Numerical study of multiparticle probabilities in $\lambda\varphi^4$ theory

Farkhtdinov Bulat[1,2]
Supervisor: Sergei Demidov[2]
[1]MIPT(SU)
[2]INR RAS

Overview

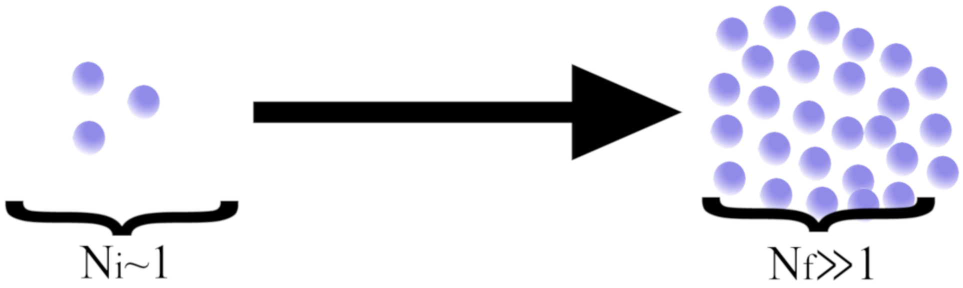
- Subject of research
- Research
- Future aims
- Q&A section

Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Multiparticle scattering

Multiparticle scattering: $N \to \infty, \; A_{tree} \sim N! \lambda^{\frac{n}{2}}$

Multiparticle creation:



If it is unsuppressed, it will introduce energy cutoff scale

Considered theory: $S = \frac{4\pi}{\lambda} \int dr' dt' [\frac{1}{2}(\frac{\partial \varphi}{\partial t'})^2 - \frac{1}{2}(\frac{\partial \varphi}{\partial r'})^2 - \frac{\varphi^2}{2} - \frac{\varphi^4}{4r'^2}]$

$$r' = mr, t' = mt, \lambda \to 0, \; \frac{\lambda N}{4\pi} = \widetilde{N}, \; \frac{\lambda E}{4\pi} = \widetilde{E}$$

Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Semiclassical approach

Path integral:

$$< f|i >= \int_{\varphi_i}^{\varphi_f} \mathcal{D}\varphi e^{iS[\varphi]}$$

$$|i>= e^{\frac{4\pi j}{\sqrt{\lambda}} \int dr\, rf(r)\varphi(0,r)}|0>; \quad < f| = \sum_a < a|\widehat{P}_E \widehat{P}_{N_f}$$

Conditions for semiclassics:

$$S \sim \frac{1}{\lambda}, \quad \lambda \to 0$$

Expansion near the saddle-point:

$$S[\varphi] = S[\varphi_{saddle}] + S''[\varphi_{saddle}](\delta\varphi)^2 + \ldots$$

Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Saddle-point equations

Equations:

$$\frac{\partial^2\varphi}{\partial t^2} - \frac{\partial^2\varphi}{\partial r^2} + \varphi + \frac{\varphi^3}{r^2} = - i\, j r f(r)\delta(t)$$

Boundary conditions:

$$\varphi(t,k) = \frac{1}{\sqrt{2\omega_k}}\left(f_k e^{-i\omega_k t + ikr} + g_k^{\dagger} e^{i\omega_k t - ikr}\right)$$

$$i:\ f_k = 0$$

$$f:\ f_k = e^{-\theta + 2T\omega_k} g_k$$

Probability in main exponential order:

$$P \sim e^W$$

$$W = 2ET - N_f\theta - 2ImS + Im\int dr\, \varphi \frac{\partial\varphi}{\partial t}\Big|_{t=t_f}$$

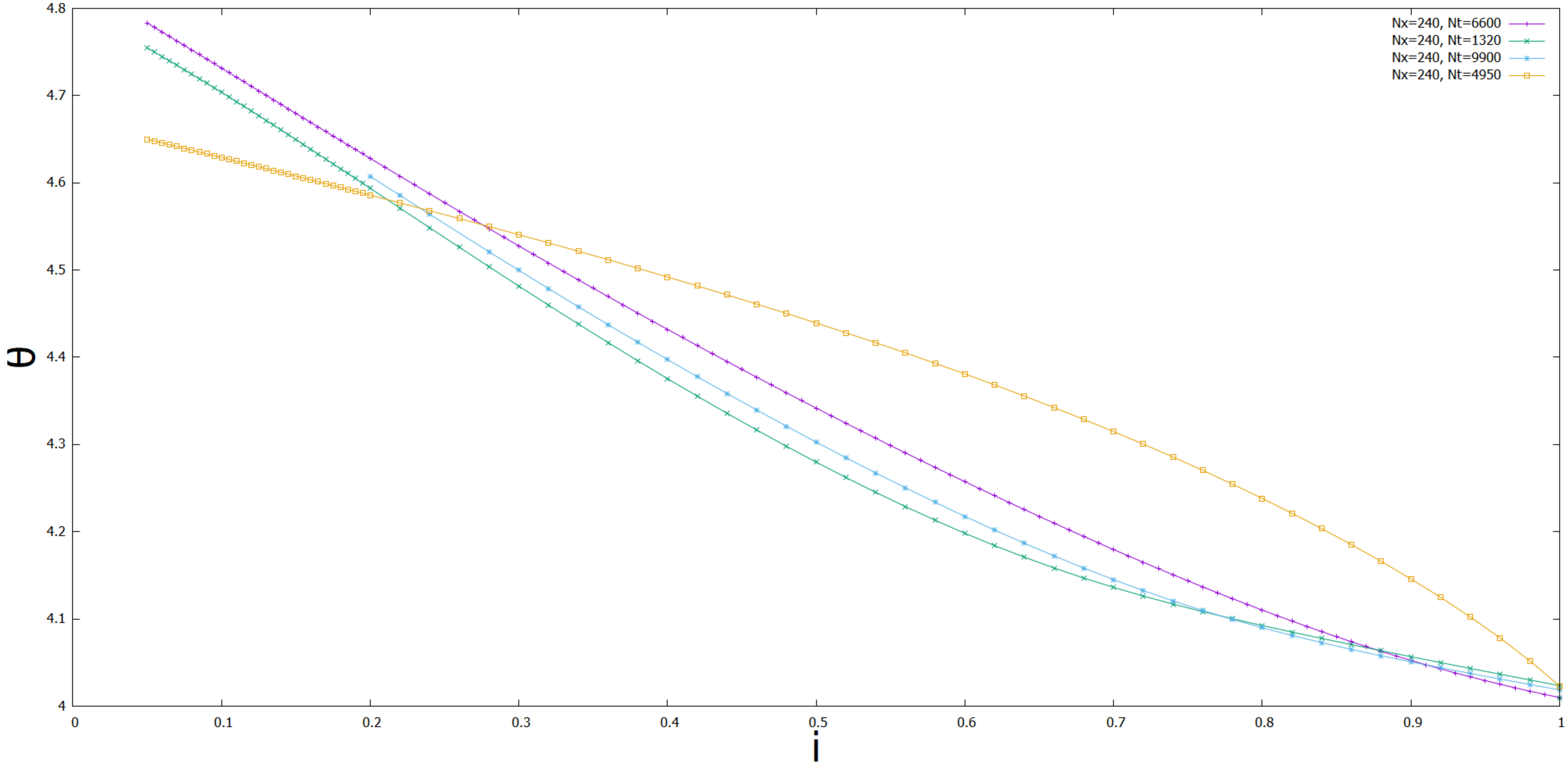
Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Numerical realisation

- Take the first approximation from a souce-dominated theory
- Use Newton-Raphson scheme to converge to the theory with self-ineraction
- Take a limit $j \to 0$ for different fixed E, N_f or T, θ

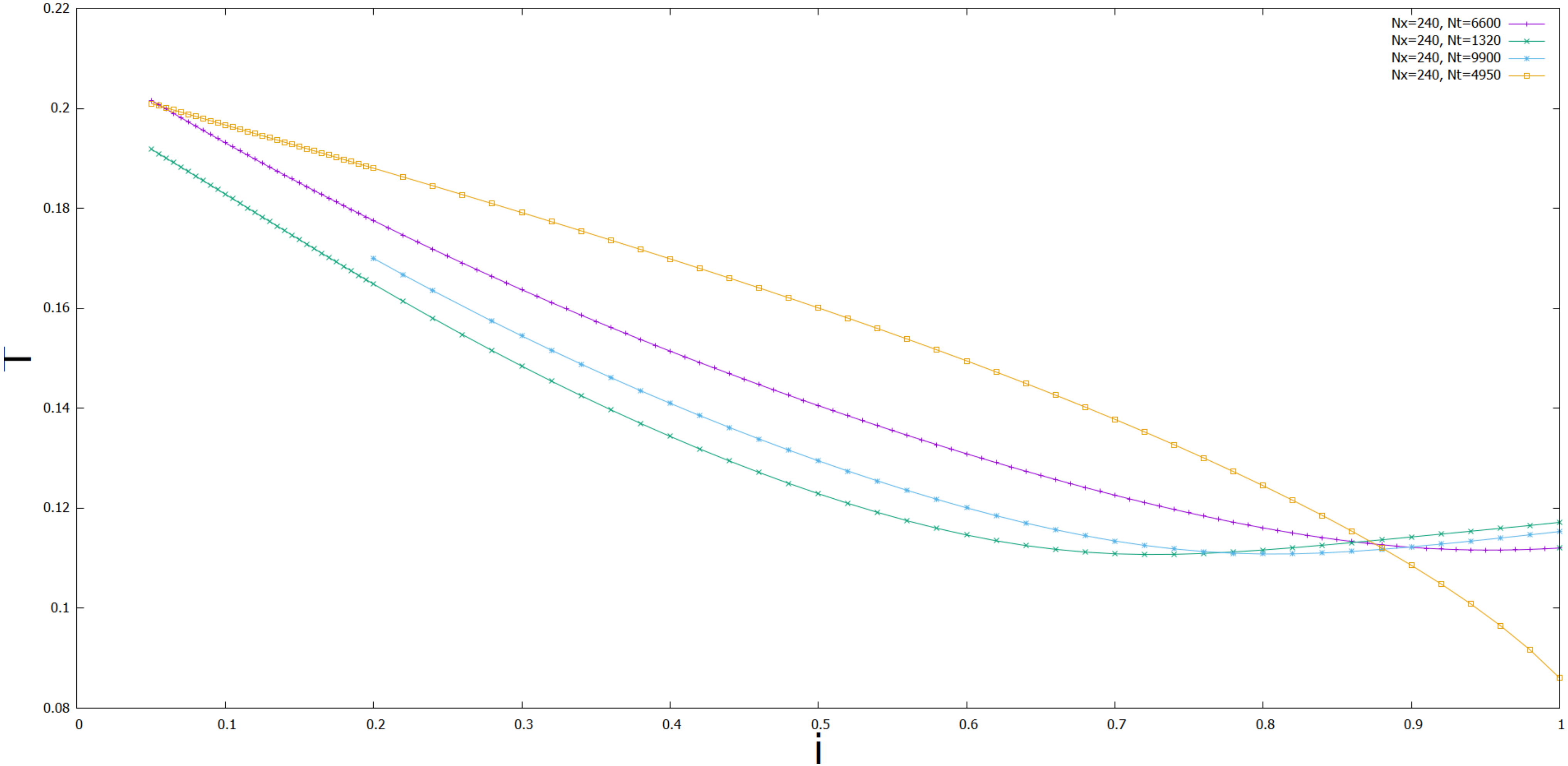
Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Limit j→0 for E,N_{out} fixed



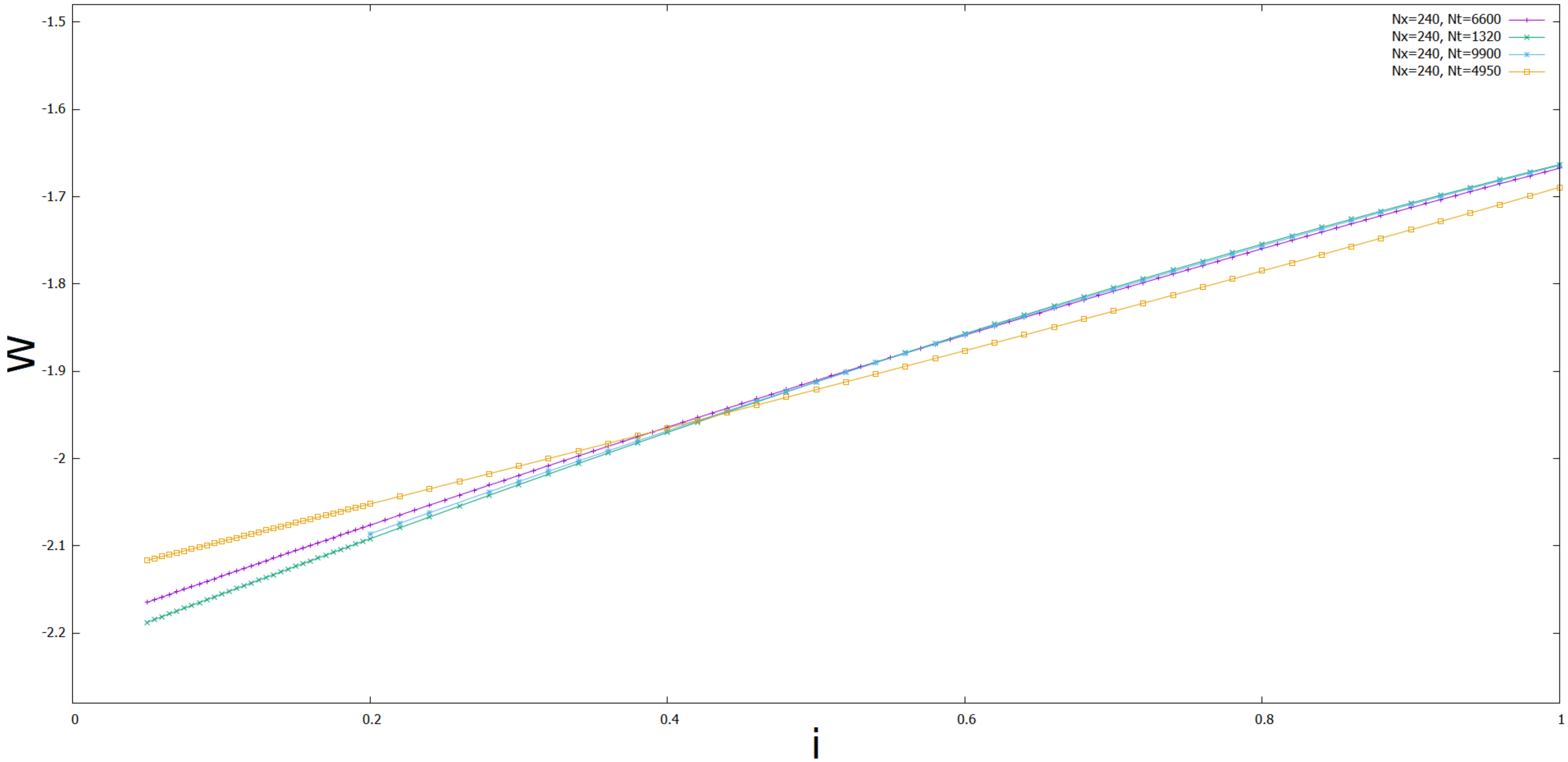
Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Limit j→0 for E,N_{out} fixed



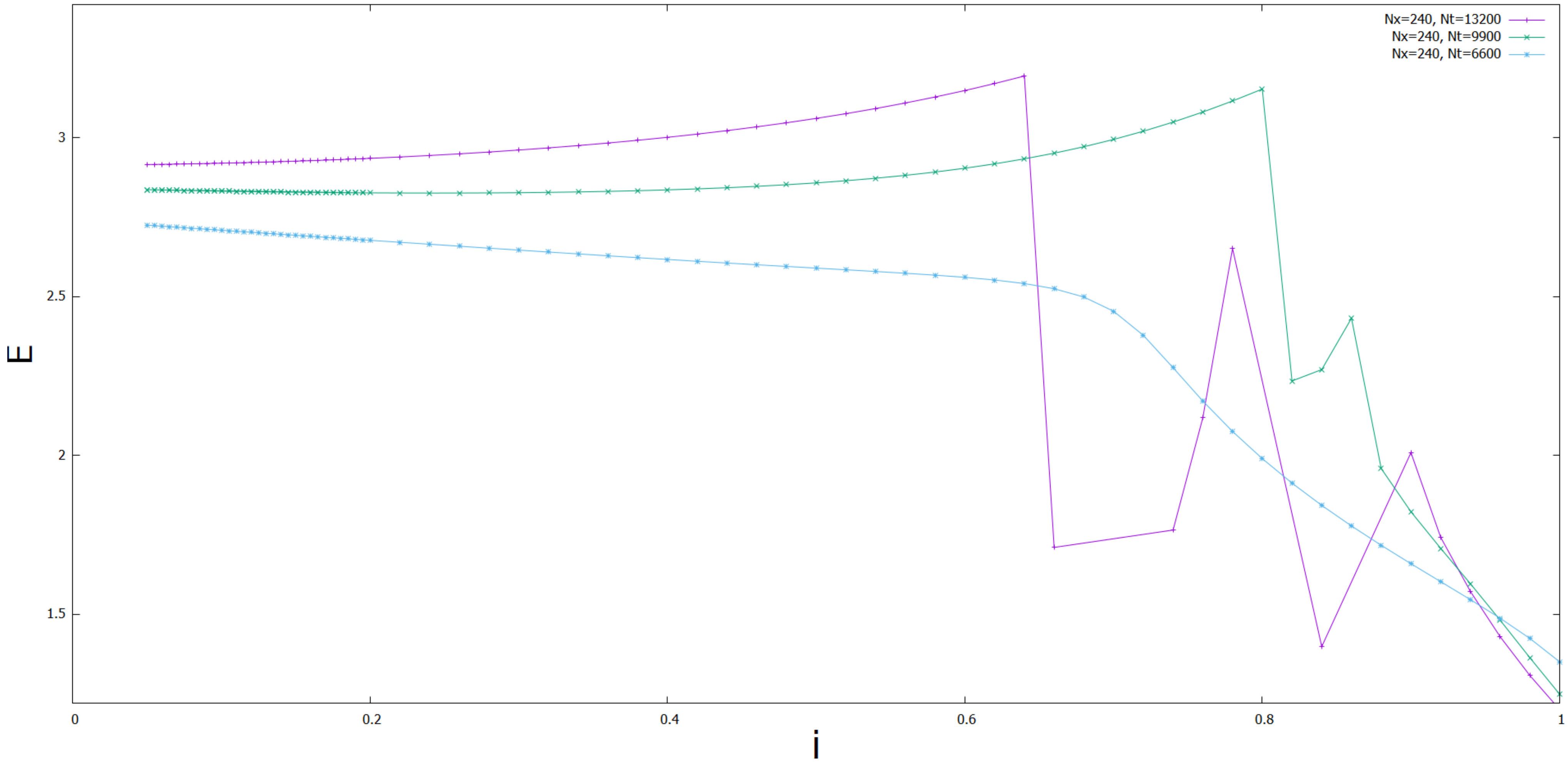
Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Limit $j \to 0$ for E, N_{out} fixed



Farkhtdinov Bulat
E-mail: farkhtdinov@phystech.edu

Limit j→0 for T,θ fixed



What shoud be done next

- Analytically find saddle-point solutions when $j \to 0$ in regimes which allow it
- Find dependence of $E, N_f, (T, \theta), W$ on j
- Consider broken φ^4 theory

Any questions?