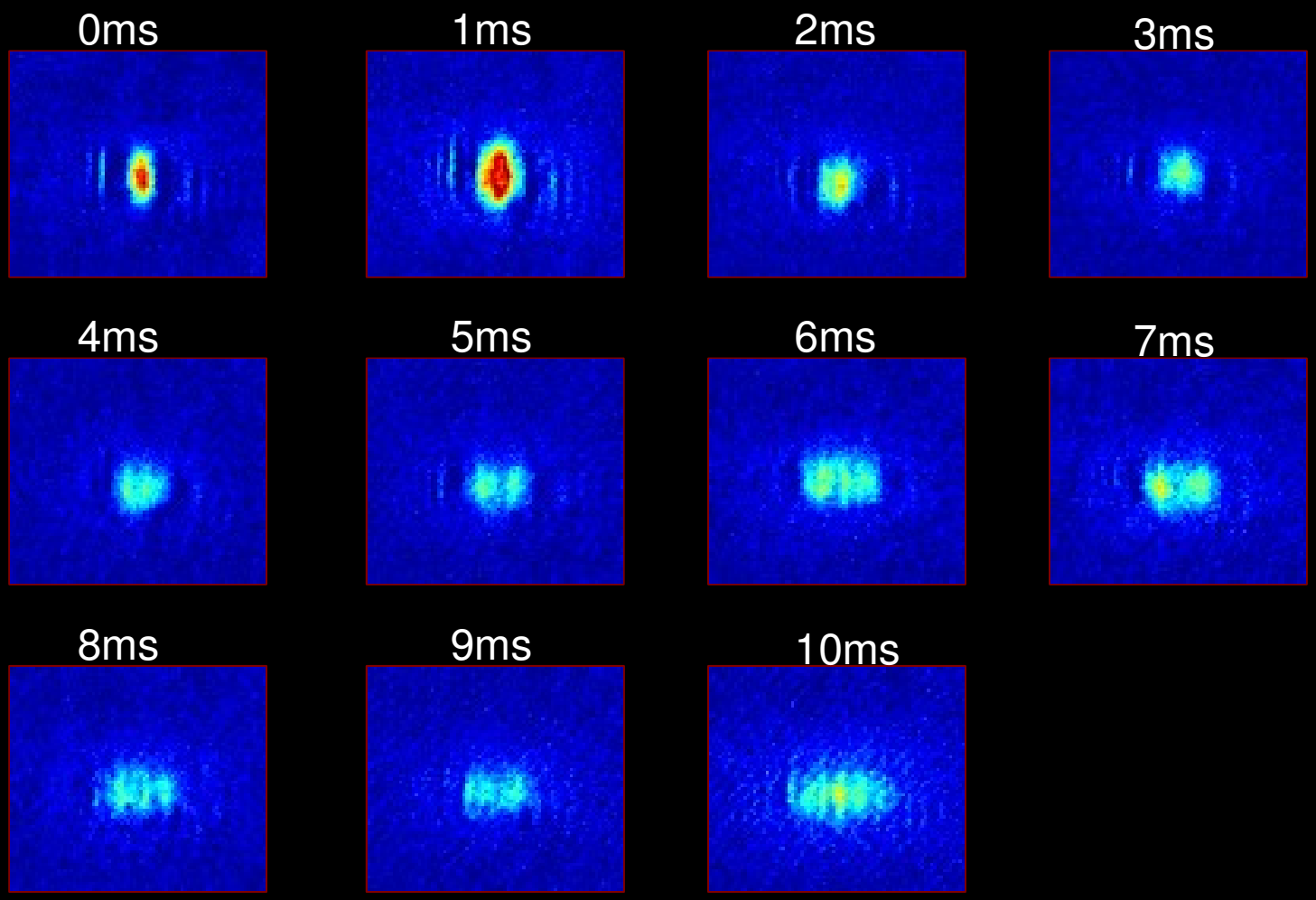
Shock Waves

- Condensates support non-linear pressure waves.
- Shock waves predicted (eg. Damski *et al.*)
  - Occur with and without quantum pressure.
  - GPE predicts interesting features.

GPE Prediction



Tales from the Laboratory



Outlook

- Test the simulations against experiment
  - Perform new experiments at lower laser power.
  - Run simulations matching older experiments.
- Find a clear signature of in-trap wave breaking.

Thank You