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NOVEL THERMODYNAMIC CONCEPTS FOR NUCLEATION PROCESSES

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Nucleation is one of the basic processes involved in phase transitions like crystallization, describing the first occurrence of entities able to grow. For a better understanding of this process, which usually starts at a nanoscopic scale, one has to introduce novel thermodynamic properties in terms of the only four basic geometrical characteristics in a two-phase system. These are the four so-called Minkowski functionals, which are: volume, interfacial area, mean curvature integral over the interfacial area and the Euler-Poincaré characteristics. The latter two quantities, although introduced already in the early 19th century, have been mainly ignored so far in natural and technical sciences. The simple assumption of linear coefficients for the work differential in terms of the differential change of the four Minkowski functionals leads (in addition to pressure and interfacial energy) to two novel energetic properties: edge force and item energy. They dominate the behaviour at structural scales in the nm range. For example, the classical Young-Laplace equation stating the proportionality of the pressure jump across an interface and the mean curvature of the interface (with twice the interfacial tension as proportionality constant) has to be extended by a second term proportional to the Gaussian curvature of the interface with the edge force as proportionality constant. As a consequence, one has in polymer melts already at temperatures above the thermodynamic melting temperature stable clusters which, however, are unable to grow. At quick cooling one finds a simple relationship for the well-known temperature of homogenous nucleation in terms of the edge force.

Recent Publications:

1. G Eder and H Janeschitz Kriegl (1997) Structure development during processing: crystallization In Materials Science and Technology. Wiley VCH. 18:269-342.
2. H Janeschitz Kriegl, G Eder, M Stadlbauer and E Ratajski (2005) A thermodynamic frame for the kinetics of polymer crystallization under processing conditions. Chem. Monthly. 136(7):1119-1137.
3. P Hierzenberger, E Leiss Holzinger, B Heise, D Stifter and G Eder (2014) *In-Situ* Optical coherence tomography for the time-resolved investigation of crystallization processes in polymers. Macromolecules. 47(6):2072-2079.
4. G Eder (2018) The role of Minkowski functionals in the thermodynamics of two-phase systems. AIP Advances. 8(1). Doi:10.1063/1.5017592.

Biography

Gerhard Eder is a Professor at the Institute of Polymer Science, Johannes Kepler University Linz, Austria. He got Diploma in Mathematics and Physics in 1982 and 1983 and finished his PhD in 1989 with a thesis on rheology of polymer melts. In 1989/90 he was Research Scientist at the Philips Natuurkundig Laboratorium in Eindhoven, Netherlands. Since 1997 he is an Associate Professor at Johannes Kepler University. In 2002, he was Visiting Professor in Yamagata University, Japan. He gave more than 20 invited lectures at international conferences. In 2013 he received the Hermann Mark Medal for his work on polymer characterization. His research interests are focused on structure development of polymers under extreme conditions as present in usual processing, a field which is situated between and strongly interacting with the classical transport phenomena: heat transfer, flow dynamics and mass diffusion. During the last few years his interest widened towards thermodynamics of phase transitions and kinetic modelling.

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