Virus particles in a doughnut-shaped chamber form fixed patterns

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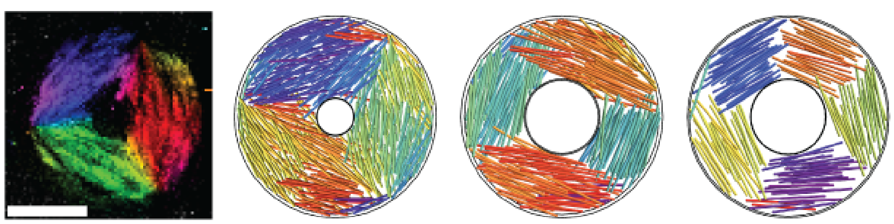

Patterns of virus particles enclosed in doughnut-shaped micro-chambers. Far left: processed microscope image in which the directions of the particles are shown as colors. This reveals a threefold symmetrical pattern. Next to this, 'snaphots' of computer simulations are shown, which show that when the innermost hole of the doughnut increases in size, first of all three domains are formed and after that increasingly more. Credit: Fundamental Research on Matter (FOM)

Large biomolecules in a small space spontaneously form symmetrical patterns. Researchers from FOM institute AMOLF discovered this together with colleagues from Oxford and Jülich when they confined rod-shaped virus particles in doughnut-shaped micro-chambers. What started as a chance discovery has opened up a whole new area in the physics of ultrasmall liquid crystal cells with potential applications in new displays. The results of the research will be published on June 29 2016, in *Nature Communications*.

"Biology is our main source of inspiration. In this case we wanted to understand how cytoskeleton polymers, which give biological cells their stiffness, are influenced by the spatial boundaries within the cell," says AMOLF group leader professor Bela Mulder. Experiments in the group of his colleague professor Gijsje Koenderink revealed that interesting patterns arise if the semi-flexible polymer actin is confined in square micro-chambers on a chip.

Model system

Via colleagues from Oxford and Jülich the AMOLF researchers were given the perfect model system to further investigate these patterns: rod-shaped, stiff virus particles of equal length. Mulder and Koenderink investigated the behavior of these virus particles in a small chamber. They did this 'virtually', via computer simulations of the thermal movement of rods confined in a small chamber, and in the lab, where rod-shaped virus particles were enclosed in micro-chambers on the surface of a glass plate.

Mulder: "In disc-shaped chambers with a hole—a sort of doughnut—surprising patterns arose, namely multiple symmetrically positioned domains of aligned rods. The simulations revealed that depending on the size of the hole, three or more domains are formed. And in the experiments we could see the threefold symmetrical version of this pattern as well."

New physics

This research shows that the behaviour of colloidal liquid crystals strongly changes if the individual particles 'know' the size of the space they are confined in. Virus particles have a far greater length (about one micrometer) than the particles normally investigated in liquid-crystal physics. "This is new physics, inspired and facilitated by biology," says Mulder. "Interesting applications come to mind. For instance, we can study how these small chambers scatter the light. This information can then inspire us to design a new type of 'building blocks' that can be used to make improved displays."

Theoretician in the lab

That Mulder and Koenderink focused their research on doughnut-shaped micro-chambers is pure serendipity. To stay involved in the scientific 'hands-on work' all AMOLF group leaders had to spend a day in the lab, which is hardly an everyday activity for theoretician Mulder. Together with an experimental colleague he examined a chip with thousands of microchambers under the microscope. These chambers were filled with a solution of actin filaments. Even the letters and numbers etched in the chip as hallmarks behaved as micro-chambers. "And it was exactly there that we observed the most interesting patterns," says Mulder. "That is how we hit on the idea of studying the behaviour in a doughnut-shaped microchamber - inspired by the letter O - in more detail."

More information: Finite particle size drives defect-mediated domain structures in strongly confined colloidal liquid crystals, Ioana C. Gârlea ,

Pieter Mulder , José Alvarado , Oliver Dammone, Dirk G. A. L. Aarts, M. Pavlik Lettinga, Gijsje H. Koenderink, Bela M. Mulder, *Nature Communications* (2016). [DOI: 10.1038/NCOMMS12112](https://doi.org/10.1038/NCOMMS12112)

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