False Vacuum Decay on a Quantum Annealer

Jaka Vodeb

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Nanocenter

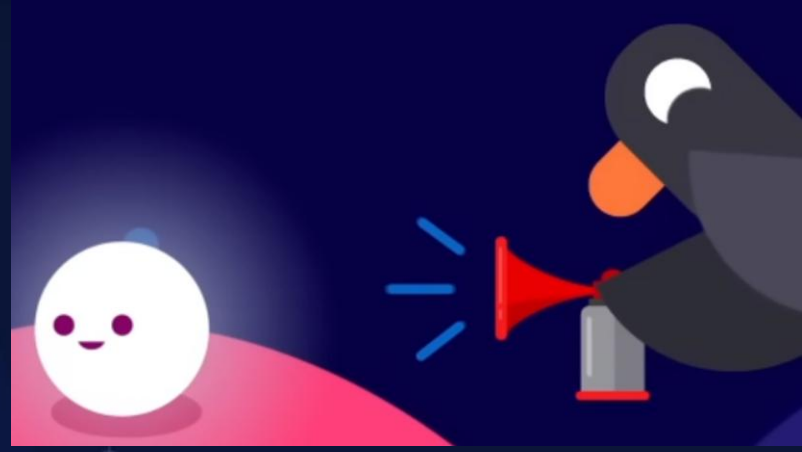
PHYSICAL REVIEW D VOLUME 15, NUMBER 10 15 MAY 1977

Fate of the false vacuum: Semiclassical theory*

Sidney Coleman
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(Received 24 January 1977)

It is possible for a classical field theory to have two homogeneous stable equilibrium states with different energy densities. In the quantum version of the theory, the state of higher energy density becomes unstable through barrier penetration; it is a false vacuum. This is the first of two papers developing the qualitative and quantitative semiclassical theory of the decay of such a false vacuum for theories of a single scalar field with nonderivative interactions. In the limit of vanishing energy density between the two ground states, it is possible to obtain explicit expressions for the relevant quantities to leading order in h; in the more general case, the problem can be reduced to solving a single nonlinear ordinary differential equation.

YouTube



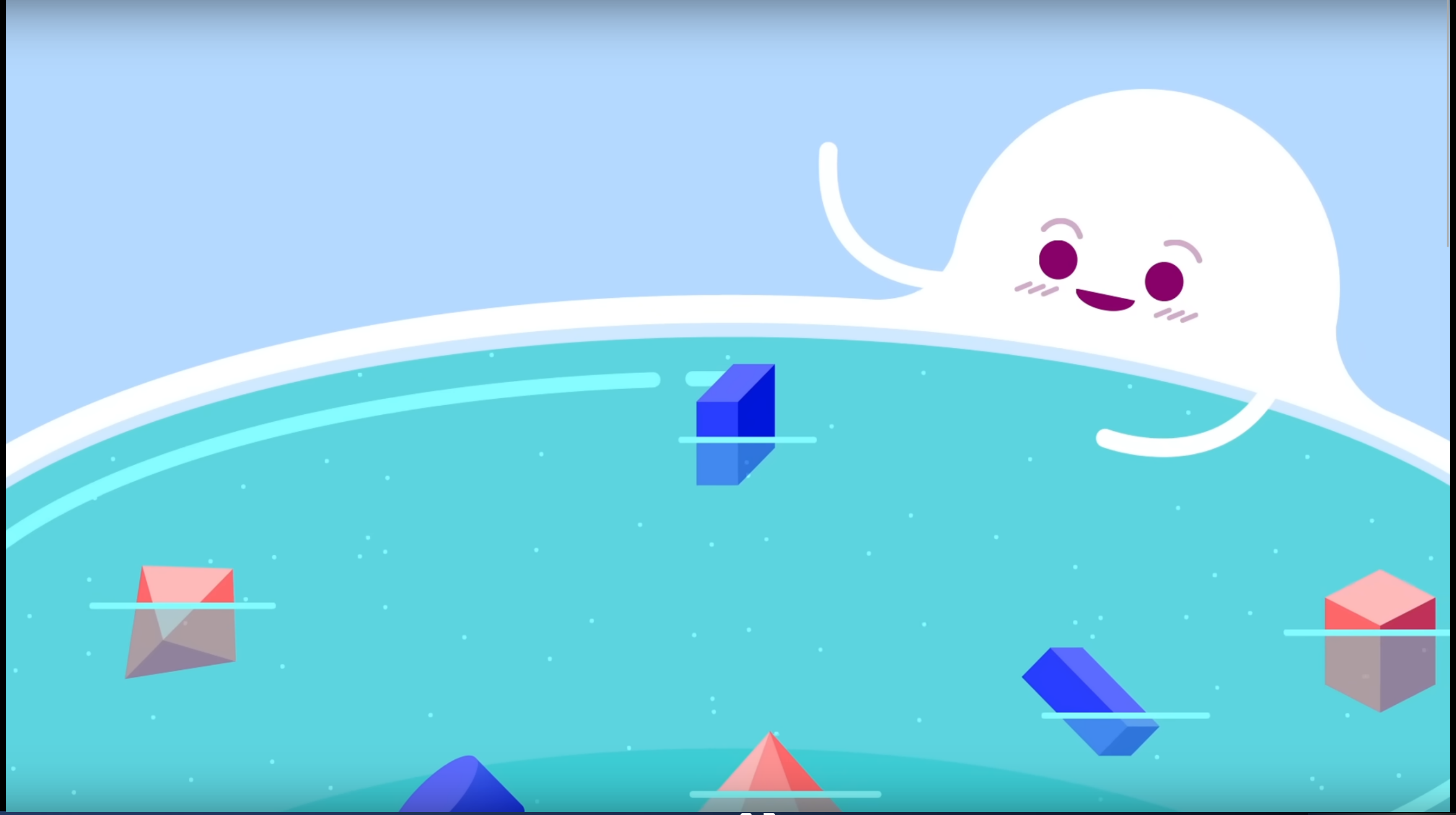
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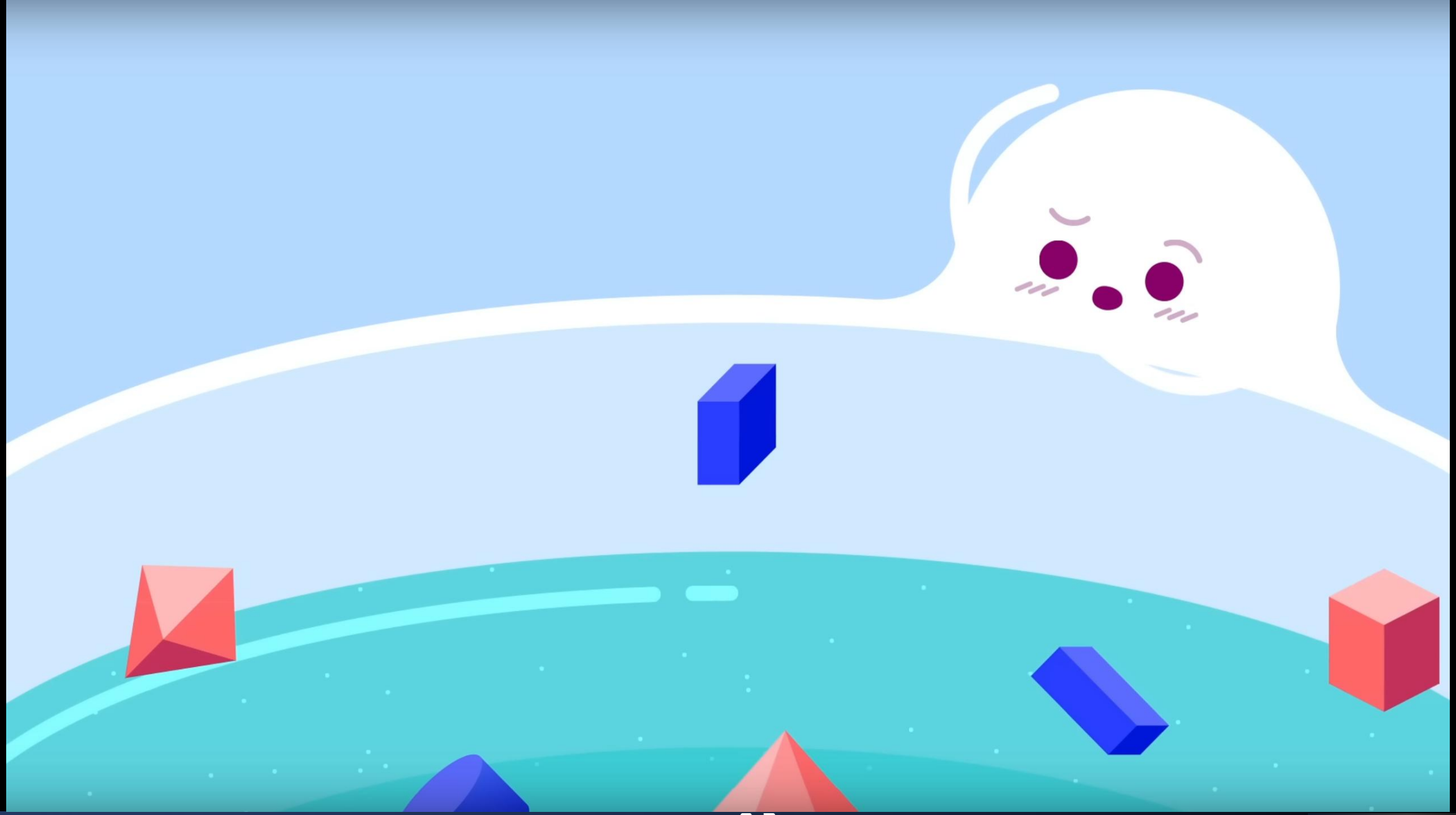
— IN A NUTSHELL —

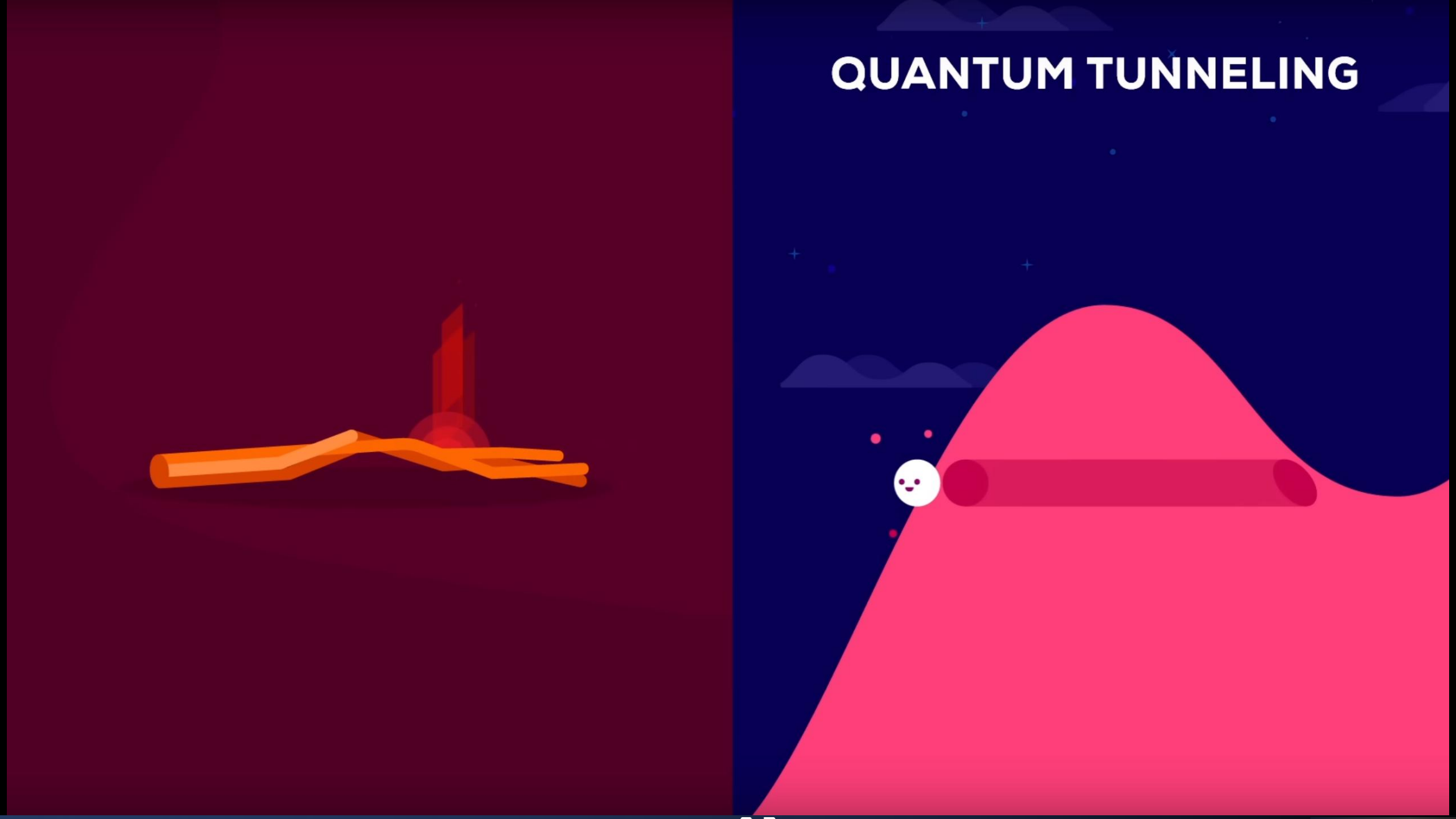
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HIGGS FIELD

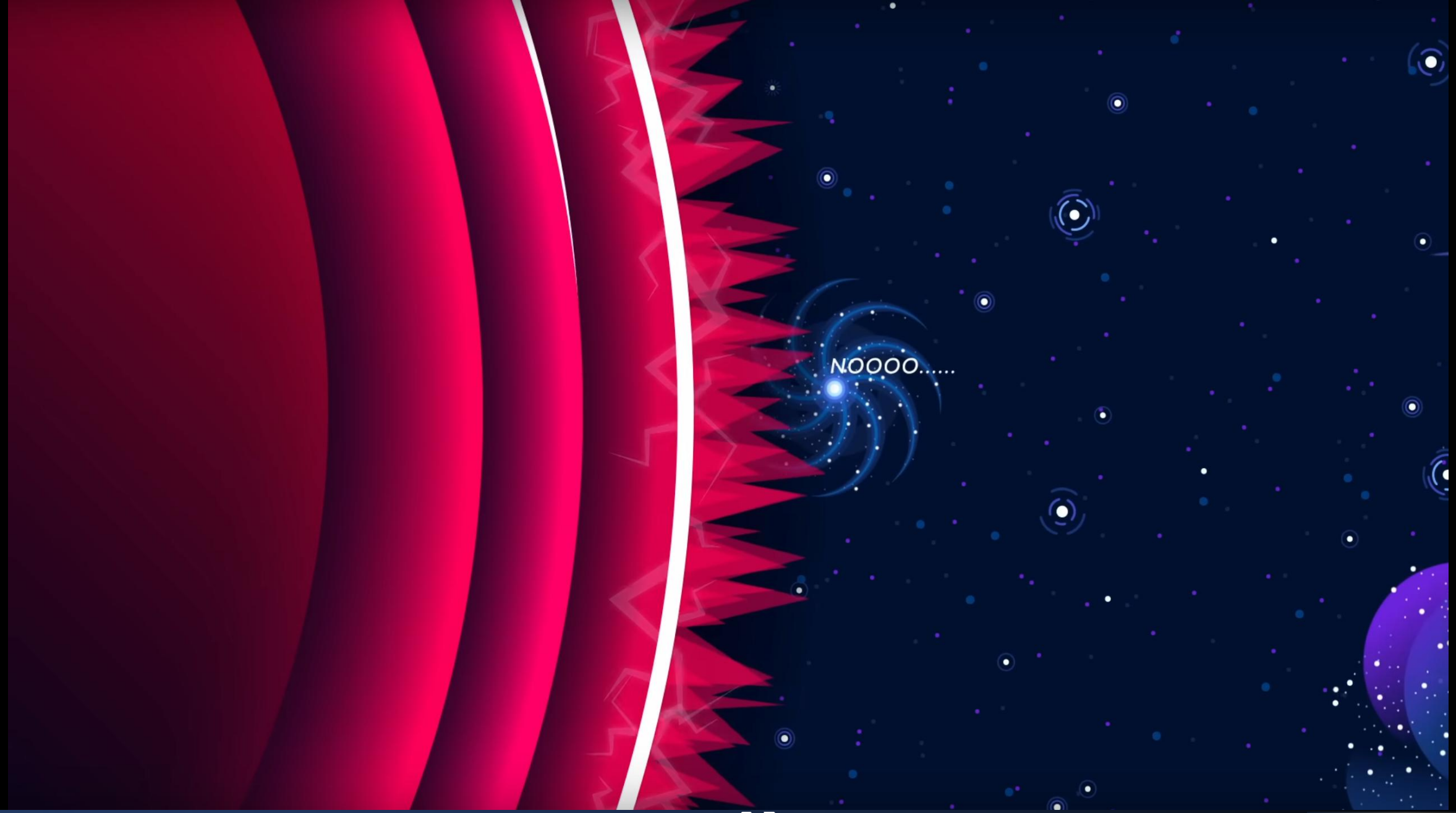




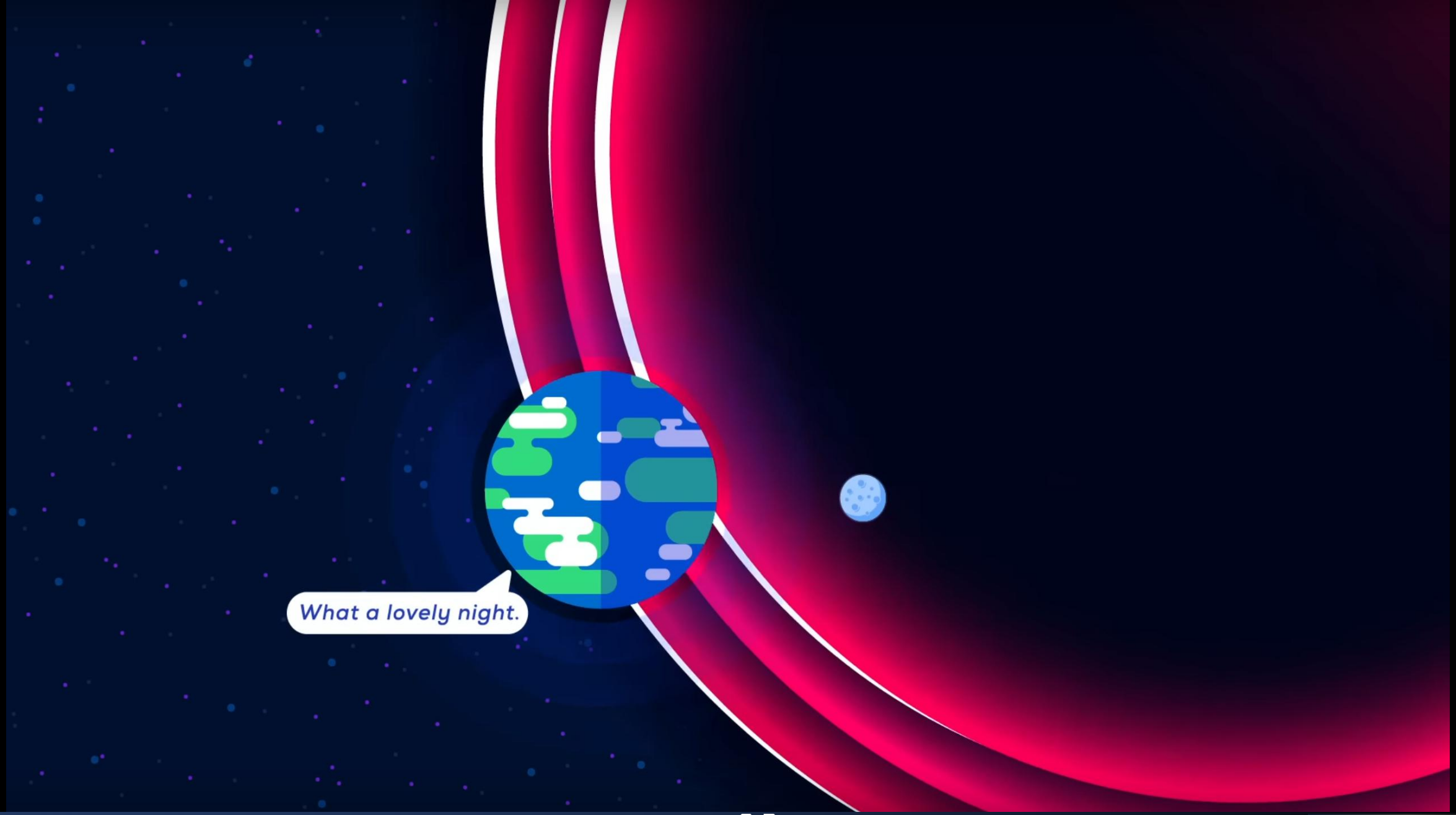

QUANTUM TUNNELING

STABLE HIGGS FIELD

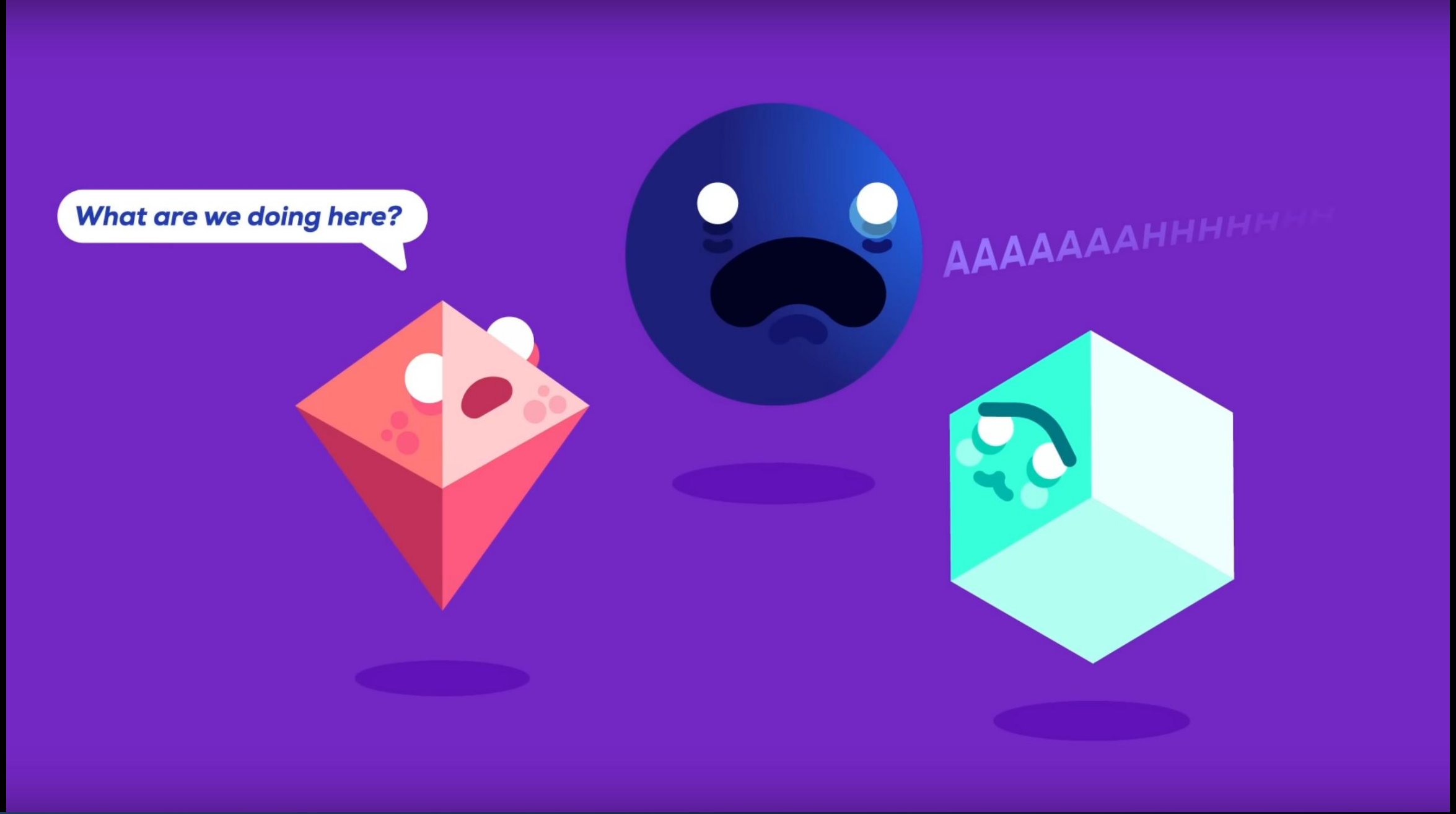



NOOOO.....




What a lovely night.

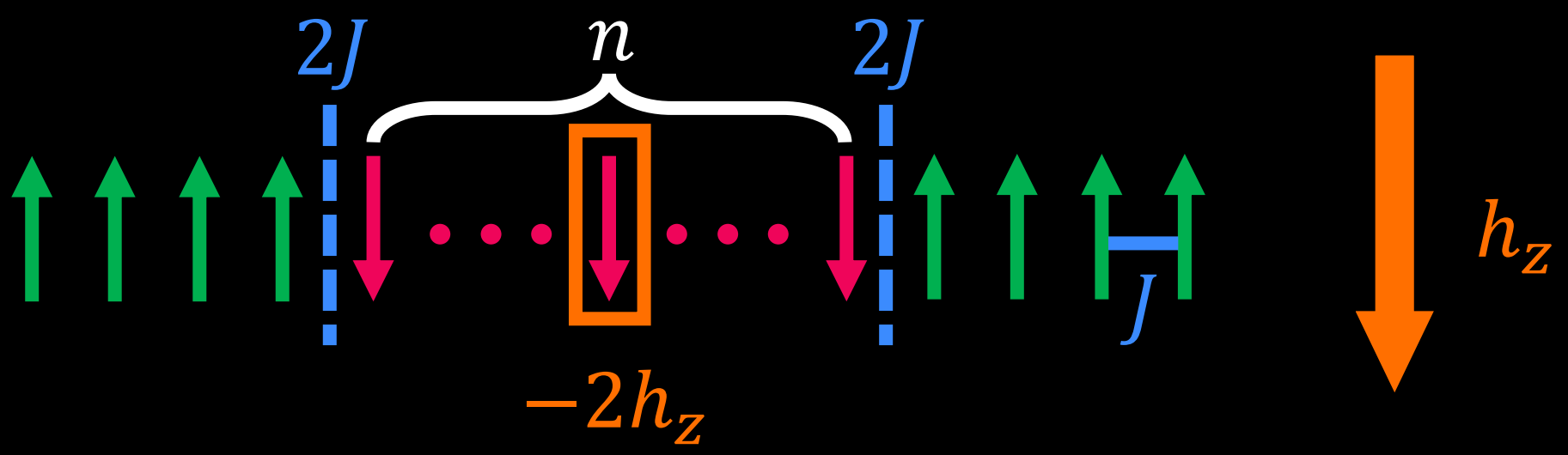

What a lovely night.


What are we doing here?
AAAAAAAHHHHHHH


Might be wrong.

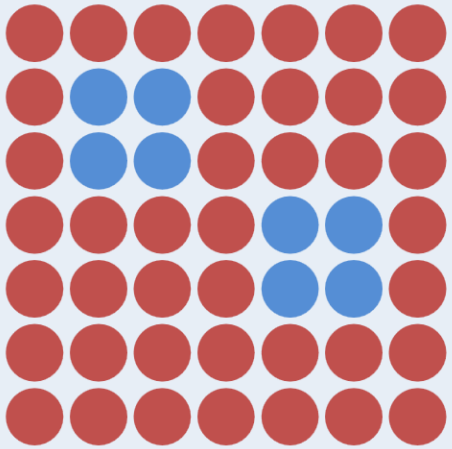
$$0 < h_x \ll 1$$

$$H = -J \sum_{j=1}^{L} \sigma_j^z \sigma_{j+1}^z - h_z(t) \sum_{j=1}^{L} \sigma_j^z - h_x \sum_{j=1}^{L} \sigma_j^x$$



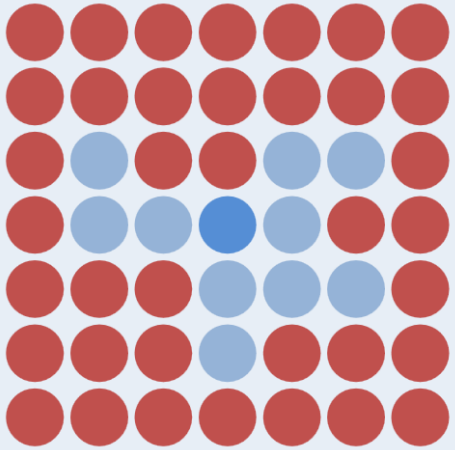
$$4J = -2h_z n \rightarrow h_z = -2J/n \qquad H_{eff} \propto h_x^n$$

$h_z = 2J$



1. <u>Nucleation of 2×2 bubbles</u>

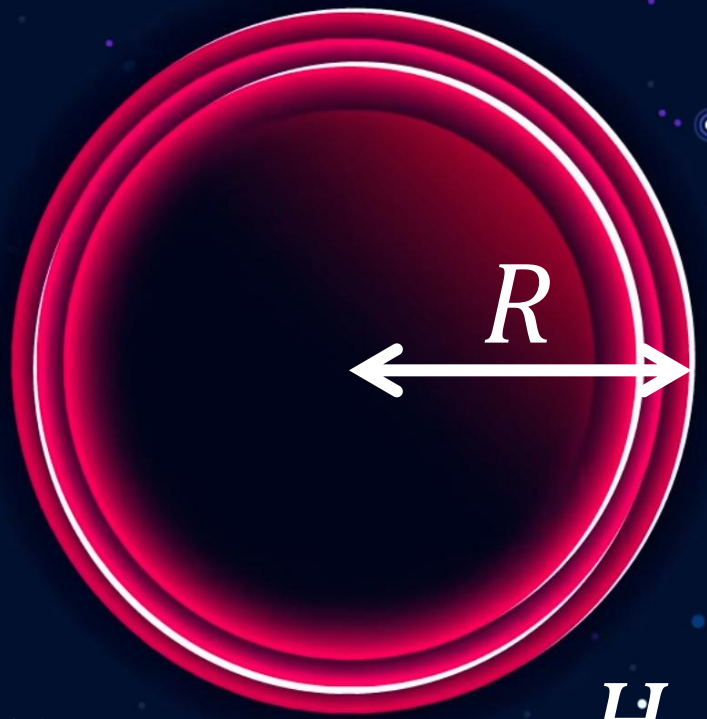
- Nucleation condition: $2h_z A = 2J\partial A$
- $r_{FVD} \propto h_x^4$



2. <u>Expansion from a seed bubble</u>

- Adding a spin to an existing bubble
- Energy balance: $\Delta E = 2h_z \cdot 1 - 2J \cdot 2 = 0$
- $r_{FVD} \propto h_x^1$

STABLE HIGGS FIELD

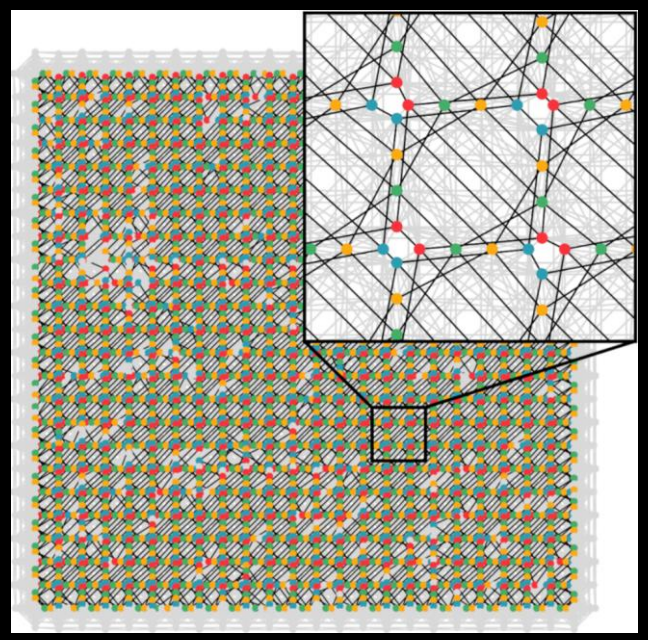


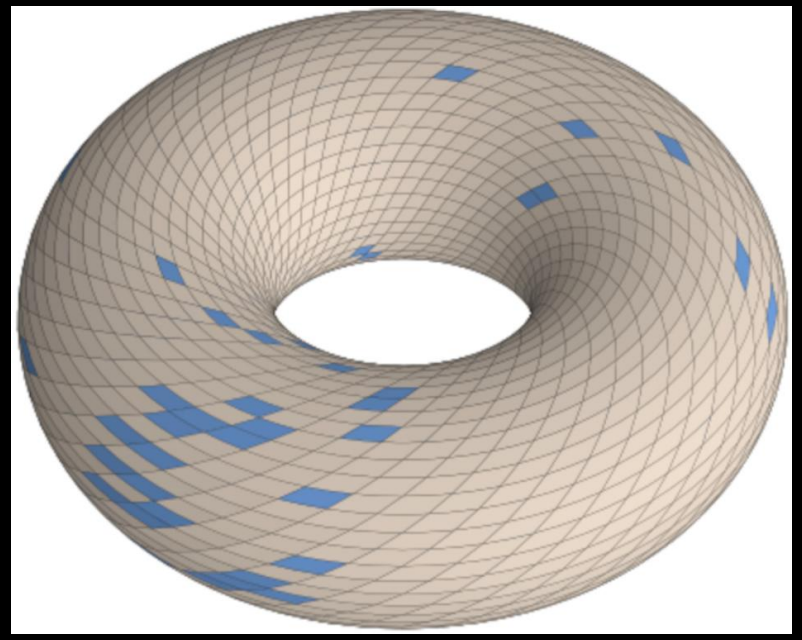
$h_z = -2J/n$

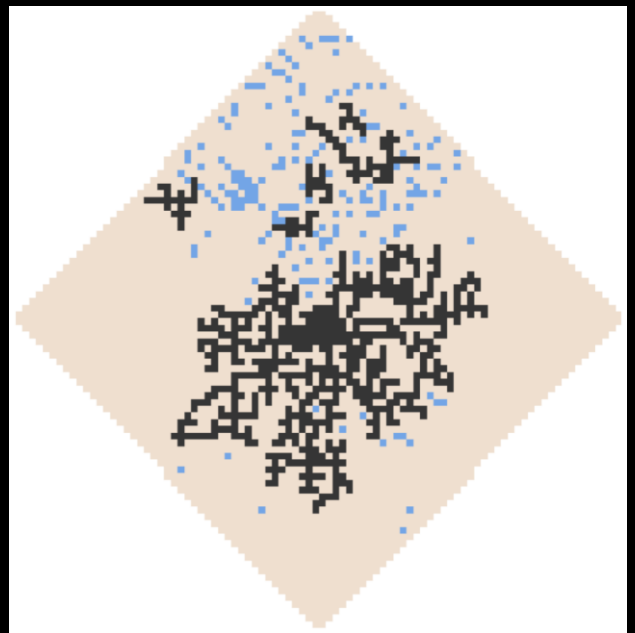
h_z *tunes* R.

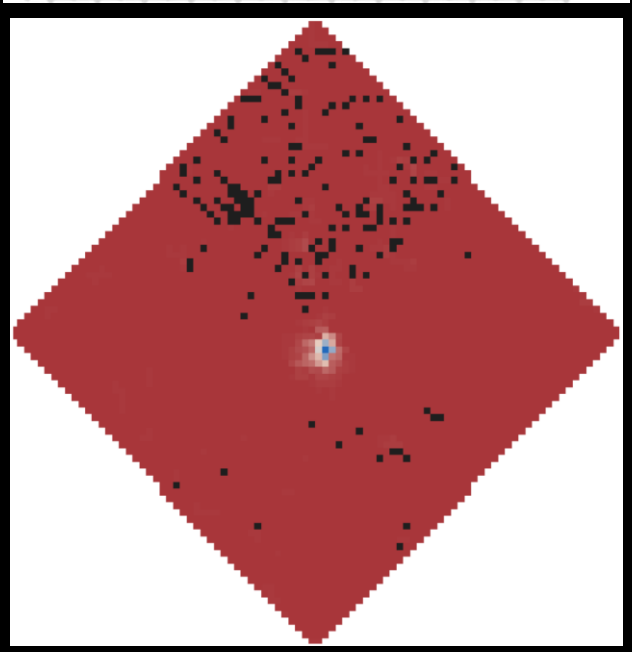
$H_{eff} \propto h_x^n$

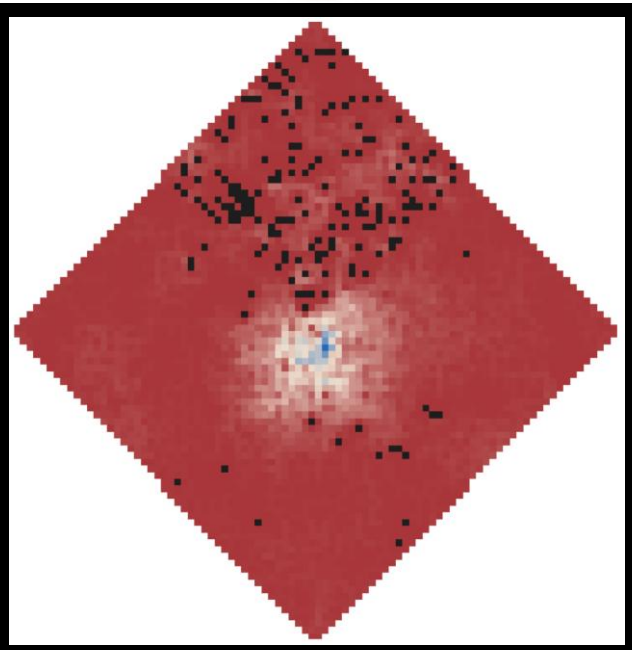
Tunnelling rate $\propto e^{-CR^4}$.

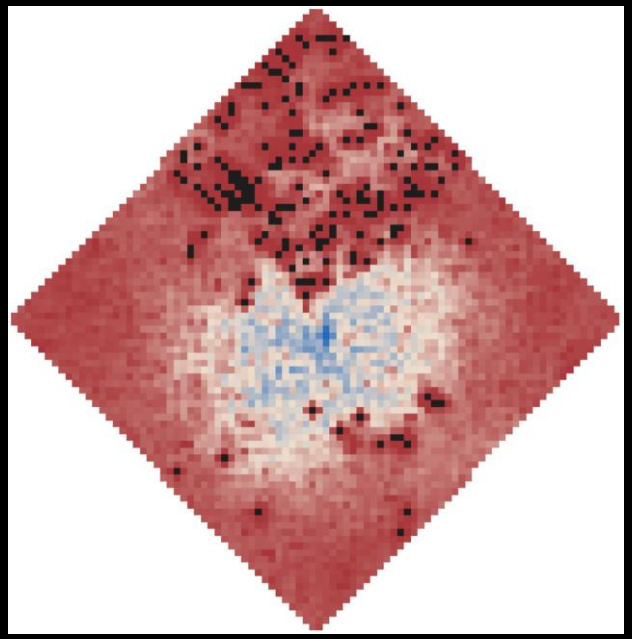






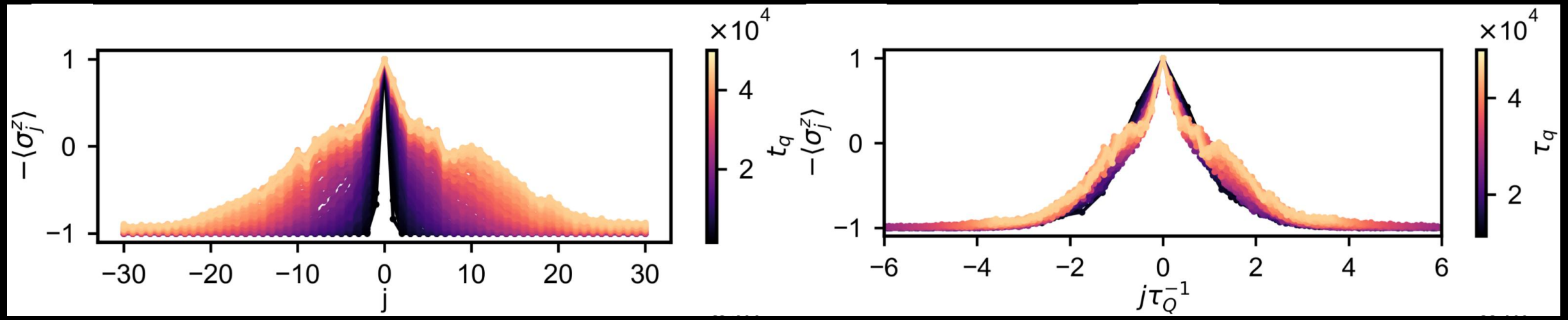


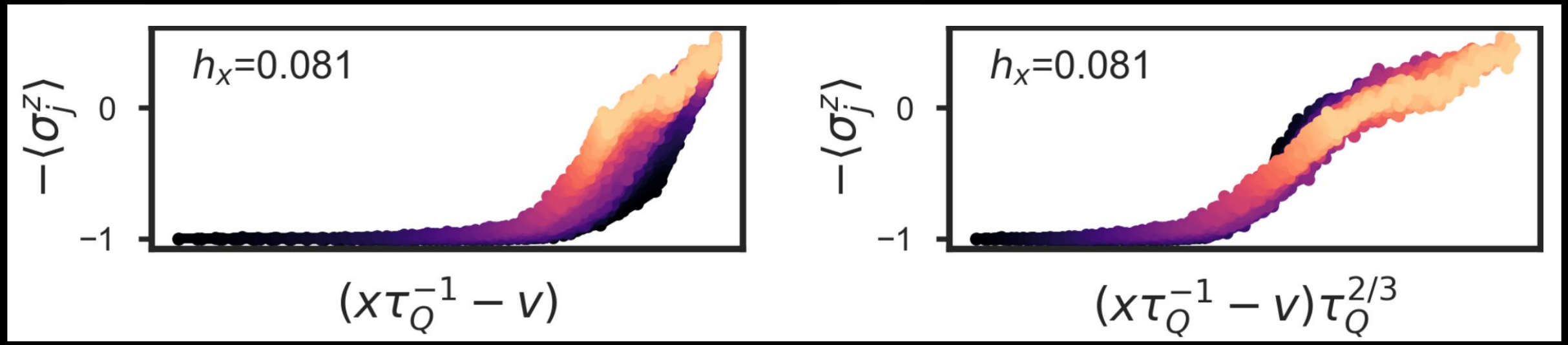




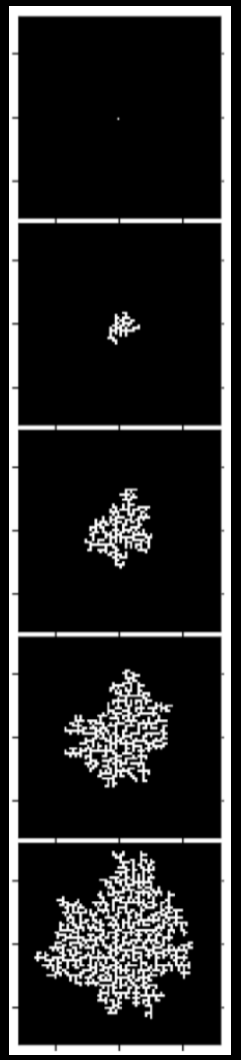


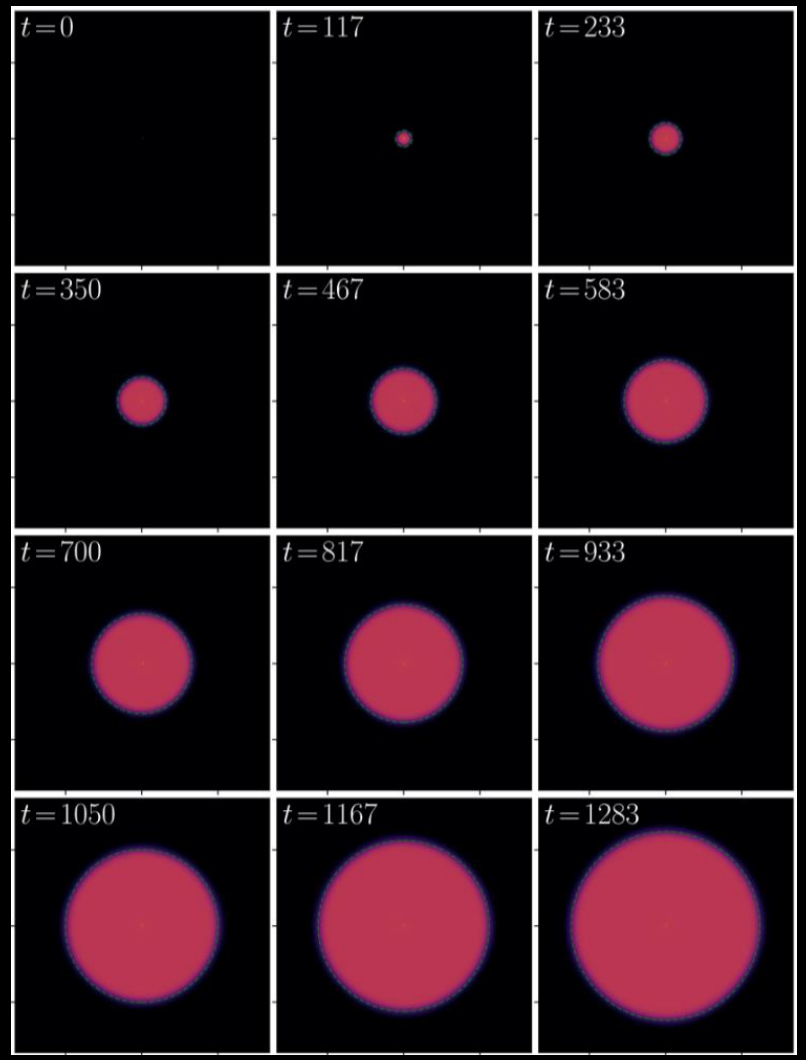
Gregor Humar, JSI


$\times 10^4$
1
0
−1
$-\langle\sigma_j^z\rangle$
−30
−20
−10
0
10
20
30
j
4
2
t_q
$\times 10^4$
1
0
−1
$-\langle\sigma_j^z\rangle$
−6
−4
−2
0
2
4
6
$j\tau_Q^{-1}$
4
2
τ_q


h_x=0.081
$-\langle\sigma_j^z\rangle$
0
−1
$(x\tau_Q^{-1}-v)$
h_x=0.081
$-\langle\sigma_j^z\rangle$
0
−1
$(x\tau_Q^{-1}-v)\tau_Q^{2/3}$

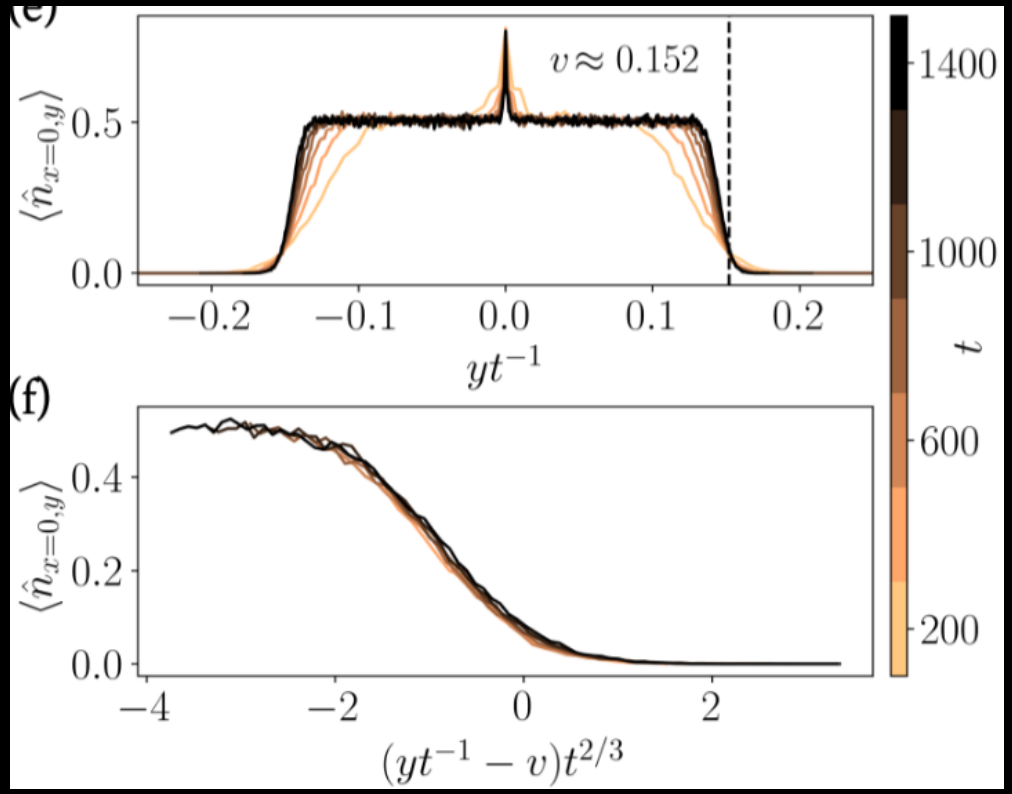
Stochastic circuits



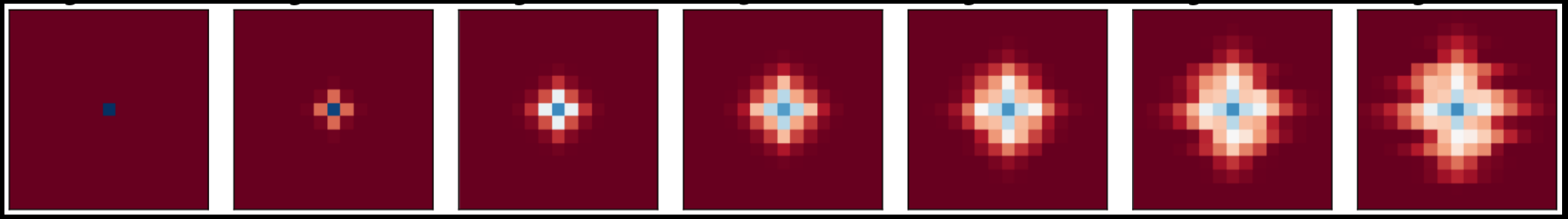




Jean-Yves Desaules
ISTA

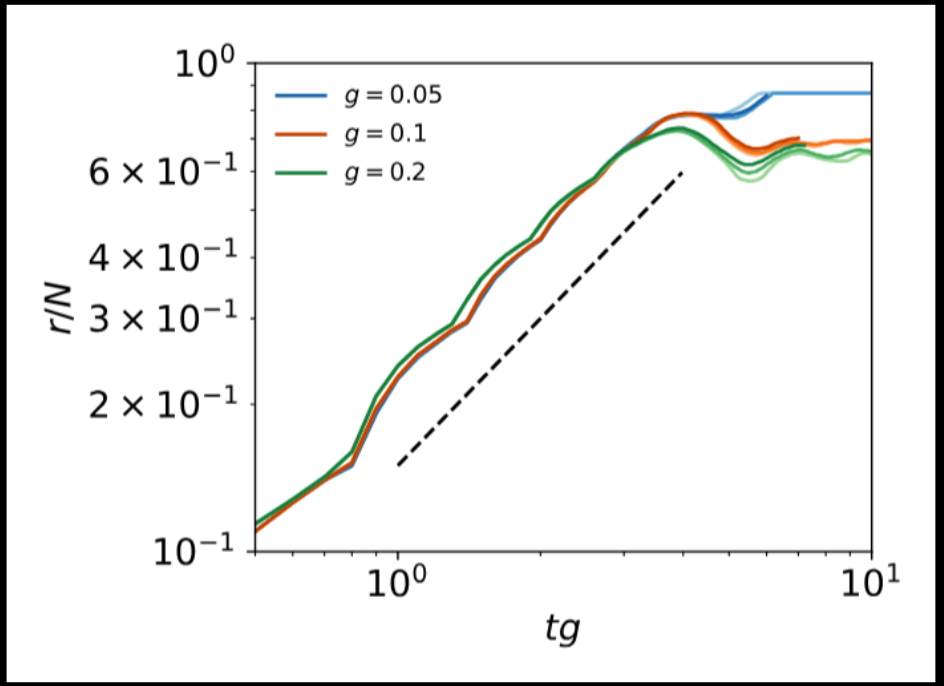


Tensor networks





Luka Pavešić, UNIPD



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Thank you for your attention!