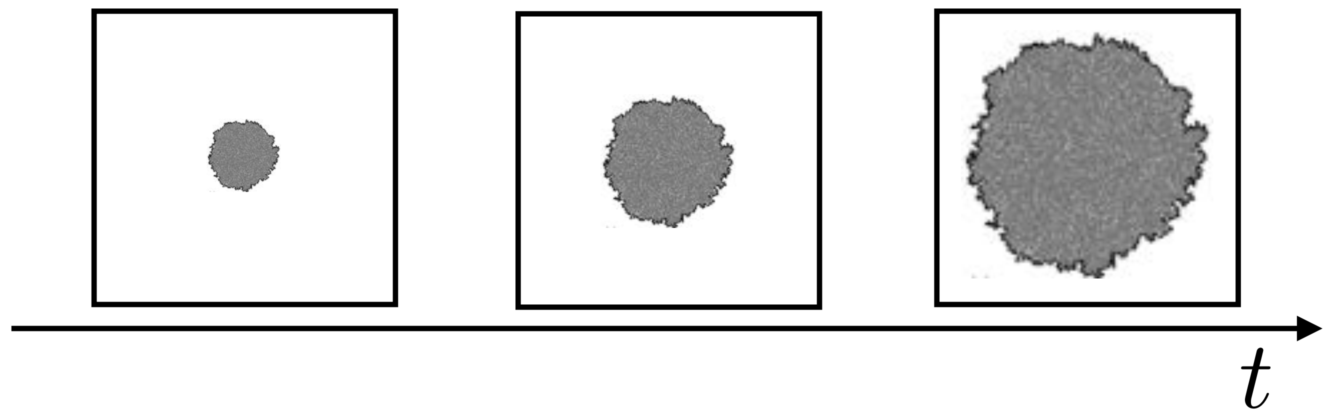
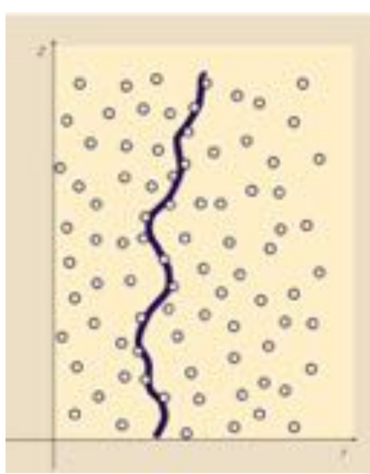
KPZ universality and memory

KPZ universality class



Kardar-Parisi-Zhang (KPZ)

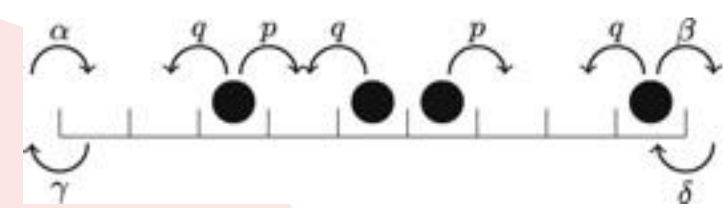


Directed Polymer

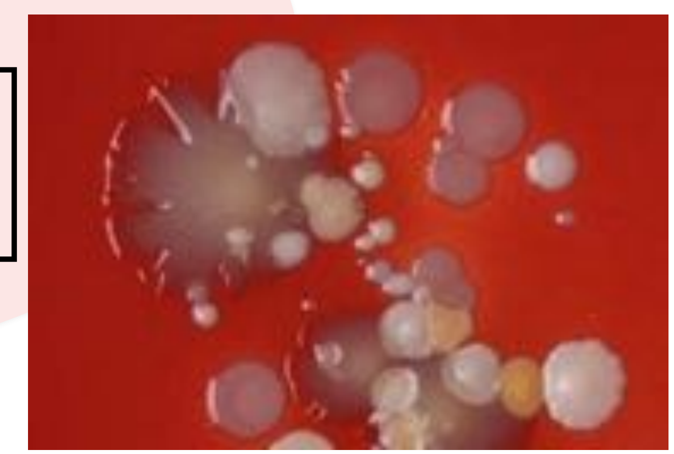
Quantum systems

Matrices aléatoires

Exclusion Processes



Colonies of bacteria



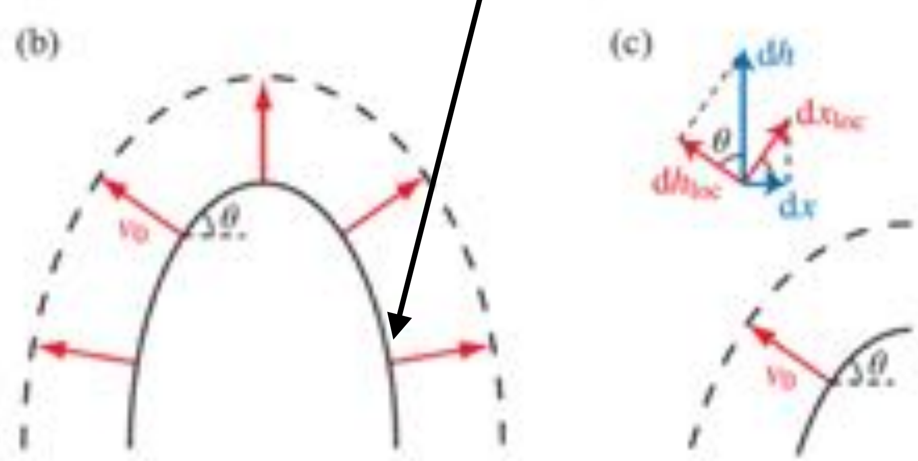
$$\partial_t h(x,t) = \nu \partial_x^2 h(x,t) + \frac{\lambda_0}{2}(\partial_x h(x,t))^2 + \sqrt{D}\ \xi(x,t)$$

Solved in 2010

KPZ universality class

$$\partial_t h(x,t) = \nu \partial_x^2 h(x,t) + \frac{\lambda_0}{2}(\partial_x h(x,t))^2 + \sqrt{D}\,\xi(x,t)$$

$$\partial_t h_{\text{local}}(x_{\text{local}},t) = \nu \partial_{x_{\text{local}}}^2 h_{\text{local}}(x_{\text{local}},t) + \sqrt{D}\eta(x_{\text{local}},t)$$



$$dh = dh_{\text{local}}\sqrt{1+(\partial_x h)^2}$$

$$dx = dx_{\text{local}}/\sqrt{1+(\partial_x h)^2}$$

An appetizer to modern developments on the Kardar-Parisi-Zhang universality class

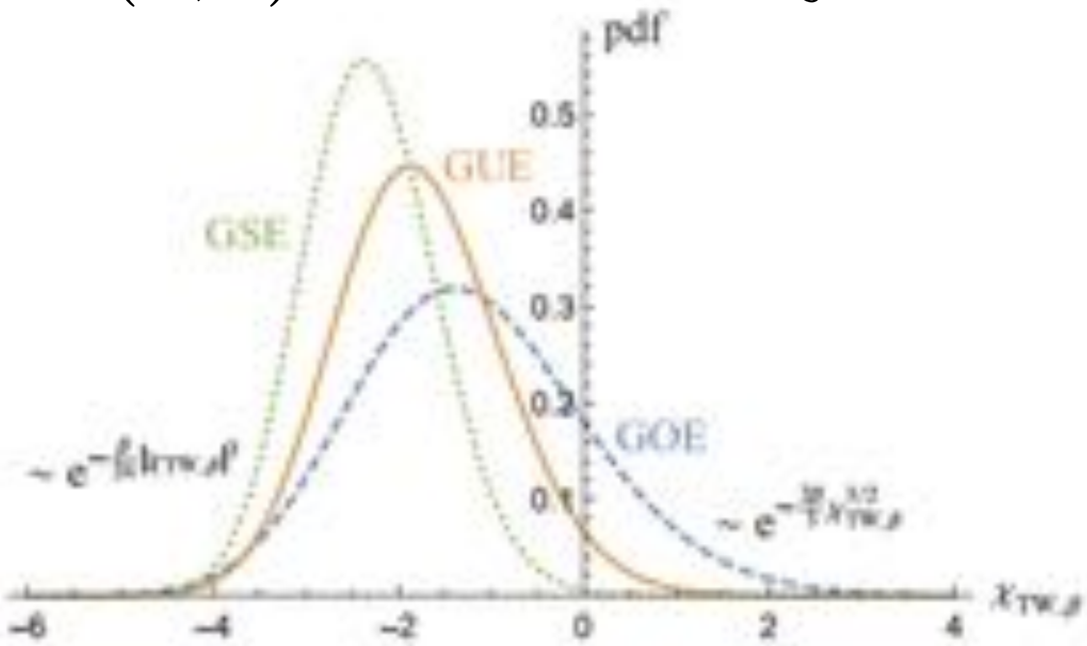
Kazumasa A. Takeuchi

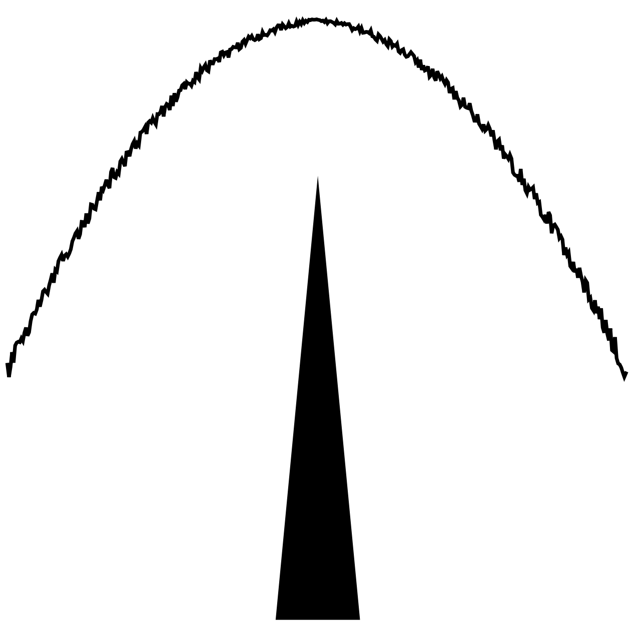
Department of Physics, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8551, Japan.

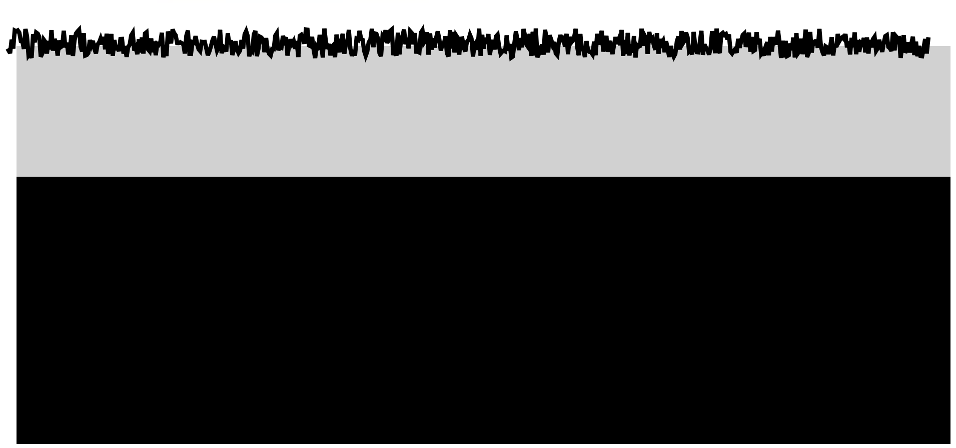
KPZ universality class

$$\partial_t h(x,t) = \nu \partial_x^2 h(x,t) + \frac{\lambda_0}{2}(\partial_x h(x,t))^2 + \sqrt{D}\,\xi(x,t)$$

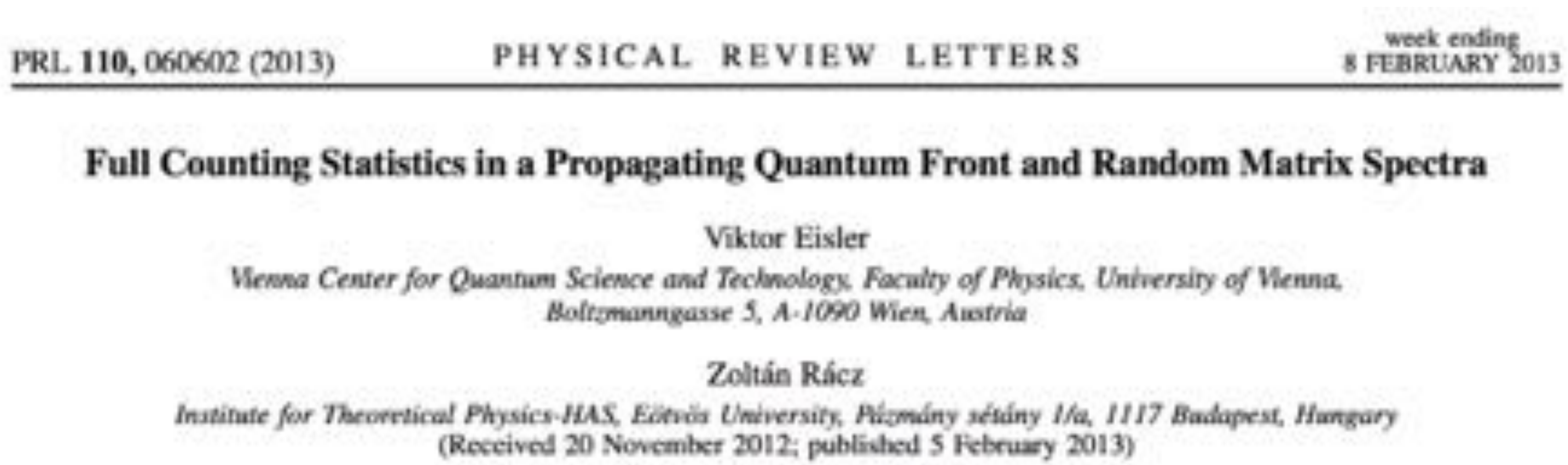
$$h(0,t) = vt + t^{1/3}\xi + \ldots$$







KPZ universality class - quantum systems


PRL **110**, 060602 (2013) PHYSICAL REVIEW LETTERS week ending 8 FEBRUARY 2013

Full Counting Statistics in a Propagating Quantum Front and Random Matrix Spectra

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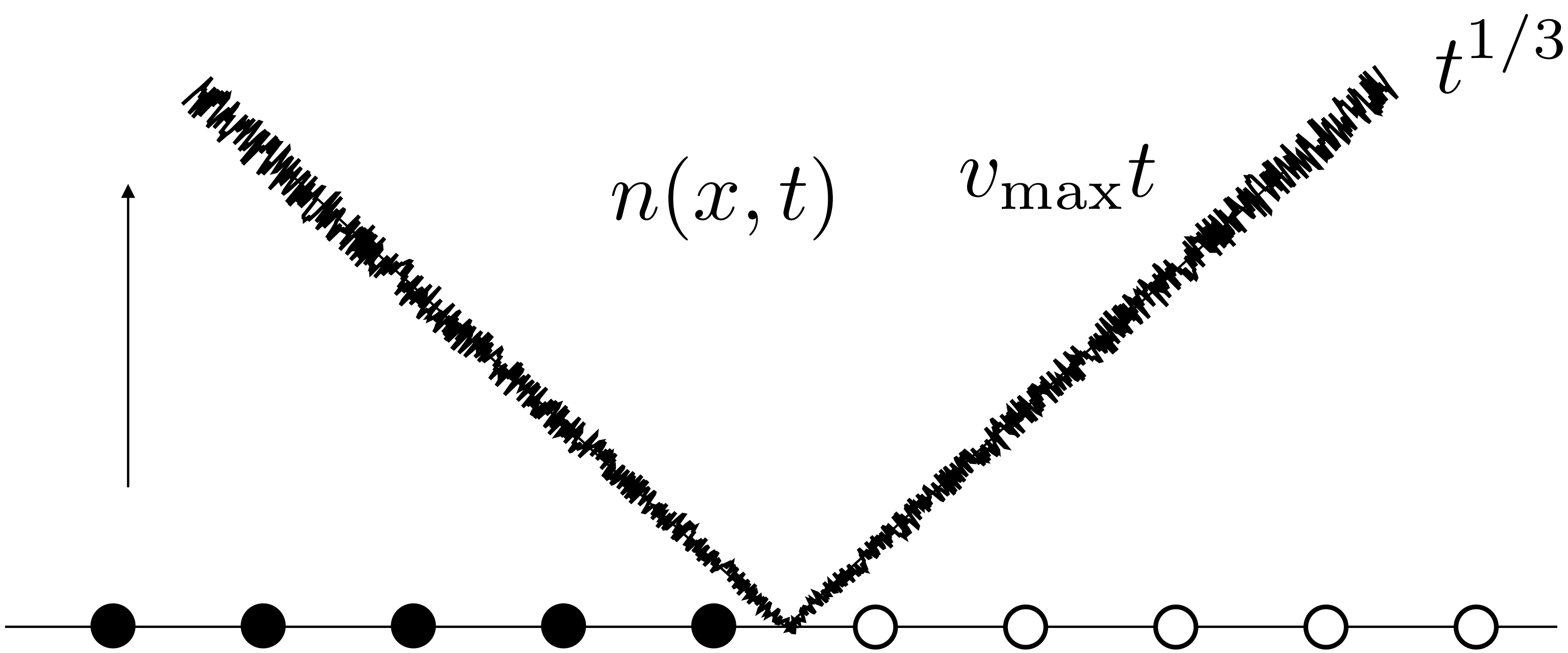
Vienna Center for Quantum Science and Technology, Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Wien, Austria

Zoltán Rácz
Institute for Theoretical Physics-HAS, Eötvös University, Pázmány sétány 1/a, 1117 Budapest, Hungary
(Received 20 November 2012; published 5 February 2013)



KPZ universality class - quantum systems

PRL **117**, 070403 (2016) PHYSICAL REVIEW LETTERS week ending 12 AUGUST 2016

Exact Short-Time Height Distribution in the One-Dimensional Kardar-Parisi-Zhang Equation and Edge Fermions at High Temperature

Pierre Le Doussal,[1] Satya N. Majumdar,[2] Alberto Rosso,[2] and Grégory Schehr[2]
[1]*CNRS-Laboratoire de Physique Théorique de l'Ecole Normale Supérieure, 24 rue Lhomond, 75231 Paris Cedex, France*
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(Received 25 April 2016; published 11 August 2016)

KPZ universality class - quantum systems

PHYSICAL REVIEW X 7, 031016 (2017)

Quantum Entanglement Growth under Random Unitary Dynamics

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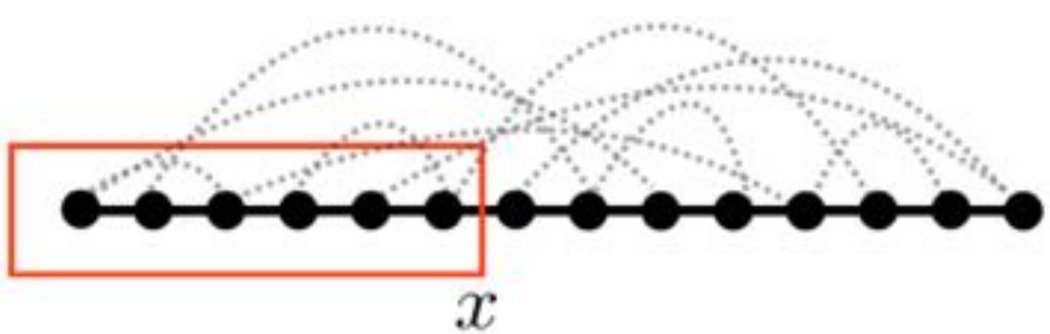
(Received 1 September 2016; revised manuscript received 16 April 2017; published 24 July 2017)

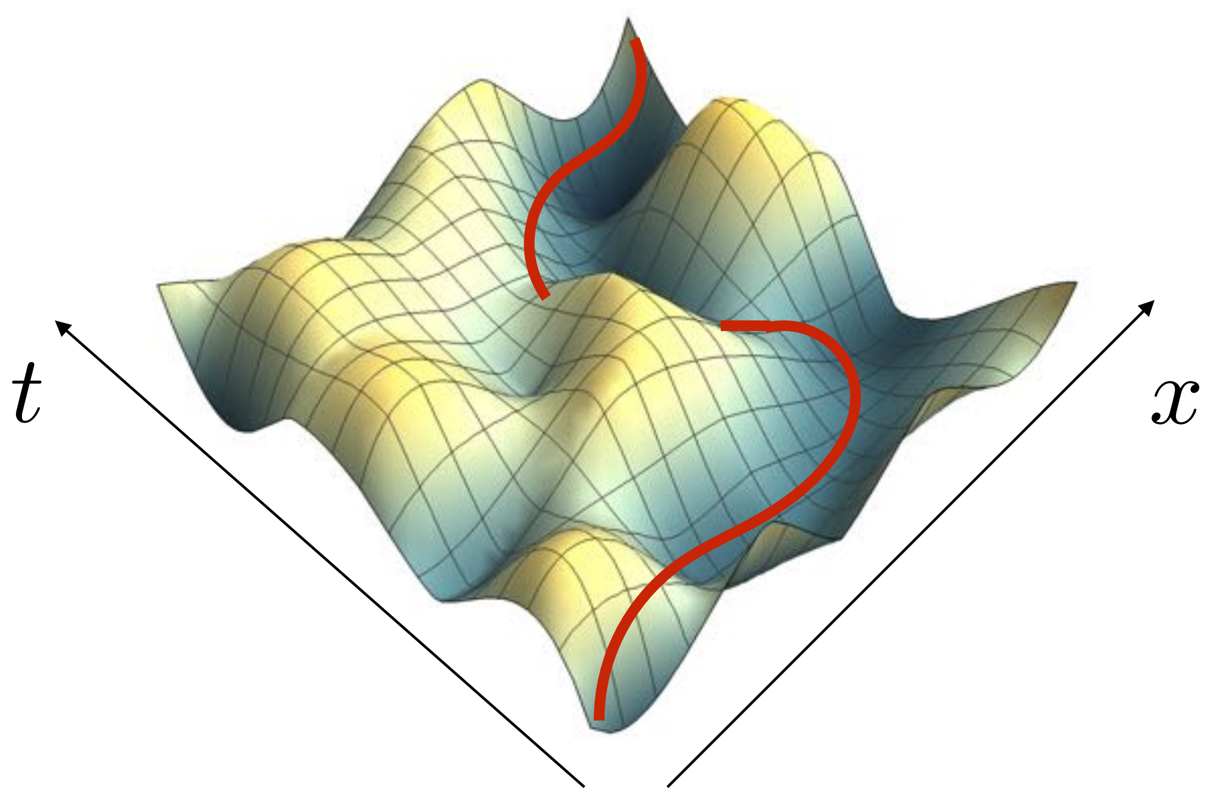


Solution of the KPZ equation via replicas

$$\partial_t h(x,t) = \nu \partial_x^2 h(x,t) + \frac{\lambda_0}{2}(\partial_x h(x,t))^2 + \sqrt{D}\,\xi(x,t)$$

$$Z(x,t) = e^{h(x,t)}$$

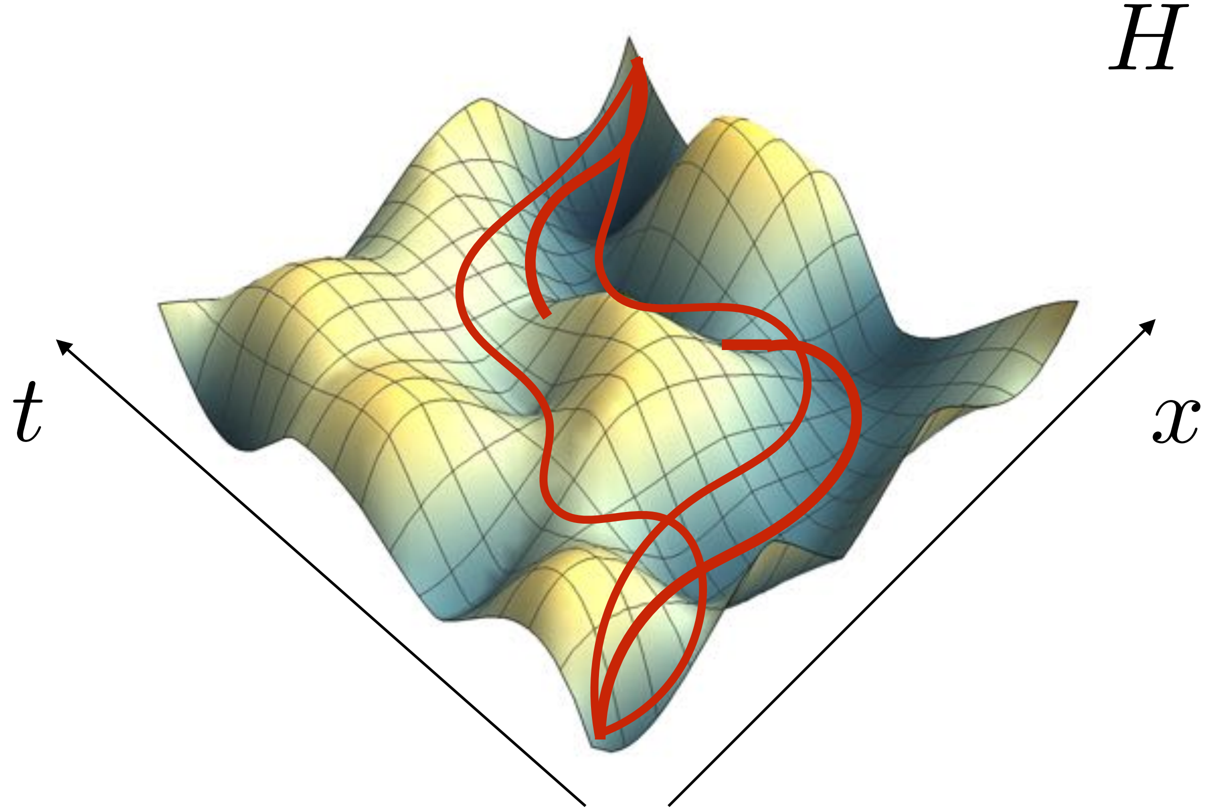
$$\partial_t Z(x,t) = \nu \partial_x^2 Z(x,t) + D\eta(x,t) Z(x,t)$$



Solution of the KPZ equation via replicas

$$\partial_t Z(x,t) = \nu \partial_x^2 Z(x,t) + D\eta(x,t) Z(x,t)$$

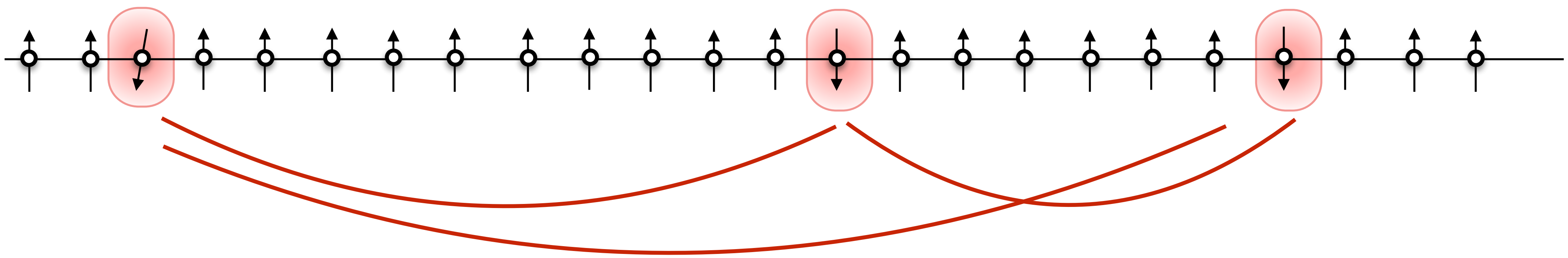
$$\langle e^{nh(x,t)} \rangle = \langle Z^n(x,t) \rangle \quad = \langle \vec{x}_0 | e^{-tH} | \vec{x}, t \rangle$$



$$H = \sum_j \partial_{x_j}^2 - 2\bar{c} \sum_j \delta(x_i - x_j)$$

The attractive Lieb-Liniger model

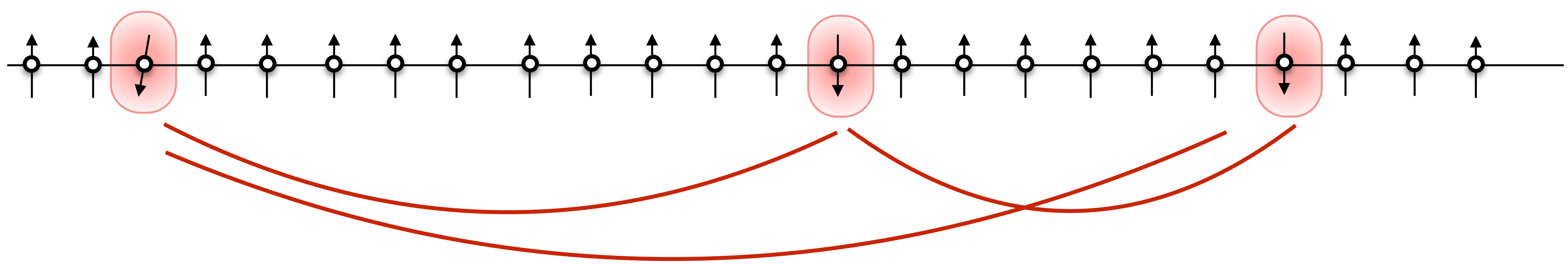
$$H = \sum_j \partial^2_{x_j} - 2\bar{c} \sum_j \delta(x_i - x_j)$$



$$E(k, s) = sk^2 - \frac{\bar{c}}{12}(s^3 - s)$$

The attractive Lieb-Liniger model

$$H = \sum_j \partial^2_{x_j} - 2\bar{c} \sum_j \delta(x_i - x_j)$$

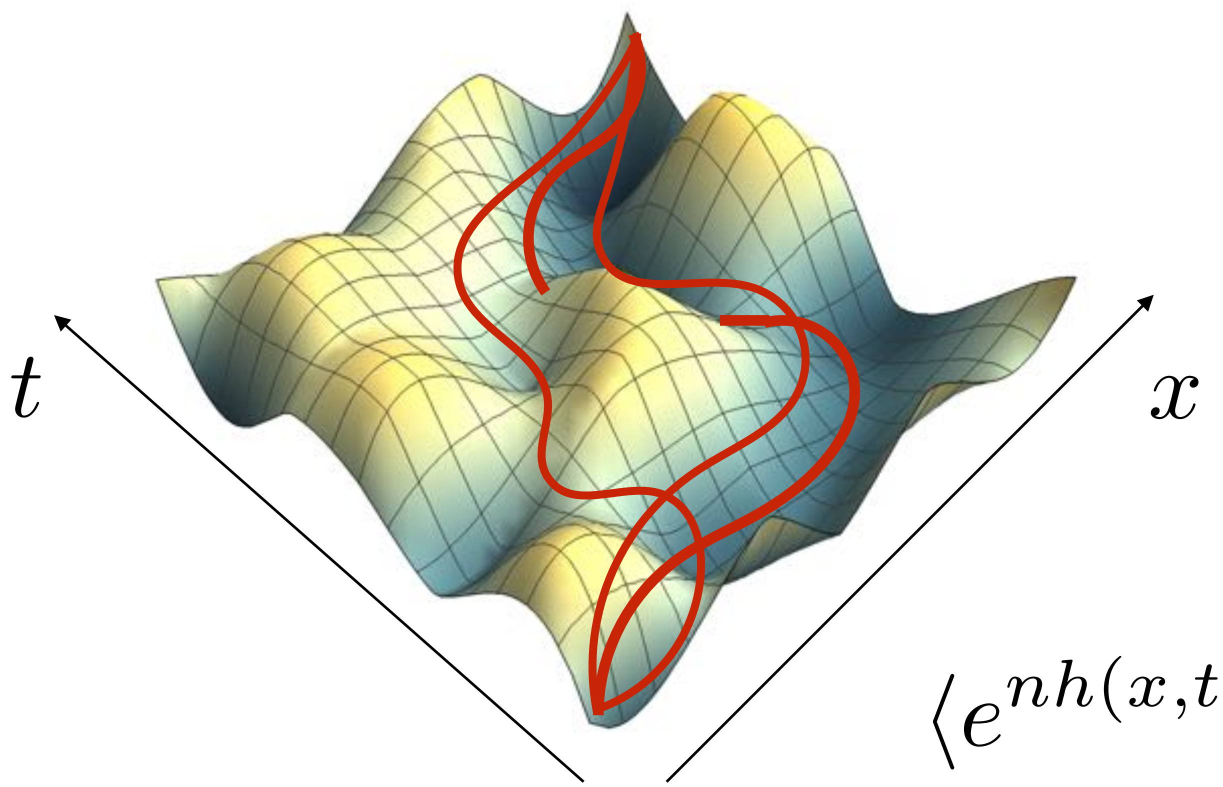


$$E(k,s) = sk^2 - \frac{\bar{c}}{12}(s^3 - s)$$

$$\langle e^{nh(x,t)} \rangle = \langle Z^n(x,t) \rangle \quad = \langle \vec{x}_0 | e^{-tH} | \vec{x}, t \rangle \sim e^{-\bar{c}t/12(n^3-n)}$$

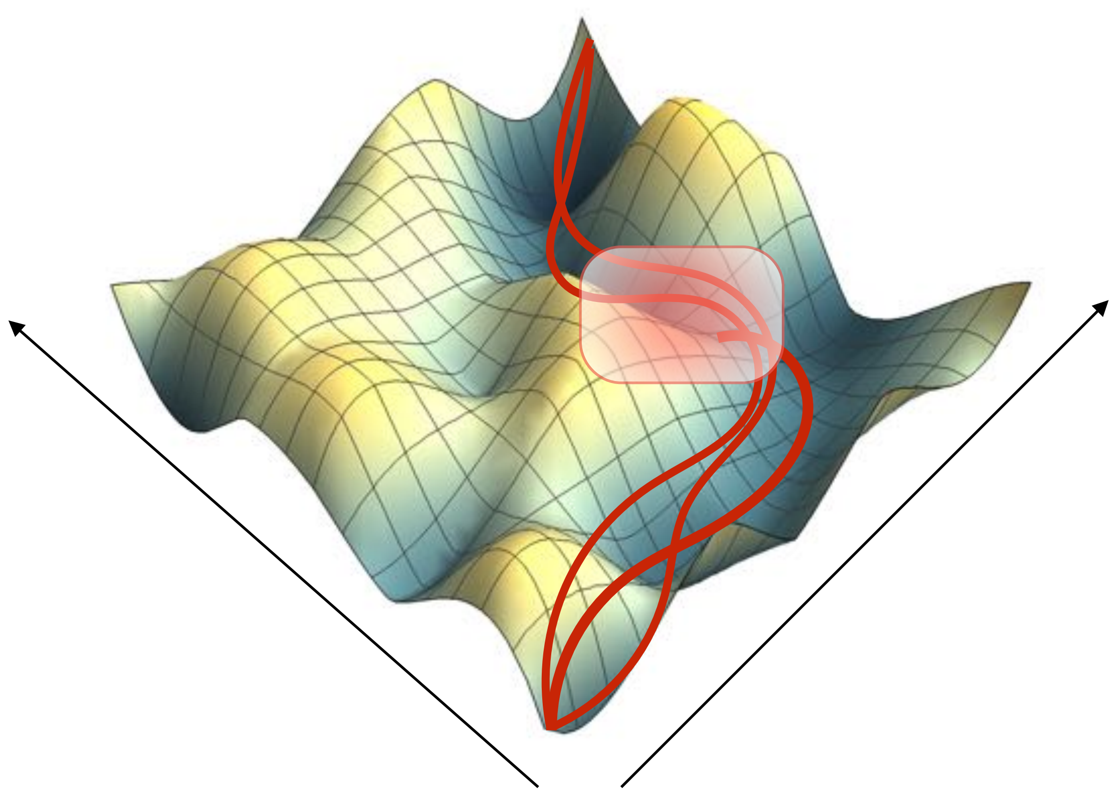
$$n \sim \alpha t^{-1/3} \qquad h(x,t) t^{-1/3} \sim \alpha t^{2/3} + \beta$$

The attractive Lieb-Liniger model



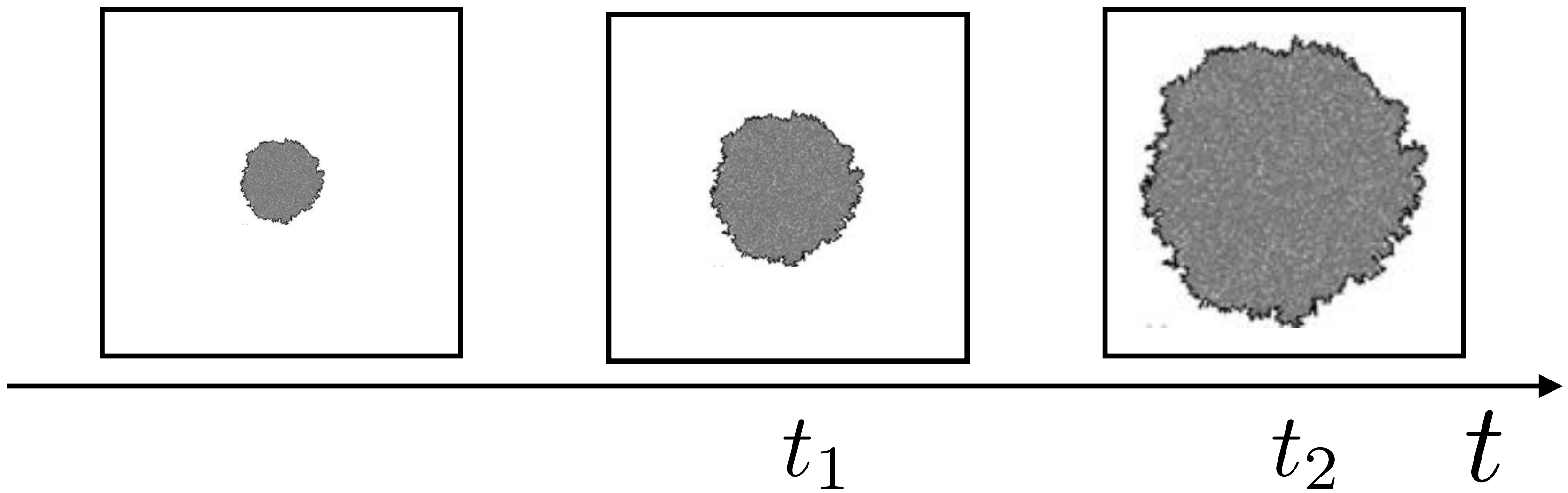
Rare realization

$$\langle e^{nh(x,t)}\rangle = \langle Z^n(x,t)\rangle$$
$$= \langle \vec{x}_0|e^{-tH}|\vec{x},t\rangle$$



Typical realization

Memory in KPZ class

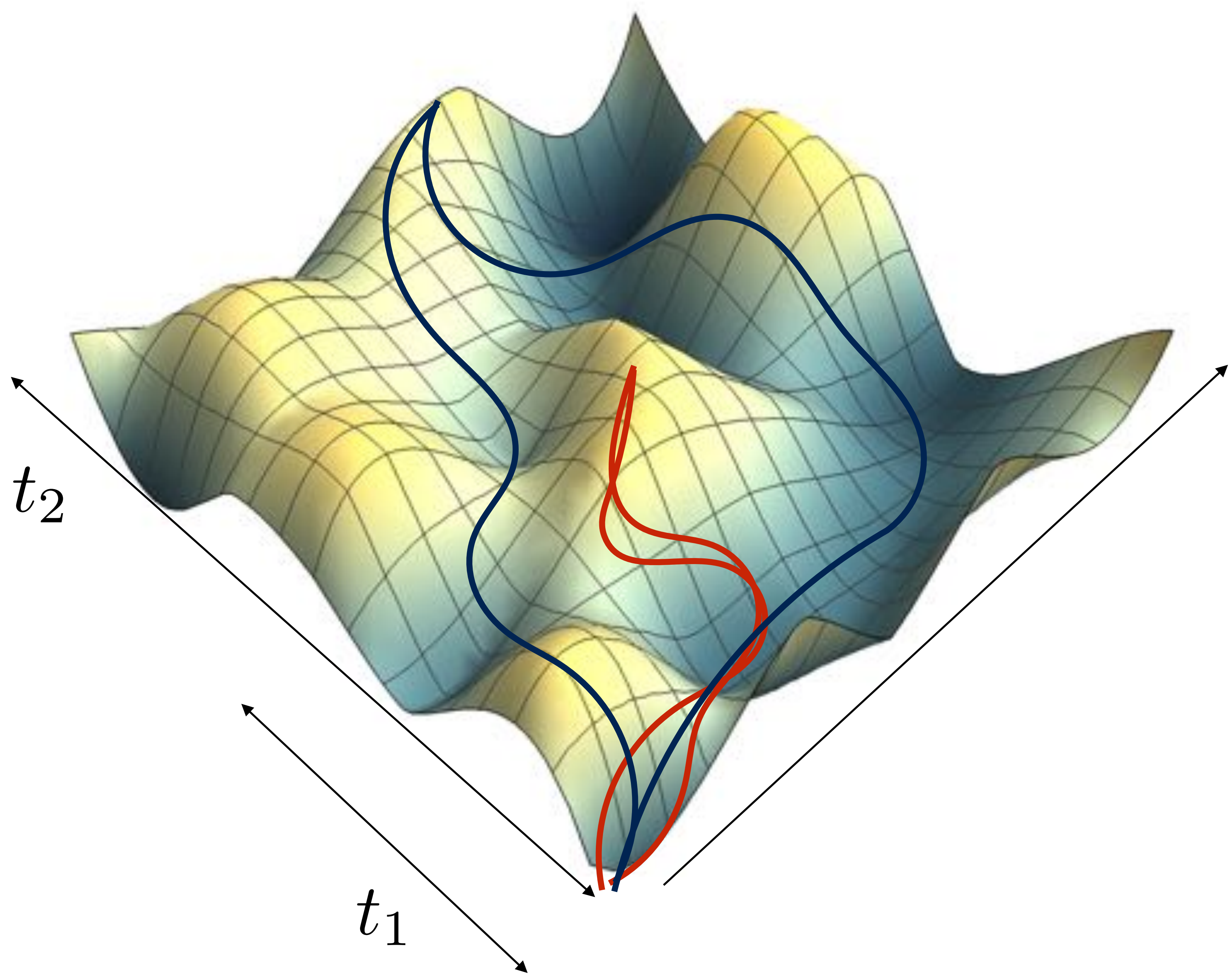


$$\mathrm{cov}(t_1, t_2) = \frac{\langle h(x,t_1)h(x,t_2)\rangle_c}{\langle h(x,t_1)^2\rangle_c}$$

$$\xrightarrow{t_2/t_1 \to \infty} \quad 0.623\ldots$$

Memory in the directed polymer

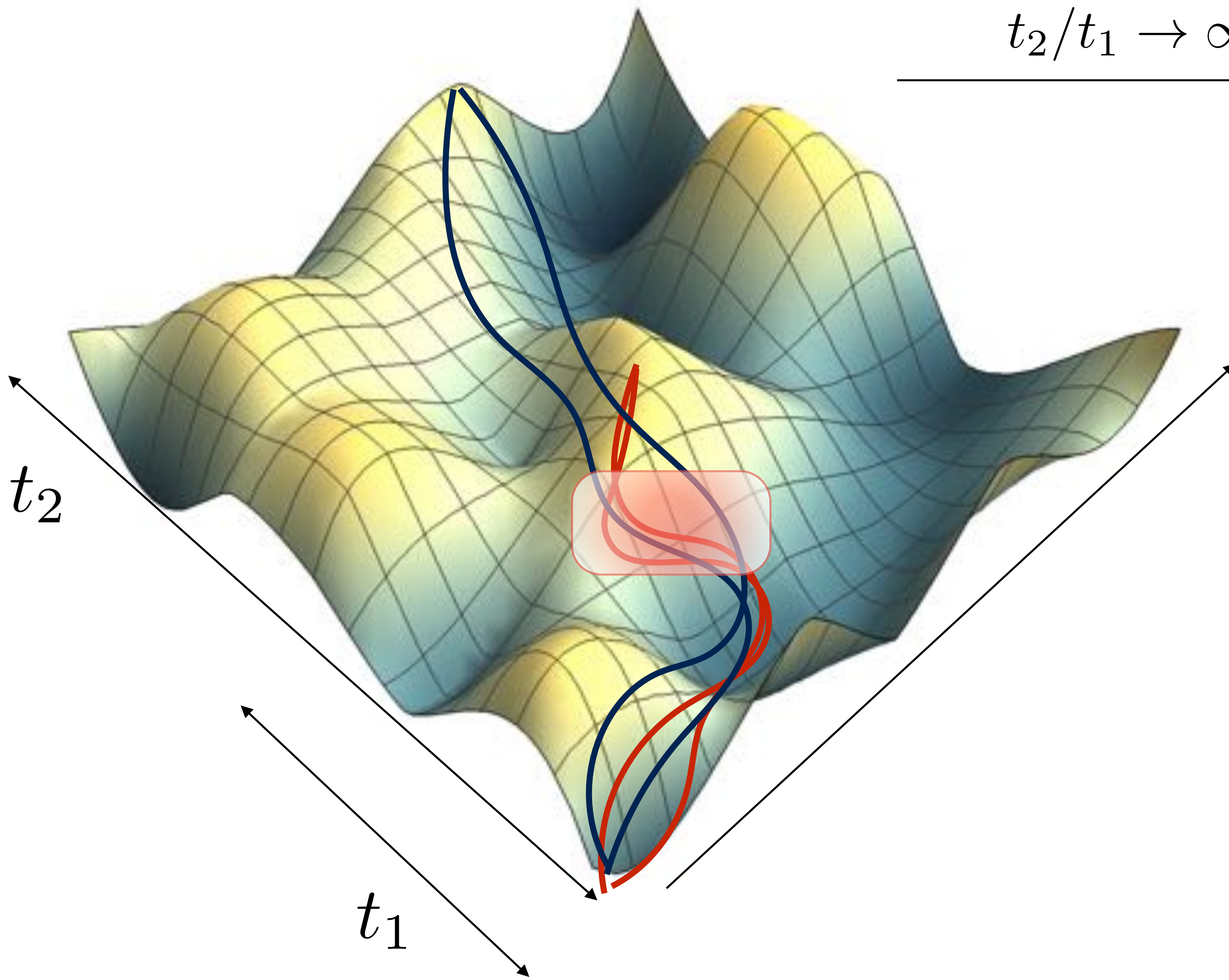
$$\mathrm{cov}(t_1, t_2) = \frac{\langle h(x,t_1) h(x,t_2) \rangle_c}{\langle h(x,t_1)^2 \rangle_c} \propto \text{shared path in } [0, t_1]$$



Memory in the directed polymer

$$\mathrm{cov}(t_1, t_2) = \frac{\langle h(x,t_1)h(x,t_2)\rangle_c}{\langle h(x,t_1)^2\rangle_c} \propto \text{shared path in } [0, t_1]$$

$$\xrightarrow{t_2/t_1 \to \infty} \propto 0.623\ldots$$



Conclusions

Conclusion

GGE steady states in interacting systems

Bound states in the steady state

Generalized hydrodynamics and Drude weights

Finite Drude weights in the gapless regime

Divergence of the diffusion constant

growth phenomena in KPZ equation

Persistence of correlations in the KPZ class

Divergence of the dressed charge of large bound states

Divergence of the binding energy of large bound state

$$v_s^{\text{eff}} q_s^{\text{dr}} \sim s$$

$$E_s \sim s^3$$