Karlsruher Institut für Technologie

Bachelor-/Masterarbeit/ HiWi Stelle

Institut für Angewandte Materialien

Beyond Phenomenology: Reexamining the Physical Origin of the Lotus Effect

Background:

Water droplets on lotus leaves remain highly contact angle and mobility, a phenomenon known as the lotus effect. This behavior is widely reproduced in biomimetic designs by introducing surface roughness to stabilize a Cassie wetting state. However, a fundamental contradiction remains. Experimental studies show that the intrinsic surface chemistry of lotus leaves is hydrophilic, for which classical wetting theory predicts a Wenzel rather than a stable Cassie state. The persistent Cassie-like behavior observed on lotus leaves therefore cannot be explained by phenomenological roughness arguments alone and calls for a reexamination of the physical origin of the lotus effect.

Your tasks:

The main objective of this project is to use the principle of free-energy minimization to understand why a Cassie state can emerge and remain stable on hydrophilic surfaces.

Stepwise Objectives:

- Derive classical wetting theory (Cassie-Wenzel theory) from the principle of free-energy minimization.
- Develop a free-energy model for droplets on hydrophilic rough surfaces, including contributions from surface energies and interface geometries.
- Perform calculations to determine the conditions under which the Cassie state is favored.
- Analyze the role of roughness geometry in stabilizing the Cassie state.

Qualifications:

Applicants are expected to have a solid background in calculus and basic linear algebra, an interest in physics, especially thermodynamics and surface science, and a basic understanding of energy concepts. Previous programming experience, such as MATLAB, is a plus but not mandatory.

What we offer:

- Intensive support and close collaboration with experienced researchers
- Training in theoretical modeling, free-energy analysis, and scientific writing
- Collaboration with international partners
- Potential opportunity for co-authorship on a journal publication, depending on contribution

Interested?

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