Re-entrant wetting of associating fluids

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1. Abstract

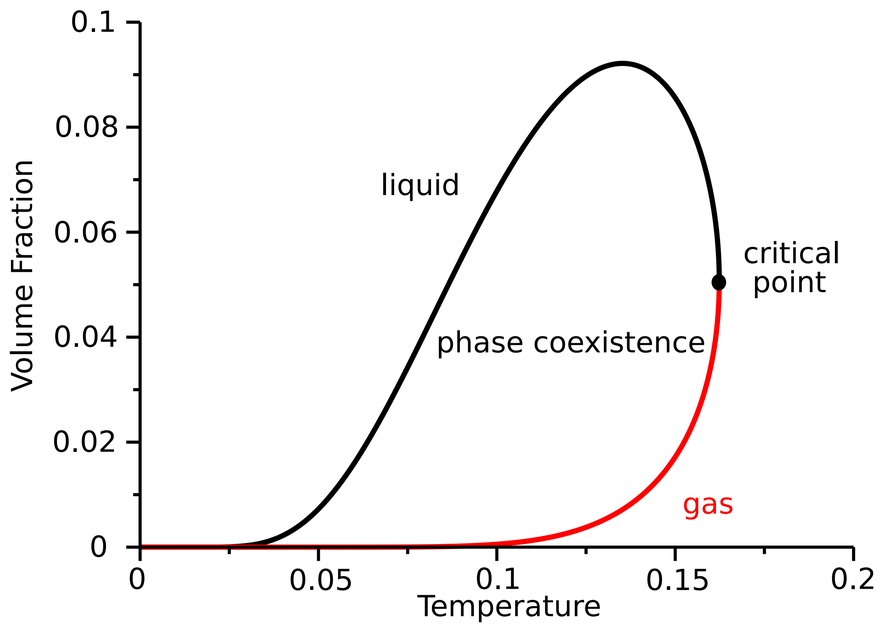
- We study the wetting properties of associating fluids.
- Associating fluids (such as patchy colloids or micro-emulsions) can have a re-entrant phase diagram.
- The re-entrance in the phase diagram leads to "funny" wetting properties.
- All the properties can be calculated with a very simple model.

2. Introduction: Associating Fluids

- Several important soft materials fall under the category of *associating fluids*.
- These associating fluids are fluids whose components can *aggregate* in larger components, such as chains. Examples include *dipolar fluids*, *micro-emulsions*, *patchy colloids*, etc [1,2].
- There is a certain *universality* of the thermodynamic behaviour of these fluids, because the thermodynamics is dominated by *chaining* and *branching* of the components.
- This universality is well captured by a simple Landau-Safran [1] free energy density:

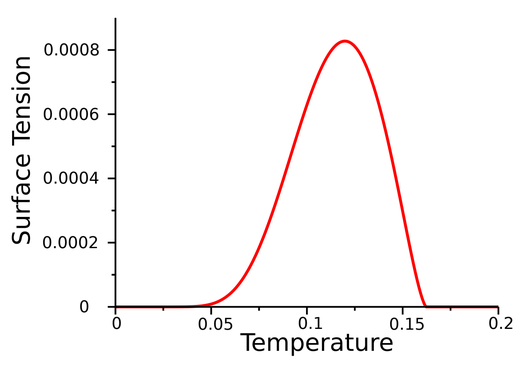
$$f = -(2\phi)^{1/2}\mathrm{e}^{-\varepsilon_1/T} - 1/3(2\phi)^{3/2}\mathrm{e}^{-\varepsilon_2/T} + 1/2\phi^2$$

- This free-energy leads to the re-entrant phase diagram below:

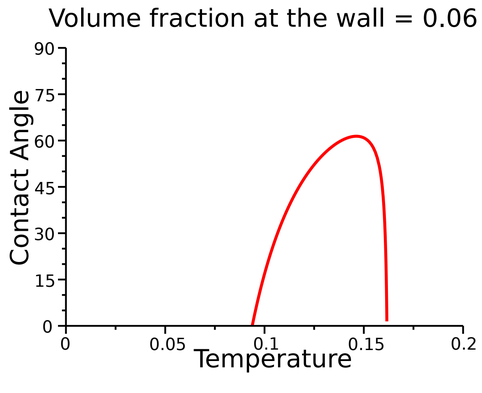


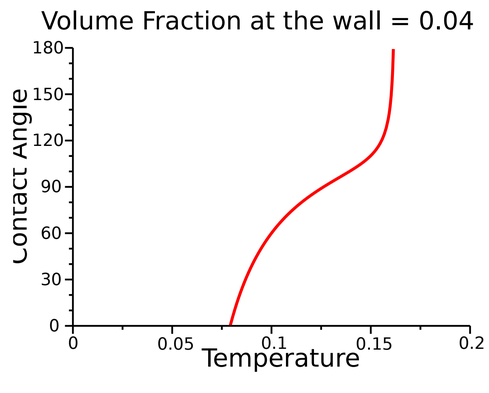
3. Surface Tension and Contact Angle

- Liquid-gas surface tension:



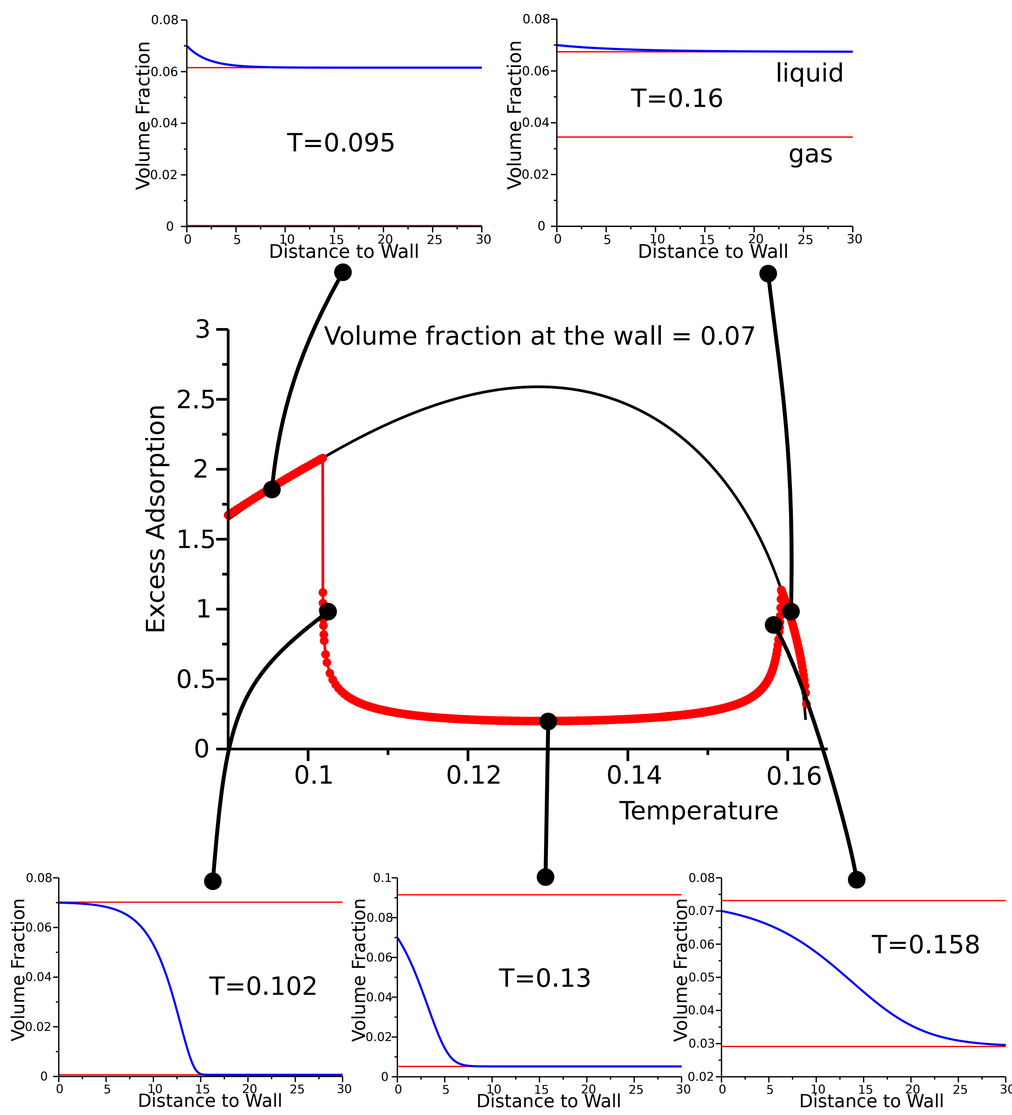
- Contact angle:





4. Adsorption and Wetting Transitions

- Two "colliding" wetting transitions:



5. Simple Minded Calculations

- All these features are captured by the World's Simplest DFT: Double-Parabola Landau Theory:

$$\Omega = \mathrm{Min}[1/2(\phi - \phi_{\mathrm{gas}})^2, 1/2(\phi - \phi_{\mathrm{liquid}})^2]$$

  with $\phi_{\mathrm{gas}} = 1$ and $\phi_{\mathrm{liquid}} = 2(1 - (T-1)^2)$.
- With this simple model we can calculate everything, at mean-field level, including surface tensions, contact angles, density profiles, and properties of the wetting transitions.
- It is a clean, pedagogical, example to learn wetting phenomena.

6. Conclusions

- Interesting interfacial properties of associating fluids due to re-entrance in the phase diagram, also observed in [3].
- Re-entrant wetting, with the "collision" of two wetting transitions.
- We can calculate all the interesting properties with the World's Simplest DFT: Double-Parabola Landau Theory.

7. References & Acknowledgements

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