Phase separation and nucleation: from frustration to control

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Ever since it was suggested that the anomalous properties of liquid water could explained by an amorphous to amorphous liquid-liquid transition, the hunt has been on for other examples of such transitions. [1] Surprisingly, only two other examples of liquid-liquid transitions were found in molecular liquids and even these are highly controversial. I will show that one of these (in *n*-butanol) is, in fact, a liquid crystal transition but one in which the liquid crystal is not "in between" the liquid and the crystal but instead frustrates the formation of the crystal. [2]

However, we are not content to passively observe phase transitions but desire to gain control over the nucleation of new phases. Although there are now numerous examples of control using laser-induced nucleation, a physical understanding is absent and preventing progress. I will show that concentration fluctuations in the neighbourhood of a liquid-liquid critical point can be harnessed by a laser-tweezing potential to induce concentration gradients. [3] A simple theoretical model shows that the stored electromagnetic energy of the laser beam produces a free-energy potential that forces phase separation or triggers the nucleation of a new phase. Experiments in a liquid mixture using a low-power laser diode confirm the effect. Phase separation and nucleation through a laser-tweezing potential explains the physics behind non-photochemical laser-induced nucleation and suggests new ways of manipulating matter.

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2 Syme, C. D., Mosses, J., González Jiménez, M., Shebanova, O., Walton, F. & Wynne, K. Frustration of crystallisation by a liquid–crystal phase. *Sci. Rep.* **7**, 42439 (2017). https://doi.org/10.1038/srep42439

3 Walton, F. & Wynne, K. Control over phase separation and nucleation using a laser-tweezing potential. *Nat. Chem.* **10**, 506-510 (2018). https://doi.org/10.1038/s41557-018-0009-8