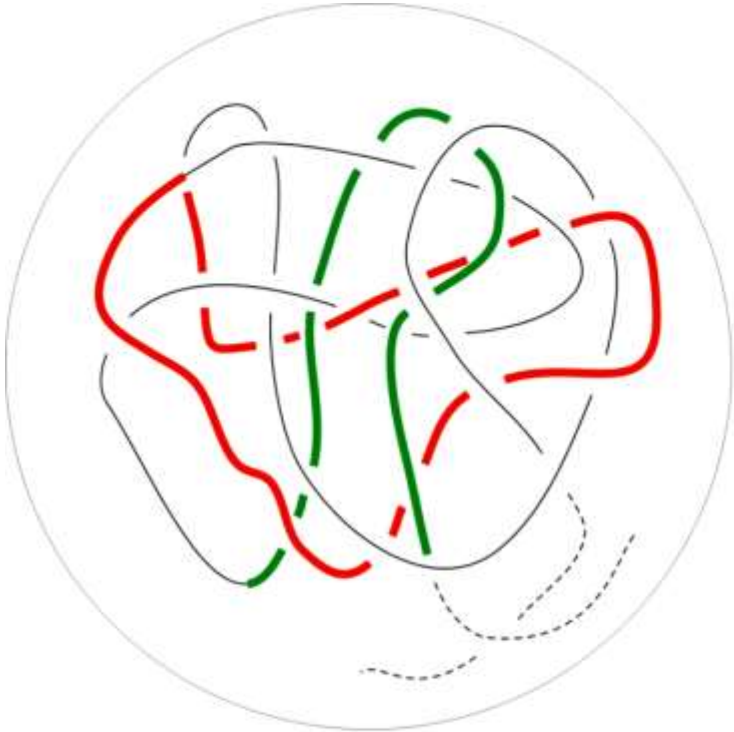
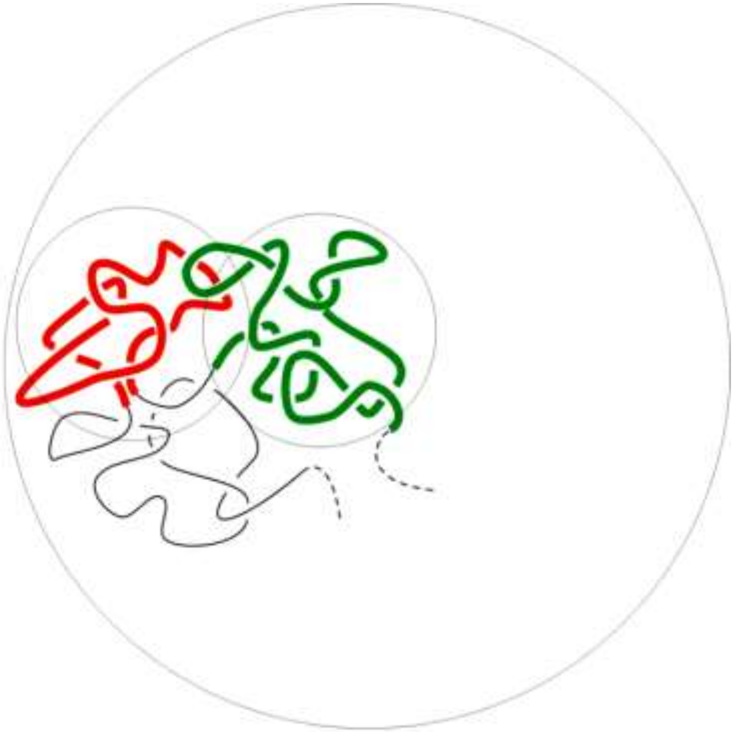
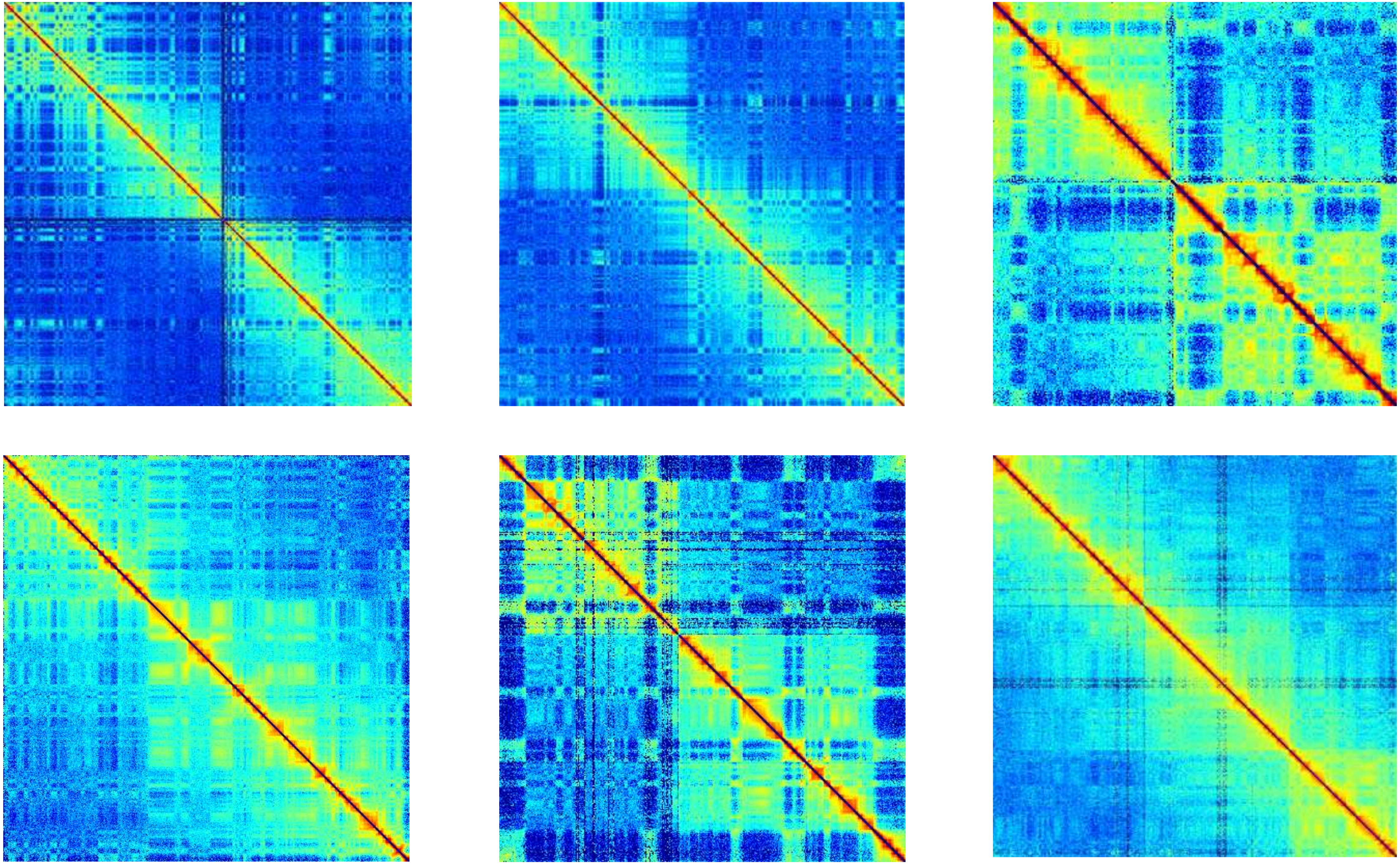
How fill the space by linear chains such that every subchain is (almost) unknotted?



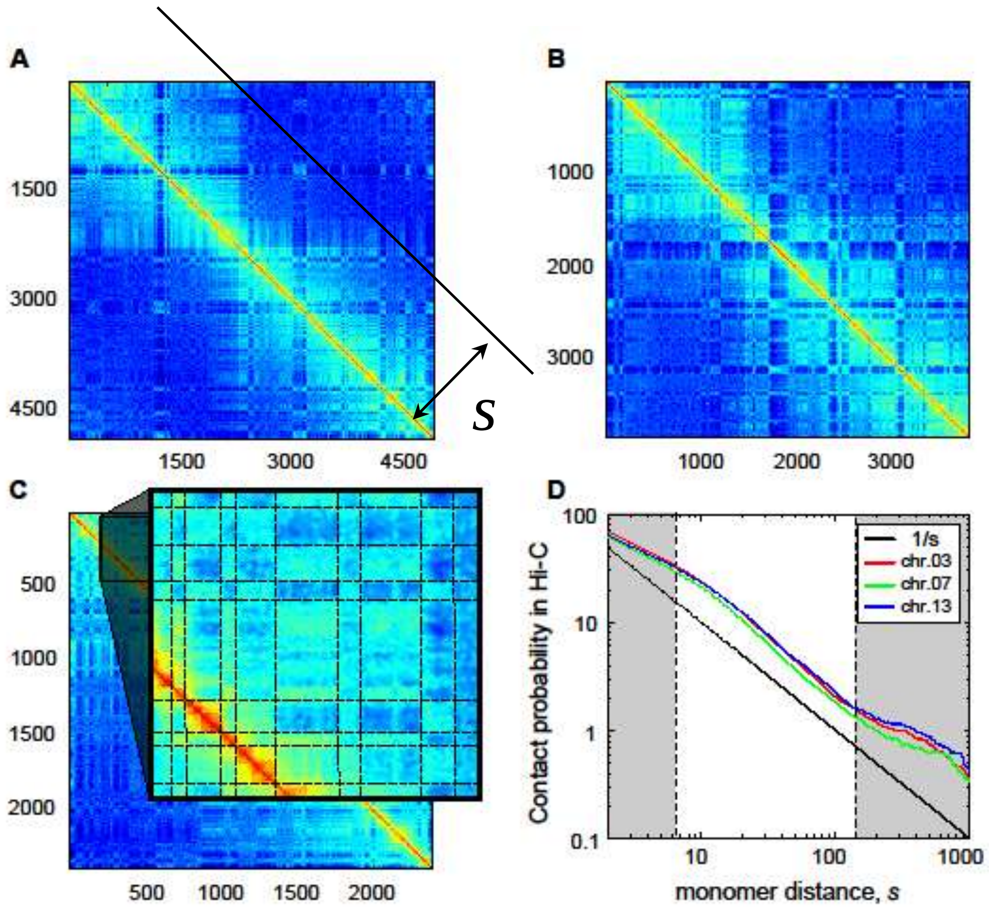
Different chain parts penetrate into each other and entangle



Different chain parts form hierarchical set of crumples



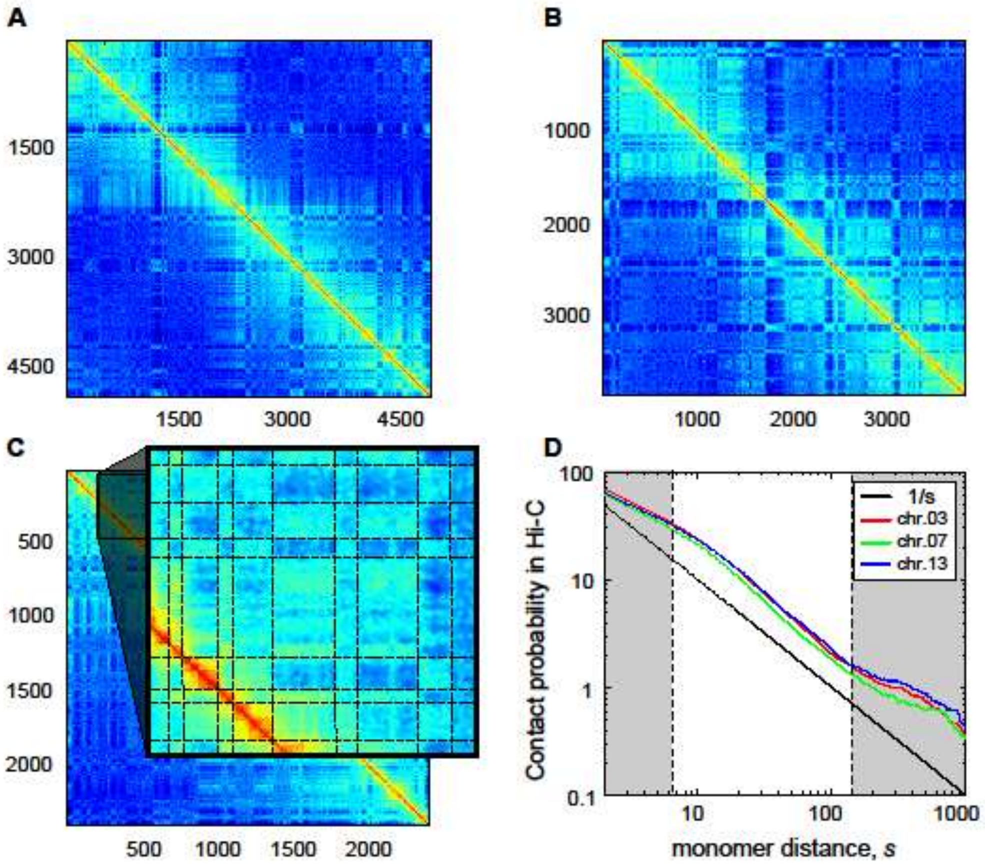
Hi-C experiments (J.Dekker *et al, 2009*)
(genome-wide chromosome conformation capture method)

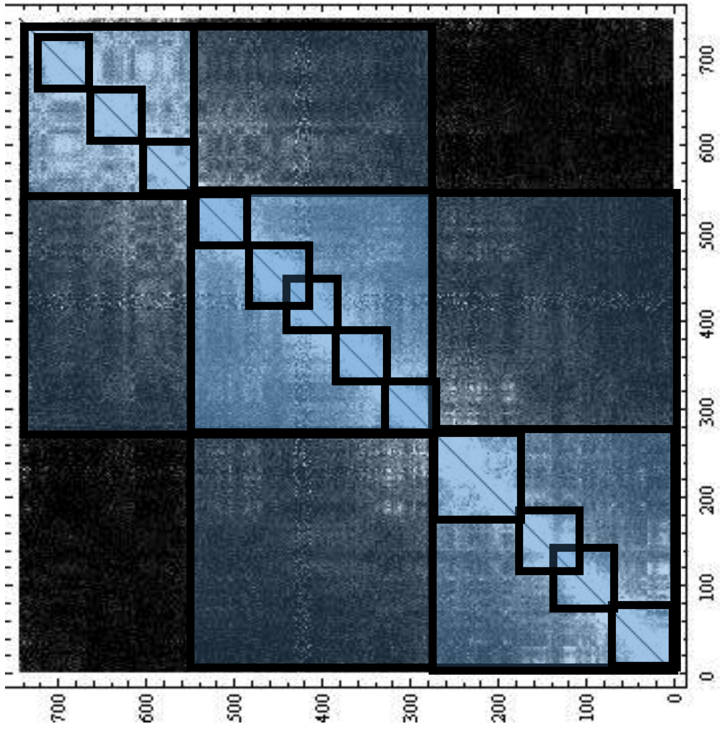


Intensity - the probability of a contacts between fragments i and j

The average intensity decreases as $1/s$

Hi-C experiments (J.Dekker *et al, 2009*)
(genome-wide chromosome conformation capture method)

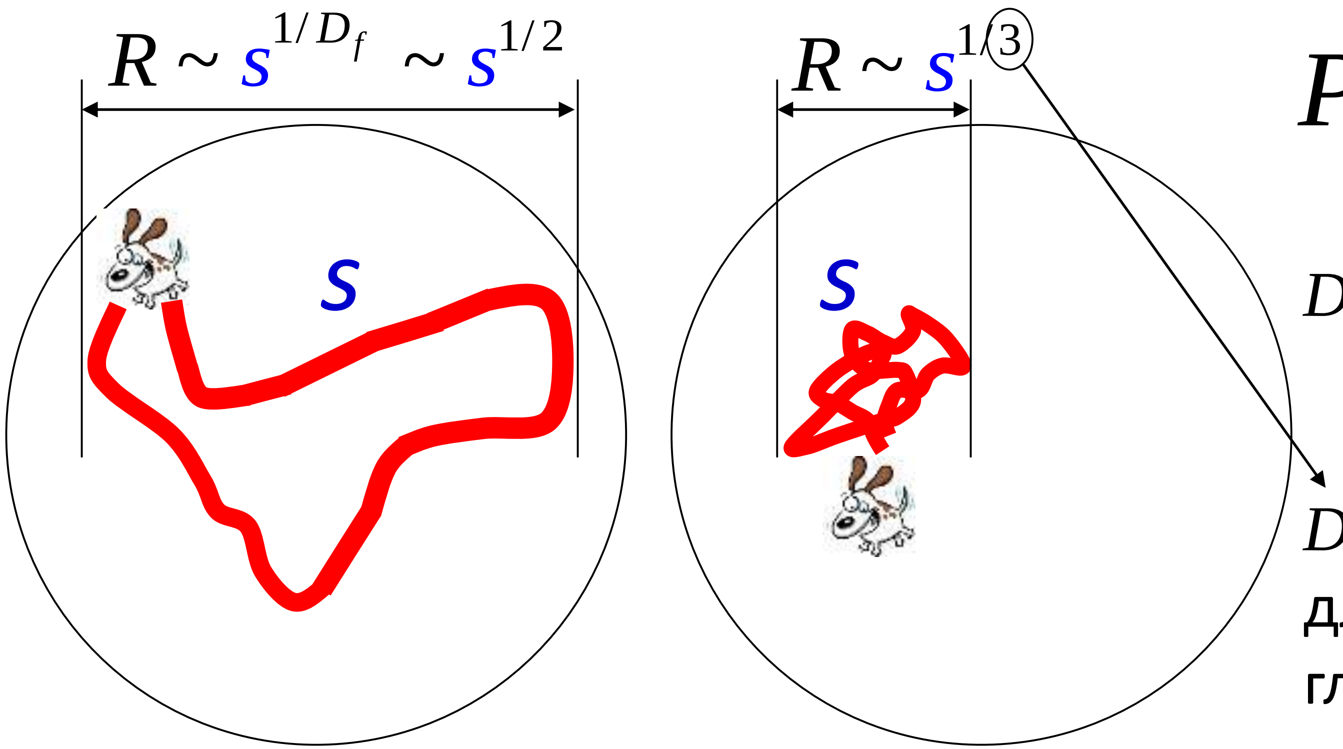




Что определялось в Hi-C эксперименте?

(genome-wide chromosome conformation capture method)

Какова вероятность того, что концы участка ДНК длины s в хромосоме окажутся рядом?



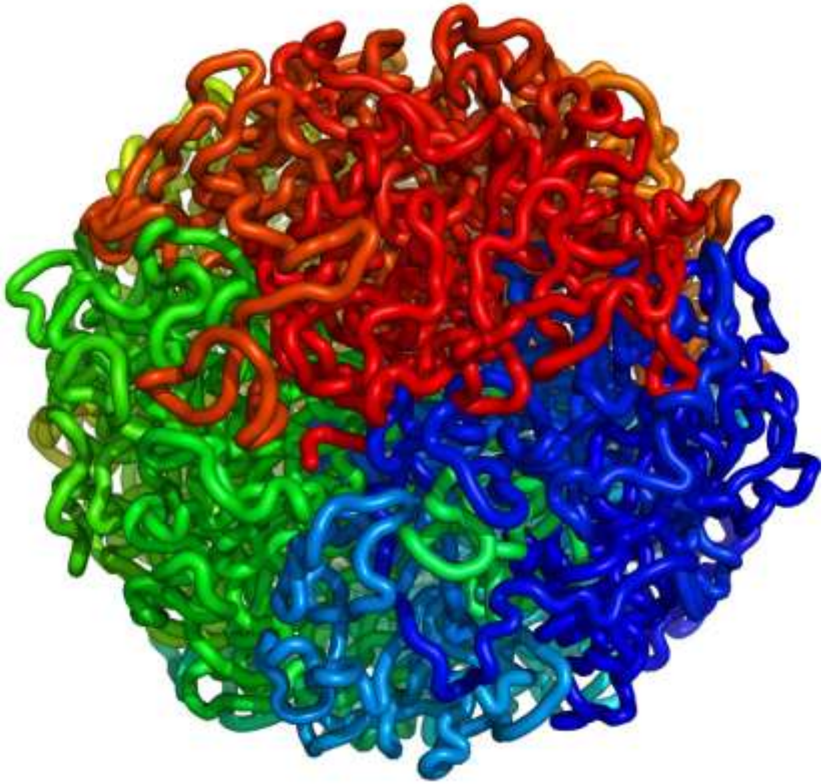
$$P(s) \sim \frac{1}{s^{3/D_f}}$$

D_f - фрактальная размерность

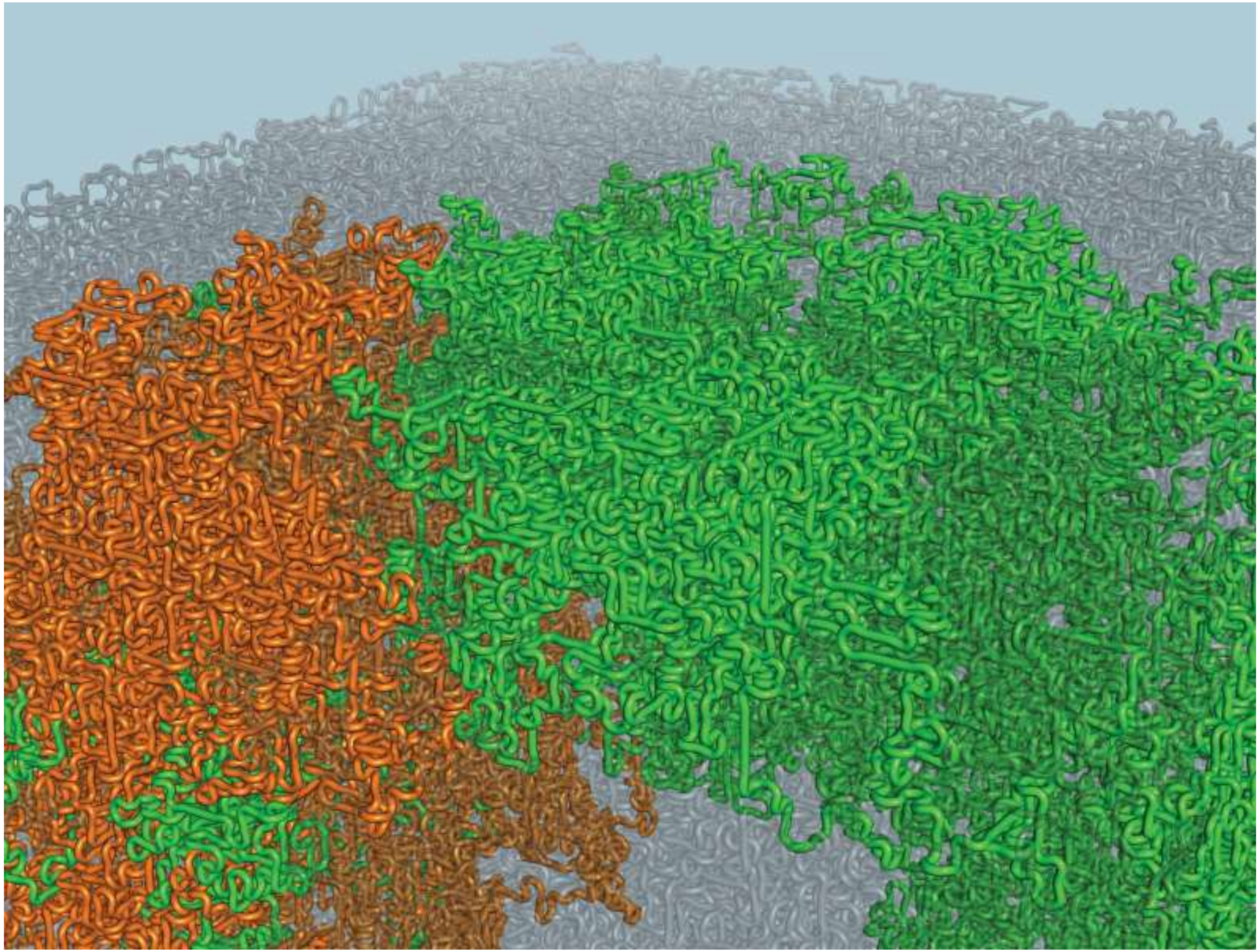
$D_f = 3$ для складчатой глобулы

How fill the space by linear chains such that every subchain is (almost) unknotted?

L. Mirny, M. Imakaev

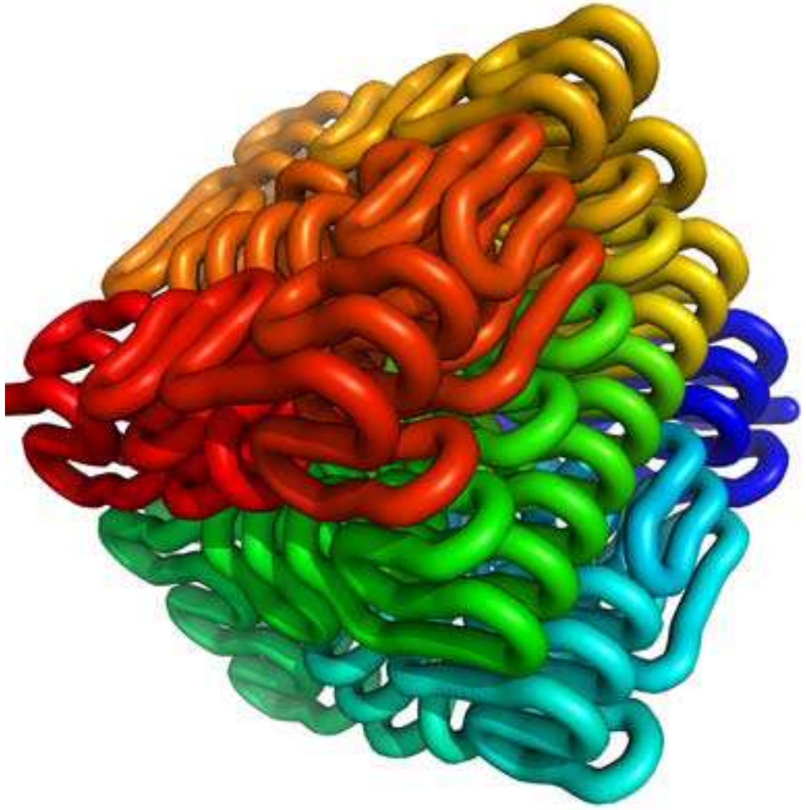


crumpled globule



cover page of Soft Matter – January 2015

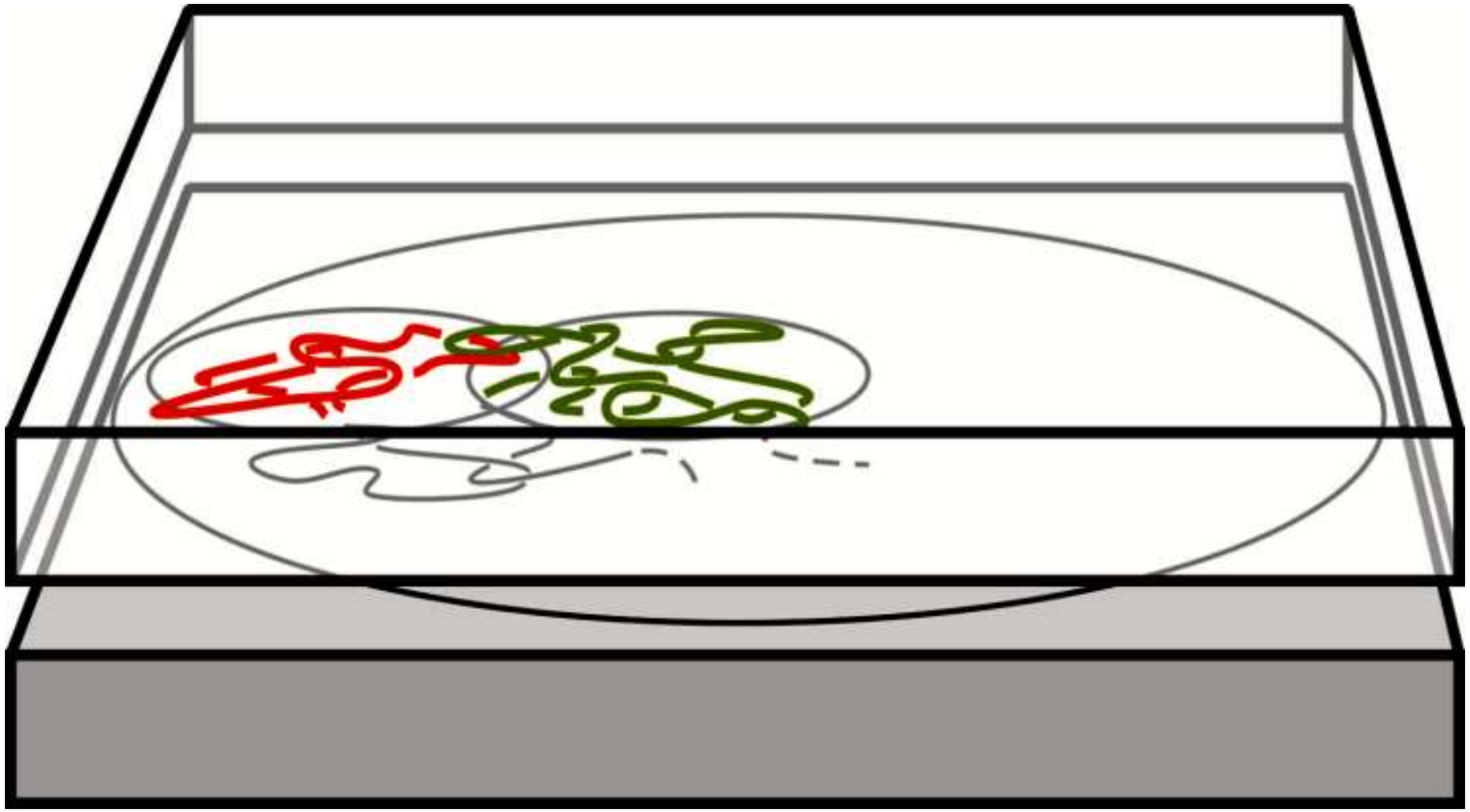
How fill the space by linear chains such that every subchain is (almost) unknotted?



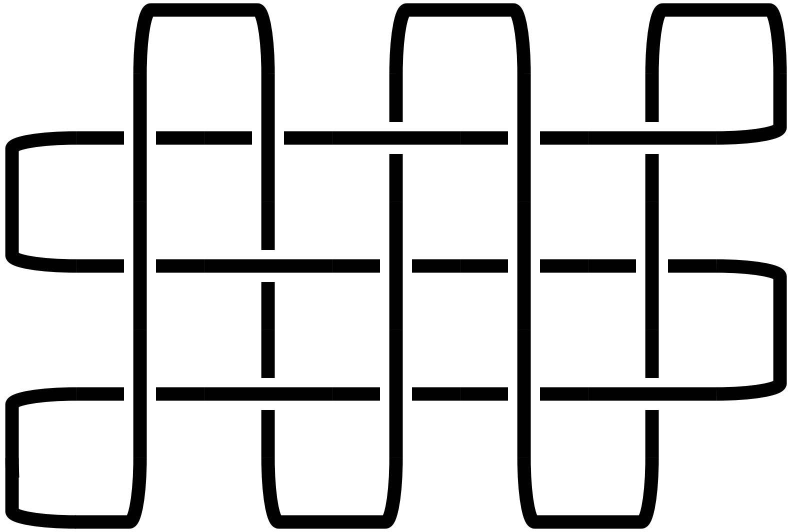
Crumpled globule

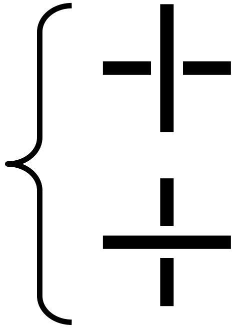
도시락

Quasi-two-dimensional system: polymer globule in a thin slit



Consider a dense knot diagram completely filling the rectangular lattice $L_h \times L_w$. Thus, we keep only the **“topological disorder”**:





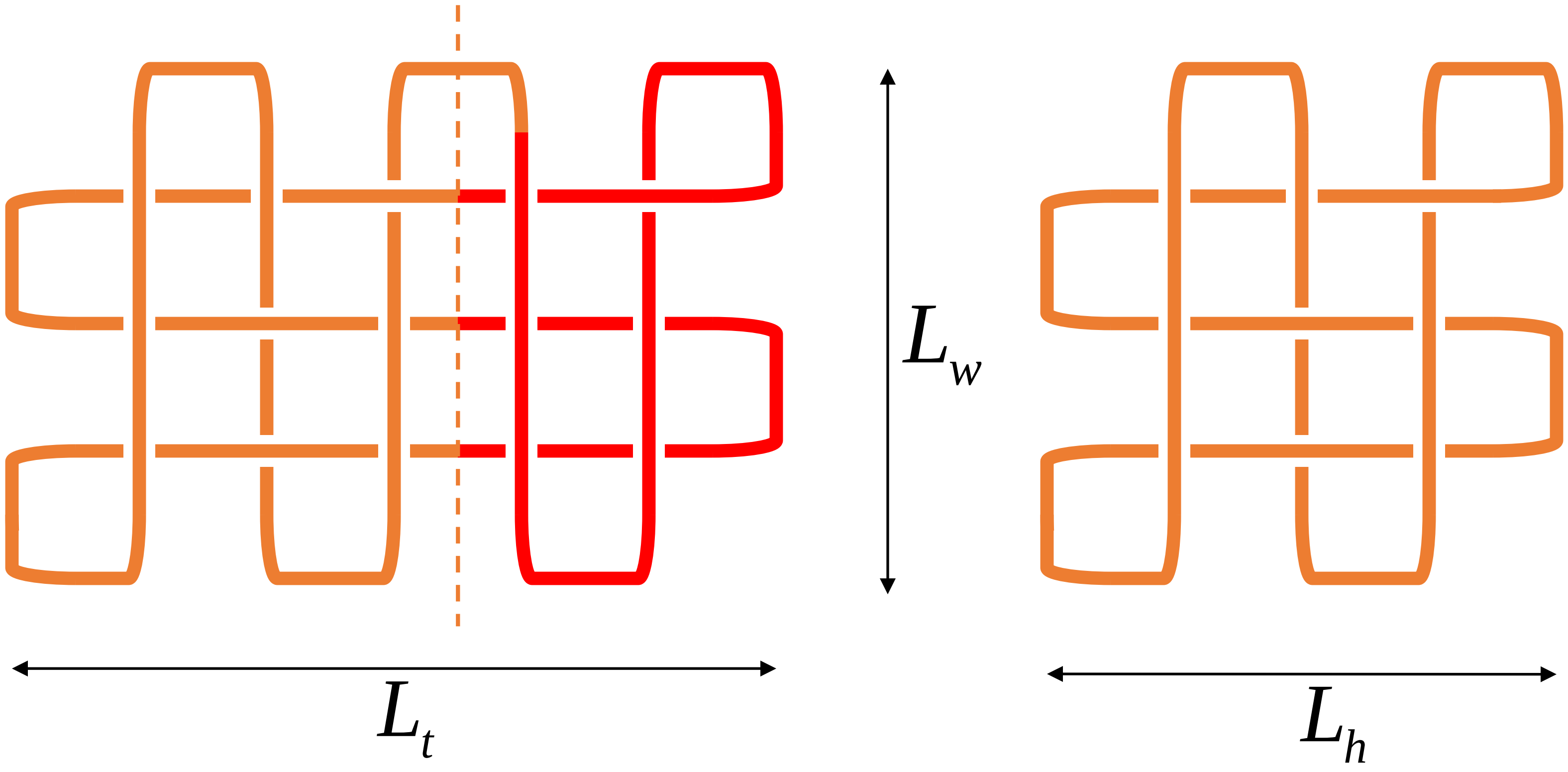
$$b_k = +1$$

$$b_k = -1$$

To the vertex k we assign the value of a “disorder” depending on the crossing type: $b_k = \pm 1$

Conditional distributions of knot invariants

What is a typical topological state of a "**daughter**" (quasi)knot under the condition that the "**parent**" knot is trivial?

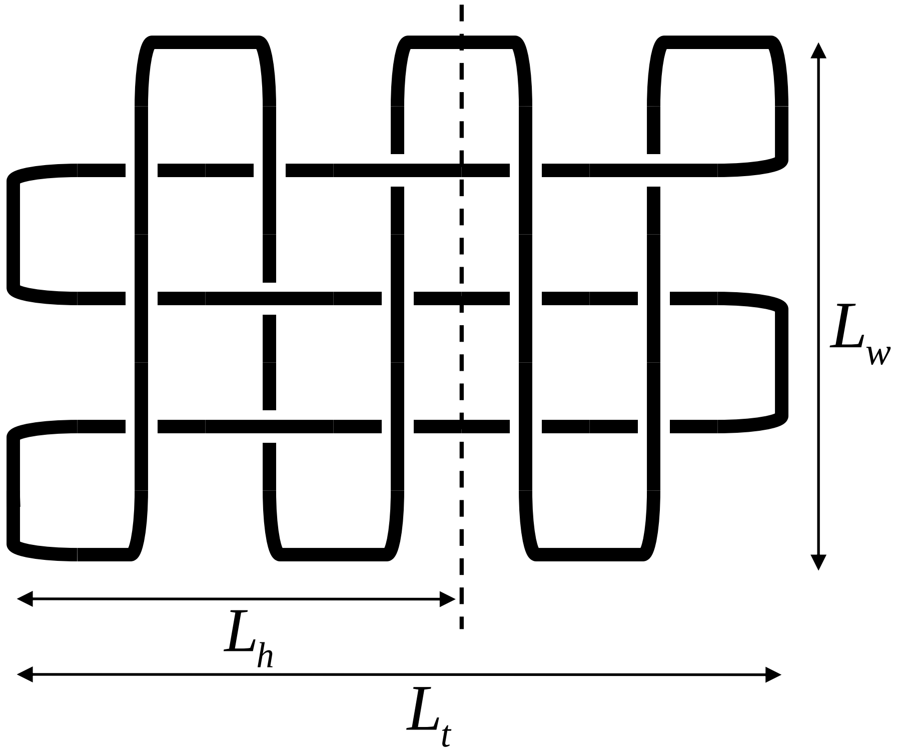


Typical **unconditional** knot complexity n of a random knot is asymptotically

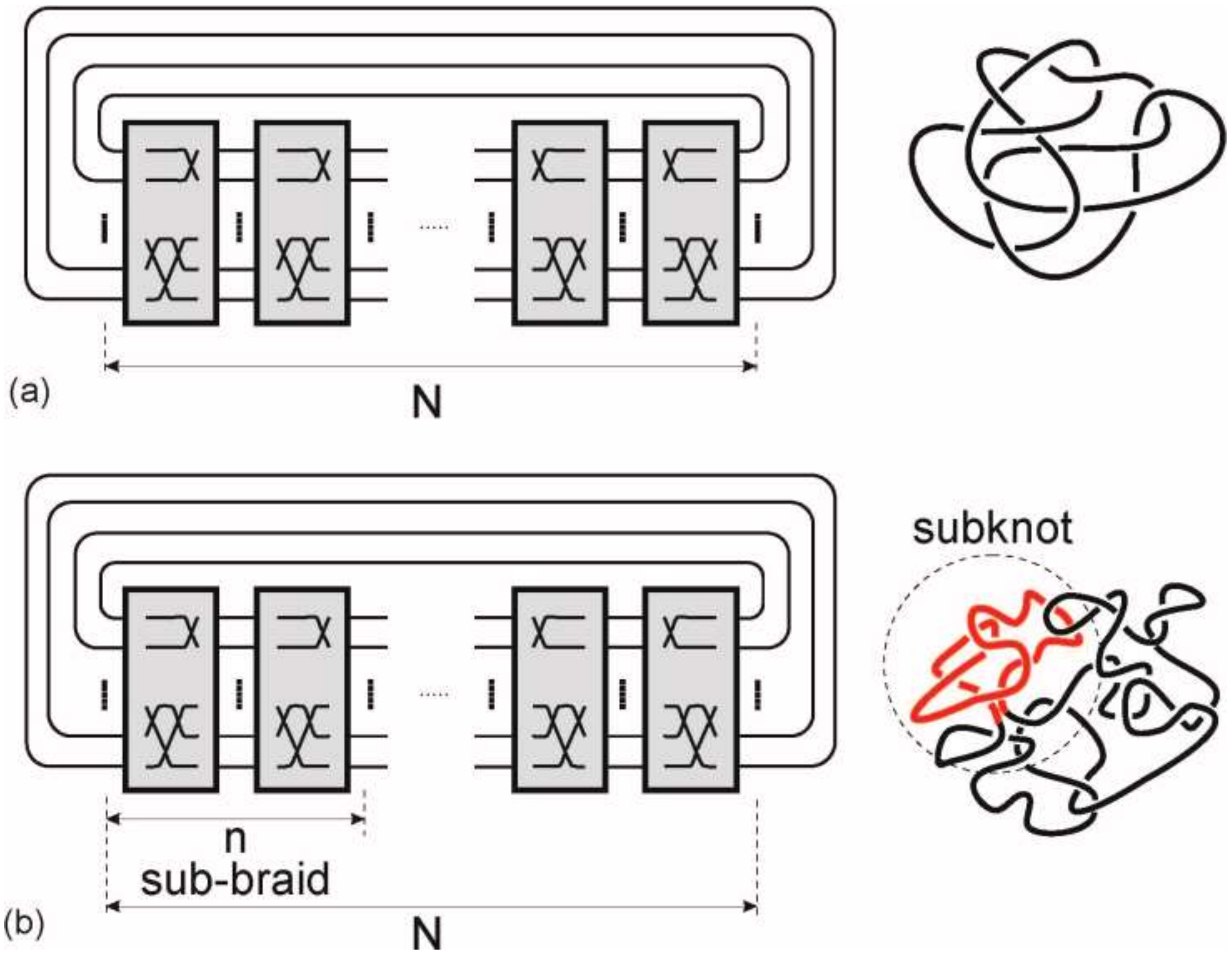
$$n \sim L_t \times L_w \sim N$$

Typical **conditional** knot complexity n^* of a daughter (quasi)knot, which is a part of a parent trivial knot, is asymptotically:

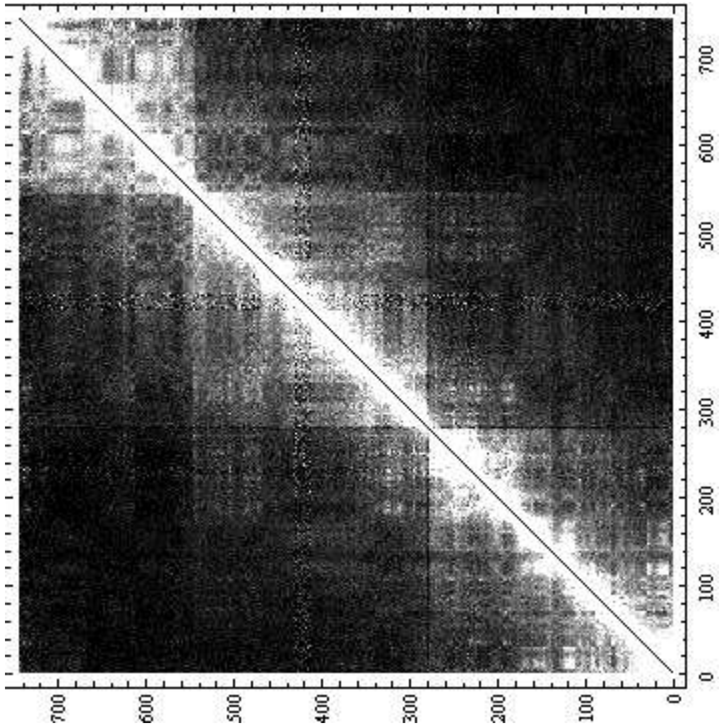
$$n^* \sim \sqrt{L_h \times L_w} \sim c\sqrt{N}$$



The space of all topological states is **exponentially growing (hyperbolic)**



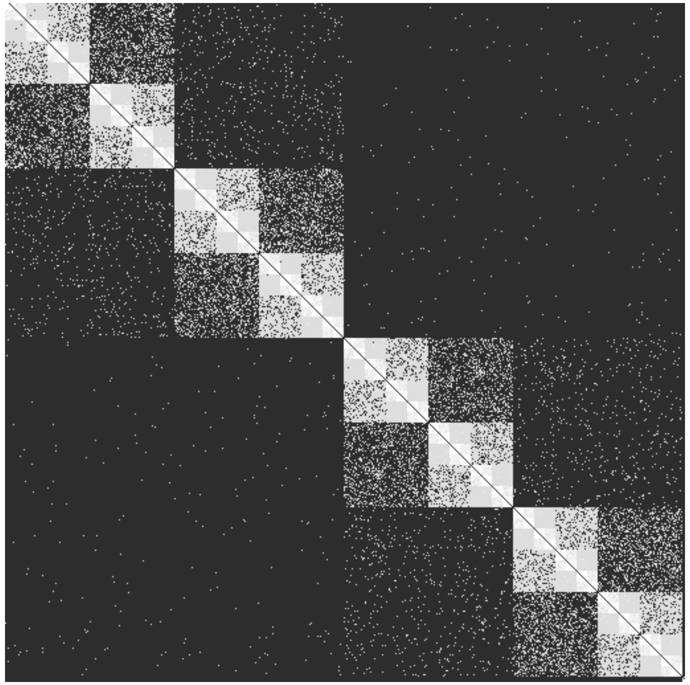
Пример карты Hi-C



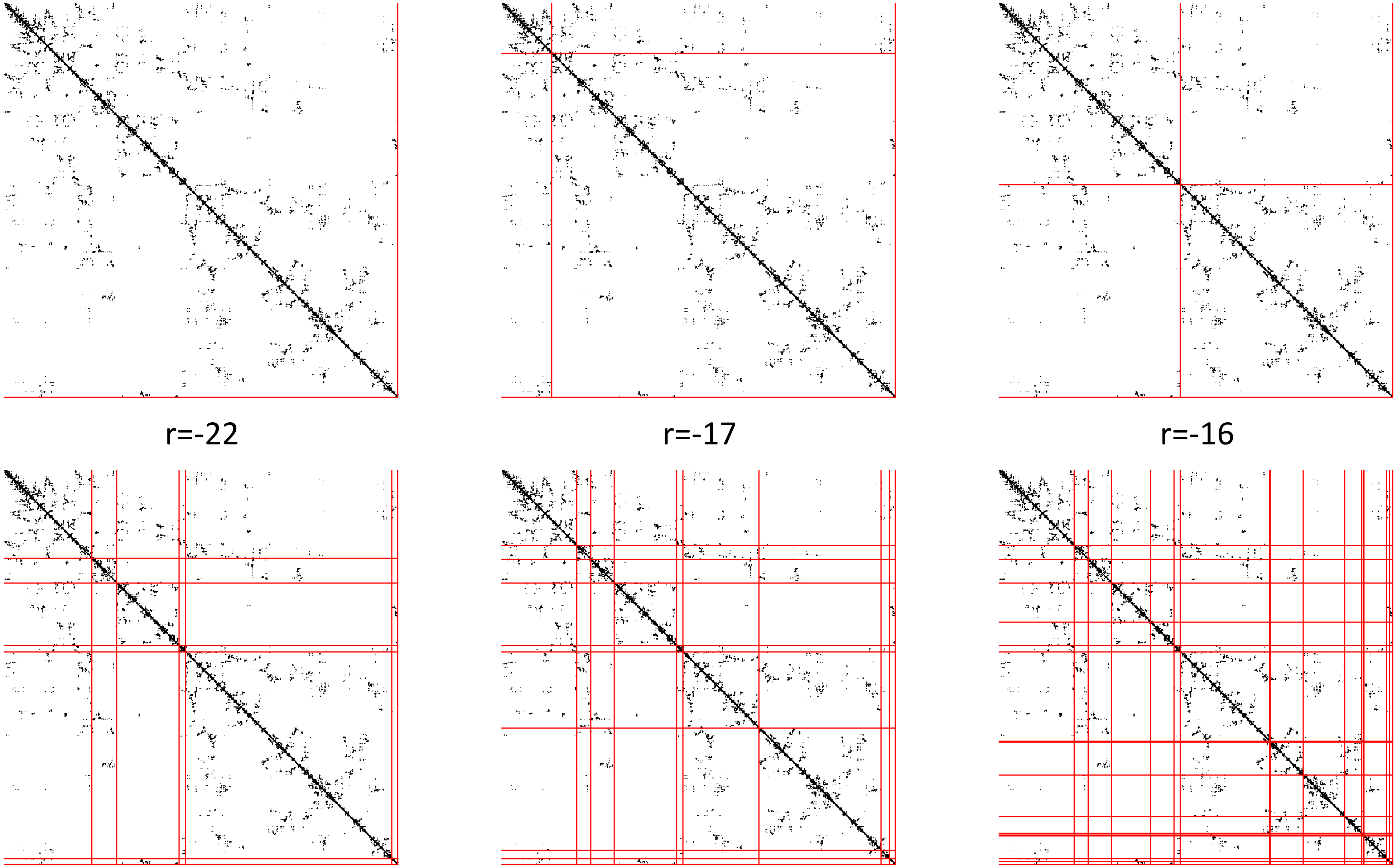
Наилучшее разрешение
2 килобазы

Яркость (в среднем) спадает как $1/s$

Яркость - вероятность контакта i-ого и j-ого фрагмента



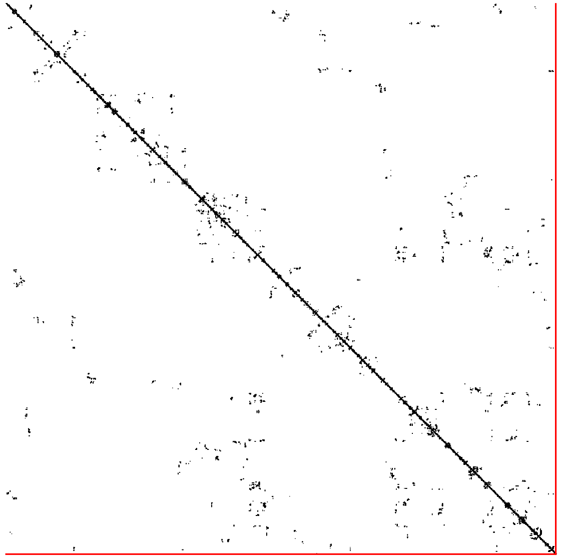
Складчатая структура



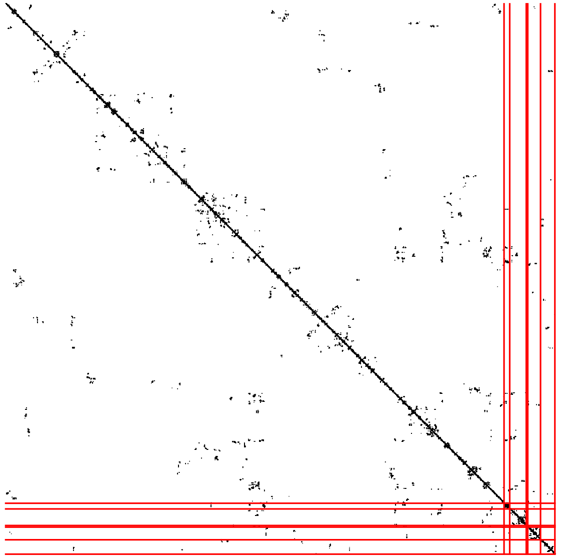
r=-22 r=-17 r=-16

r=-14 r=-12 r=-6

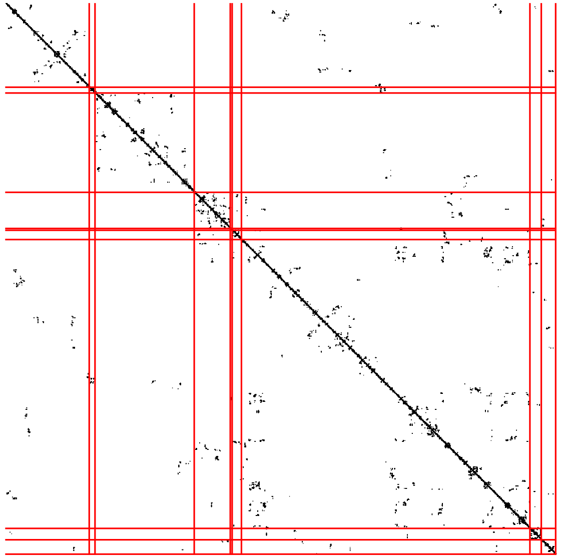
Обычная структура



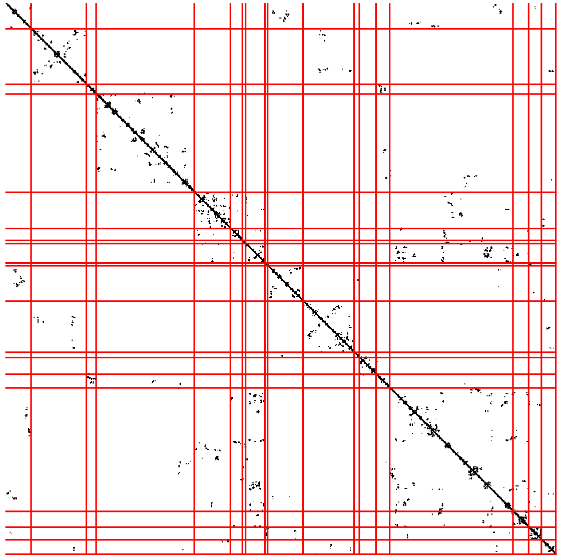
r=-22



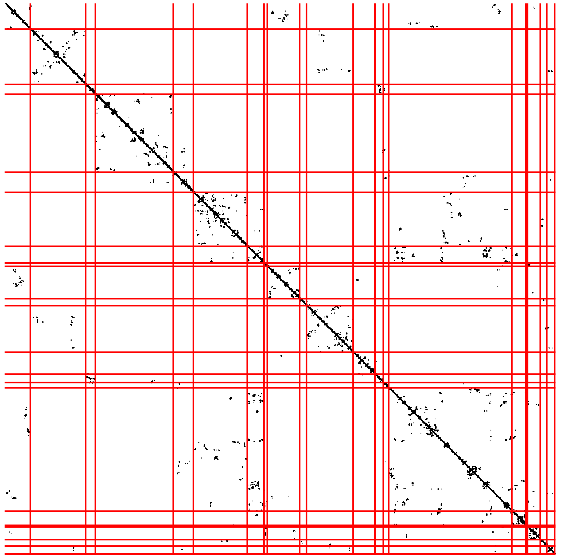
r=-9



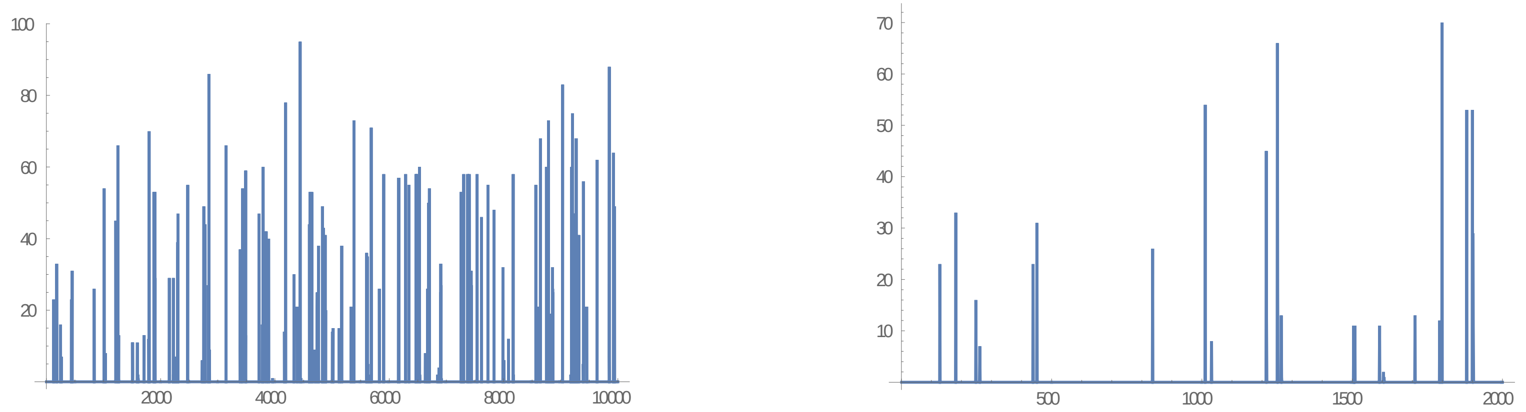
r=-8



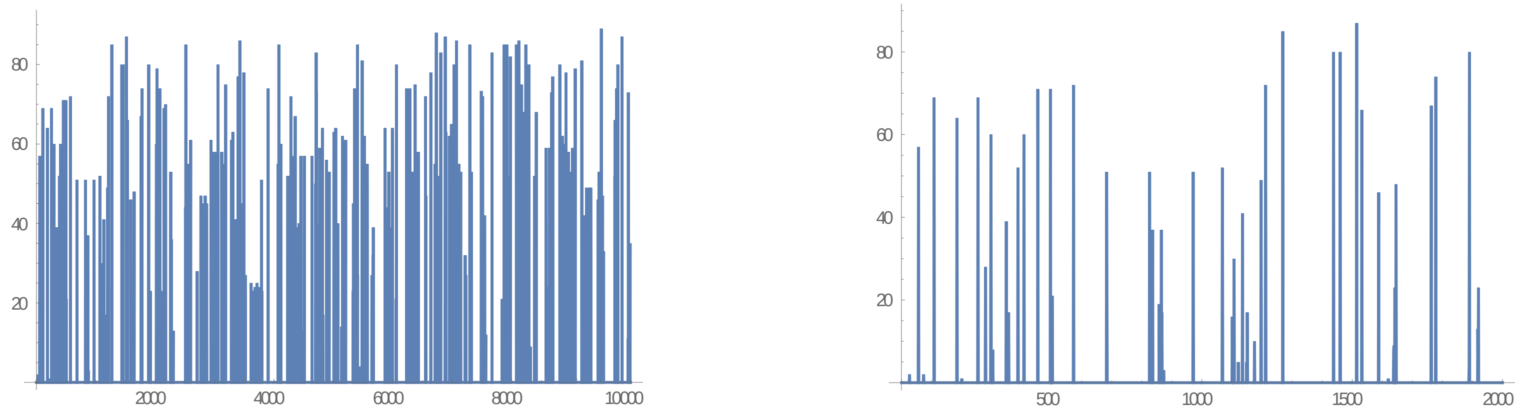
r=-7



r=-6

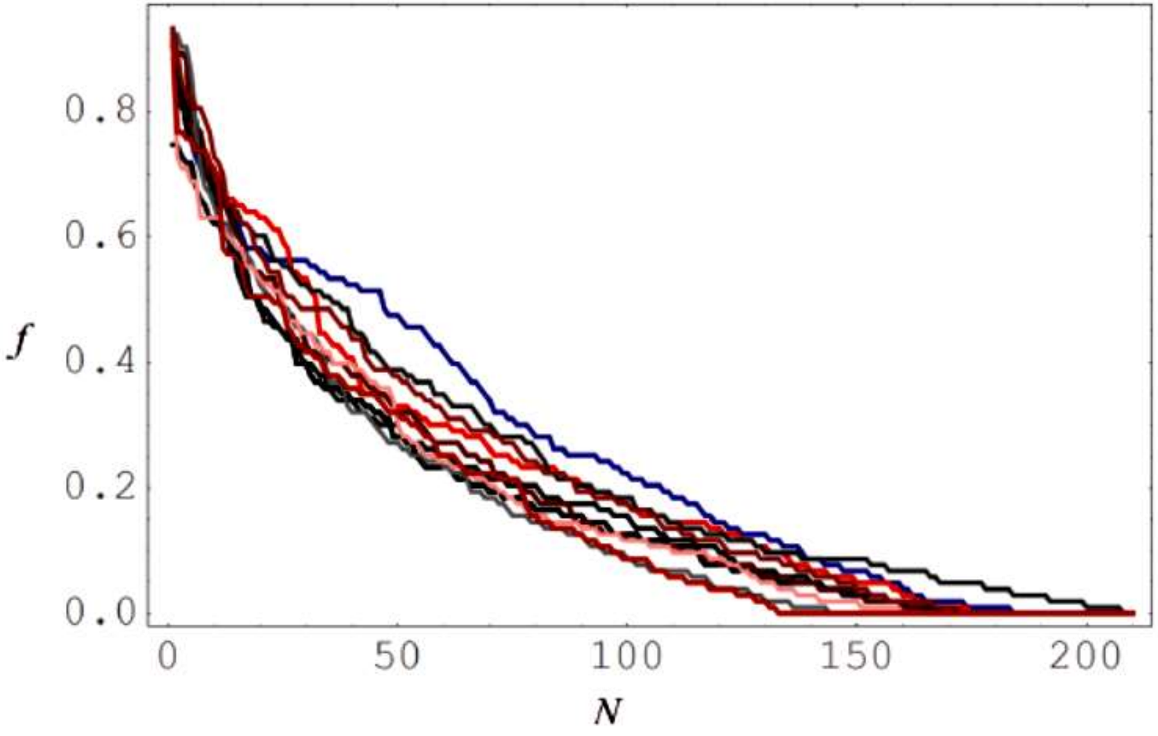


Спектр границ кластеров складчатой глобулы (справа – увеличенный масштаб)



Спектр границ кластеров обычной глобулы (справа – увеличенный масштаб)

Устойчивость границ
в складчатой глобуле



Устойчивость границ
в обычной глобуле