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The origin of irreversibility in thermodynamic processes – or is 'memory' a new parameter for the physical state of matter?

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ABSTRACT

Most elementary theories describing processes of matter, like Newtonian dynamics and quantum mechanics, are symmetric with respect to time-reversal, but thermodynamics is not and describes processes that come to rest at equilibrium. A long-standing dispute is represented by the question: "How can microscopic equations of motion that are symmetric to time reversal give rise to macroscopic behaviour that clearly does not share this symmetry?" The answer is commonly sought in size, with small systems being time-reversible and large systems not.

It turns out that this is not correct. Time-reversibility and thermodynamic reversibility are two different issues. Thermodynamic equilibria are well-defined in terms of entropy or free energy and are reached in processes described by the "arrow of time". But the process of equilibration can be either reversible or irreversible with respect to time, independent of the system size.

There is a second criterion, the system's memory of a previous state, which does not contribute to thermodynamic parameters.

Time-reversible processes are deterministic, and if the past is understood, the future can be predicted. What destroys time-reversibility are non-Newtonian processes, mostly of probabilistic nature, like the decay of excited states.

BIOGRAPHY

Retired Chair of Physical Chemistry, University of Stuttgart, and Retired Extraordinary Professor, Chemistry Department, University of Pretoria Emil Roduner has worked in various fields of physical chemistry, with a focus on muonium chemistry, proton conductivity and degradation of polymer electrolyte fuel cells, nanomaterials, elementary steps of catalysis in transition metal doped zeolites and electrocatalytic conversion of CO_2 to liquid solar fuels.

A more recent focus is on selected long-standing problems of the description of matter and processes.

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