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New method to measure Entropy production on the Nanoscale

Entropy, the amount of molecular disorder, is produced in several systems but cannot be measured directly. Entropy is a measure of irreversibility and disorder and is central in thermodynamics. Two centuries ago, it was part of a conceptual breakthrough, building the theoretical framework for machines, fundamental for the industrial revolution. Today, we are seeing advances in new areas of nano and quantum devices, but still, entropy is a pivotal concept.

An equation developed by researchers at Chalmers University of Technology in Sweden, and Heinrich Heine University Düsseldorf, now sheds new light on how entropy is produced on a very short time scale in laser excited materials. "New computational models give us new research opportunities. Extending thermodynamics for ultrashort excitations will provide novel insights into how materials function on the nanoscale," says Matthias Geilhufe, Assistant Professor at the Department of Physics at Chalmers University of Technology. "A system usually wants to evolve to a state with large disorder, i.e. maximum entropy. It can be compared to a sugar cube dissolving in a glass. While the sugar dissolves, the system composed of water and sugar slowly increases its entropy. The reverse process—a spontaneous formation of a sugar cube—is never observed," says Matthias Geilhufe.

A computational model for entropy

"If we turn to how entropy is formed in devices, they all need to be turned on and off, or need to move something from A to B. As a consequence, entropy is produced. In some cases, we would like to minimize the entropy production, for example to avoid information loss," says Matthias Geilhufe. While entropy has become a well-established concept, it cannot be measured directly. However, Matthias Geilhufe together with researchers Lorenzo Caprini and Hartmut Löwen at Heinrich Heine University Düsseldorf, have developed a computational model to measure entropy production on a very short time scale in laser excited crystalline materials. (Source: Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-023-44277-w)