11. Kosmologietag

Vacuum Selection on Axionic Landscapes

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Motivation

- Multifield inflation appear generic in String Theory.
- The concrete construction is unknown.
- Create large numbers of random landscapes and investigate their statistical properties.
- Can we identify generic features of inflation on random landscapes?

D. Battefeld, T. Battefeld, S. Schulz 2012

Questions

- How likely is Inflation in a random potential?
- Duration of inflation? Distribution of number of efoldings?
- How do the answers change with increasing randomness?
- What is the type of Inflation?
- Distribution of Minima, Maxima, Saddles?

T. Higaki, F. Takahashi 2014

- Where is the final resting place dynamical evolution on the potential?

Axionic potential

$\Lambda_i^4 \in \mathcal{U}\{0,1\}$

$n_{ij} \in \mathcal{N}\{0;2\}(|n_{ij}| < 3)$

$$V = \sum_{i=1}^{N_{source}} \Lambda_i^4 \left(1 - \cos\left(\sum_{j=1}^{N_{axion}} n_{ij}\frac{\phi_j}{f_j} + \theta_i\right)\right) + C$$

$\theta_i \to 0$, $C \to 0$

J.E. Kim, H.P. Nilles, M. Peloso 2004
M. Kawasaki, K. Nakayama 2013
T. Higaki, F. Takahashi 2014

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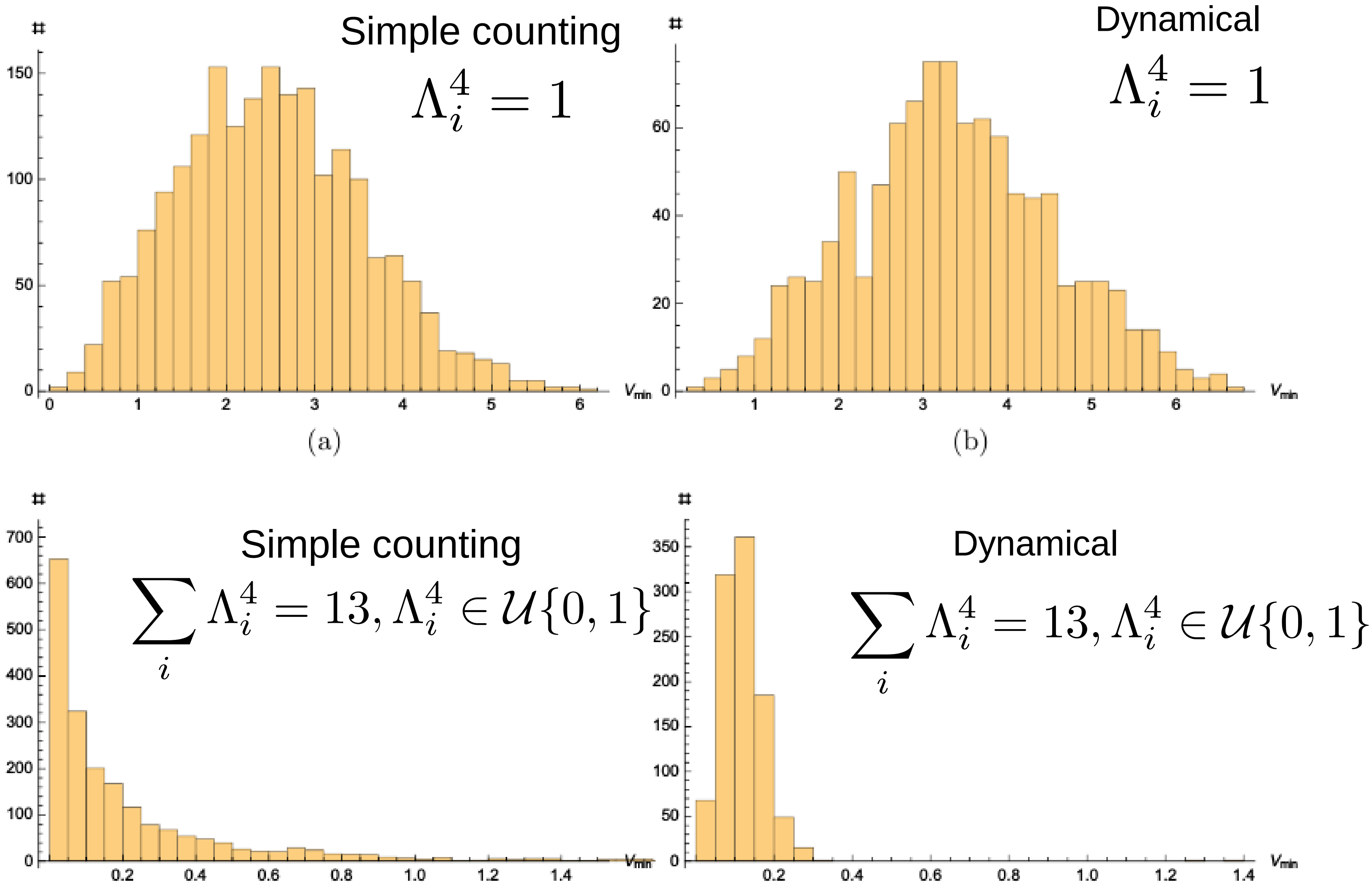
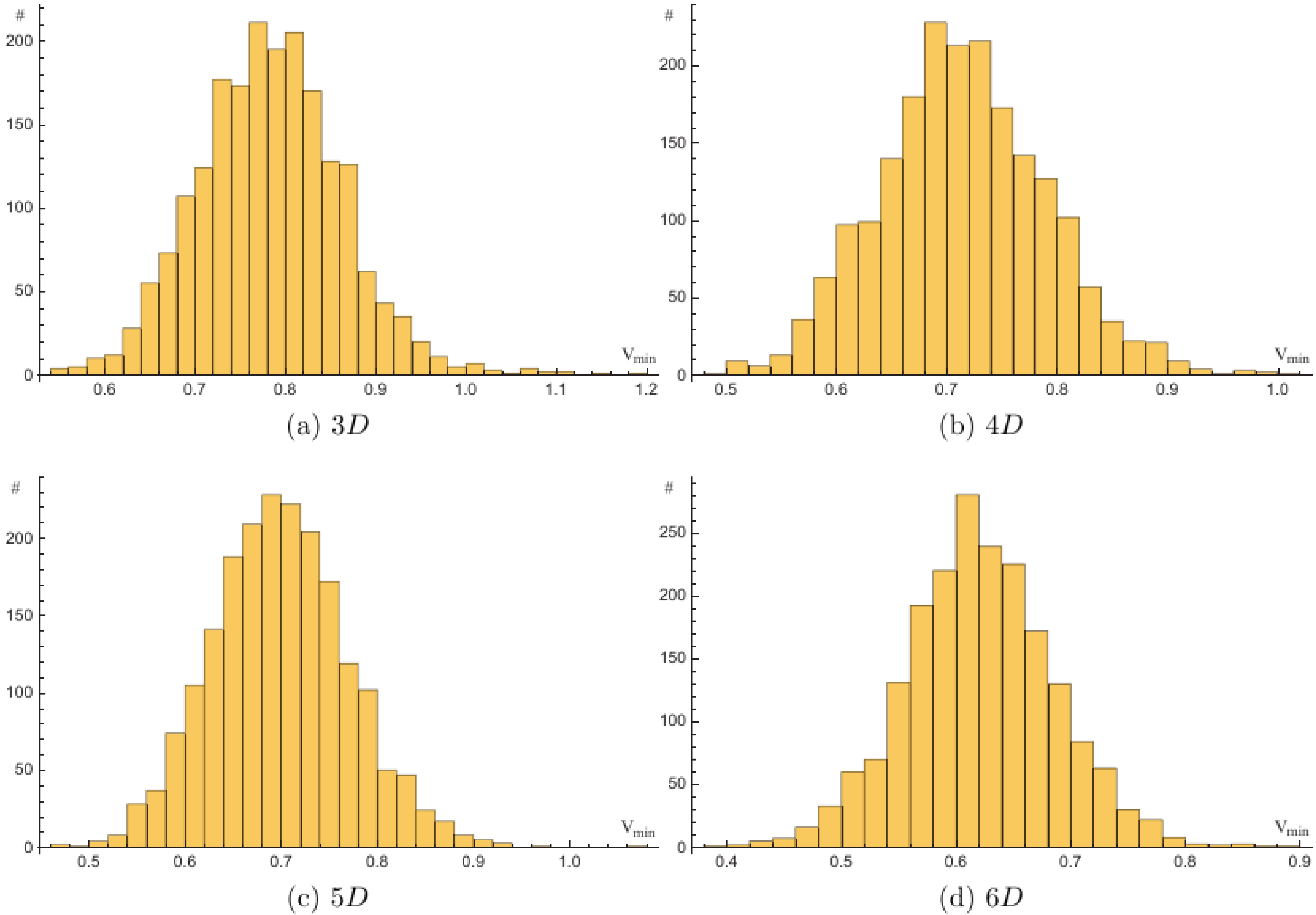
Numerical approach



$$D = 8, N_s = 13$$

Numerical approach



(a) $3D$ (b) $4D$

(c) $5D$ (d) $6D$

$$N_s = 125$$

Analytical approach – Methods

R.Easther, L. McAllister 2005

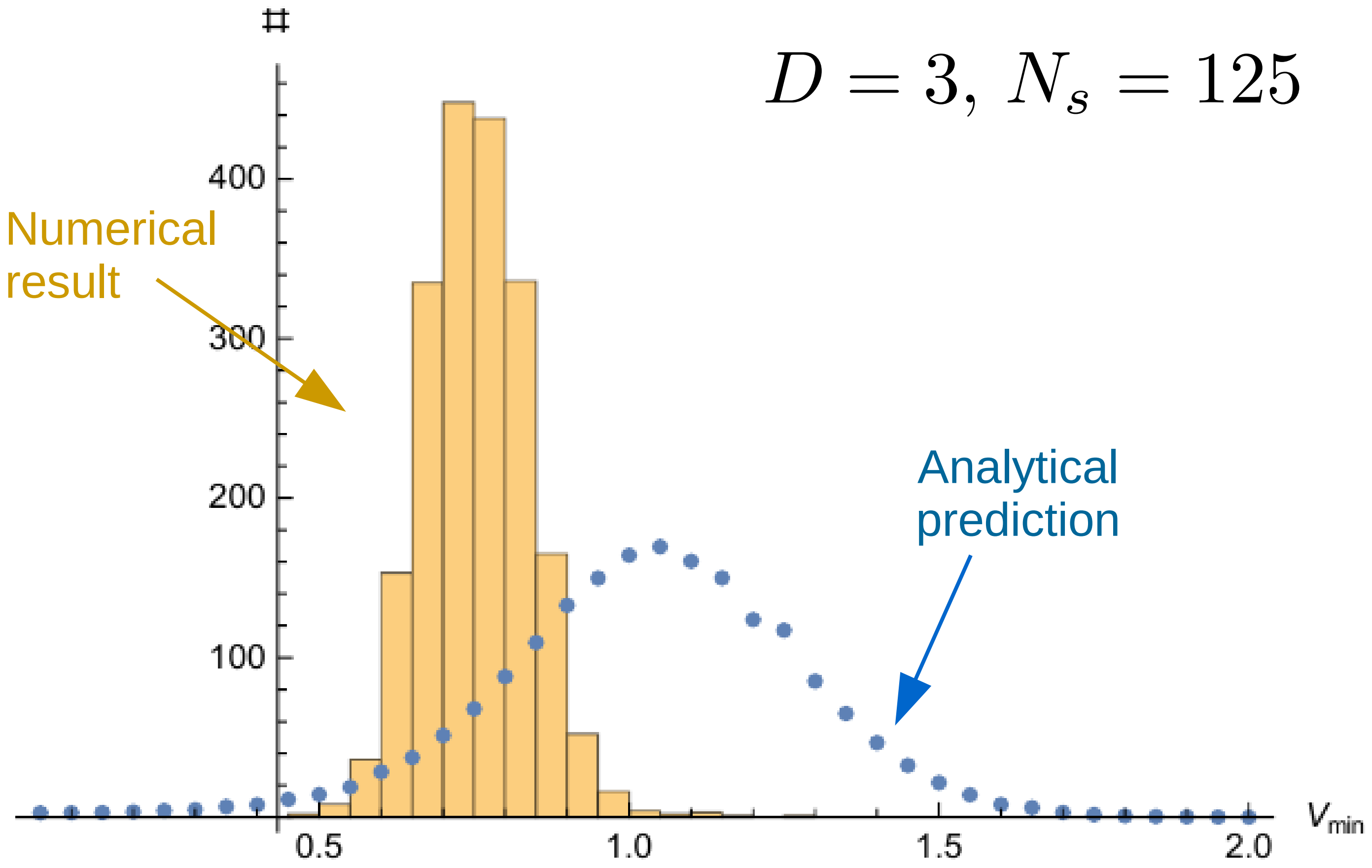
- Number of minima to number of critical points ratio:
  -Random Matrix Theory (RMT)

$$P_{min} = \frac{\#\text{Minima}}{\#\text{Critical points}}$$

- Mean distance to the next critical point ΔV
  -Ansatz (numerically tested)

→ **Expectation value for the peaks**

Analytical approach



- However, no knowledge about dynamics!

Empirical approach

- Abandon RMT

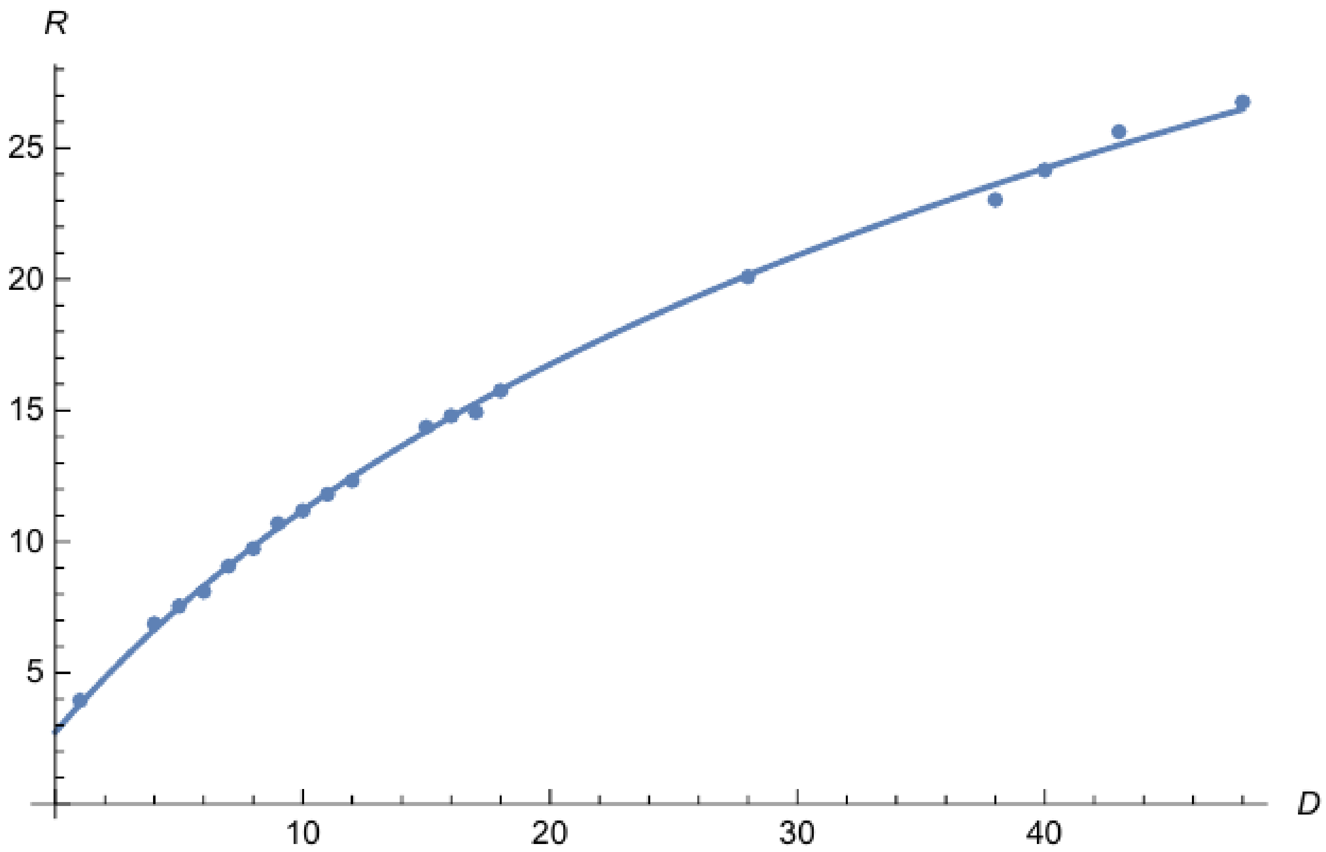
$$P_{min} \neq \frac{\#\text{Minima}}{\#\text{Critical points}}$$

We define:

$$R(D) = \frac{dV}{\Delta V}$$

- Determine the minimum to critical point ratio $R(D)$ empirically.
- Use analytical value for ΔV.
- Combine $R(D)$ and ΔV to obtain the final resting place.

Empirical approach – $R(D)$

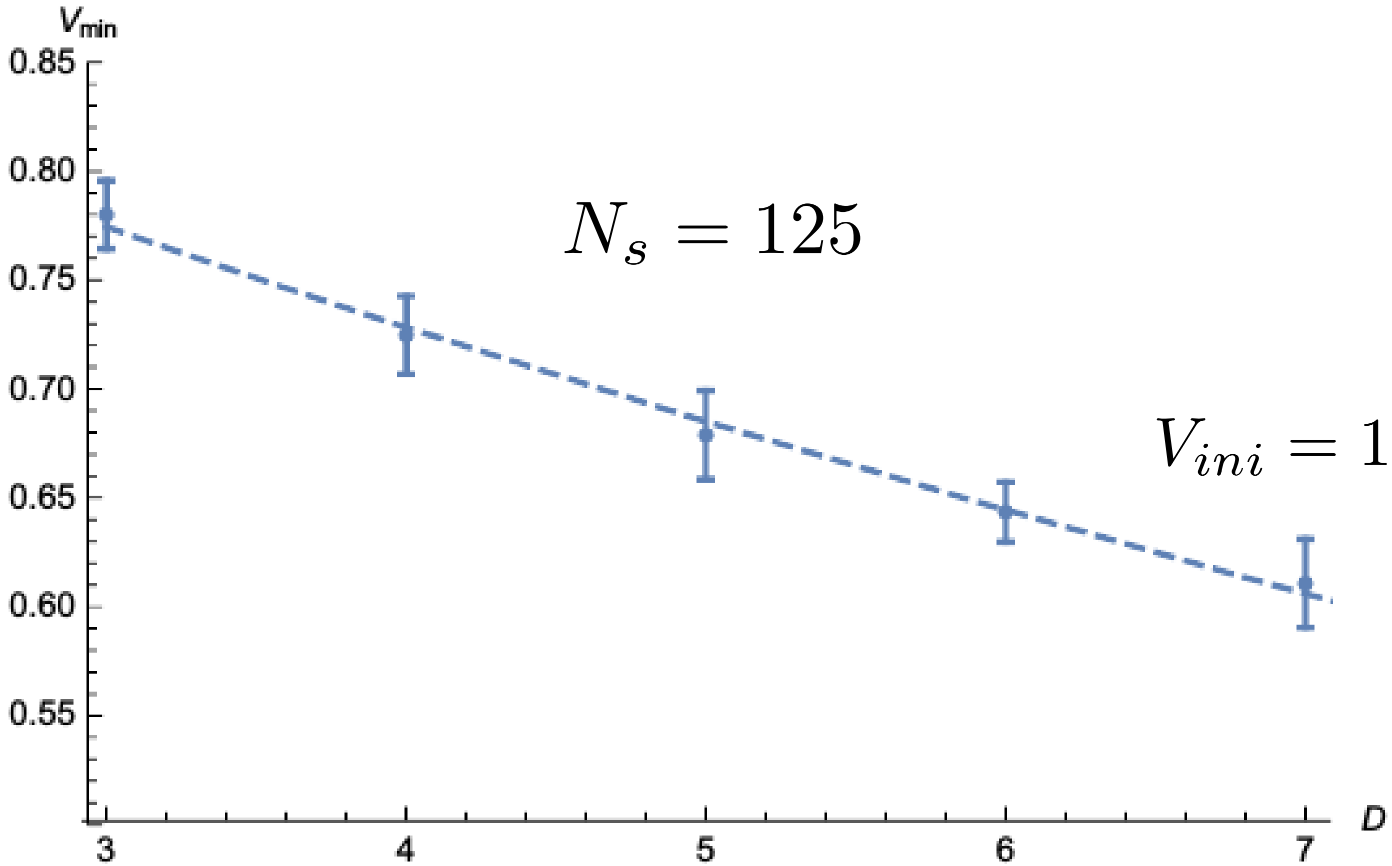


$R(D)$ is computed numerically for selected D and N_s =125.
$R(D)$ is not a function of N_s

Best fit: $R(D) = 16.38 \ln(15 + D) - 41.56$

Final resting place

$$V_{min}(D, N_s) = V_{ini} - dV(D, N_s) = V_{ini} - R(D) \cdot \Delta V$$



$V_{ini} = 1.037 \pm 0.0023$

(a) $\bar{V}_{\mathrm{min}}$

Comparison of V_{min} as a function of D with the numerical results.

Conclusion

- We successfully predict the peaks.
- Need include dynamics.
- RMT can't explain the logarithms dependency.
- Quantum stability? A. Masoumi, A. Vilenkin 2016

Next step

- Develop computational efficient techniques to study these landscapes

M.C.D. Marsh, L. McAllister, E. Pajer, T.Wrase 2013
T. Battefeld, C. Modi 2014

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