Double Interpenetrating Networks: Microphase Separation in Collapsed and Swollen States

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Alexei Gavrilov, Vladimir Rudyak, Pavel Kos and Elena Kozhunova

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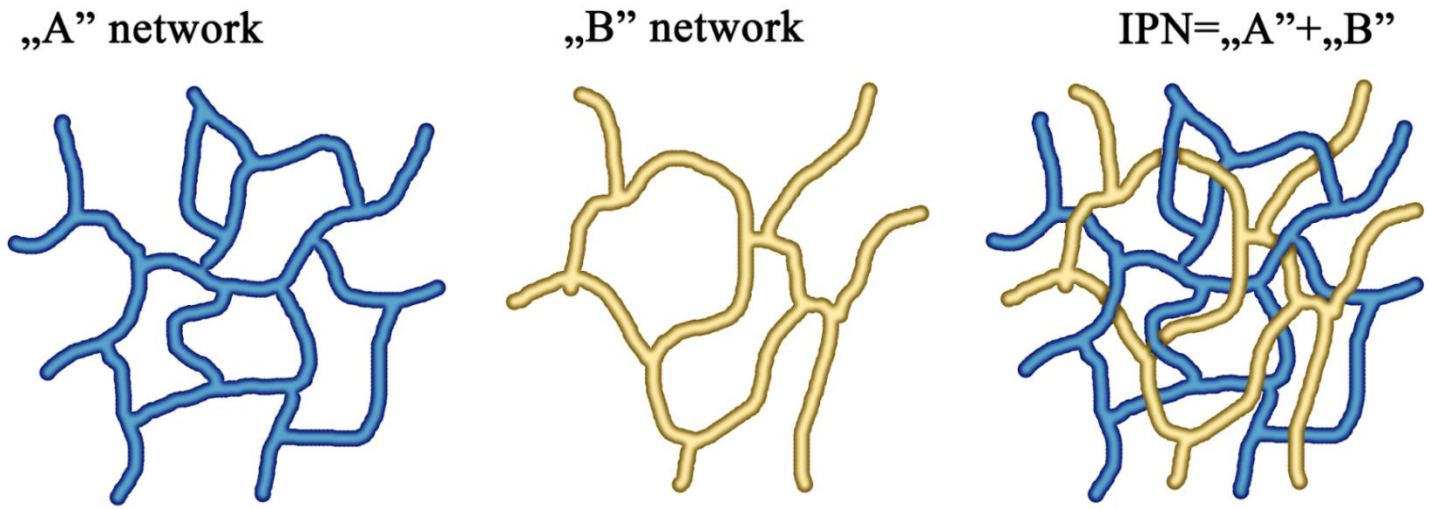
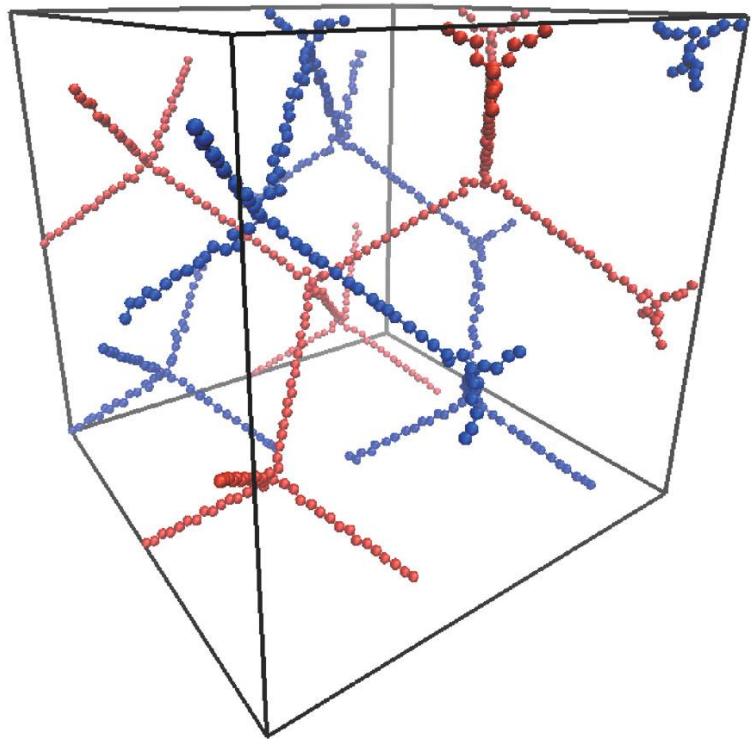
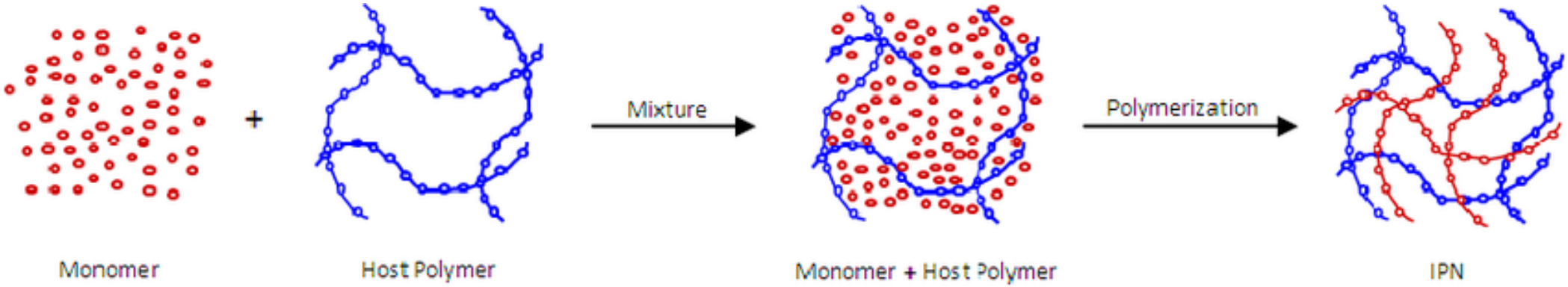
What is Double Interpenetrating Network?





Typical method of synthesizing:



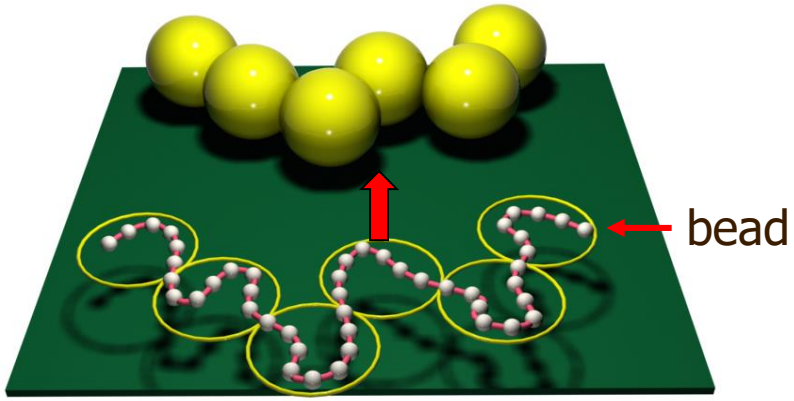
New class of polymer objects, which is not single molecule, but cannot be divided

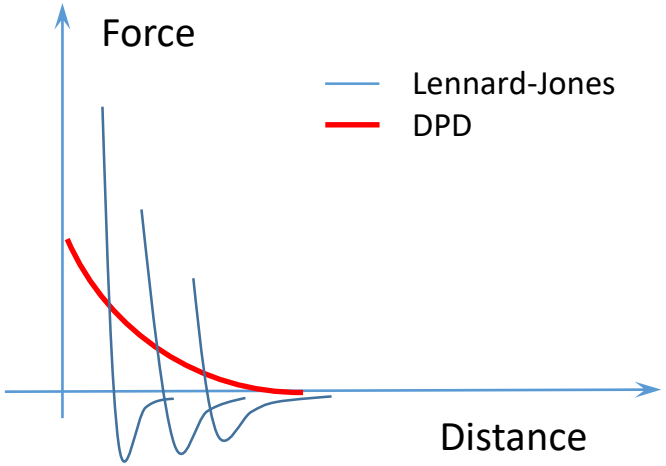
Computer simulation in soft matter and polymer science

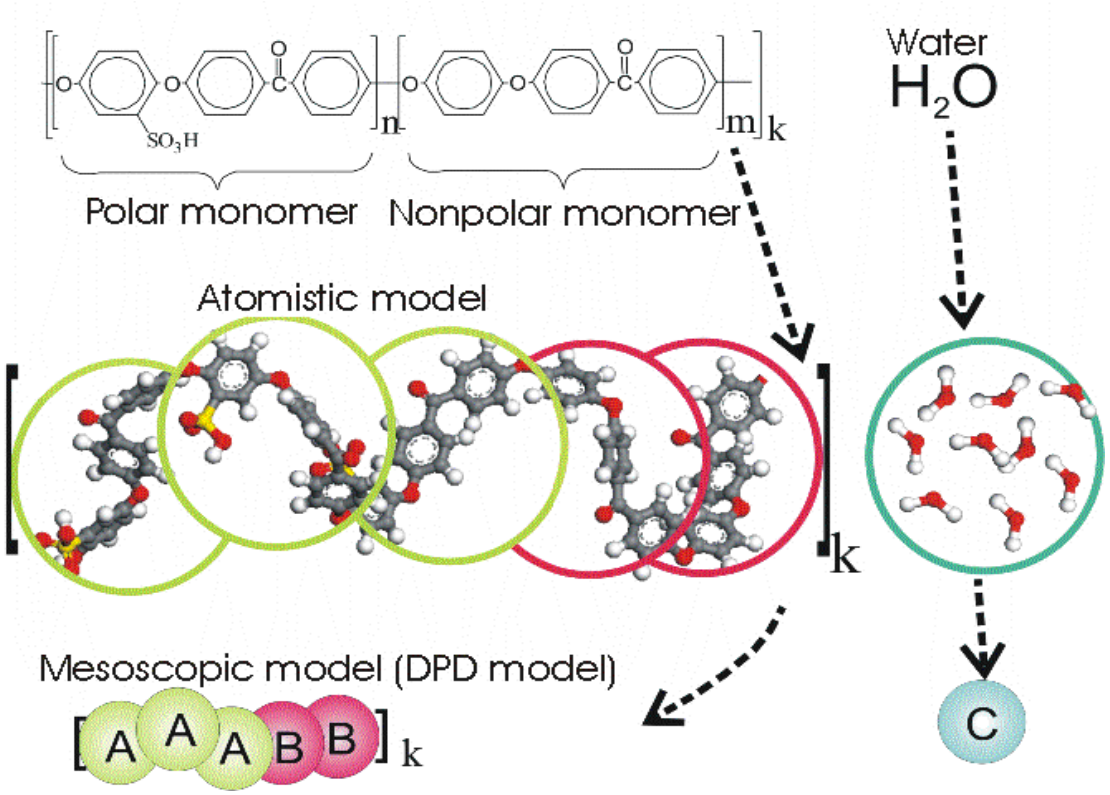
DPD (Dissipative Particle Dynamics)

Groot R.D. and Warren P.B. J. Chem. Phys. ***107*** *(1997) 4423*

$$\mathbf{F}_{ij} = \mathbf{F}_{ij}^{Cons} + \mathbf{F}_{ij}^{Diss} + \mathbf{F}_{ij}^{Random}$$



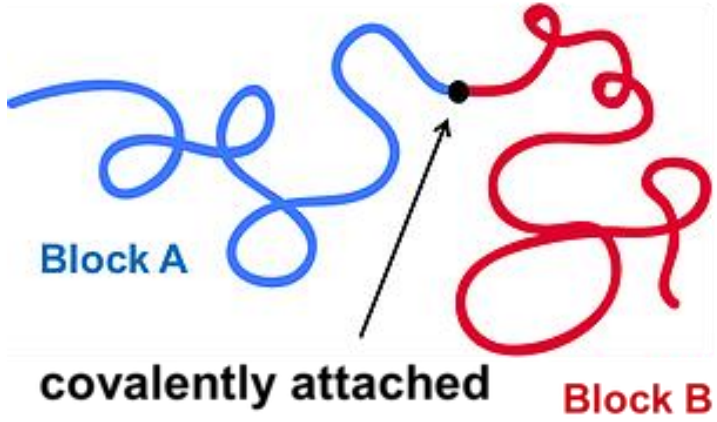




Coarse-graining methodology allow to consider statistical physics (including conformational entropy) for very complex polymer system

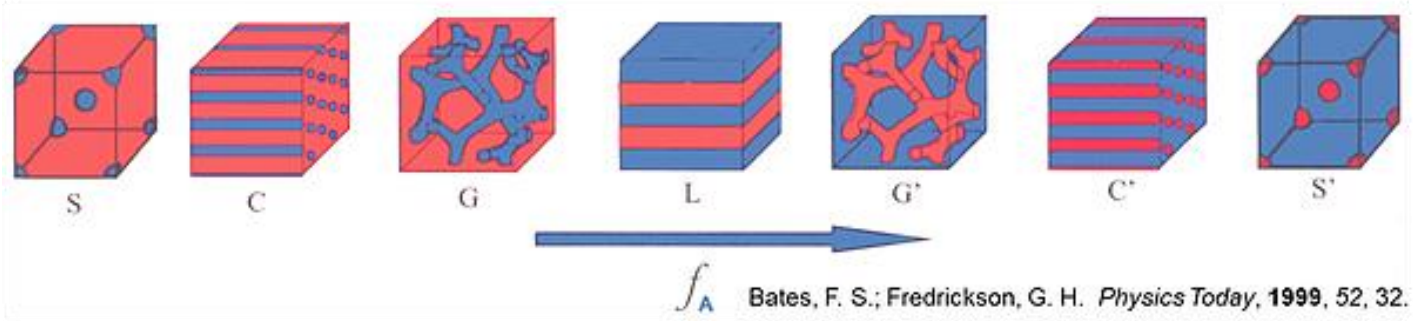
Comparison of IPN and diblock copolymer

Classical microphase separation



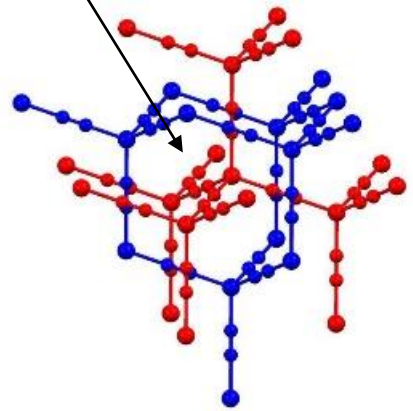
Key Parameters

f	volume fraction of each block (composition)
N	degree of polymerization (size)
χ	interaction parameter (compatibility)



Bates, F. S.; Fredrickson, G. H. *Physics Today*, **1999**, *52*, 32.

Topologically entangled



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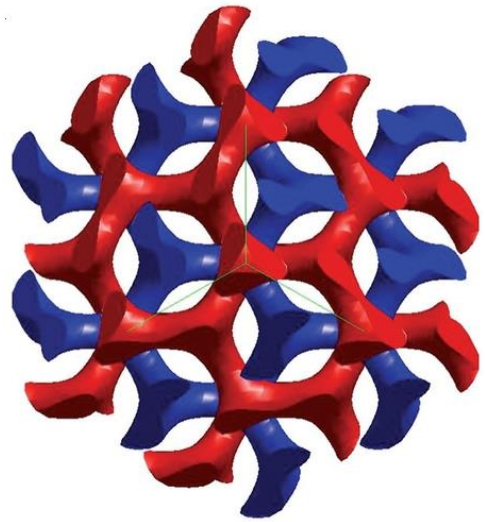
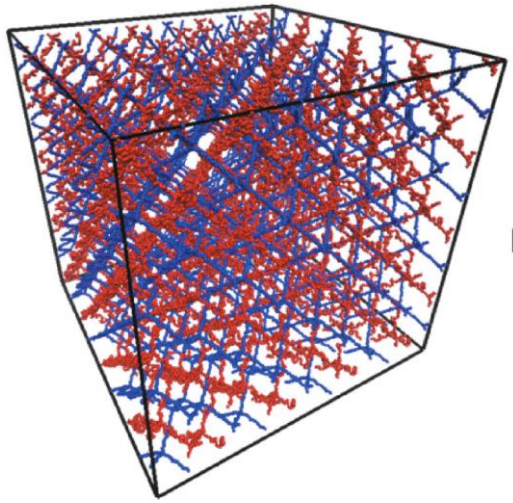


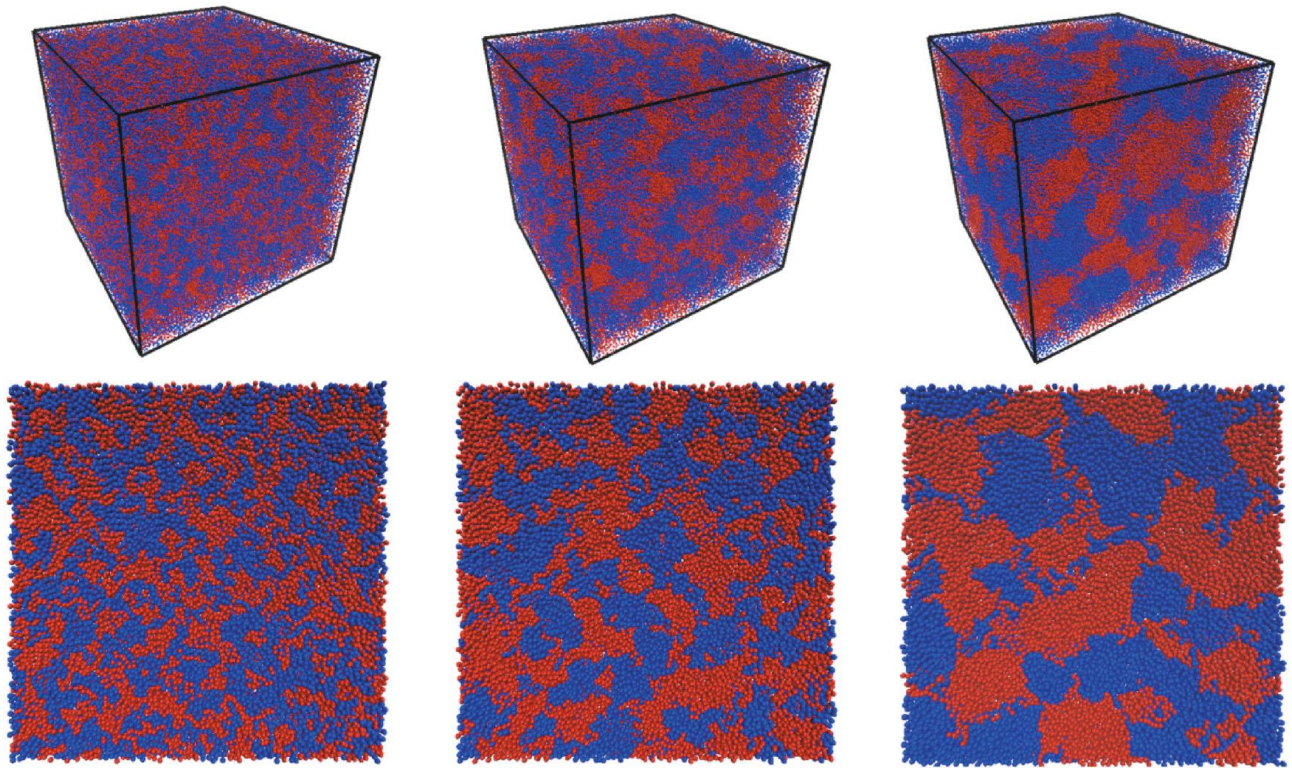
Is it possible to obtain microphase separation for topologic, not covalent entanglements?

IPN rubber

Influence of subnetworks compatibility (Flory-Huggins χ parameter)



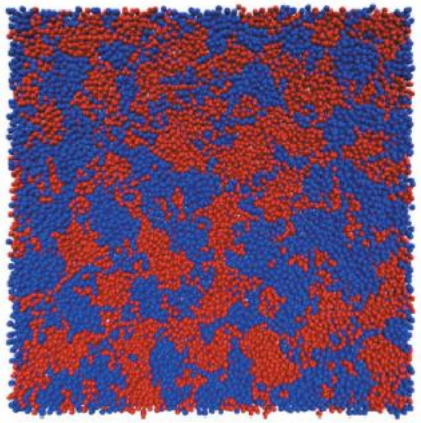
$\chi = 0.0$ $\chi = 1.5$ $\chi = 6.0$



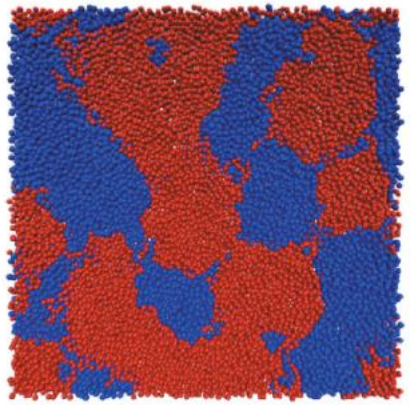
In contrast with diblock copolymers, no microphase separation with long range order is possible!

IPN rubber: influence of mesh size

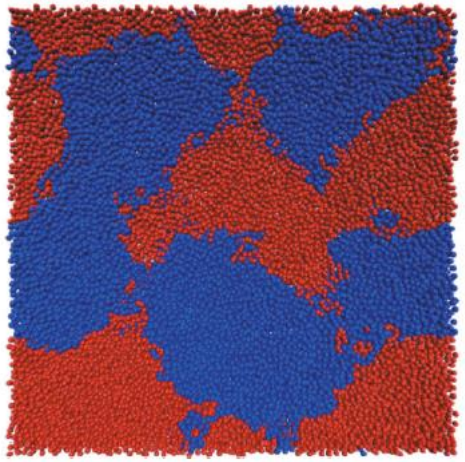
$l_1 = l_2 = 10$

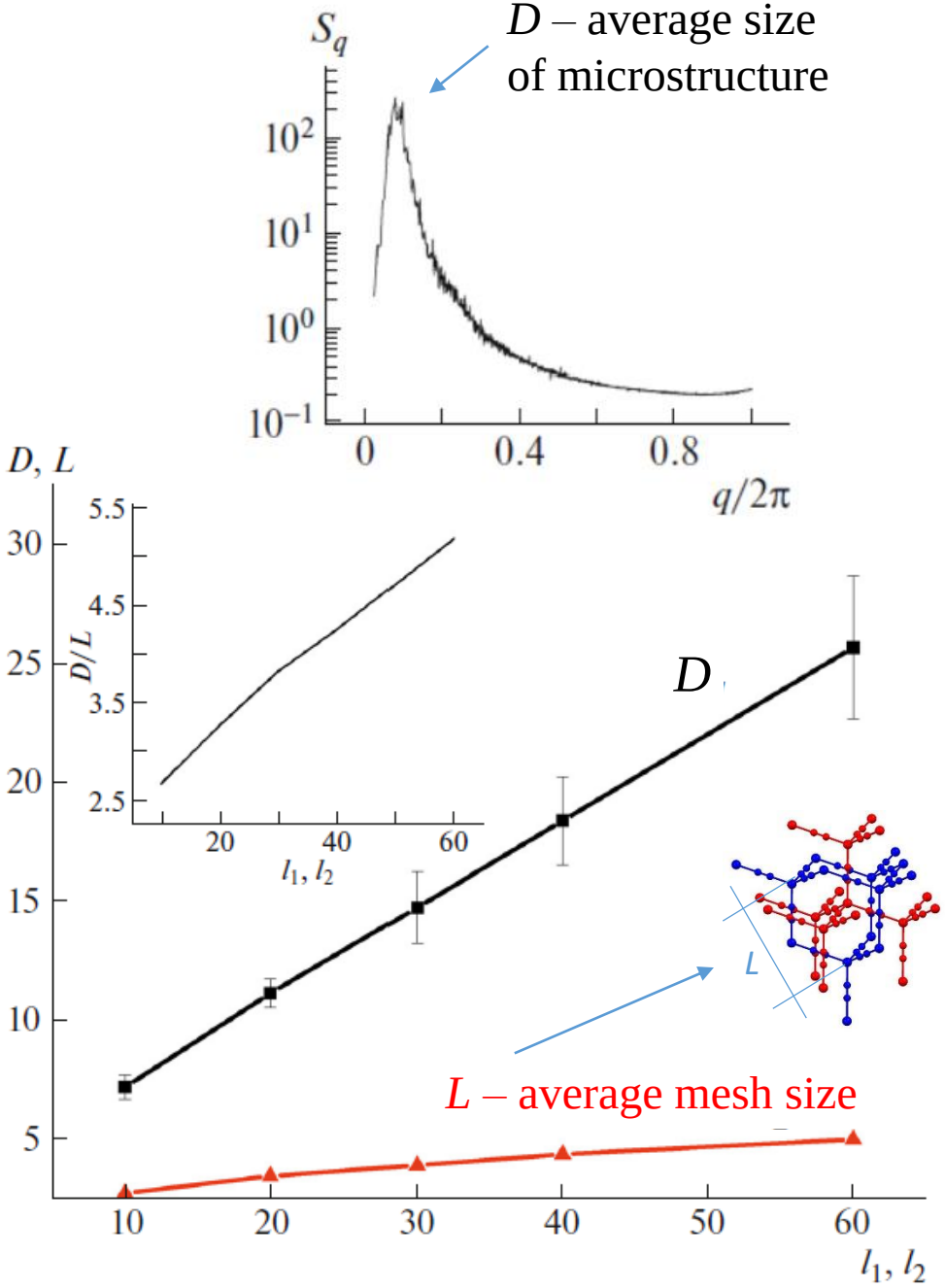


$l_1 = l_2 = 30$



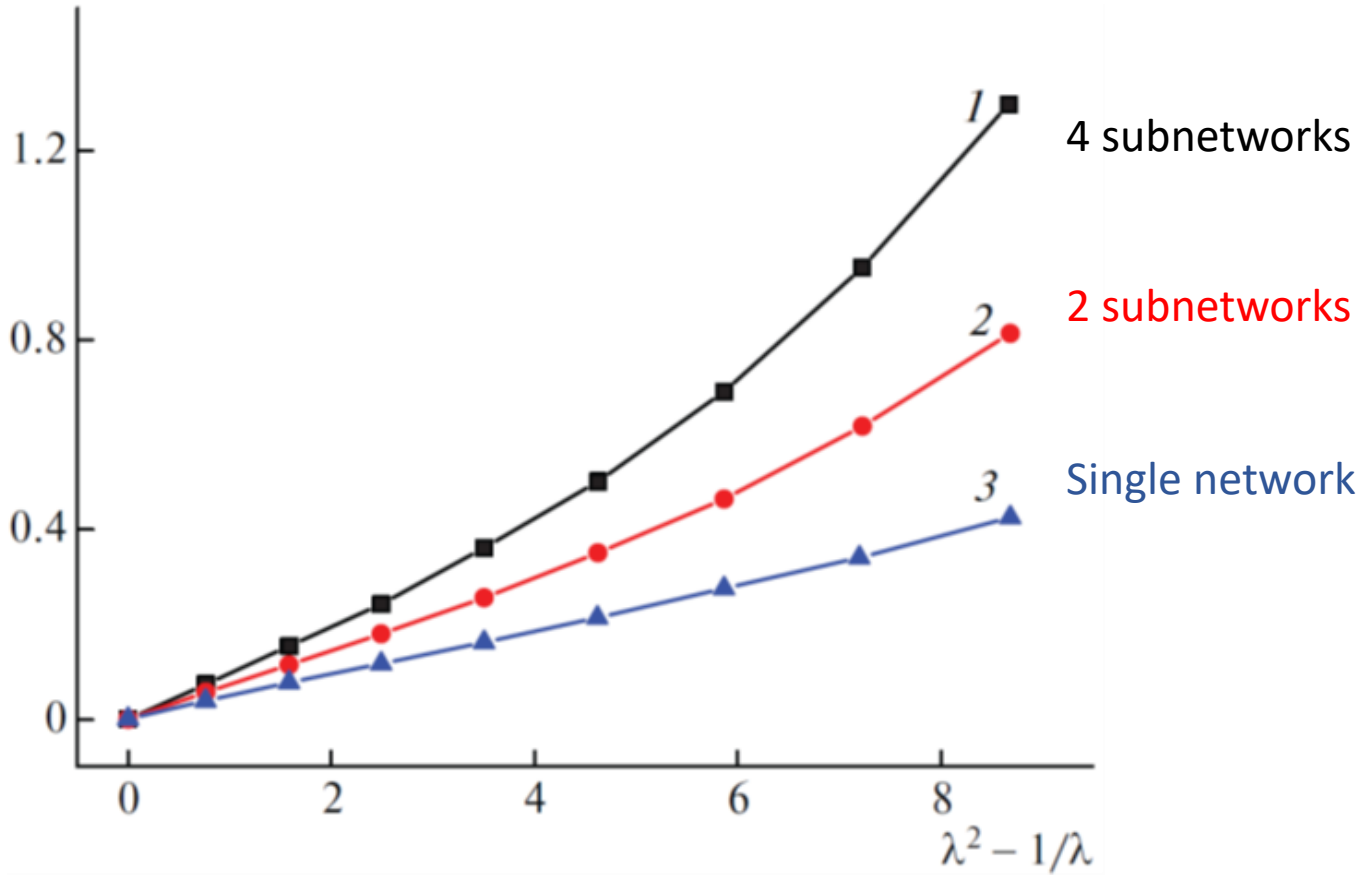
$l_1 = l_2 = 60$





IPN topological entanglements are “sliding” and do not correspond directly to mesh size, so no special size is preferable during fluctuations.

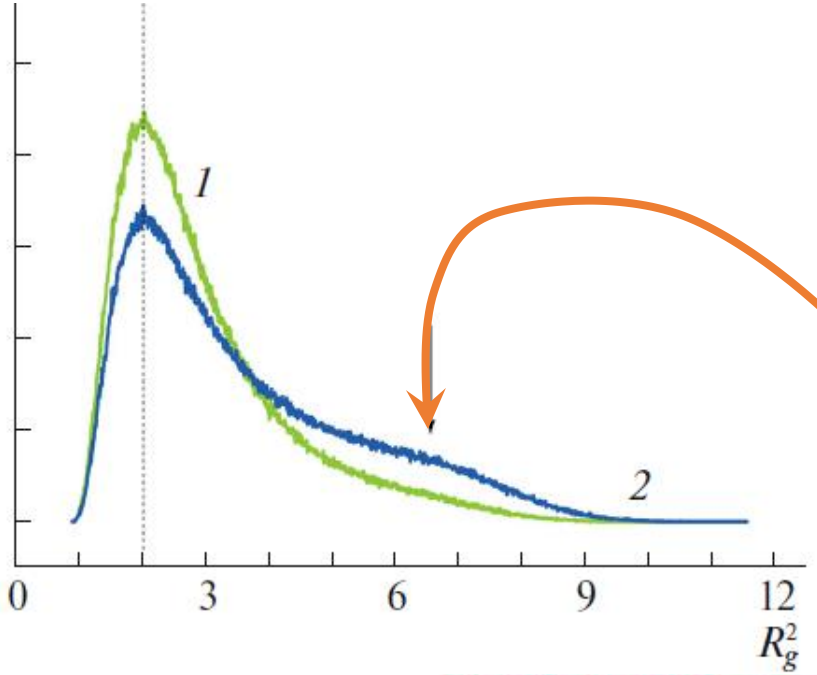
Influence of subnetworks number on IPN rubber elastisity

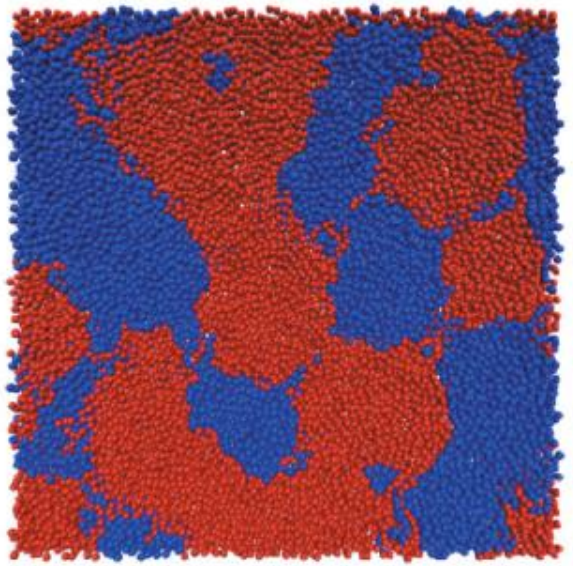


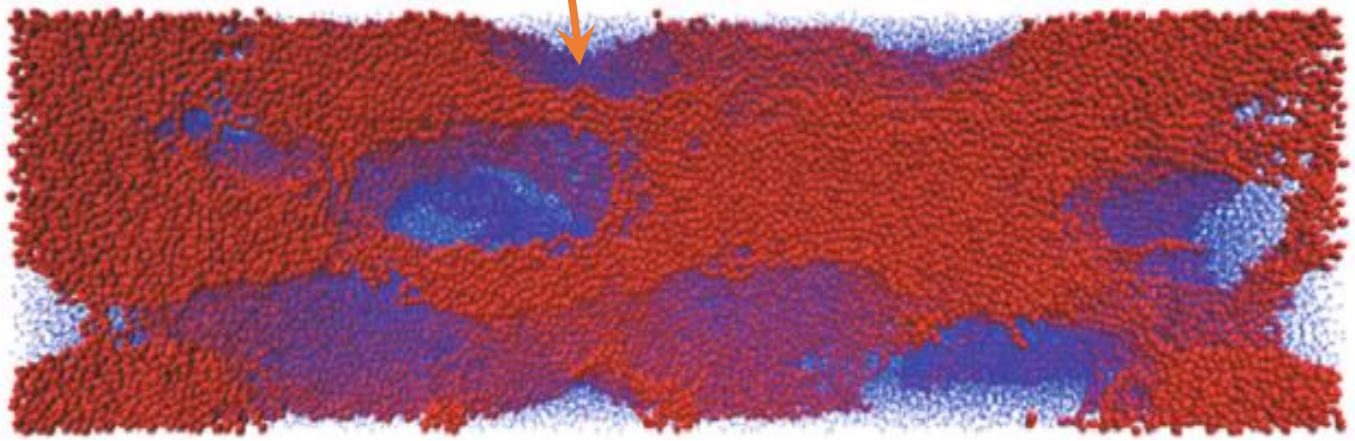
The more subnetworks the more strong and nonlinear stress-deformation

This is the effect of smaller fraction of elastic-active subchains

Deformation of partly segregated IPN rubber

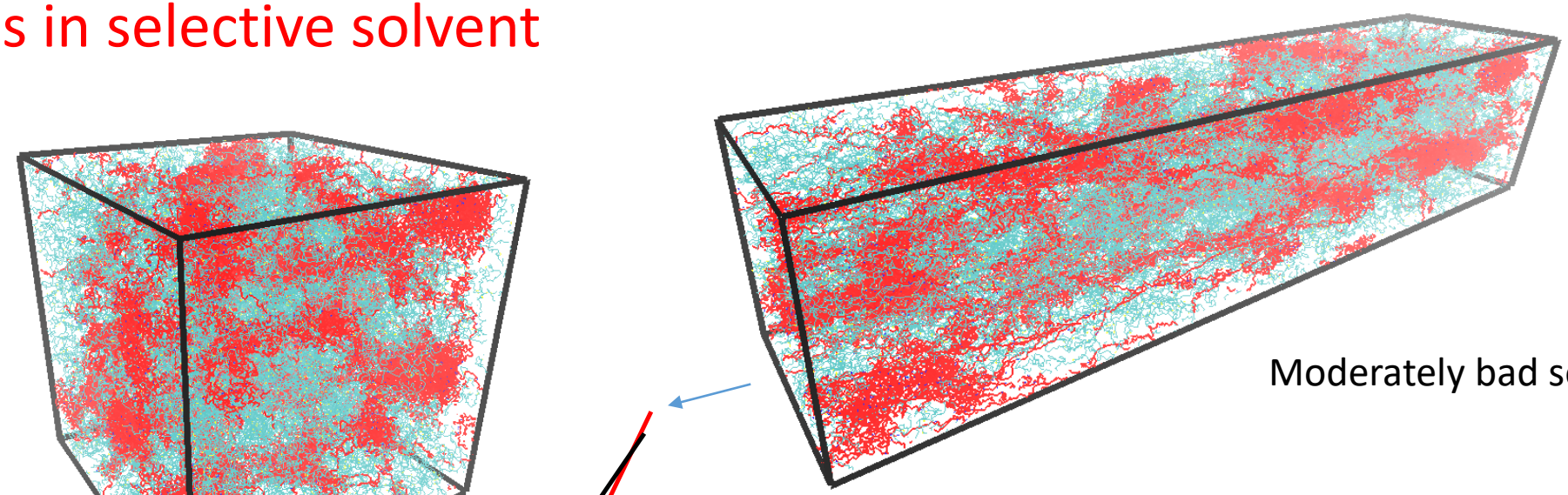




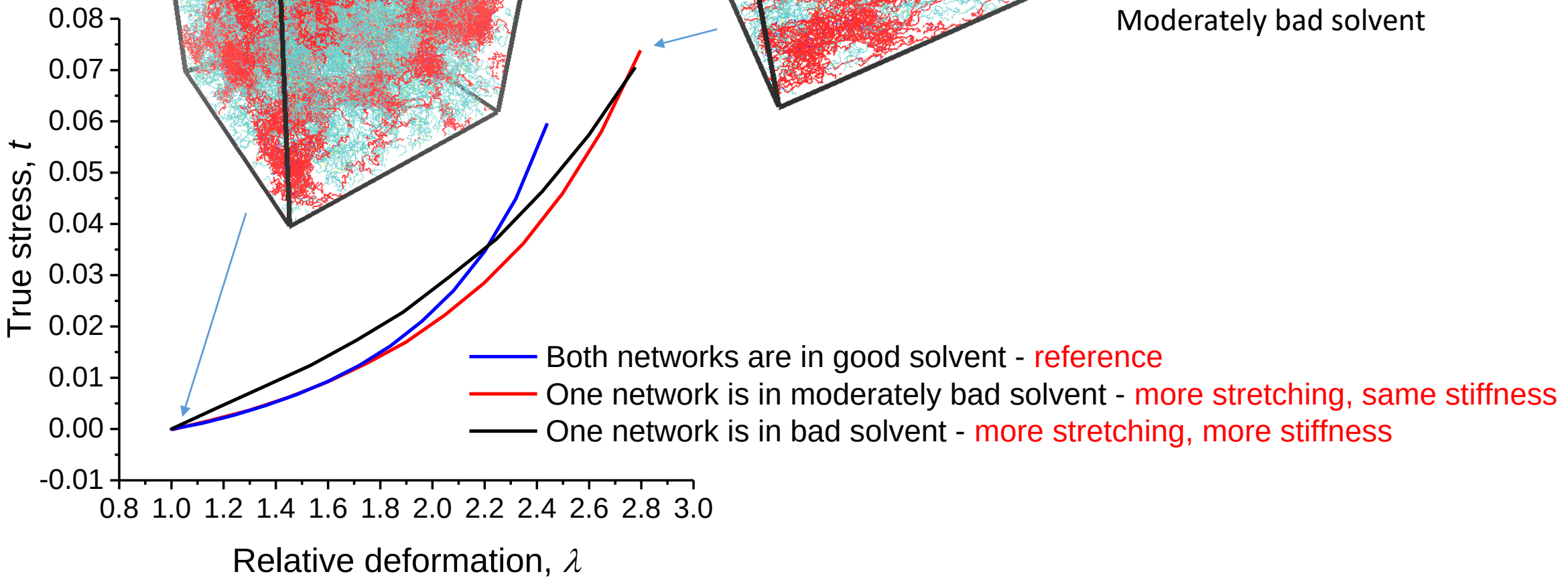


Partly segregated subnetworks have special fraction of very deformed subchains

IPN gels in selective solvent

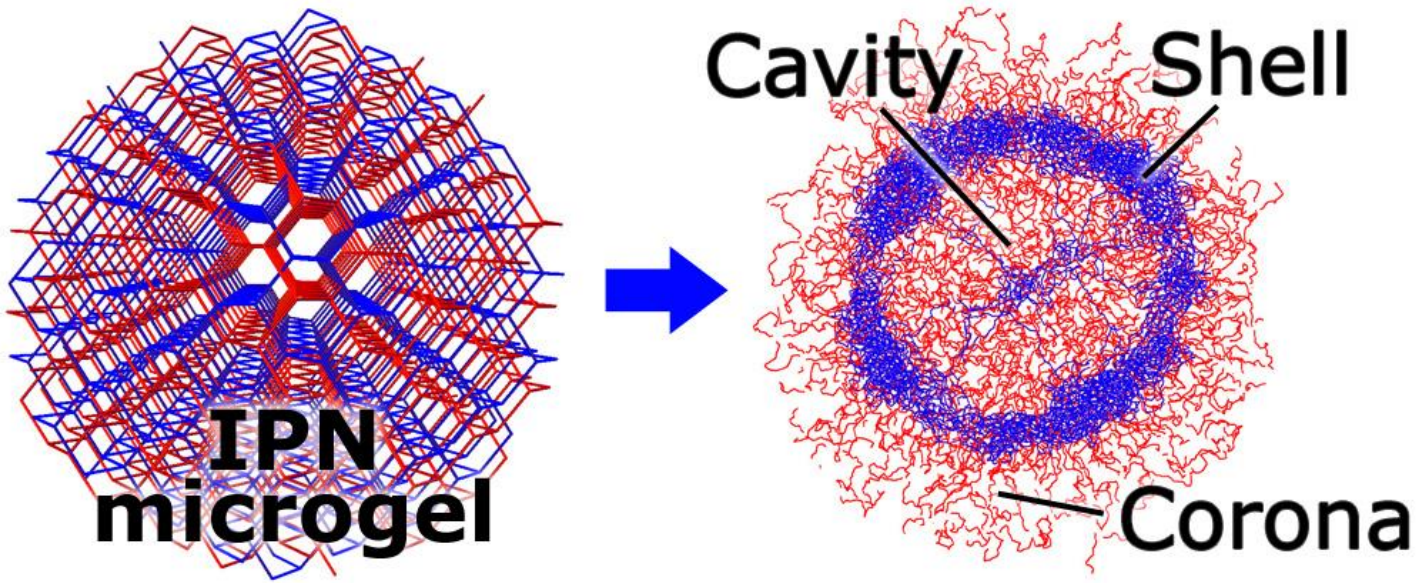


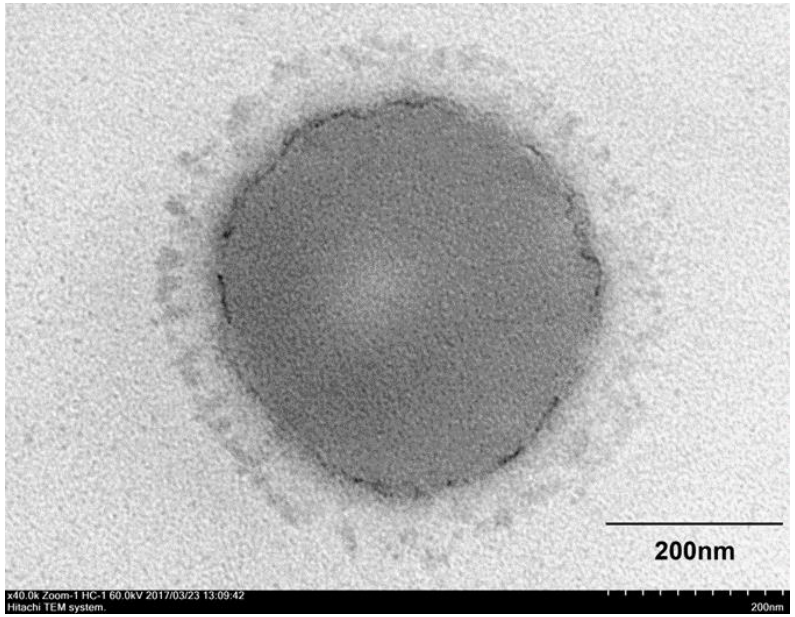
Moderately bad solvent



Selective solvent in IPN gel can control its toughness and elasticity!

IPN Microgel in selective solvent

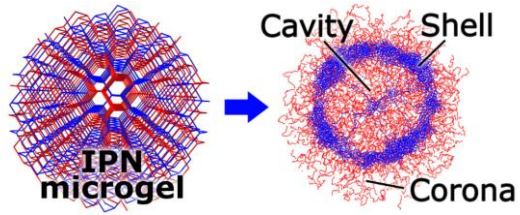


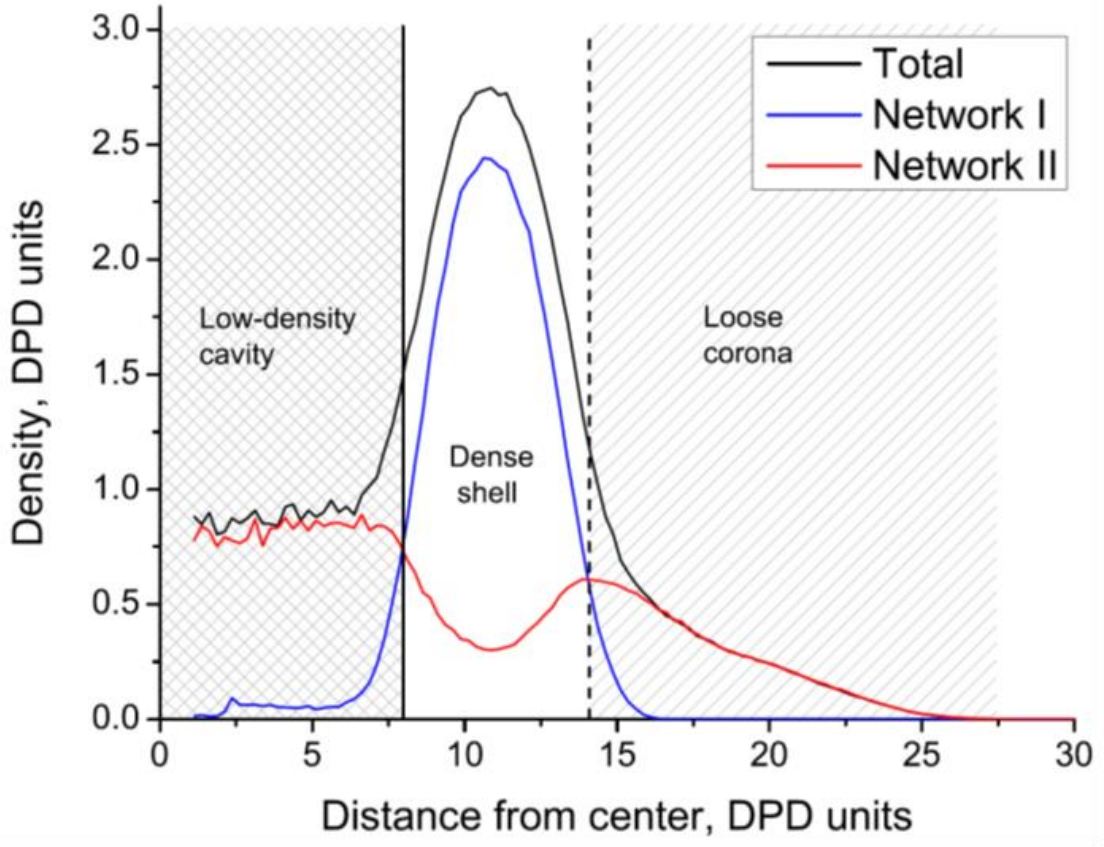


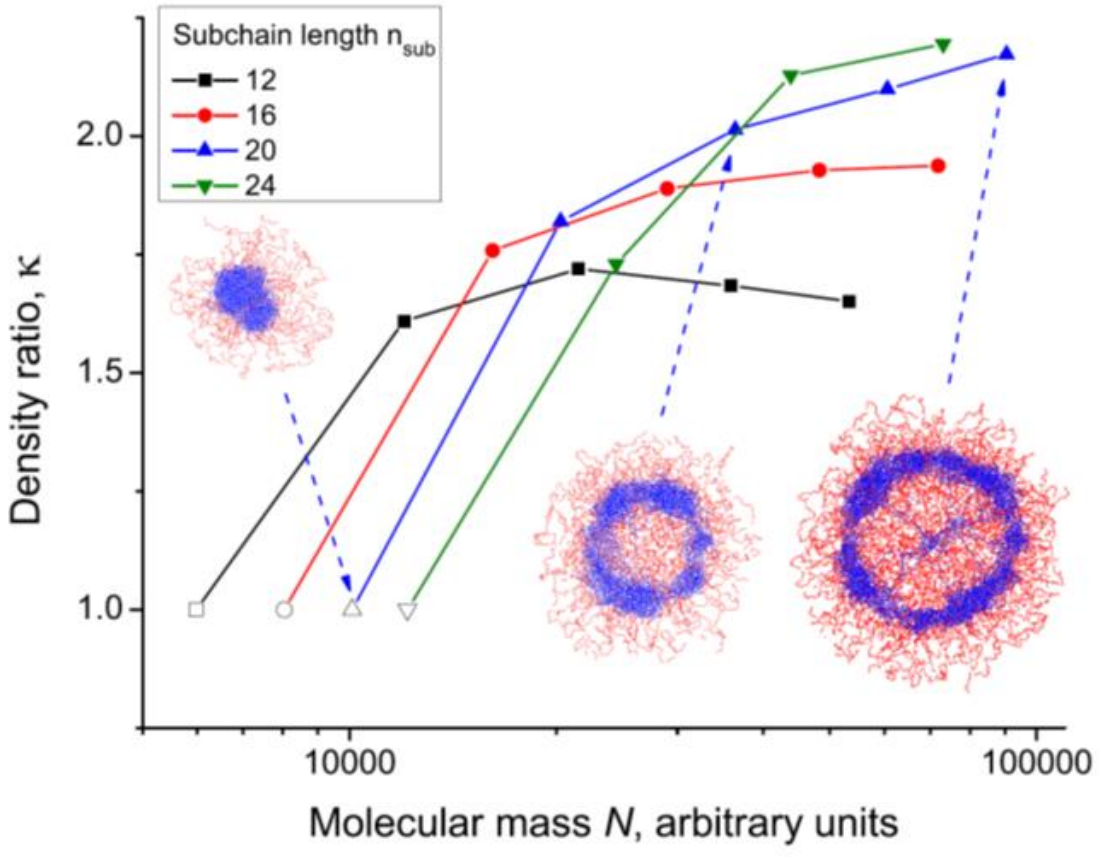
Experimental example: PNIPA + PAA = pH + Temperature sensitivity
Poster 4_303 by Elena Kozhunova

Set of topological entanglements prevents the collapse of blue network into a single core

IPN Microgel in a selective solvent

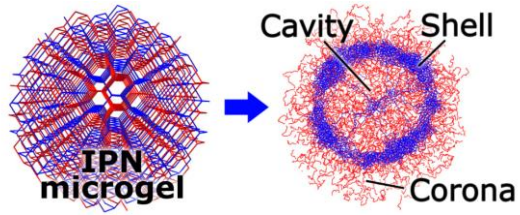




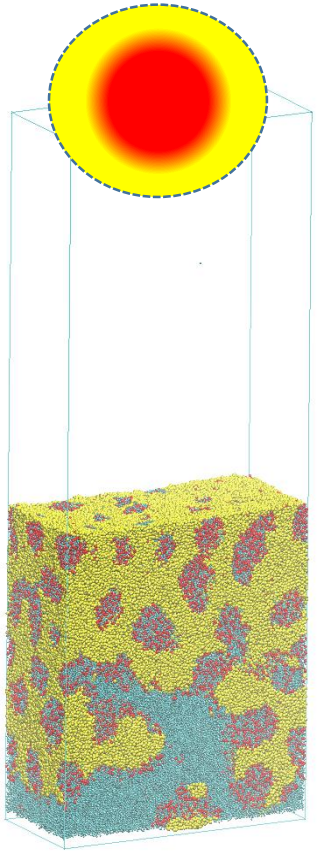


This is size-dependent effect, work only for large mesh size or small gel size

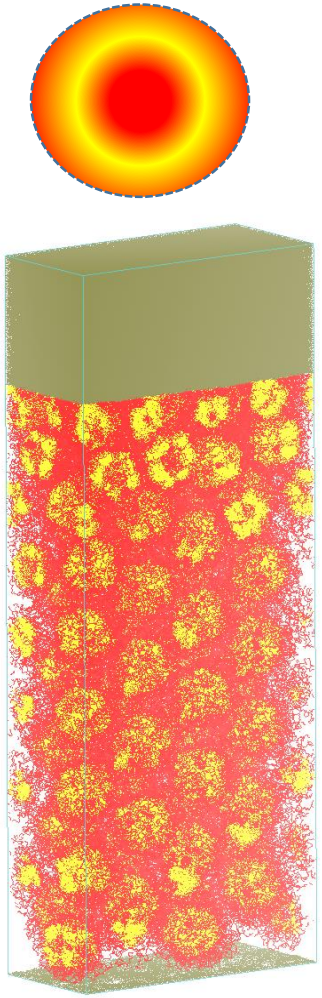
IPN Microgel as small molecules container



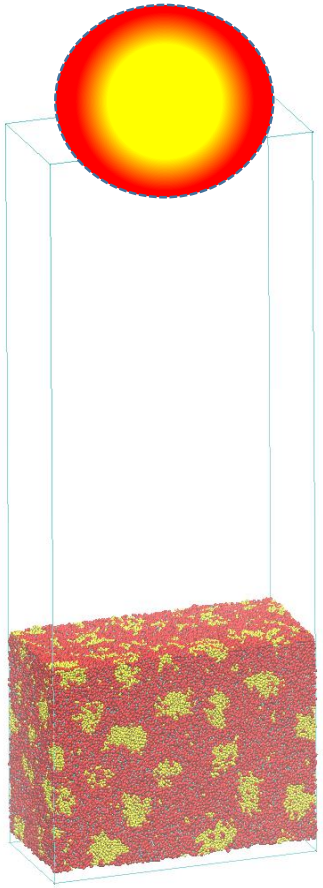
Hydrophilic core – hydrophobic shell Microgel



IPN Microgel



Hydrophobic core – hydrophilic shell Microgel



- No aggregation
- No guest molecules leakage

hydrophilic

hydrophobic

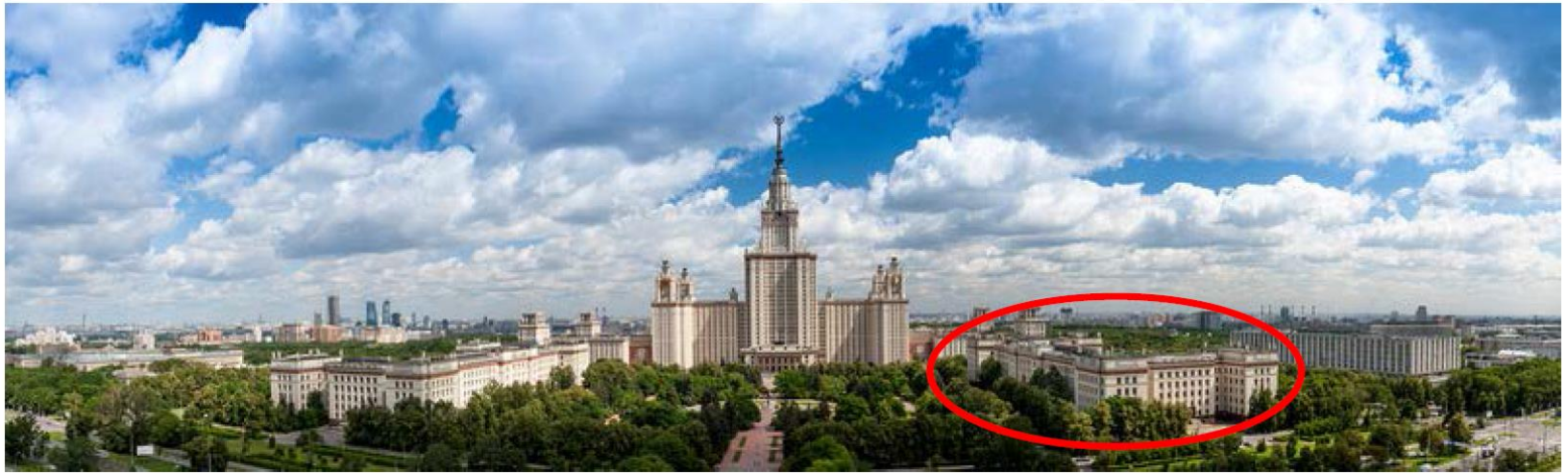
solvent

vapor

IPN microgel could be used as universal container for many different guest molecules

Acknowledgements: Alexey Gavrilov, Vladimir Rudyak, Pavel Kos

Chair of Polymer and Crystal physics @ MSU Physics Department



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