Phase Behaviour of Polyelectrolyte/Homopolymer Blends

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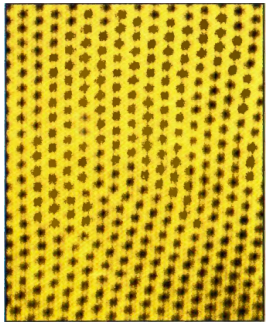
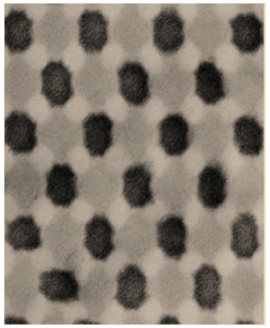
Pattern Formation In Nature:



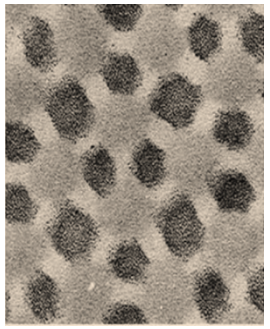
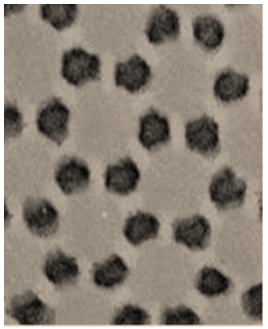

Ferrofluid

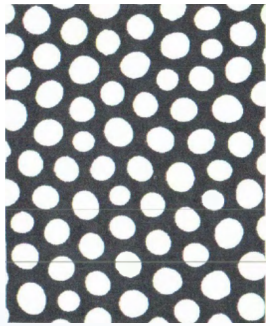



Polymers

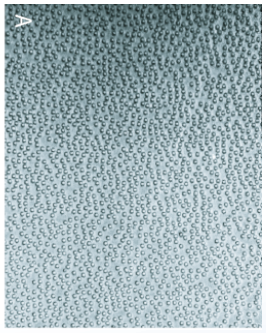
Organic Films


Polymers



Magnetic



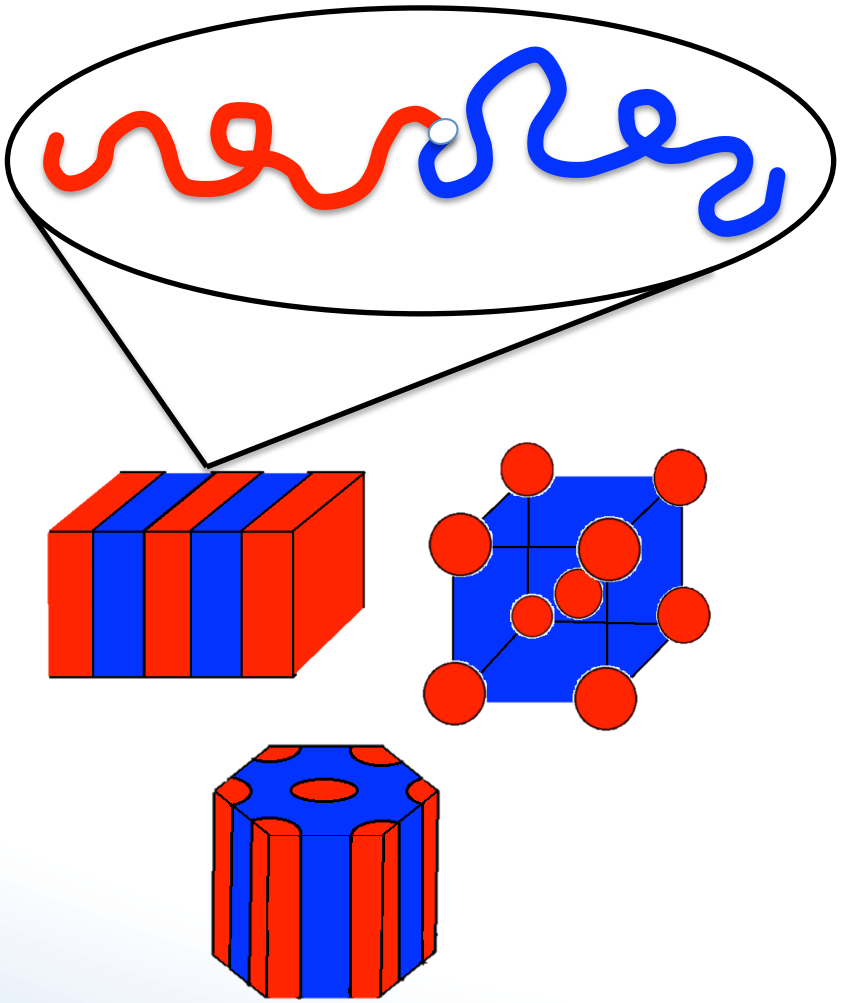
Colloids

http://physics.nyu.edu/grierlab/surface14c/

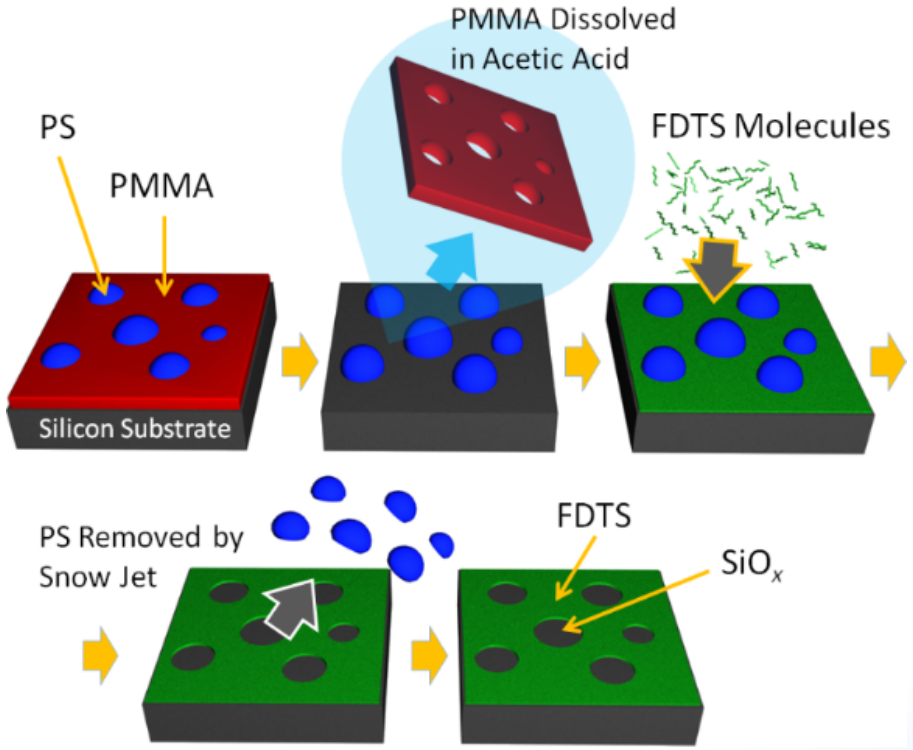
Seul, Michael, and David Andelman. "Domain shapes and patterns: the phenomenology of modulated phases." *Science* 267.5197 (1995): 476-483.

Observation of Cylinder-Based Microphase-Separated Structures from ABC Star-Shaped Terpolymers Investigated by Electron Computerized Tomography
A. Takano,*,†,‡,, S. Wada,‡, S. Sato,†, T. Araki,†, K. Hirahara,†, T. Kazama,†, S. Kawahara,†,
B. Y. Isono,†, A. Ohno,§, N. Tanaka,§ and, and Y. Matsushita‡
Macromolecules **2004** *37* (26), 9941-9946

Self-Assembly in Polymers:



Lithography



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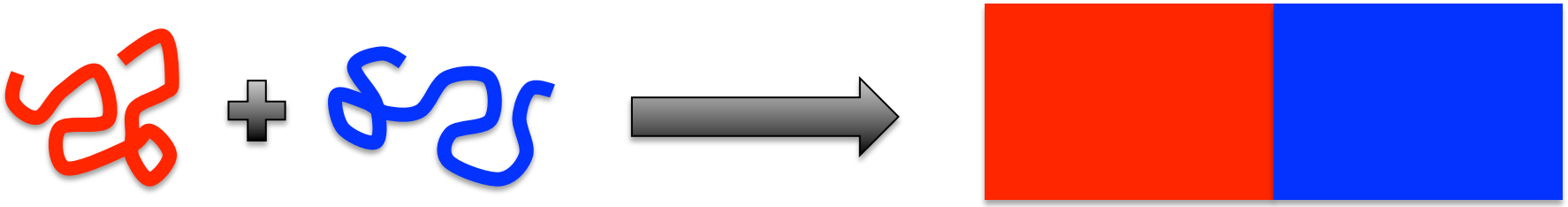
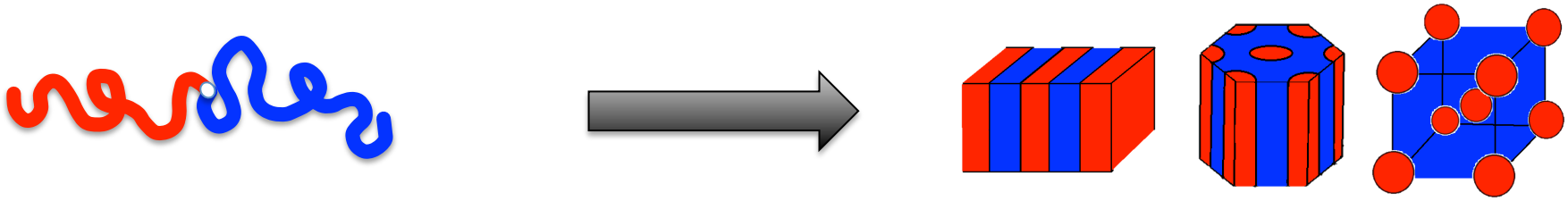
[1]Institute of Nanotechnology (INT), Karlsruhe Institute of Technology (KIT), 76021 Karlsruhe, Germany
[2]Institute of Applied Physics and Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology (KIT), 76128 Karlsruhe, Germany
[3]Joint Research Laboratory Nanomaterials Karlsruhe Institute of Technology (KIT)/Darmstadt University of Technology, 64287 Darmstadt, Germany

Introducing the Model:

Binary Blends of Homopolymers:

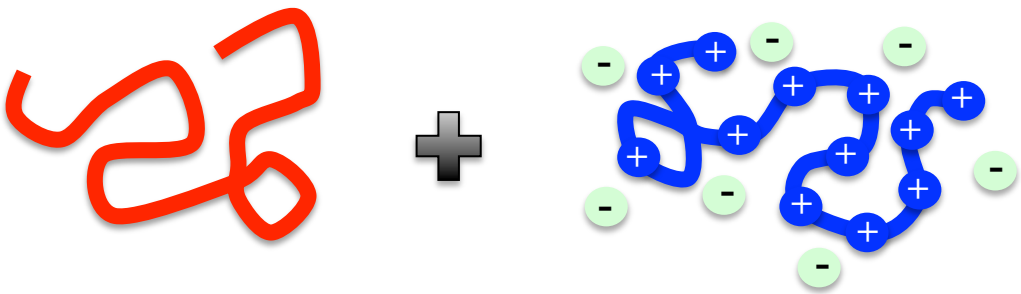


Block Copolymer Blends:



Polyelectrolyte/Homopolymer Blends:

Introducing the Model:



$$H_0 = \frac{3}{2b^2}\int_0^N ds\left[\frac{d\mathbf{R}(s)}{ds}\right]^2$$

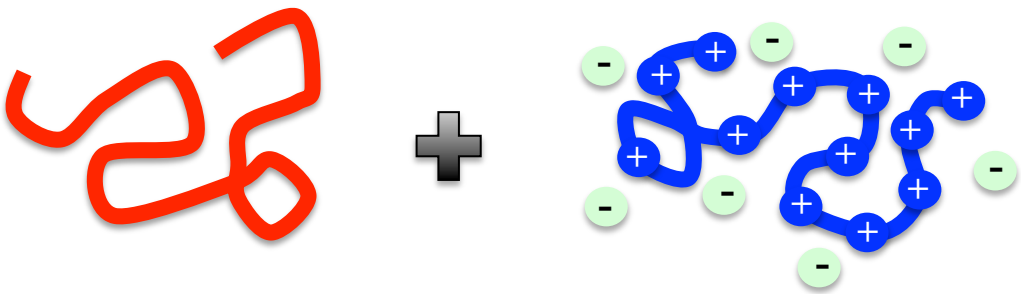
$$H_1 = \int d\mathbf{r}\chi\phi_A(\mathbf{r})\phi(\mathbf{r})$$

$$H_2 = \int d\mathbf{r}\left[\phi_e(\mathbf{r})\psi(\mathbf{r}) - \frac{\epsilon}{8\pi e^2}|\bigtriangledown\psi(\mathbf{r})|^2\right]$$

$$\frac{\partial q(\mathbf{r},s)}{\partial s} = \left[\bigtriangledown^2 - \omega(\mathbf{r})\right]q(\mathbf{r},s)$$

$$\bigtriangledown.\left[\epsilon\bigtriangledown\psi(\mathbf{r})\right] = -\phi_e(\mathbf{r})$$

Introducing the Model:



$$\phi_A(\mathbf{r}) = \frac{\bar{\phi}_A}{Q_A}\int_0^1 ds q_A(\mathbf{r},s)q_A(\mathbf{r},1-s)$$

$$\phi_C(\mathbf{r}) = \frac{\bar{\phi}_C}{Q_C\kappa}\int_0^\kappa ds q_C(\mathbf{r},s)q_C(\mathbf{r},\kappa-s)$$

$$\phi_I(\mathbf{r}) = \frac{\bar{\phi}_I}{Q_I} q_I(\mathbf{r},\frac{1}{N})$$

$$\omega_A(\mathbf{r}) = \chi_{AC}\phi_C(\mathbf{r}) + \eta + P_A\psi(\mathbf{r})$$

$$\omega_C(\mathbf{r}) = \chi_{AC}\phi_A(\mathbf{r}) + \eta$$

$$\omega_I(\mathbf{r}) = -\psi(\mathbf{r})$$

$$\nabla^2\psi(\mathbf{r}) = -\frac{N}{\epsilon}\left[P_A\phi_A(\mathbf{r}) - \phi_I(\mathbf{r})\right]$$

$$1 = \phi_A(\mathbf{r}) + \phi_C(\mathbf{r})$$

Parameters:

$\phi_A(\mathbf{r})$ $\phi_C(\mathbf{r})$

$\kappa = \frac{N_C}{N_A}$

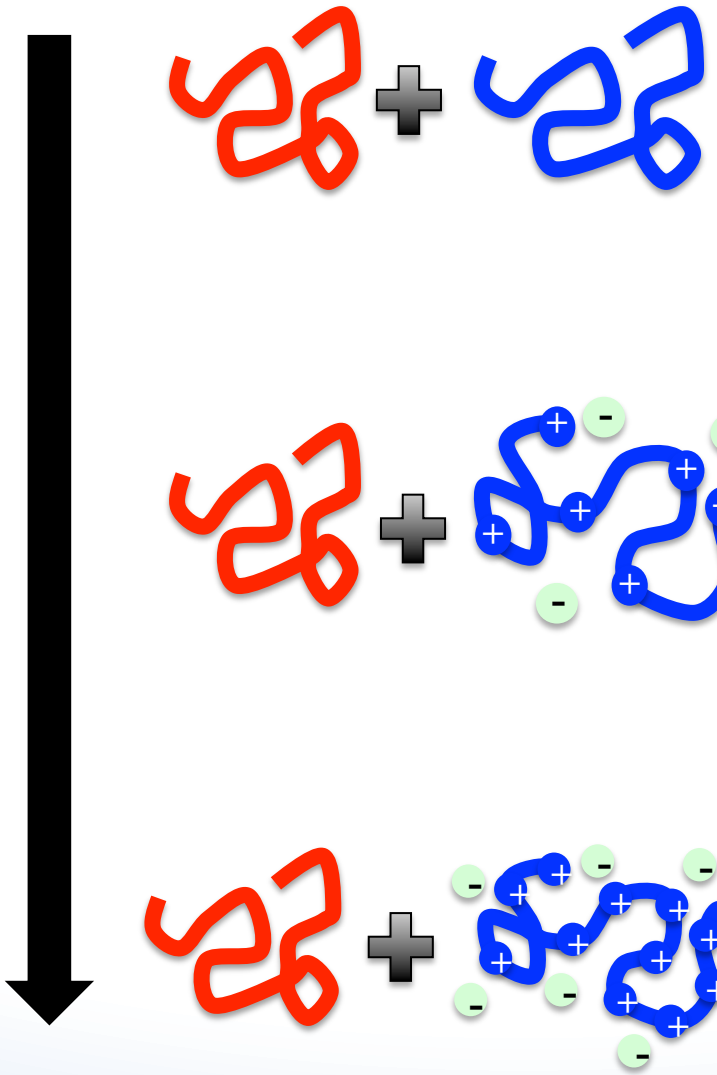
ϵ

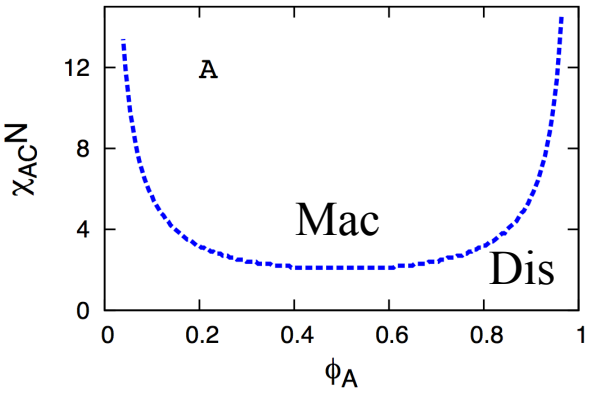
P_A

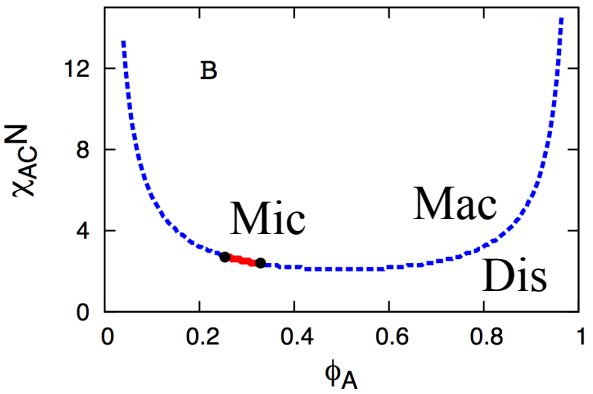
χ_{AC}

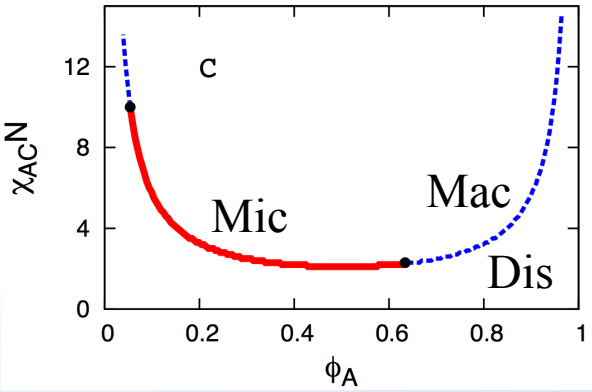
Studying the Phase Diagram Using Random Phase Approximation:

Increasing P_A

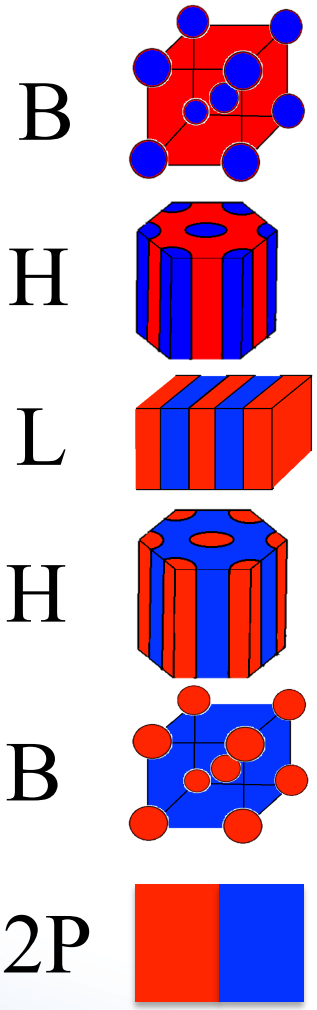


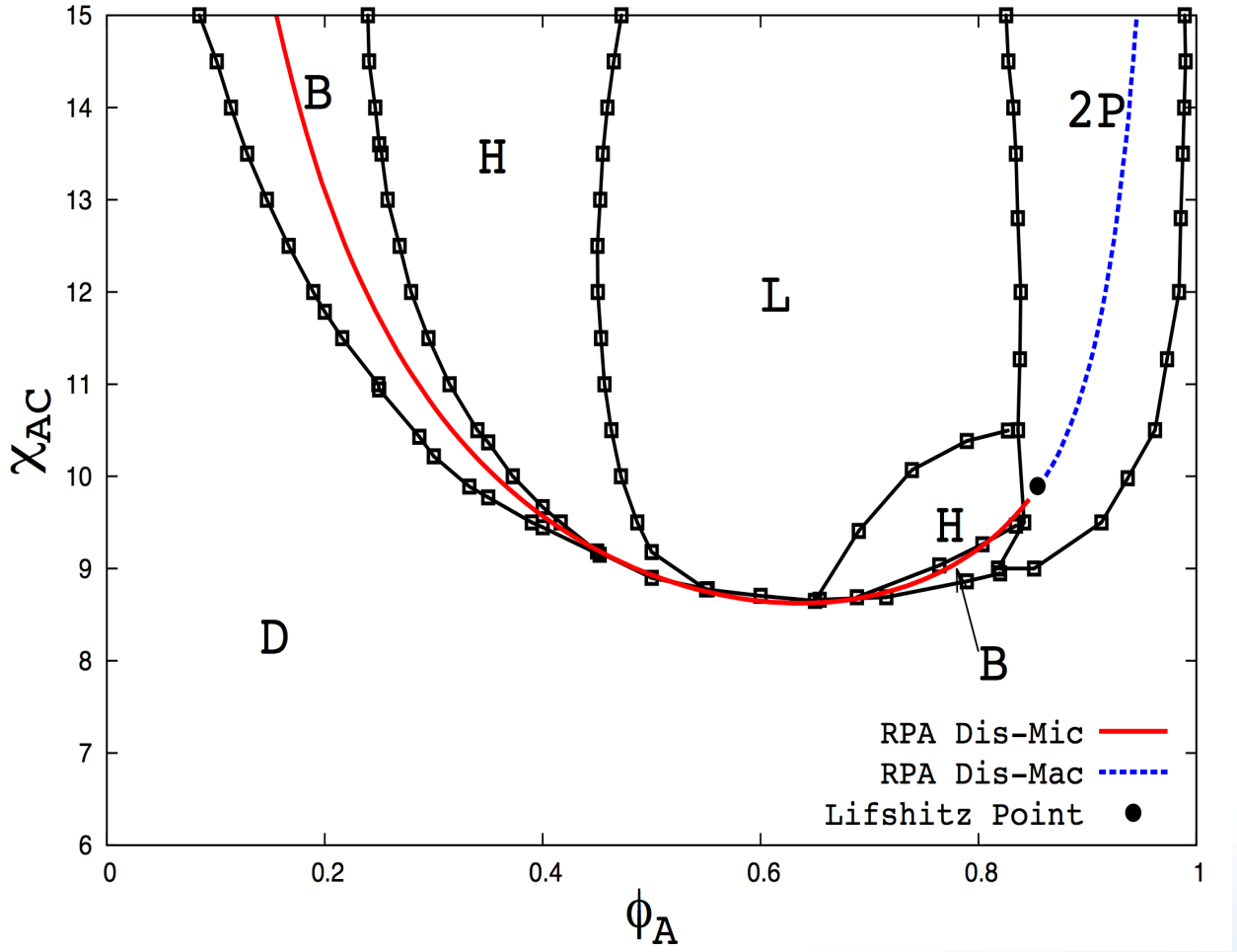






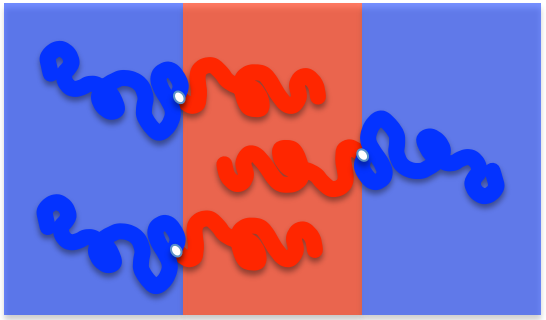
Studying the Phase Diagram Using Self-Consistent Field Theory:



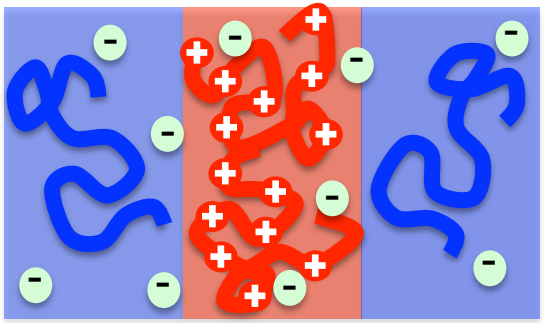


Unique Properties of The Polyelectrolyte/ Homopolymer System:

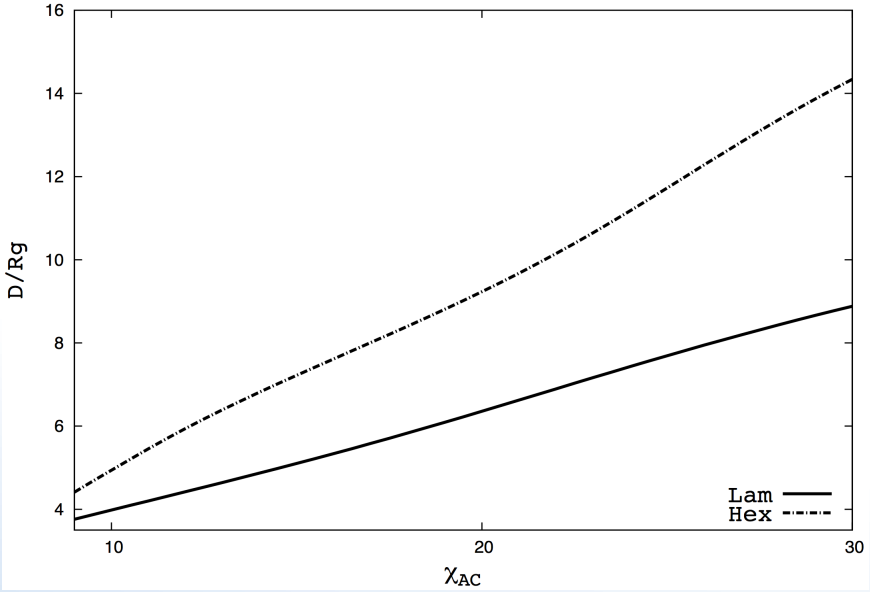
Block Copolymer Blends

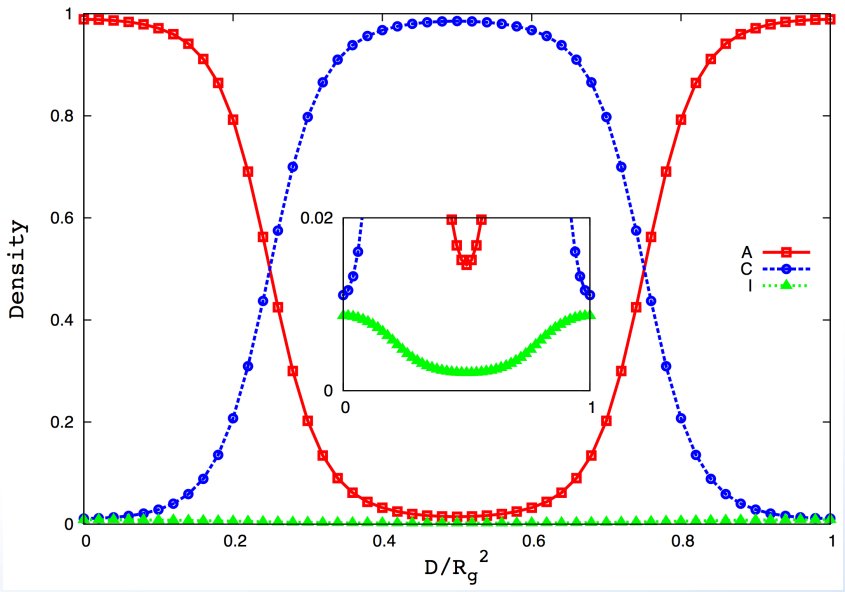


Polyelectrolyte/Homopolymer Blends



Polyelectrolyte/Homopolymer Blends





Understanding the Underlying Physics:

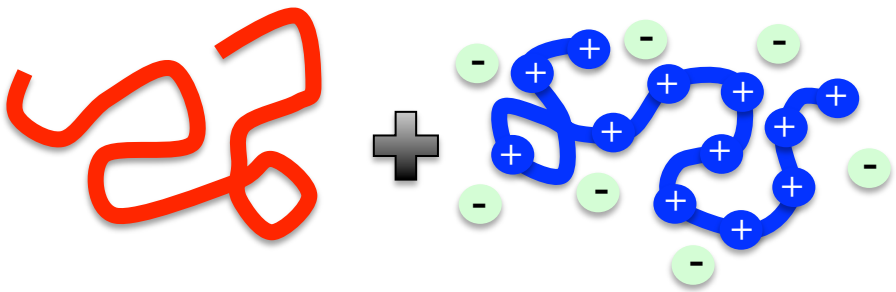
Demixing

Repulsive interaction between the A and C segments.

Electrostatic interaction between Ions and Counter-Ions.

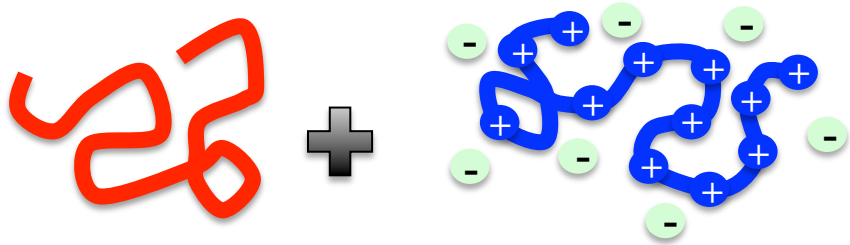
Mixing

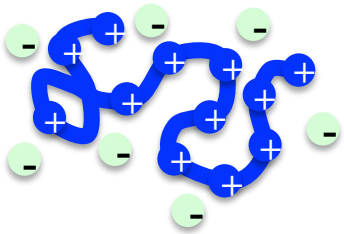
Mixing entropy of polymers and Ions.

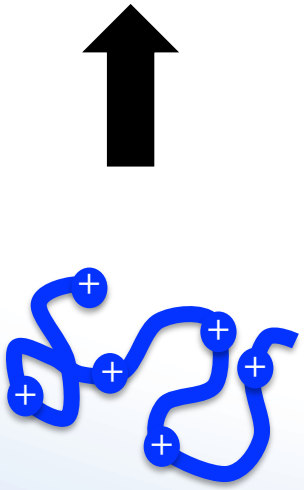


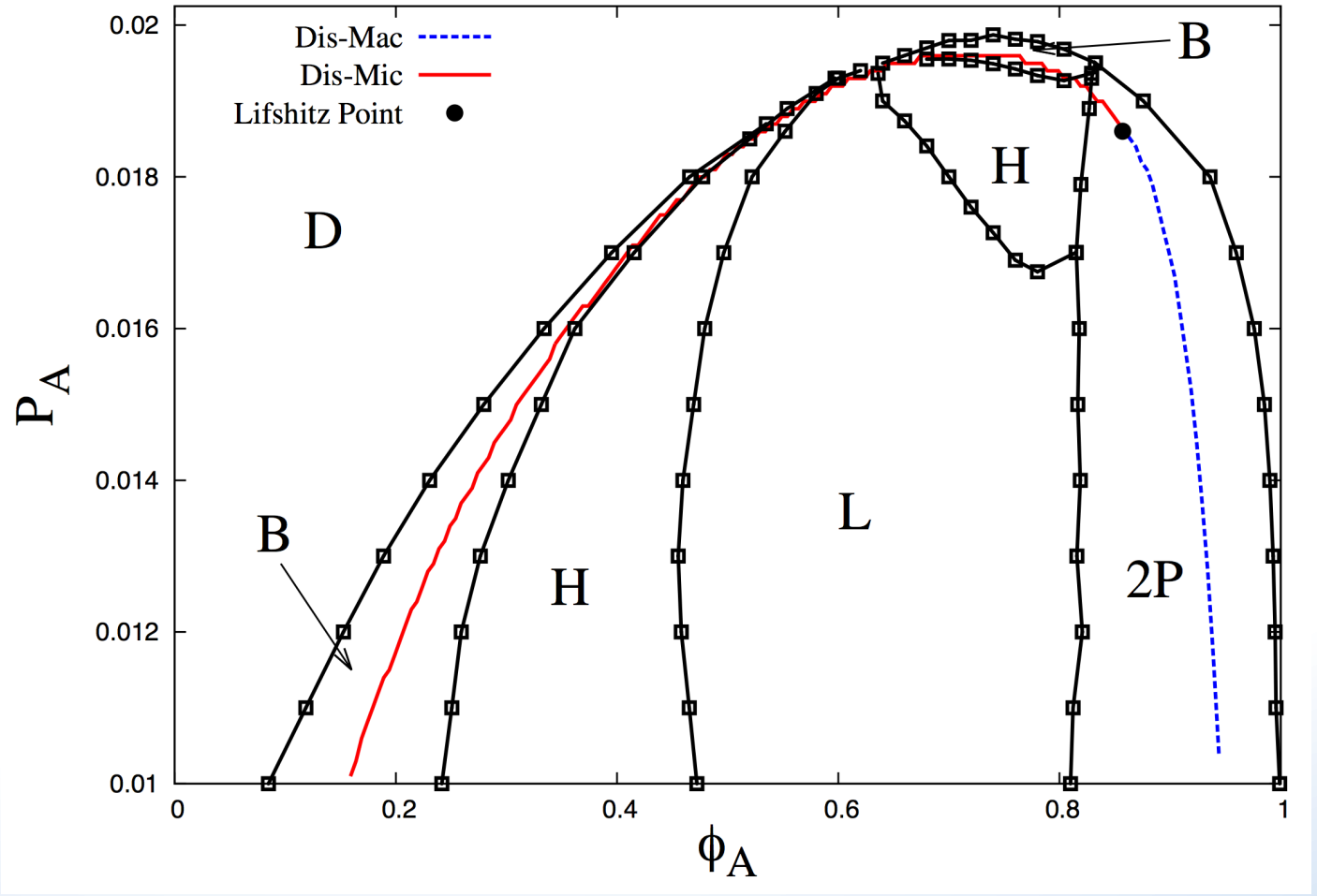
Balance between the short/long interactions and the mixing entropy.

Sensitivity of The System to Charge Density:







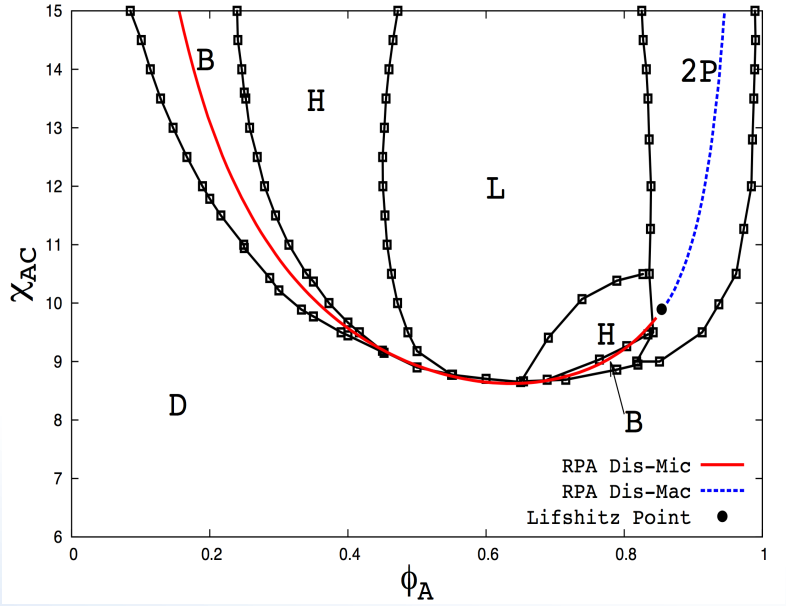


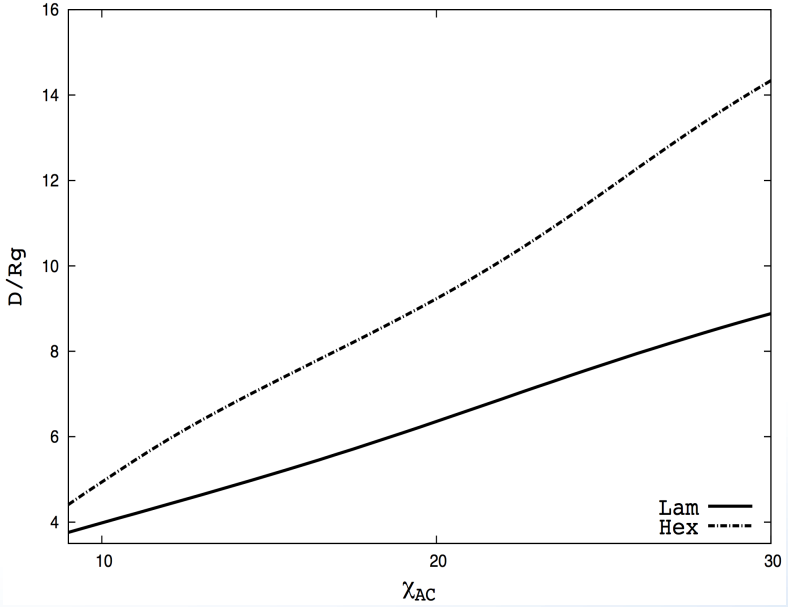
Conclusion:

1. The phase behavior of the Homopolymer/Polyelectrolyte blends includes:

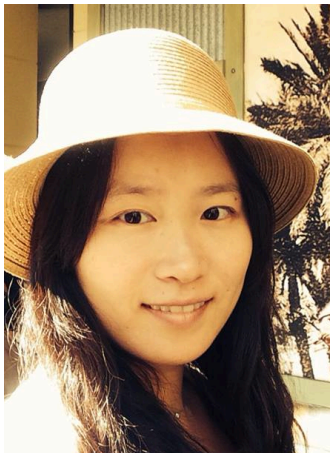
   Microphase Separation and Macrophase Separation

2. Highly tunable domain sizes.





Collaborators and Resources:



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Dr. An-Chang Shi

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