Local quenches with TN

ER, Deformations ...

M.C. Bañuls[2], L. Tagliacozzo[1], A. Zamora[1],

[1]ICFO, The Insitute of Photonic Sciences Barcelona

[2]Max Planck Institute Garching

Benasque 2012

Outline

1. Motivation
   - Personal motivation
   - Experiments in cold atoms
   - Time dependent correlation functions
   - Previous work
2. Aim, an RG view on local quenches
   - Background material
3. Results
   - Bending the light cone

Outline

Post-doc search

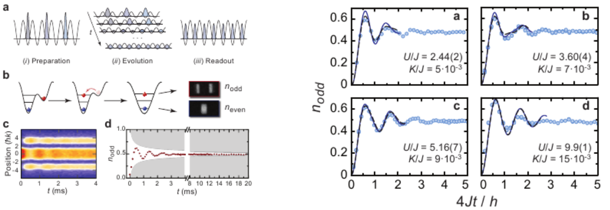
...However, your experience mostly in static properties of strongly correlated systems does not appear not to match so favorably with our research interests in the dynamics of cold atomic gases...

Outline

Long time dynamic

Probing the relaxation towards equilibrium in an isolated strongly correlated 1D Bose gas

S. Trotzky[1−3], Y.-A. Chen[1−3], A. Flesch[4], I. P. McCulloch[5], U. Schollwöck[1,6], J. Eisert[6,7] and I. Bloch[1−3]



Can One Trust Quantum Simulators?

Philipp Hauke,[1,*] Fernando M. Cucchietti,[1,2] Luca Tagliacozzo,[1] Ivan Deutsch,[3,4] and Maciej Lewenstein[1,5]

Outline

Protocol

$$H = \sum_{<ij>} h_{ij} \tag{1}$$

$$H\,|\Omega\rangle = E_o|\Omega\rangle \tag{2}$$

$$\langle B_y(t)A_x(0)\rangle = e^{iE_o t}\langle\Omega|B_y e^{-iHt}A_x|\Omega\rangle \tag{3}$$

$$|\psi_0\rangle = A_x|\Omega\rangle, |\psi_t\rangle = e^{-iHt}|\psi_0\rangle \to \mathscr{L}_t = log|\langle\psi_t|\psi_0\rangle|^2 \tag{4}$$

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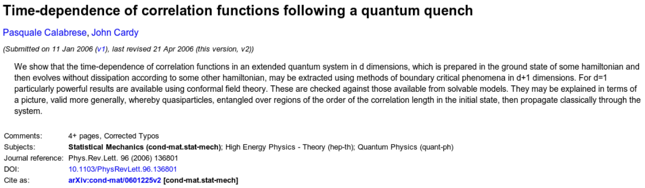
Analytical results

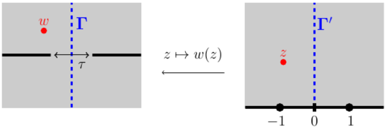

Time-dependence of correlation functions following a quantum quench

Pasquale Calabrese, John Cardy

(Submitted on 11 Jan 2006 (v1), last revised 21 Apr 2006 (this version, v2))

We show that the time-dependence of correlation functions in an extended quantum system in d dimensions, which is prepared in the ground state of some hamiltonian and then evolves without dissipation according to some other hamiltonian, may be extracted using methods of boundary critical phenomena in d+1 dimensions. For d=1 particularly powerful results are available using conformal field theory. These are checked against those available from solvable models. They may be explained in terms of a picture, valid more generally, whereby quasiparticles, entangled over regions of the order of the correlation length in the initial state, then propagate classically through the system.

Comments:	4+ pages, Corrected Typos
Subjects:	**Statistical Mechanics (cond-mat.stat-mech)**; High Energy Physics - Theory (hep-th); Quantum Physics (quant-ph)
Journal reference:	Phys.Rev.Lett. 96 (2006) 136801
DOI:	10.1103/PhysRevLett.96.136801
Cite as:	**arXiv:cond-mat/0601225v2 [cond-mat.stat-mech]**



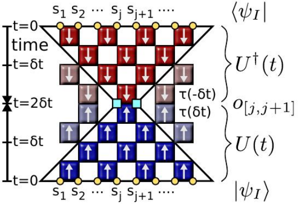
+ Free fermions +....

Numerical results

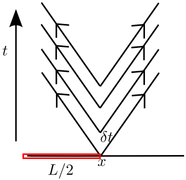
- Vidal TEBD ... White Feiguin tDMRG
- Hastings LIGTH CONE MP
- M. Rizzi et al. MERA
- M.C. Bañuls et al. FOLDING
- Enss Light cone DMRG
- F. Anders and A. Schiller tNRG
- Halleberg, Dargel et. al LANCZOS for dynamical correlation functions
- Mc Culloch et al. FREQUENCY space DMRG
- P. Ho INFINITE BOUNDARY conditions

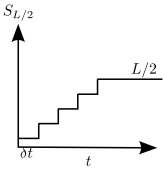
Why is it complex

- Lieb Robinson bounds $S_{L/2}(t) \propto t$



4. arXiv:1104.1643 [pdf, ps, other]
Lightcone renormalization and quantum quenches in one-dimensional Hubbard models
Tilman Enss, Jesko Sirker
Comments: published version
Journal-ref: New J. Phys. 14, 023008 (2012)
Subjects: **Strongly Correlated Electrons (cond-mat.str-el)**; Quantum Gases (cond-mat.quant-gas); Statistical Mechanics (cond-ma



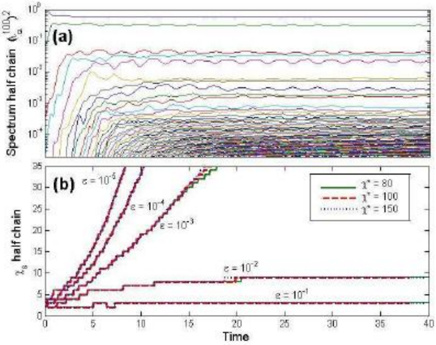


Gapped Hamiltonians

(Intuitively)

- Area law for low energy states
- Small energy initial state + gap
- Moderate growth of the entanglement

Counter Intuitive results



. arXiv:0711.3676 [pdf, ps, other]

Entanglement growth and simulation efficiency in one-dimensional quantum lattice systems

Alvaro Perales, Guifre Vidal

Comments: 6 pages, 5 figures

Journal-ref: Phys. Rev A 78, 042337 (2008)

Subjects: **Strongly Correlated Electrons (cond-mat.str-el)**; Quantum Physics (quant-ph)

$$H = \sum_i \sigma_i^x \sigma_{i+1}^x + \sigma_i^z + \sigma_i^x ;\ A(0) = \sigma^x \qquad (5)$$

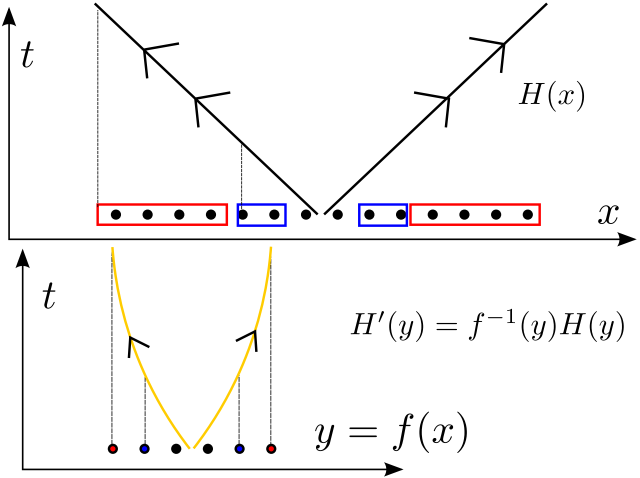
$S_t \propto log(t)???$

Gapless Hamiltonians the CFT case

- Logarithmic corrections to entropies for low lying states (see Cardy Calabrese, Ibañez Alcaraz Sierra)
- Small energy but no gap
- Logarithmic increase of the entropy

$$S_t = \frac{c}{3} log\, t \tag{6}$$

A time dependent RG



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Two basic ingredients

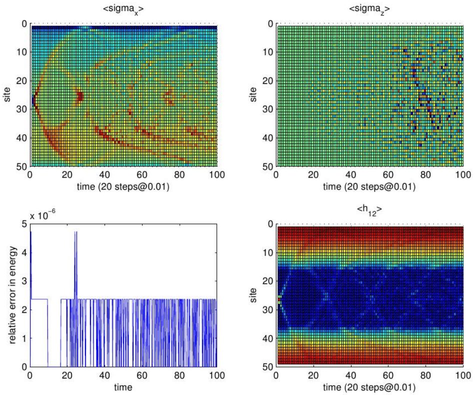
1. Finite velocity v_l
2. Different length scales (induced by inhomogeneous RG)

Induce different time scales

- *Small* blocks oscillate *fast*
- *Large* blocks oscillate *slow*

The Exponential deformations

$$H = \sum_{r=-\infty}^{-d-1} e^{\alpha r} h_{r,r+1} + \sum_{r=d}^{d} h_{r,r+1} + \sum_{r=d+1}^{\infty} e^{-\alpha r} h_{r,r+1} \qquad (7)$$

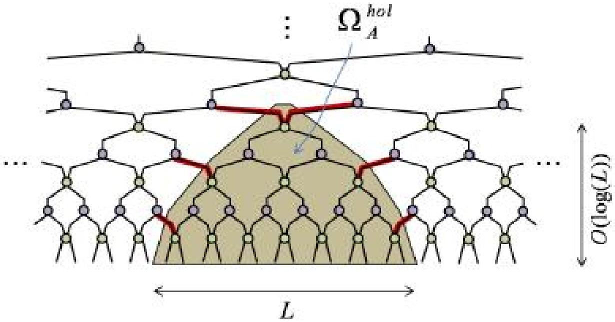


$$H = \sum_x f(x) h(x)$$

$$f'(x) \to 0;$$

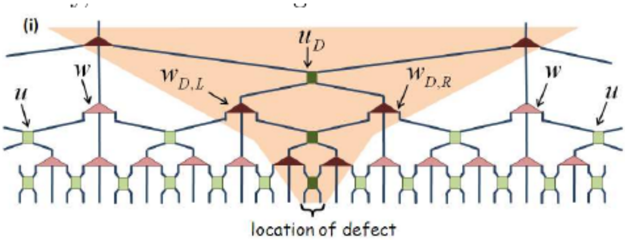
$$\to v_l \propto f(x) (\mathrm{WKB})$$

The MERA

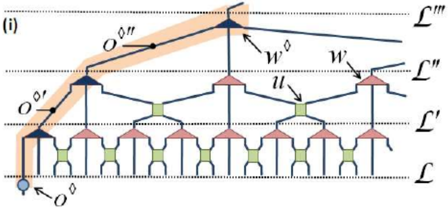


$$S_L \propto \log L \qquad (11)$$

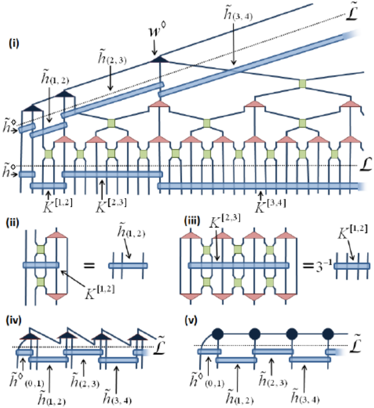
Boundaries and impurities with the MERA



Boundary quantum critical phenomena with entanglement renormalization
G. Evenbly, R. N. C. Pfeifer, V. Pico, S. Iblisdir, L. Tagliacozzo, I. P. McCulloch, G. Vidal
Comments: 8 pages, 12 figures, for a related work see arXiv:0912.2893
Journal-ref: Phys. Rev. B 82, 161107(R) (2010)
Subjects: **Strongly Correlated Electrons (cond-mat.str-el)**



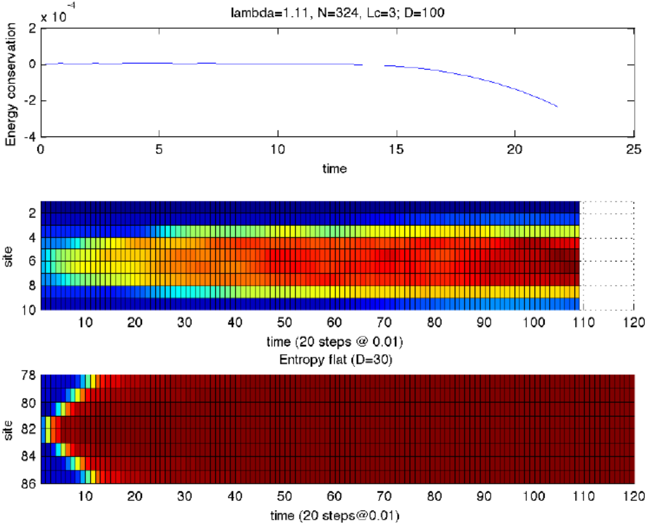
Effective Hamiltonians



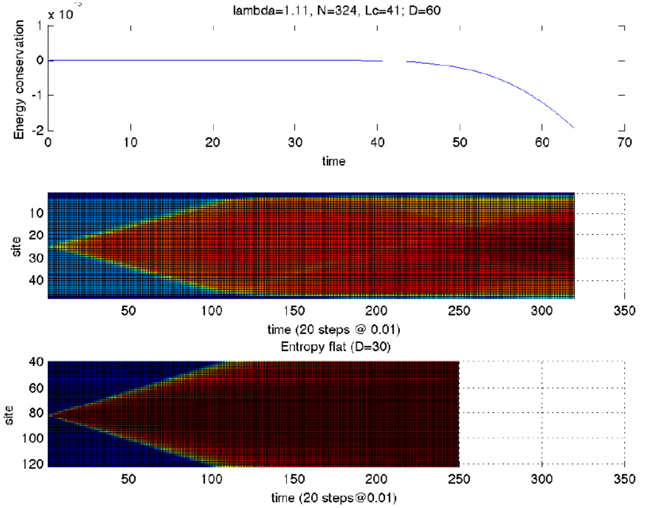
$$H_{eff} = \tilde{h}^{\diamondsuit} + \Lambda^{1-k} \sum_{k=1}^{\infty} \tilde{h}_{k,k+1} \tag{12}$$

Outline

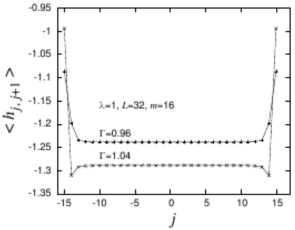
Curved space



Bouncing from the boundaries

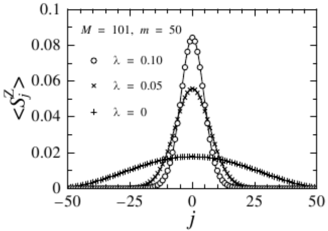


Origin of the bounce



arXiv:1008.3458 [pdf, ps, other]
Transverse Field Ising Model Under Hyperbolic Deformation
Hiroshi Ueda, Andrej Gendiar, Valentin Zauner, Takatsugu Iharagi, Tomotoshi Nishino
Comments: 5 pages, 7 figures
Subjects: **Statistical Mechanics (cond-mat.stat-mech)**; Quantum Physics (quant-ph)

Ground State

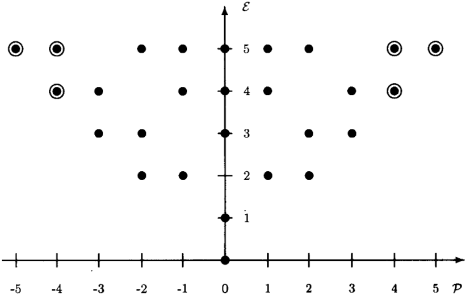


arXiv:0812.4513 [pdf, ps, other]
Gap Estimation by means of Hyperbolic Deformation
Hiroshi Ueda, Hiroki Nakano, Koichi Kusakabe, Tomotoshi Nishino
Comments: 11 pages, 13 figures, submitted to JPSJ
Subjects: **Statistical Mechanics (cond-mat.stat-mech)**; Quantum Physics (quant-ph)

Excitations

Possible solutions and extensions

- excitations



- dissipation

Summary

- We still miss a complete RG analysis of local quenches.
- We manage to curve the light cone.
- Generalize the map to the impurity problem to allow transmission of excitations .

- Outlook
  - Optimize last layers of tensors including some excitations
  - Dissipation ...