Soiltons as the early stage of quasicondensate formation during evaporative cooling

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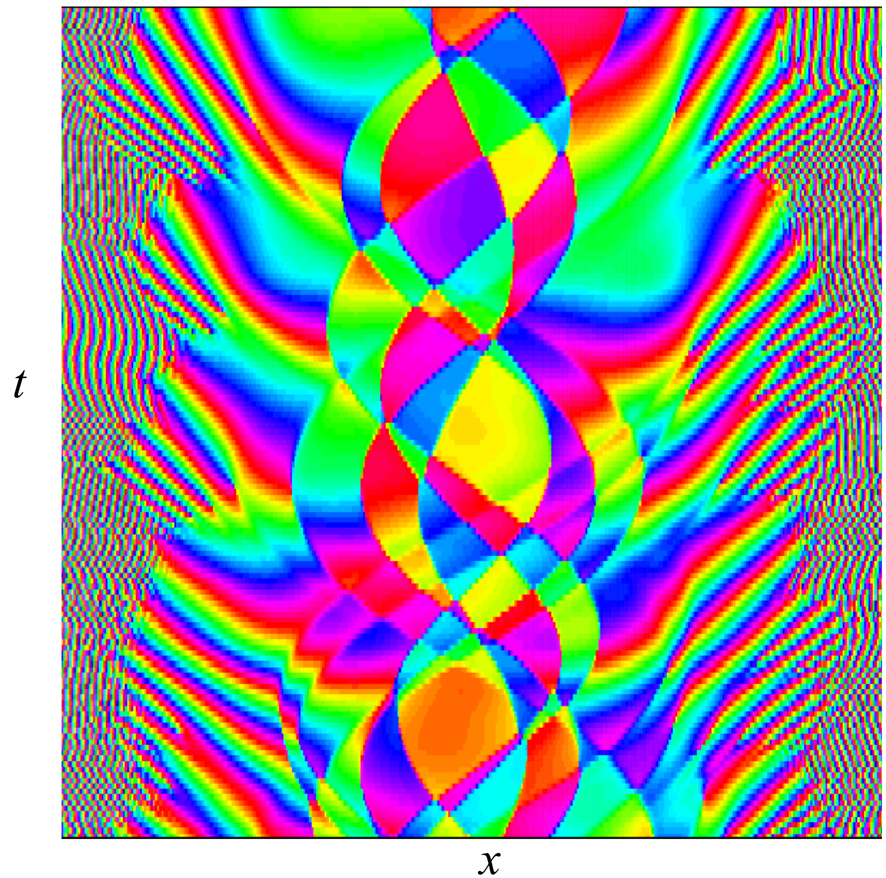


PRL **106**, 135301 (2011)

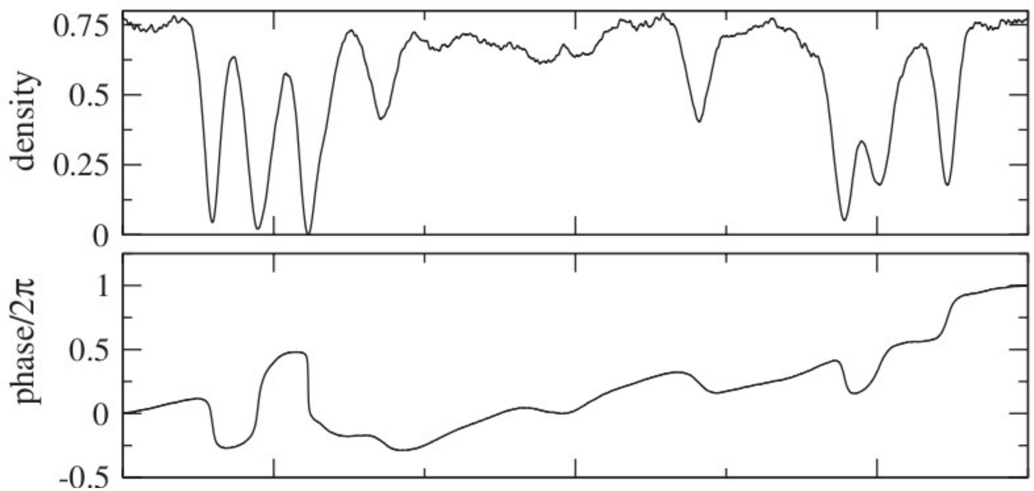
Aim: to reconcile two aspects of phase coherence

1D trapped Bose gas

$$H(z,t) = -\frac{1}{2}\frac{\partial^2}{\partial z^2} + V(z,t) + g_{1D}|\psi(z,t)|^2$$

Repulsive contact interactions $g_{1D} > 0$

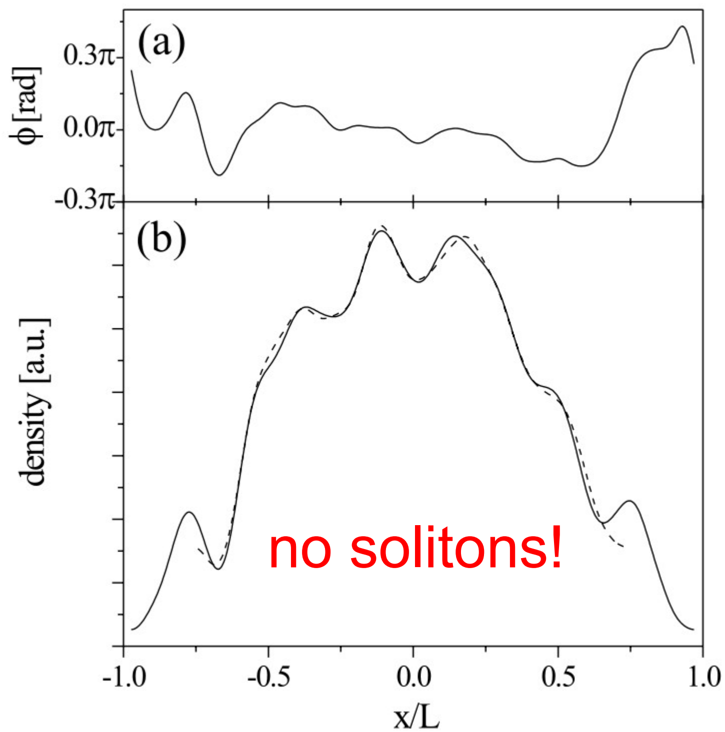
(1): Solitons formed in a quench via Kibble-Zurek mechanism



B. Damski, W. Żurek, PRL **104,** 160404 (2010)

Quench of μ in thermal bath

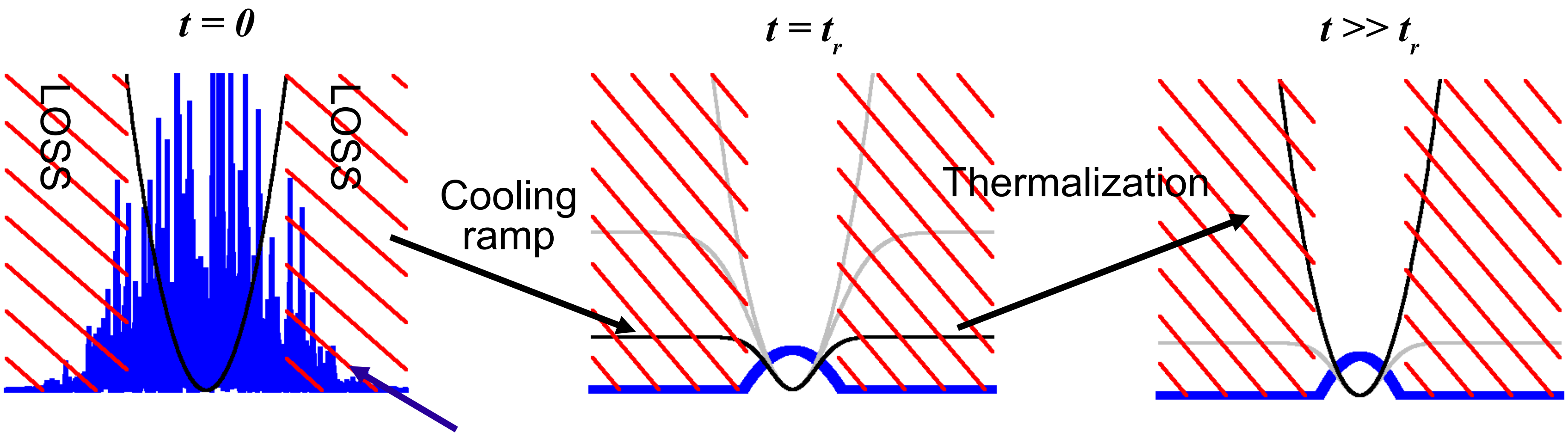
(2): Smooth quasicondensate phase in thermal equilibrium



S. Dettmer *et al*, PRL **87,** 160406 (2001)g

Evaporative cooling of 1D Bose gas

THE MODEL



- Initial condition: gas at thermal equilibrium, above T_c

E. Witkowska, M. Gajda, K. Rzążewski Opt. Commun. **283**, 671 (2010)

Simulation: *classical fields (c-field) method*

Recent review: P. Blakie, A. Bradley, M. Davis, R. Ballagh, C. Gadiner, Adv. Phys. **57**, 363 (2008)

$$\hat{\Psi}(x) \rightarrow \psi(x)$$

$$i\partial_t \psi(z,t) = [H(z,t) - i\Gamma(z,t)]\psi(z,t),$$

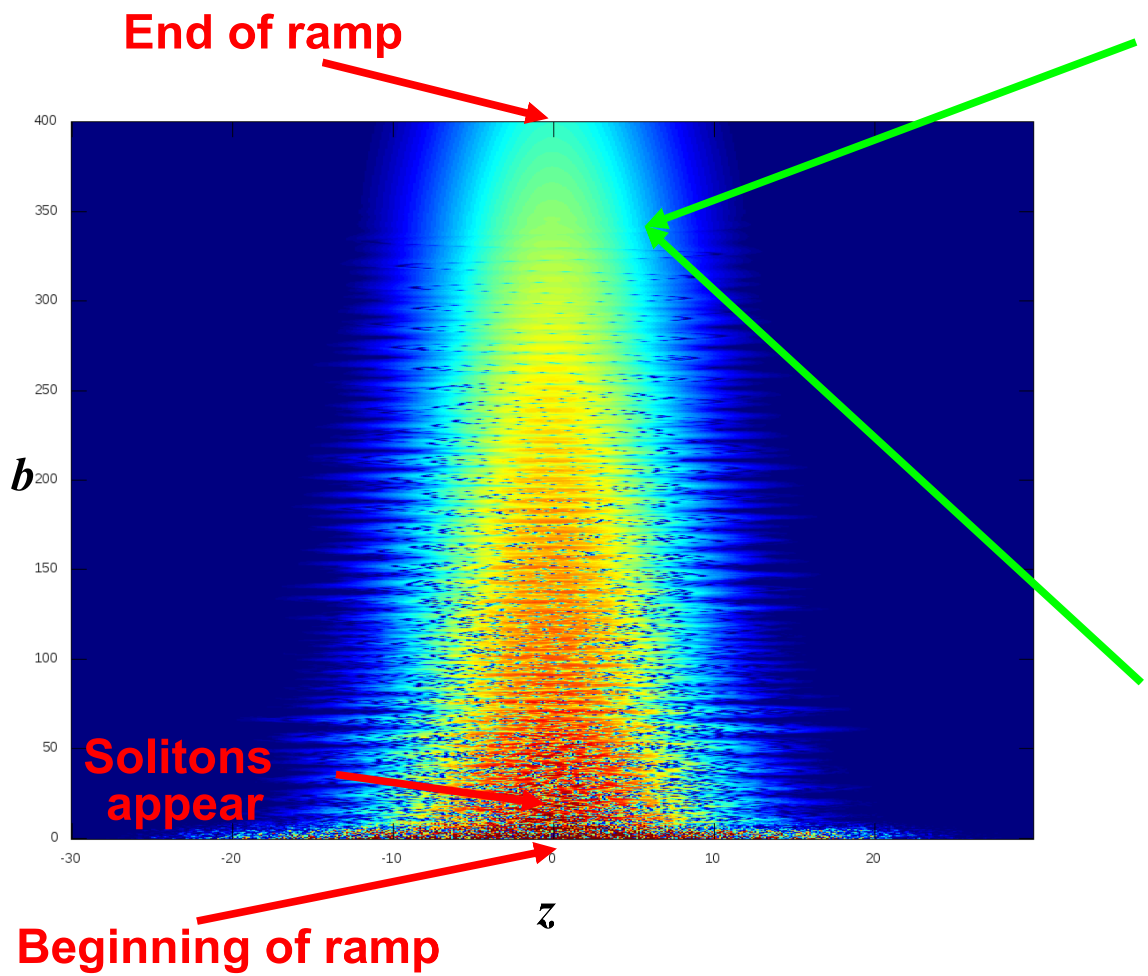
$$H(z,t) = -\frac{1}{2}\frac{\partial^2}{\partial z^2} + V(z,t) + g_{1D}|\psi(z,t)|^2$$

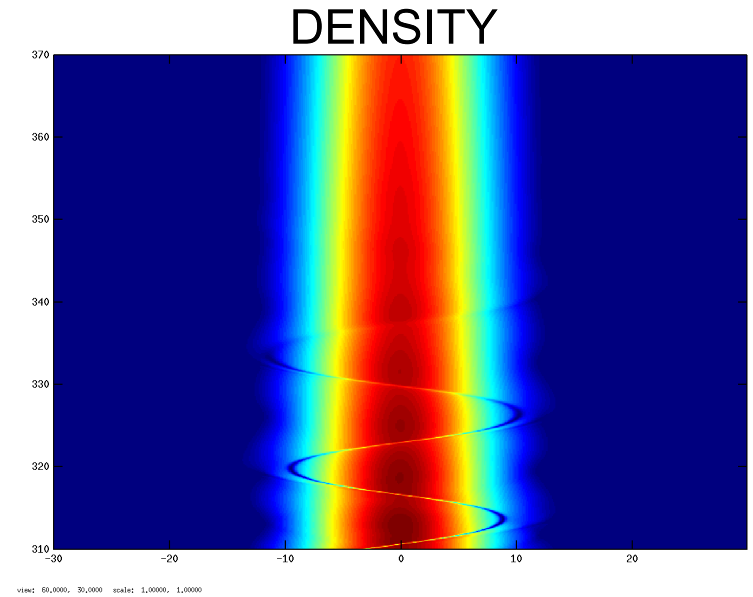
$$\left[\hat{\Psi}(x), \hat{\Psi}^\dagger(x')\right] = \delta(x - x') \quad \rightarrow \quad [\psi^*(x), \psi(x')] = 0$$

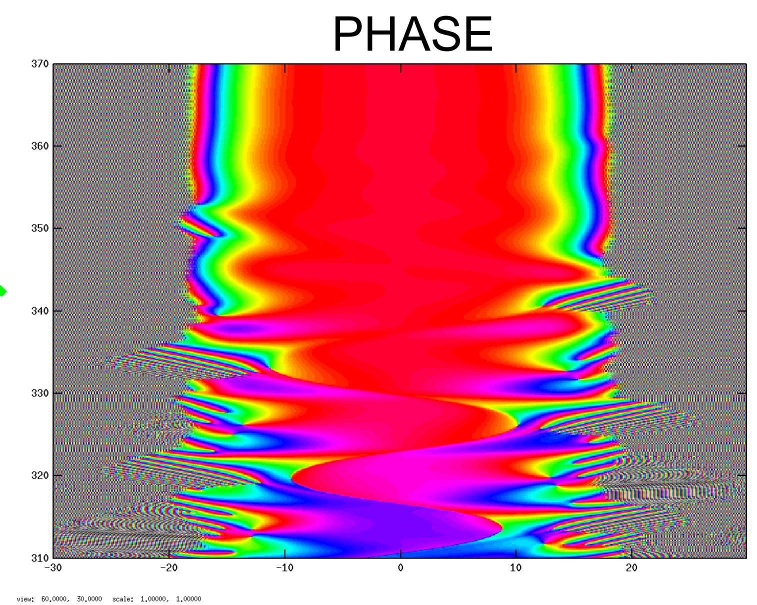
i.e. *fine* as long as many atoms are involved

Simulation - slow ramp → BEC

Slow ramp $\omega\, t_r = 400$

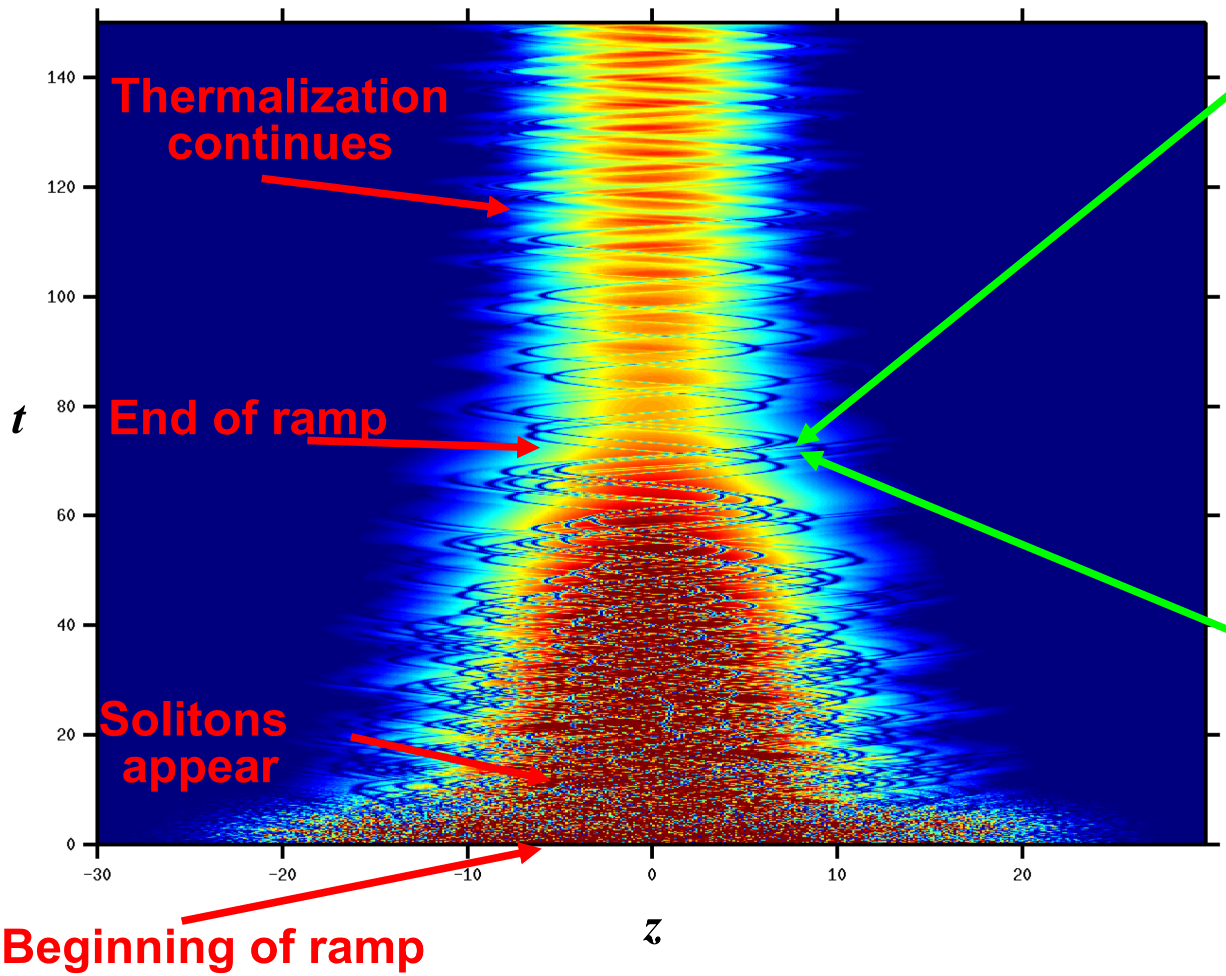




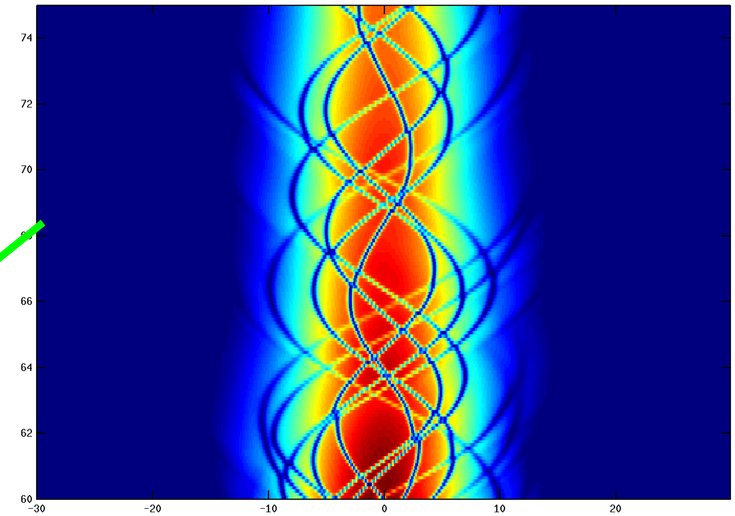


Fast ramp → quasicondensate precursor

Fast ramp $\omega\, t_r$=75



DENSITY



PHASE

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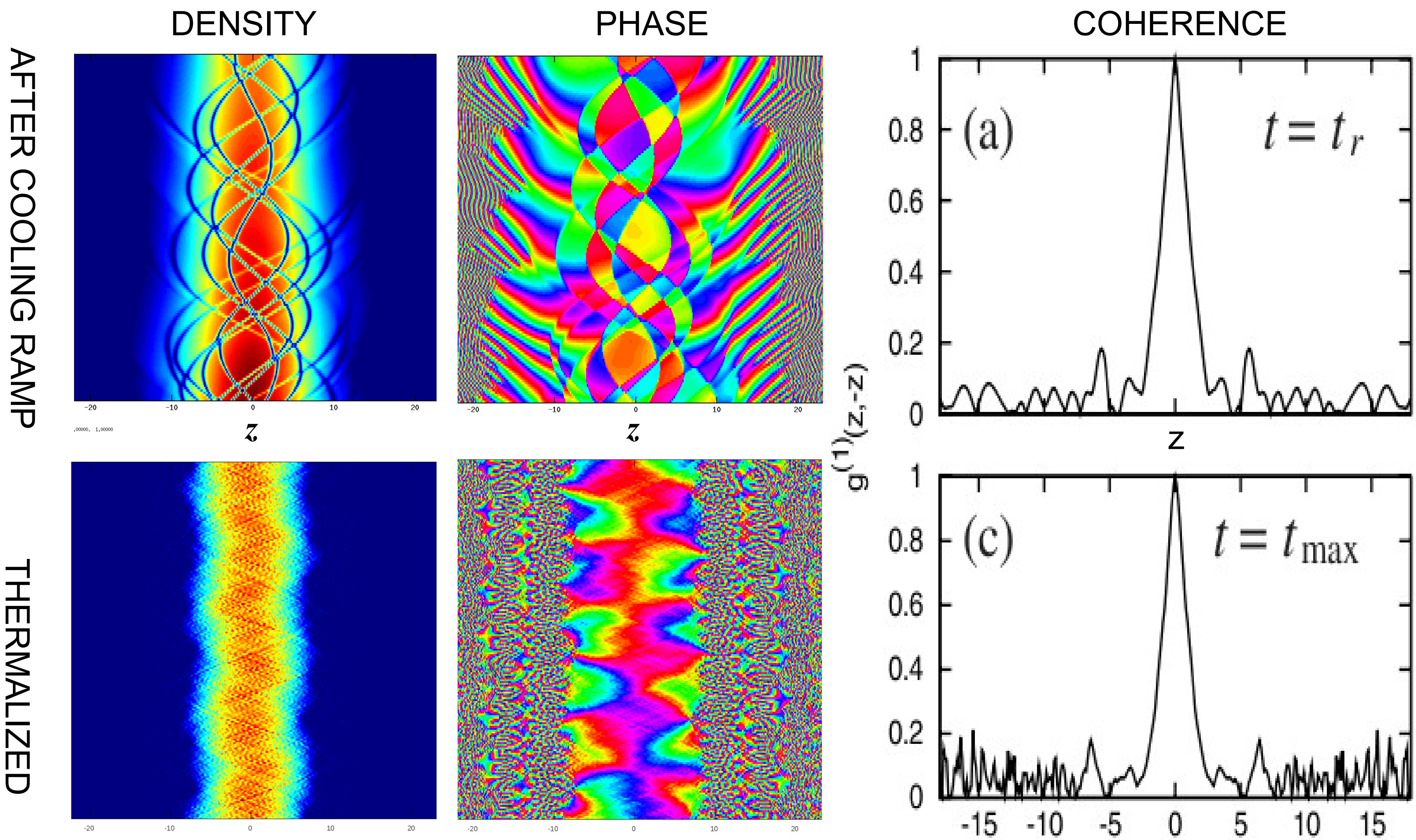
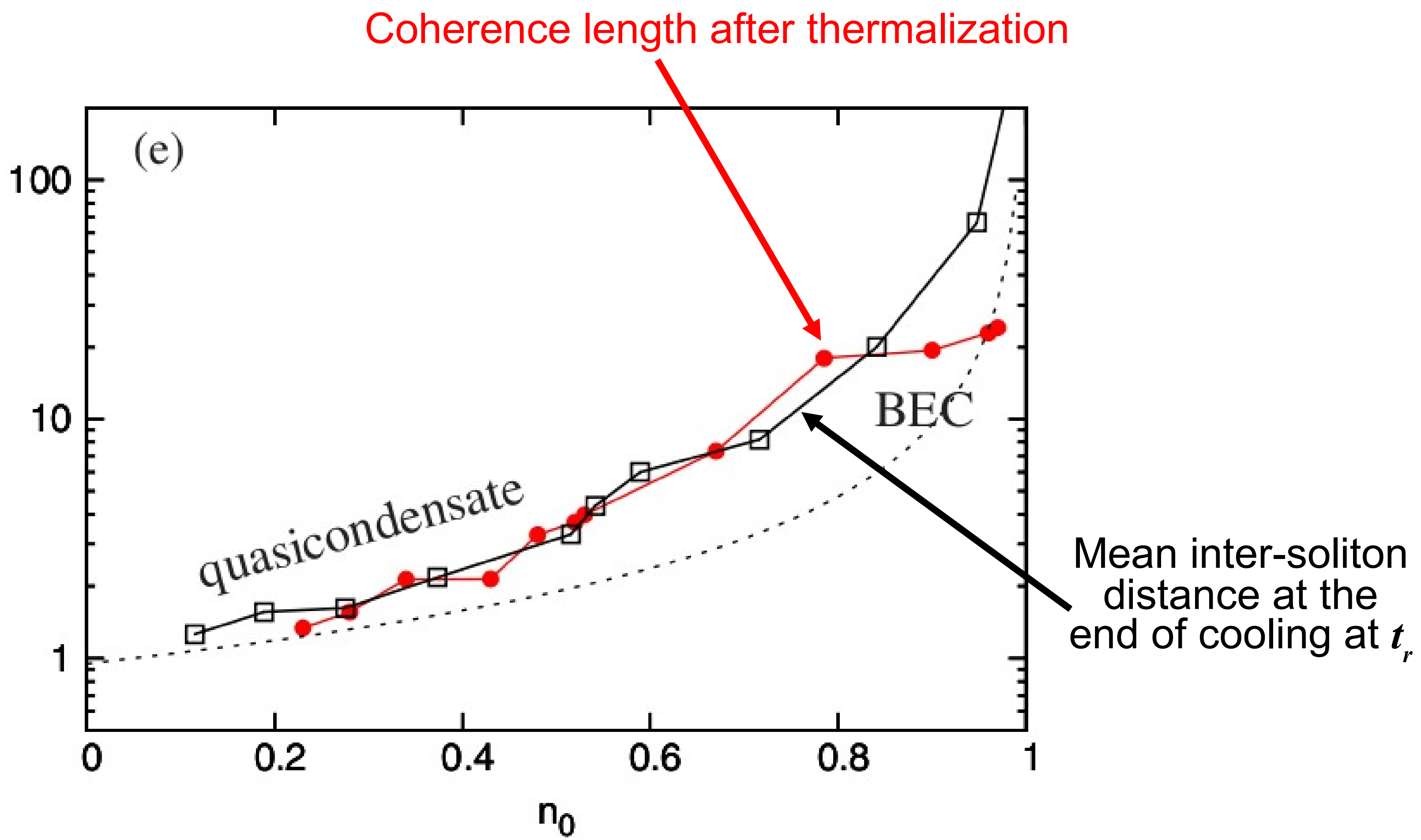
Thermalization to a quasicondensate



Solitons as the “larval stage” of equilibrium fluctuations



Domain formation – not like the standard story

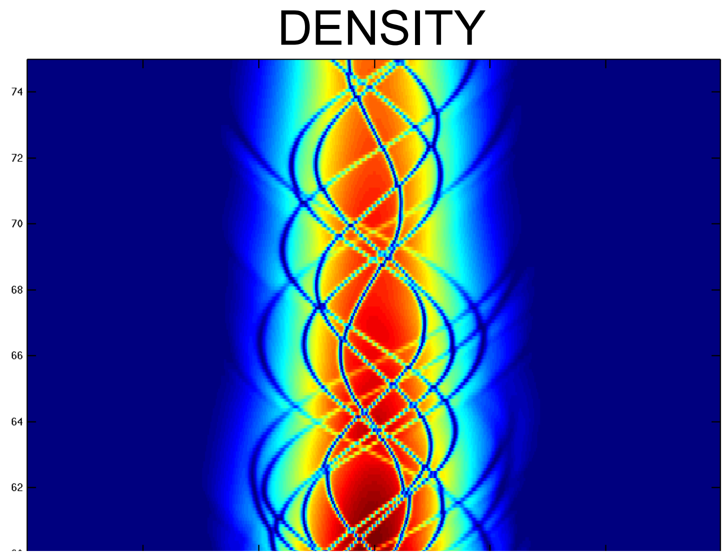
- We did NOT see the usual scenario:

  "domain seeds grow with time and defects form where they meet"

  e.g. compare to spin domains in 2D
  → *Srivatsan Charkam, Mukund Vengelattore*

- Instead:
  - domains are fleeting
  - solitons are the stable entities
  - coherence length conserved

- Not yet fully understood



Summary

- 1D evaporative cooling is quite different to the usual scenario
- Coherence length conserved during thermalization of solitons
- Solitons NOT phase domains are the long-lived objects
- *Details:*

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- *Movies:* www.ifpan.edu.pl/~deuar/