Jorge's Mosaic of Interests

Leticia F. Cugliandolo

Sorbonne Université

leticia@lpthe.jussieu.fr
www.lpthe.jussieu.fr/˜leticia

Jorge's fest, 14-15 April 2025

From sometime ago & far way

to nearby & present times

Onsager Prize, APS Global Summit 2025

A bit of embarrassment

From sometime ago & far way

to nearby & intermediate times

thanks to Vicky Kurchan for the picture

Prix Servant Académie de Sciences 2005

More embarrassment

Jorge

From long ago & far way to intermediate times

Prix Servant Académie de Sciences 2005

Prizes since very young age

for running very very fast (?)

Still more embarrassment

Very porteño*

Universidad de Buenos Aires - Comisión de Energía Atómica

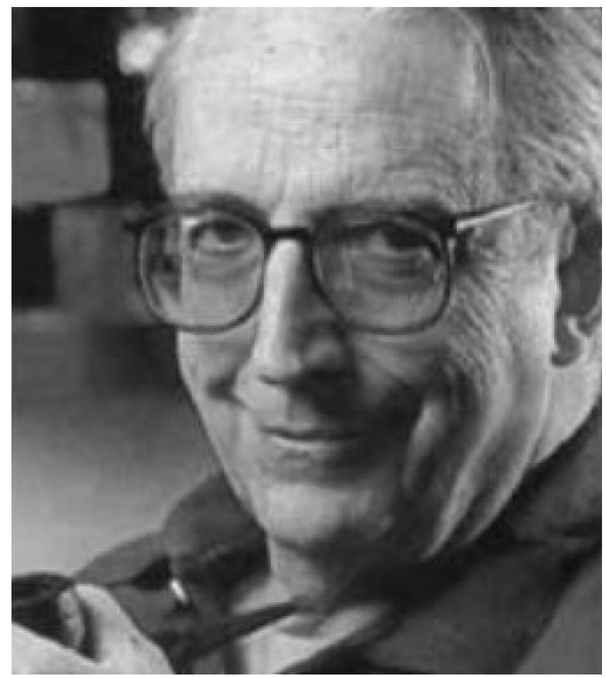
Undergrad

PhD

*From Buenos Aires. Not always loved by people from “province” – like me.

Studies

Universidad de Buenos Aires - Comisión de Energía Atómica



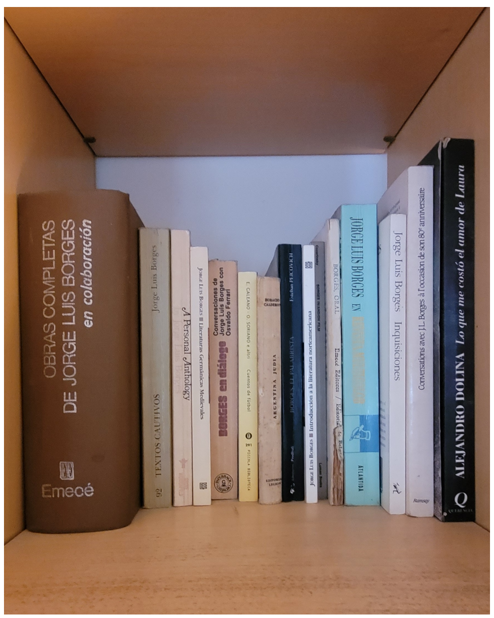
Chat chat chat at the cafeteria...

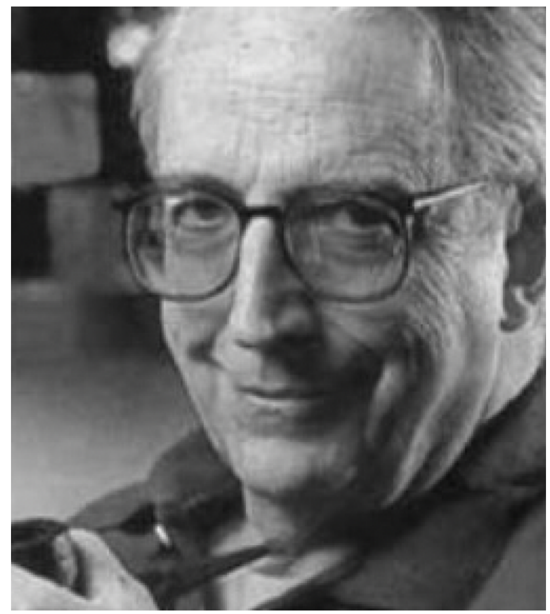
Daniel Bes PhD Supervisor

A lot of psychoanalysis (deep porteño culture)

Studies

Universidad de Buenos Aires - Comisión de Energía Atómica





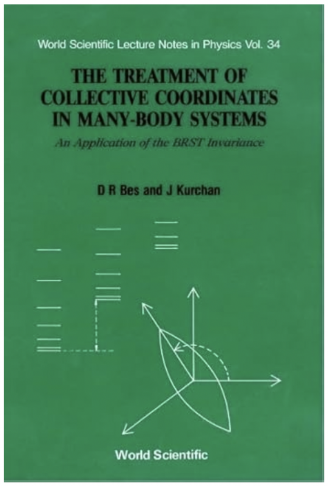
Chat chat chat at the cafeteria...

but also Borges & literature

Daniel Bes PhD Supervisor

PhD Thesis

Nuclear Physics



Read sample

TREATMENT OF COLLECTIVE COORDINATES IN MANY-BODY SYSTEMS, THE: AN APPLICATION OF THE BRST INVARIANCE (World Scientific Lecture Notes in Physics)

by Daniel R Bes (Author), J Kurchan (Author)

See all formats and editions

These lecture notes deal with the problem of collective coordinates in many-body systems, which are treated as gauge systems in (0+1) dimensions. The resulting classical Dirac brackets are discussed, as well as the structure of the quantal space of wavefunctions. Emphasis is made on the application of the BRST formalism. Several systems displaying an approximate breakdown of symmetries are treated. Many-body physicists may find

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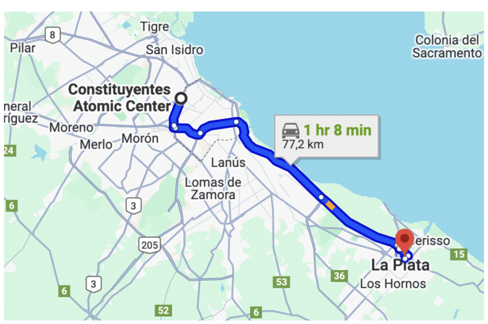

From Buenos Aires to La Plata

with P. Leboeuf et al. to attend Field Theory Lectures

with D. Bes to discuss with F. A. Schaposnik

At the time, no highway, $\sim 3h$ by car along jammed Av. Calchaquí

Weizmann Institute

Post-doc : Nuclear Physics ⟶ Statistical Physics

Journal of Physics A: Mathematical and General

Critical capacity of noisy and asymmetrically constrained perceptrons

J Kurchan and E Domany

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Journal of Physics A: Mathematical and General, Volume 24, Number 8

Citation J Kurchan and E Domany 1991 *J. Phys. A: Math. Gen.* **24** 1947

DOI 10.1088/0305-4470/24/8/032

Unfortunately Eytan had to cancel

Weizmann Institute

Post-doc : Nuclear Physics ⟶ Statistical Physics

Journal of Physics A: Mathematical and General

Critical capacity of noisy and asymmetrically constrained perceptrons

J Kurchan and E Domany

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Journal of Physics A: Mathematical and General, Volume 24, Number 8

Citation J Kurchan and E Domany 1991 *J. Phys. A: Math. Gen.* **24** 1947

DOI 10.1088/0305-4470/24/8/032

VOLUME 65, NUMBER 25 PHYSICAL REVIEW LETTERS 17 DECEMBER 1990

Phase-Space Localization: Topological Aspects of Quantum Chaos

P. Leboeuf
Division de Physique Théorique, Institut de Physique Nucléaire, 91406 Orsay CEDEX, France

J. Kurchan
Nuclear Physics Department, Weizmann Institute of Science, Rehovot 76100, Israel

M. Feingold
Lawrence Berkeley Laboratory and Department of Physics, University of California, Berkeley, California 94720

D. P. Arovas
Department of Physics, B-019, University of California at San Diego, La Jolla, California 92093
(Received 10 September 1990)

We study quantized classically chaotic maps on a toroidal two-dimensional phase space. A discrete, topological criterion for phase-space localization is presented. To each eigenfunction is associated an integer, analogous to a quantized Hall conductivity, which when nonzero reflects phase-space delocalization. A model system is studied, and a correspondence between delocalization and chaotic classical dynamics is discussed.

Roman times

La Sapienza

Roman times

La Sapienza - San Lorenzo

Quartiere San Lorenzo

Miguel Virasoro

Two very porteños together:

lots of Argentinian/World politics discussed

So many very good friends:

Raff, Gae, Tassos & Paulette,

Simona, Sergio, Giulia, Felix,

Marco, David, Marc, Enzo

Nicolas, Rémi, Thierry

Roman times

Early 90s in Rome



Daniel Amit | Miguel Virasoro | Giorgio Parisi

Neural Nets | **Disordered Systems**

Roma I Sapienza | Roma II Tor Vergata

Very lively, socially & scientifically

Mean-Field Modelling

Classical p-spin Spherical Models

Potential energy

$$\mathcal{V} = - \sum_{i_1 \neq \ldots \neq i_p} J_{i_1 \ldots i_p} \, x_{i_1} \ldots x_{i_p} \qquad\qquad p \text{ integer}$$

quenched random couplings $J_{i_1 \ldots i_p}$ drawn from a Gaussian $P[\{J_{i_1 \ldots i_p}\}]$

(over-damped) **Langevin dynamics** for continuous spins $x_i \in \mathbb{R}$

coupled to a white bath $\langle \xi(t) \rangle = 0$ and $\langle \xi(t)\xi(t') \rangle = 2\gamma k_B T \delta(t-t')$

$$\gamma \, \frac{dx_i}{dt} = - \frac{\delta \mathcal{V}}{\delta x_i} + z_t x_i + \xi_i$$

z_t is a Lagrange multiplier that fixes the spherical constraint $\sum_{i=1}^{N} x_i^2 = N$

$p = 2$ mean-field **coarsening**

$p \geq 3$ RFOT modelling of **glasses**

Kirkpatrick, Thirumalai & Wolynes 87-89

Dynamic equations

Integro-differential eqs. on the correlation and linear response

In the $\boxed{N \to \infty}$ limit exact and closed causal Schwinger-Dyson equations

(Average over randomness, random initial conditions and thermal noise)

$$(\gamma\partial_t - z_t)C(t,t') = \int dt'' \left[\Sigma(t,t'')C(t'',t') + D(t,t'')R(t',t'')\right] + 2\gamma k_B T R(t',t)$$

$$(\gamma\partial_t - z_t)R(t,t') = \int dt'' \, \Sigma(t,t'')R(t'',t') + \delta(t-t')$$

where Σ and D are the self-energy and vertex, which for p spin models read

$$D(t,t') = \tfrac{p}{2}\, C^{p-1}(t,t') \qquad \Sigma(t,t') = \frac{p(p-1)}{2}\, C^{p-2}(t,t')\, R(t,t')$$

z_t is fixed by $C(t,t) = 1$ **Sompolinsky & Zippelius 82, LFC & Kurchan 93**

Similar to Mode-Coupling Theory for liquids **Götze et al 80s** or DMFT for quantum systems **Georges & Kotliar 90s**, but not necessarily in equilibrium

Weak ergodicity breaking

$$\lim_{t-t'\to\infty} \lim_{t'\to\infty} C(t,t') = q_{\mathrm{EA}} \qquad\qquad \lim_{t\gg t'} C(t,t') = 0$$

Bouchaud 92

Weak long-term memory

$$\lim_{t-t'\to\infty} \lim_{t'\to\infty} R(t,t') \simeq 0$$

but

$$\sigma(t,t') = \int_0^{t'} dt''\, R(t,t'') \longrightarrow f(C(t,t')) = \text{finite}$$

LFC & Kurchan 93

allow us to solve the integro-differential eqs. asymptotically

Weak ergodicity breaking

$$\lim_{t-t' \to \infty} \lim_{t' \to \infty} C(t,t') = q_{\mathrm{EA}} \qquad\qquad \lim_{t \gg t'} C(t,t') = 0$$

Bouchaud 92

Weak long-term memory

$$\lim_{t-t' \to \infty} \lim_{t' \to \infty} R(t,t') \simeq 0$$

but

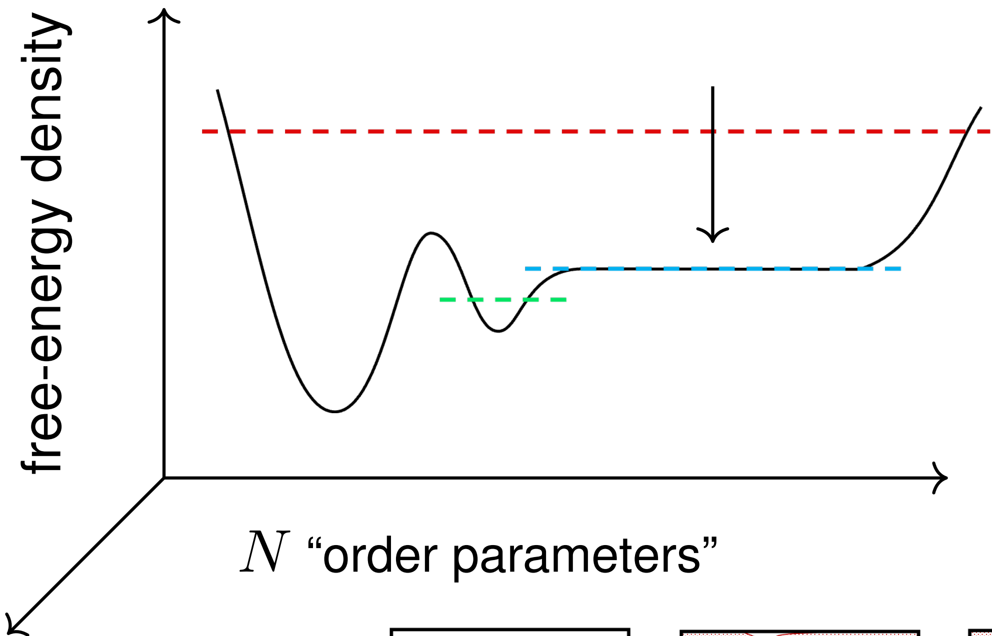
$$\sigma(t,t') = \int_0^{t'} dt''\; R(t,t'') \longrightarrow f(C(t,t')) = \mathrm{finite}$$

LFC & Kurchan 93

and capture aging, non-stationary relaxations

TAP Free-energy Landscape

$p \geq 3$ spin models

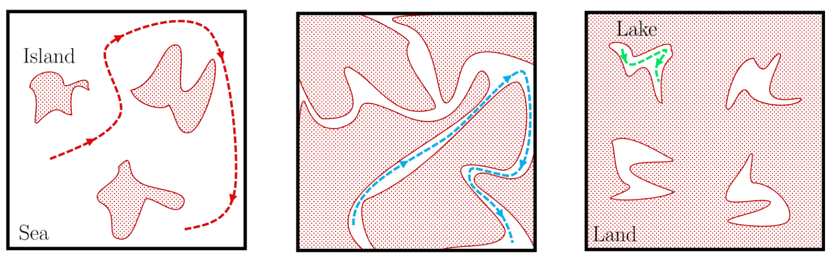


mostly maxima

threshold approached from quench

$$\lim_{t\to\infty} e(t) = e_{\rm th}$$

mostly minima

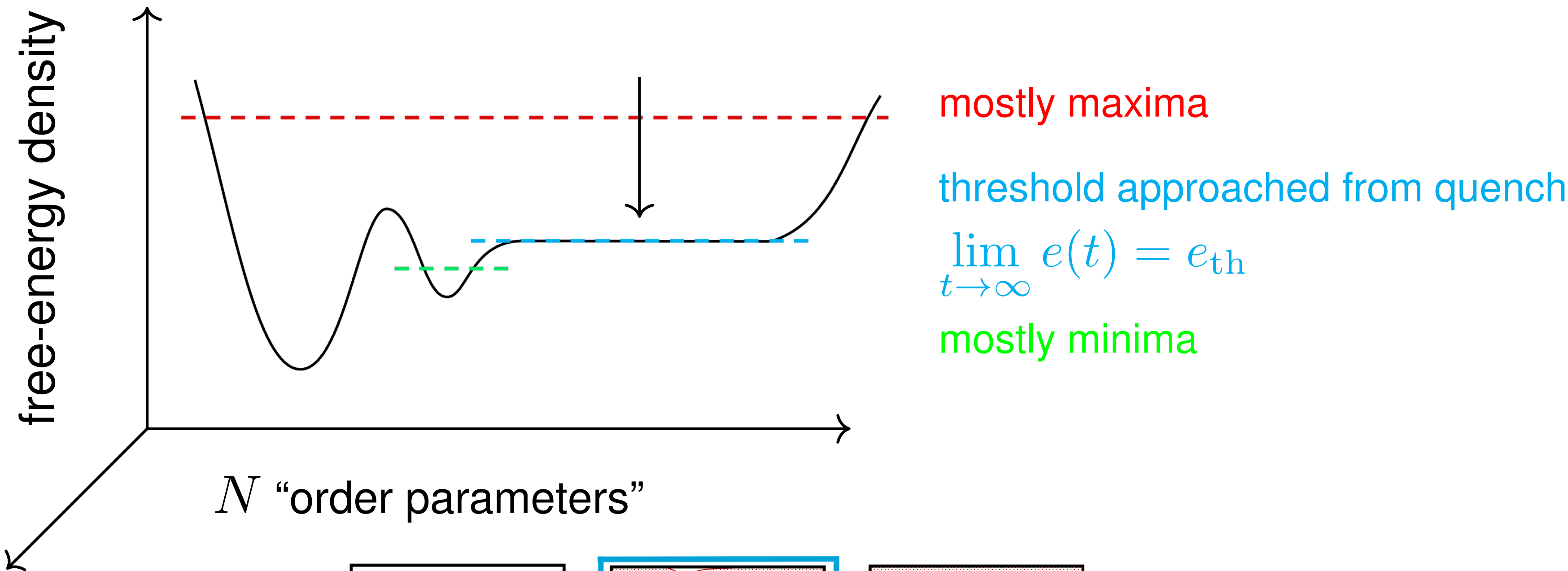


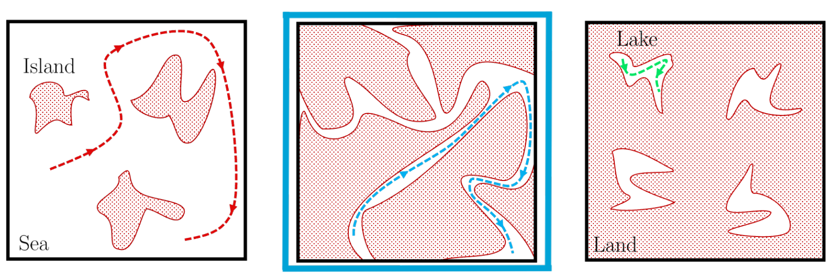
The dynamics is linked to the topography of the landscape

Both for **physical** and **algorithmic** dynamic rules

TAP Free-energy Landscape

$p \geq 3$ **spin models**





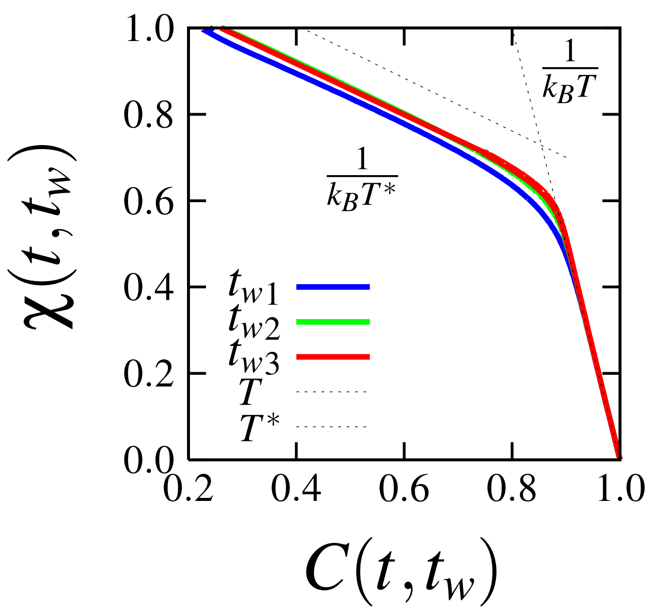
Flat threshold as an attractor for the spherical p-spin relaxation

Both for **physical** and **algorithmic** dynamic rules

Fluctuation-dissipation

Induced vs. spontaneous fluctuations in the spherical p-spin model

A quench from $T_0 \to \infty$ to $T < T_c$



parametric construction

t_w fixed

$\boxed{t_{w_1} < t_{w_2} < t_{w_3}}$

$t - t_w$: $0 \to \infty$

used as a parameter

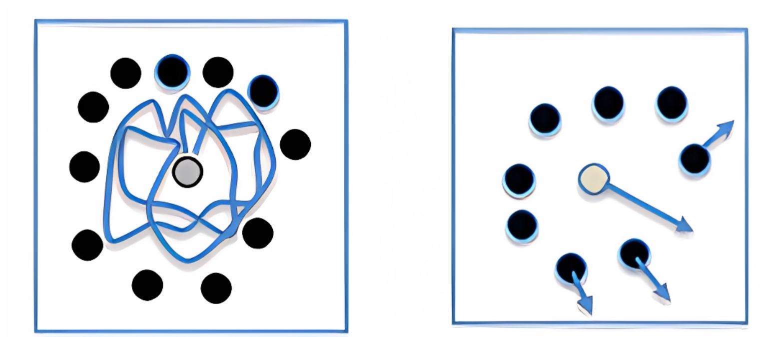
$\boxed{T^* > T}$

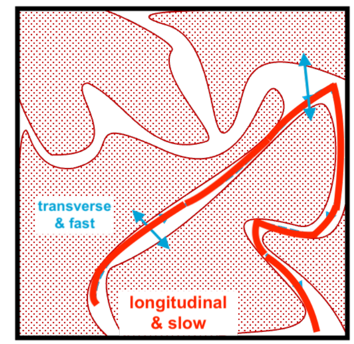
Breakdown of the equilibrium FDT $k_B T \, \chi = C$

Convergence to $k_B T \, \chi(C)$, two linear relations for $C \lessgtr q_{\rm ea}$

Fluctuation-dissipation

Interpretation in real & configurational space





Short-scale

ruled

equilibrium external bath

The fluct-diss relation

with the bath temperature T

Large-scale motion

by the

internal dynamics

holds

another temperature T^*

transverse

longitudinal

motion

in the landscape

After **cooling** from equilibrium at $T_0 > T_d$, hotter $T^* > T$

After **heating** from equilibrium at $T_0 < T_d$, colder $T^* < T$

Support for the temperature interpretation later

Rome $\longrightarrow$ France

Post-doc $\longrightarrow$ CNRS

LPT ENS

Dept. Physique ENS Lyon

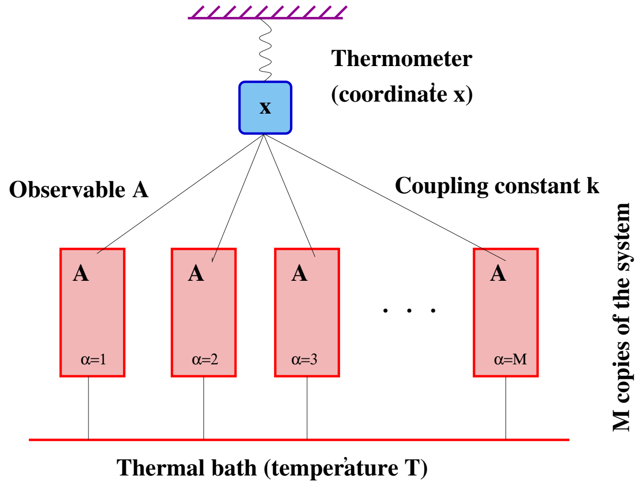
PMMH ESPCI

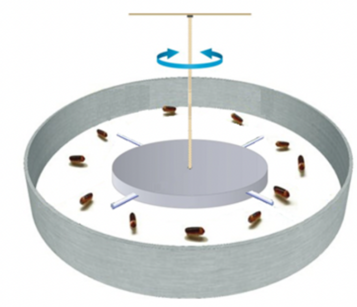
LPS - Dept. Physique ENS

Effective temperatures

Measurement with thermometers

LFC, Kurchan & Peliti 97





Grigera & Israeloff 99 - glassy

D'Anna, Mayor, Barrat, Loreto & Nori 03 - granular

Boudet, Jagielka, Guerin, Barois, Pistolesi & Kellay 24

artificial active matter - robots, etc.

- Short internal time scale fast dynamics is tested and T is recorded.
- Long internal time scale slow dynamics is tested and T^* is recorded.

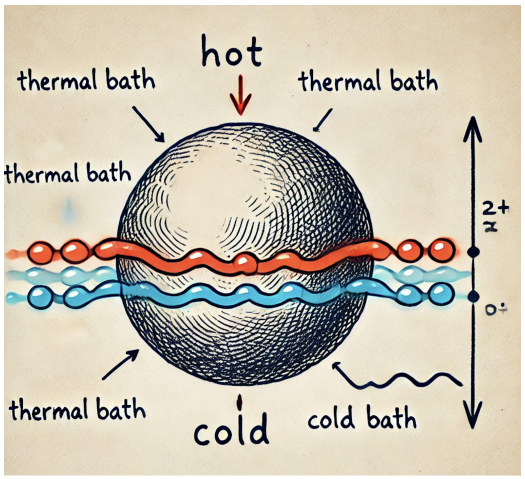
Related to the phenomenological *fictive temperatures* of **Tool 46, Gardon & Narayanaswamy 70, Moynihan et al 76, etc.** but measurable & with a thermodynamic interpretation

Also appearing in stochastic thermodynamic relations

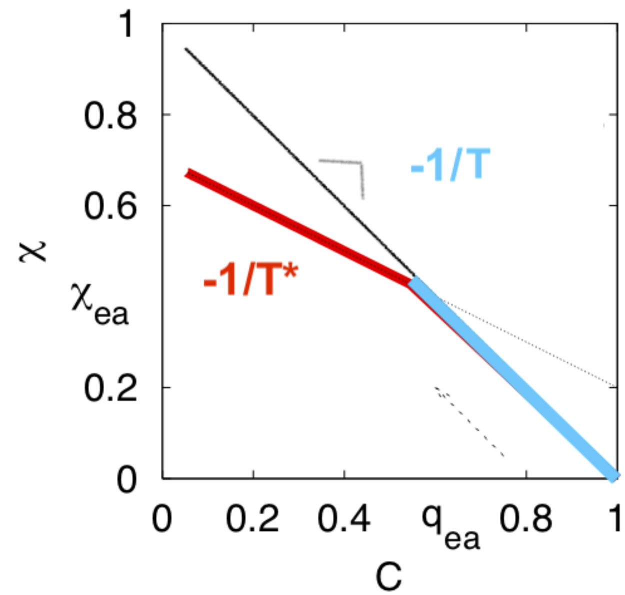
Effective temperatures

Induced by one (or more) baths

Exercise : motion in contact with a complex bath



Sketch created by ChatGPT



$\Gamma = \Gamma_{\rm cold} + \Gamma_{\rm hot}$

$\Gamma_{\rm cold}(t-t') = 2\gamma\delta(t-t')$ and T $\qquad$ $\Gamma_{\rm hot}(t-t') = \gamma_{\rm hot}/\tau \; e^{-(t-t')/\tau}$ and T^*

LFC & Kurchan 00, Zamponi et al 05, Ilg & Barrat 07, etc., cfr. tracer in pasive & active bath

Interacting systems

Self-consistency

In **classical interacting systems** (*e.g.* glasses, active matter, powders) sometimes one selects some variables and treats the rest in some self-consistent way. Say this variable is ϕ

Results in an effective Langevin equation with a **self-consistent friction**

$$\boxed{M\ddot{\phi}(t) + \int dt' \, \Gamma^{\mathbf{f}}(t,t')\dot{\phi}(t') = -\frac{\delta V(\{\phi\})}{\delta \phi(t)} + \xi(t)}$$

and **coloured noise** with correlation $\langle \, \xi(t)\xi(t') \, \rangle$

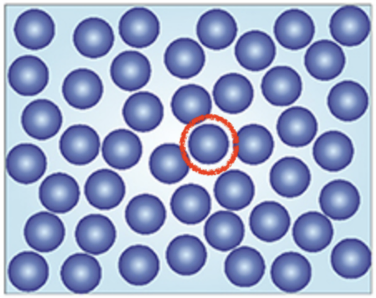
The friction $\Gamma^{\mathbf{f}}$ and noise $\langle \, \xi(t)\xi(t') \, \rangle$ kernels are self-consistently determined in terms of correlations C and linear responses R of the original variables, represented by ϕ. They also get contributions from the external bath *cfr.* **DMFT**

Sompolinsky & Zippelius 80s, LFC & Kurchan 90-early 2000s, Zamponi *et al*, **Altieri** *et al* beyond physics

Interacting systems

Self-consistency

Results in an effective Langevin equation



$$\boxed{M\ddot{\phi}(t) + \int^t dt'\, \mathbf{\Gamma^f}(t,t')\dot{\phi}(t') = -\frac{\delta V(\{\phi\})}{\delta \phi(t)} + \xi(t)}$$

with friction $\quad \mathbf{\Gamma^f} = \underbrace{\mathbf{\Gamma^f_B}}_{bath} + \underbrace{\mathbf{\Gamma^f}_{int}}_{syst} = \mathbf{\Gamma_B} + \mathbf{\Gamma^f}_{int}(C,R)$

$\searrow$

& correlated coloured noise $\quad \langle\, \xi(t)\xi(t')\,\rangle = \underbrace{k_BT\,\mathbf{\Gamma_B}}_{bath} + \underbrace{\overline{\mathbf{\Gamma}}^{\mathbf{n}}_{int}(C,R)}_{syst}$

While for an equilibrium external bath $k_BT\,\mathbf{\Gamma^f_B} = \overline{\mathbf{\Gamma}}^{\mathbf{n}}_{\mathbf{B}}$ the equilibrium fluctuation dissipation relation is not ensured for the internal contributions and it does not apply below T_g

Glassy Dynamics

Quenched random systems $\leftrightarrow$ Structural Glasses

ELSEVIER

Physica A 226 (1996) 243–273

PHYSICA A

Mode-coupling approximations, glass theory and disordered systems

Jean-Philippe Bouchaud [a,1], Leticia Cugliandolo [a,2], Jorge Kurchan [b,3], Marc Mézard [b,4]

[a] Service de Physique de l'Etat Condensé, CEA-Saclay, Orme des Merisiers, 91 191 Gif s/ Yvette Cedex, France

[b] Laboratoire de Physique Théorique de l' Ecole Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex 05, France[5]

Received 10 November 1995

Out of Equilibrium dynamics in Spin-Glasses and other Glassy Systems

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Jorge Kurchan
Laboratoire de Physique Théorique de l'École Normale Supérieure de Lyon, 46 Allée d'Italie, F-69364, Lyon Cedex-07, France

Marc Mézard
Laboratoire de Physique Théorique de l'École Normale Supérieure[a], 24 rue Lhomond, 75231 Paris Cedex 05, France

Collaboration with Jean-Philippe Bouchaud & Marc Mézard

A global picture for the dynamics of different glassy systems

Kirkpatrick, Thirumalai & Wolynes, late 80s

Kurchan & Laloux, *Phase space geometry and slow dynamics*, J. Phys. A 29, 1929 (1996)

Glassy Dynamics

Quenched random systems $\leftrightarrow$ Structural Glasses

Jorge & Marc

12th International Congress of Mathematical Physics

Brisbane, Australia

13-19 July 1997

Jorge & Jean-Philippe

Nonequilibrium Statistical Physics : Glasses, transport & friction, biological systems, and turbulence

Boulder School

2-27 July 2001

American Physical Society

LARS ONSAGER PRIZE

recognizes outstanding research in theoretical statistical physics including the quantum fluids.

The 2025 Prize is presented to

Jorge Kurchan

For fundamental advances describing out-of-equilibrium disordered systems, especially complex aging.

John Doyle

PRESIDENT

Jonathan A. Bagger

CHIEF EXECUTIVE OFFICER

March 17, 2025

Paris

A family man

Fluctuation Theorems

for Langevin dynamics: rendering them understandable

Journal of Physics A: Mathematical and General

Fluctuation theorem for stochastic dynamics

Jorge Kurchan

Published under licence by IOP Publishing Ltd

Journal of Physics A: Mathematical and General, Volume 31, Number 16

Citation Jorge Kurchan 1998 *J. Phys. A: Math. Gen.* **31** 3719

DOI 10.1088/0305-4470/31/16/003

$$\frac{P(\sigma_t)}{P(-\sigma_t)} = e^{\sigma_t}$$

Abstract

The fluctuation theorem of Gallavotti and Cohen holds for finite systems undergoing Langevin dynamics. In such a context all non-trivial ergodic theory issues are bypassed, and the theorem takes a particularly simple form. As a particular case, we obtain a nonlinear fluctuation-dissipation theorem valid for equilibrium systems perturbed by arbitrarily strong fields.

with $\sigma_t = \int_0^t dt' \; \mathbf{f}(\mathbf{x}(t')) \cdot \mathbf{v}(t') / \langle \sigma_t \rangle$ the fluctuating power of a force $\mathbf{f}(\mathbf{x}(t'))$

CNRS at ENS-Lyon – 1996 - 1999

Sheared super-cooled liquids

Non-reciprocal interaction *ante tempus*

Ludovic Berthier (PhD Student)

Jean-Louis Barrat (Co-supervisor)

PHYSICAL REVIEW E VOLUME 61, NUMBER 5 MAY 2000

A two-time-scale, two-temperature scenario for nonlinear rheology

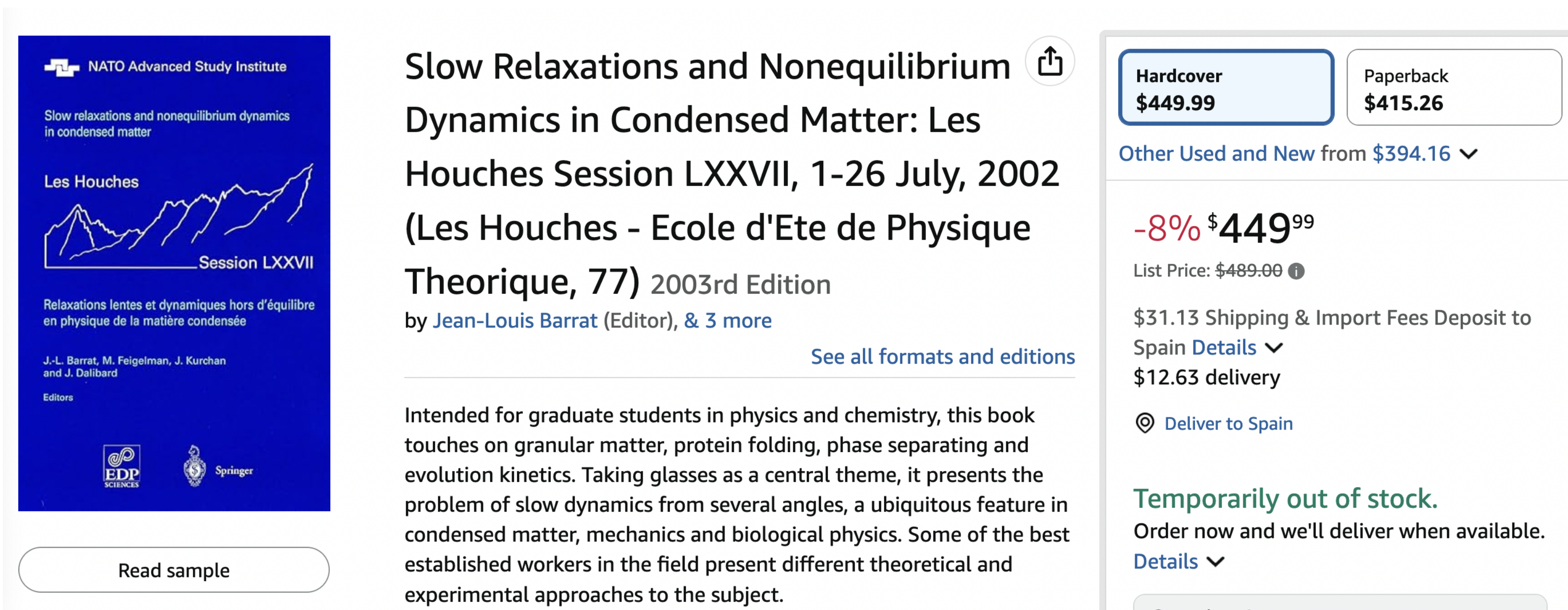
Ludovic Berthier,[1,2] Jean-Louis Barrat,[2] and Jorge Kurchan[1]
[1]*Laboratoire de Physique, ENS-Lyon and CNRS, F-69364, Lyon Cedex 07, France*
[2]*Département de Physique des Matériaux, Université Claude Bernard and CNRS, F-69622 Villeurbanne Cedex, France*
(Received 21 October 1999)

We investigate a general scenario for ''glassy'' or ''jammed'' systems driven by an external, nonconservative force, analogous to a shear force in a fluid. In this scenario, the drive results in the suppression of the usual aging process, and the correlation and response functions become time translation invariant. The relaxation time and the response functions are then dependent on the intensity of the drive and on temperature. We

CNRS at ENS-Lyon – 1996 - 1999

Organization skills

Les Houches 2002 - collaboration with Jean-Louis Barrat

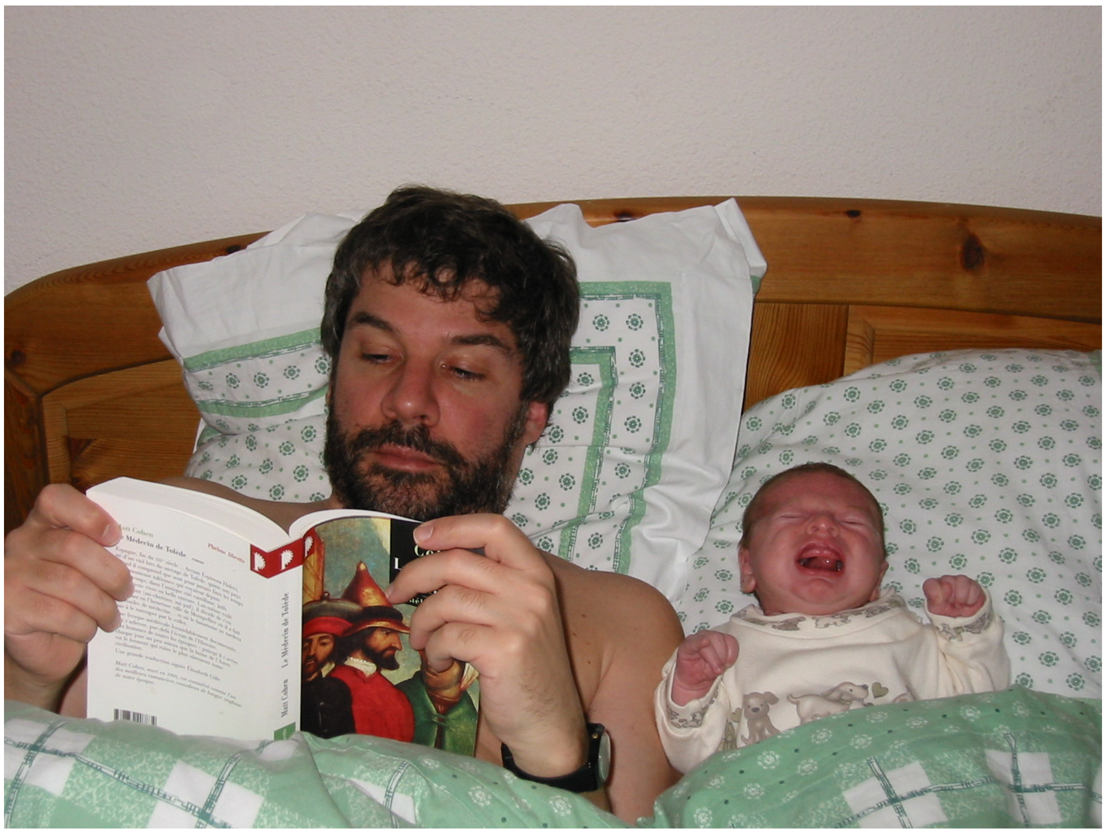


Among the students students: Eric Bertin, Giulio Biroli, Ludovic Berthier, Daniel Domínguez, Tomás Grigera, Eytan Katzav, Ale Kolton, Florent Krzakala, Greg Schehr, Guilhem Semerjian, Cristina Toninelli, Thomas Voigtmann, Olivia White, Stephen Whitelam, Emanuela Zaccarelli, Francesco Zamponi.

Do not know what happened to the students of the parallel Russian session 😀

Les Houches 2002

First steps into fatherhood



Quantum annealing

and their failure to solve hard problems

PRL **101,** 147204 (2008) PHYSICAL REVIEW LETTERS week ending 3 OCTOBER 2008

Simple Glass Models and Their Quantum Annealing

Thomas Jörg,[1] Florent Krzakala,[2] Jorge Kurchan,[3] and A. C. Maggs[2]
[1]*LPTMS, Université Paris-Sud, CNRS UMR 8626, 91405 Orsay Cedex, France*
[2]*PCT, ESPCI ParisTech, 10 rue Vauquelin, CNRS UMR 7083 Gulliver, 75005 Paris, France*
[3]*PMMH, ESPCI ParisTech, 10 rue Vauquelin, CNRS UMR 7636, 75005 Paris, France*
(Received 3 July 2008; published 2 October 2008)

We study first-order quantum phase transitions in mean-field spin glasses. We solve the quantum random energy model using elementary methods and show that at the transition the eigenstate suddenly projects onto the unperturbed ground state and that the gap between the lowest states is exponentially small in the system size. We argue that this is a generic feature of all "random first-order" models, which includes benchmarks such as random satisfiability. We introduce a two-time instanton to calculate this gap in general, and discuss the consequences for quantum annealing.

First order quantum phase transitions at $T = 0$

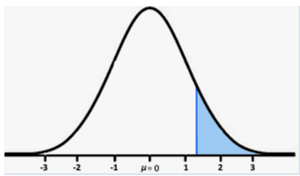
hinder quantum annealing algorithms

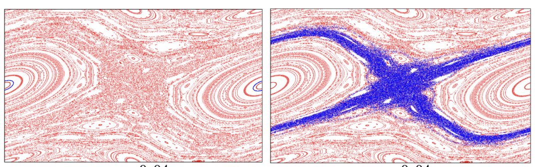
José Eduardo Wesfreid

CNRS PMMH at ESPCI – 1999 - 2012

Simulating Rare Events

part of J. Tailleur's PhD Thesis





$\alpha = -0,04$ $\alpha = 0,04$

Figure 6: **Typical Configurations for** $\alpha = \pm 0,04$. Phase space trajectories of the standard map are shown in light red whereas the trajectories localized by the Lyapunov Weighted Dynamics appear in dark blue.

J Stat Phys (2011) 145:787–811
DOI 10.1007/s10955-011-0350-4

Simulating Rare Events in Dynamical Processes

Cristian Giardina · Jorge Kurchan · Vivien Lecomte · Julien Tailleur

Abstract Atypical, rare trajectories of dynamical systems are important: they are often the paths for chemical reactions, the haven of (relative) stability of planetary systems, the rogue waves that are detected in oil platforms, the structures that are responsible for intermittency in a turbulent liquid, the active regions that allow a supercooled liquid to flow.... Simulating them in an efficient, accelerated way, is in fact quite simple.

In this paper we review a computational technique to study such rare events in both stochastic and Hamiltonian systems. The method is based on the evolution of a family of copies of the system which are replicated or killed in such a way as to favor the realization of the atypical trajectories. We illustrate this with various examples.

José Eduardo Wesfreid

CNRS PMMH at ESPCI – 1999 - 2012

More on Glasses

in large dimensions

Derivation & analysis of the free-energy density and use of Gardner's ideas:

> *"Random First Order Transition (RFOT) scenario is realized here with two thermo-dynamic transitions : the usual Kauzmann point associated with entropy crisis, and a further transition at higher pressures in which a glassy structure of micro-states is developed within each amorphous state."*

+ P. Charbonneau, G. Parisi, PF Urbani & F. Zamponi

The derivation and analysis of the effective Langevin equation for glasses

$$\boxed{M\ddot{\phi}(t) + \int^{t} dt' \, \mathbf{\Gamma}^{\mathbf{f}}(t,t')\dot{\phi}(t') = -\frac{\delta V(\{\phi\})}{\delta\phi(t)} + \xi(t)}$$

+ T. Maimburg & F. Zamponi

Just a little bit about my own work

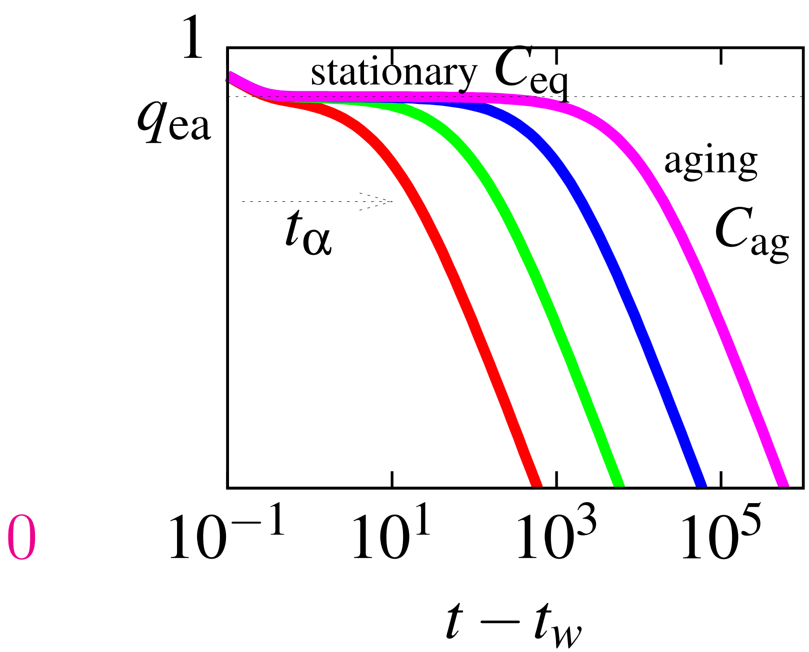
Time reparametrization invariance and fluctuations

more in Jorge's talk tomorrow, I presume

Time reparametrization invariance

In the long t_w limit

Fast $t - t_w \ll t_w$



The aging part is **slow**

$$\mathcal{R}(t)/\mathcal{R}(t_w) = \mathcal{O}(1)$$

$$C_{ag}(t, t_w) \sim f_{ag}\left(\frac{\mathcal{R}(t)}{\mathcal{R}(t_w)}\right)$$

$$\partial_t C_{ag}(t, t_w) \propto \frac{\dot{\mathcal{R}}(t)}{\mathcal{R}(t)} \xrightarrow[t\to\infty]{}$$

$$\boxed{\partial_t C_{ag}(t, t_w) \ll C_{ag}(t, t_w)}$$

Eqs. for the slow relaxation $C_{ag} < q_{ea}$ are invariant under

$$\boxed{t \to h(t) \quad C(t, t_w) \to C(h(t), h(t_w)) \quad R(t, t_w) \to \dot{h}(t')/h(t_w)\, R(h(t), h(t_w))}$$

Consequences

Characterize the spatial fluctuations

- There is an approximate dynamic symmetry :

  global time reparametrization invariance

- There is a **soft/massless** dynamic mode associated to it,

  with a **two-time diverging correlation length** $\xi(t, t_w)$

  Extract it from, *e.g*

$$C_4(r, t, t_w) = \frac{1}{N} \sum_{i,j/|\vec{r}_i - \vec{r}_j| = r} \langle s_i(t) s_i(t_w) s_j(t) s_j(t_w) \rangle_c$$

- Characterize **dynamic fluctuations - heterogeneities**

  $C_{\vec{r}}(t, t_w; \ell, \xi)$, $\rho(C_{\vec{r}}, \chi_{\vec{r}}; t, t_w; \ell, \xi)$, multi-time functions, *etc.*

- Disentangle simple **dynamic scaling** implications from **time reparametrization invariance** ones.

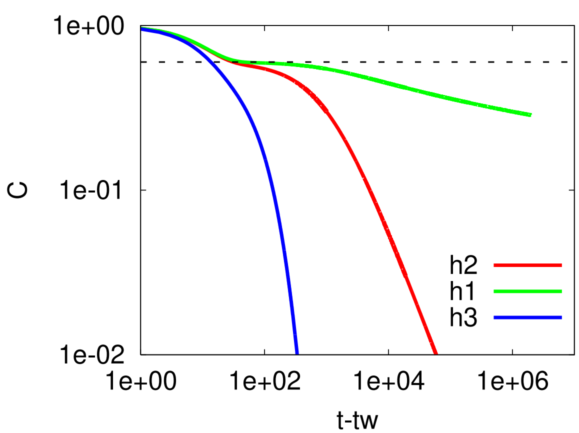
Leading fluctuations

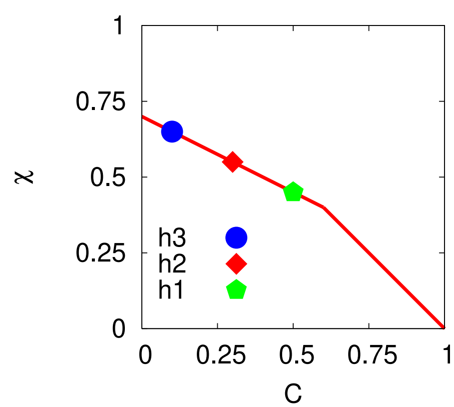
Global to local correlations & linear responses

$$C_{\rm ag}(t,t_w) \approx f_{\rm ag}\left(\frac{\mathcal{R}(t)}{\mathcal{R}(t_w)}\right)$$ **global correlation**

Global time-reparametrization invariance $\Rightarrow \; C^{\rm ag}_{\vec r}(t,t_w) \sim f_{\rm ag}\left(\frac{h_{\vec r}(t)}{h_{\vec r}(t_w)}\right)$

Ex. $h_{\vec r_1} = \frac{t}{t_0}$, $h_{\vec r_2} = \ln\left(\frac{t}{t_0}\right)$, $h_{\vec r_3} = e^{\ln^{a>1}\left(\frac{t}{t_0}\right)}$ in different spatial regions





Castillo, Chamon, LFC, Iguain & Kennett 02, 03

Chamon, Charbonneau, LFC, Reichman & Sellitto 04

Jaubert, Chamon, LFC & Picco 07

More recent perspective: time-reparametrization invariance in SYK models

Kitaev 15, Maldacena & Stanford 16, **more in J. Kurchan's talk**

Concluding words

Super imaginative : Kurchan theory alert !* 

Strong ideas : Nadie ignora**

Very generous with his ideas 

Hard worker, although it may not seem so... 

Passion for debate $\underbrace{\text{Julien, Guilhem,}}_{\text{disagreeing}}$ $\underbrace{\text{Laurette}}_{\text{agreeing}}$, etc.

Acid humor (?)

* David Dean's, ** Fernando Rodríguez Villegas contribution

The best result

and an excellent father

and now I embarrassed the boys who should be sitting in the audience too