Electric-field induced criticality in dispersions of very long and thin, charged rods

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Various phases and dynamical states can be induced by an alternating electric field, depending on the field amplitude and frequency (see Fig.1, where also depolarized images are shown of the various states). Of special interest here are the dynamical states Ds and Df ("s" stands for "slow, "f" for "fast"), where nematic domains melt and reform. There is a point (encircled in Fig.1) where several transition lines meet. This point has been shown to be a non-equilibrium critical point, in the sense that there is a time- and a length scale which both diverge on approach of that point. The time scale here is the characteristic time on which nematic domains melt and reform, and the length scale is the size of the nematic domains. The characteristic time on which domains melt and form is measured by "an image-time correlation technique". Here, a time series of depolarized CCD images is recorded (see Fig.2) , from which a time-image intensity correlation function is constructed by averaging over all CCD-pixels. These correlation functions can be accurately fitted with a single stretched exponential (see the solid lines in Fig.2b), where the time-constant in the fitting function quantifies how fast melting and forming of domains occurs. Critical exponents are determined, of which Fig.3 is an example of typical experimental data. Results for values of critical exponents are given in Fig.4.critical. There are power-law and logarithmic divergences, and also off-critical divergence of the time-scale is observed.

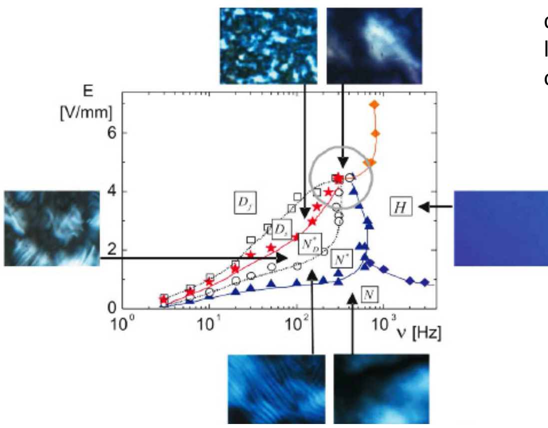


Fig.1: The phase/state diagram. The various phases/states are: N: coexistence of isotropic and nematic, N: field-induced chiral-nematic phase, Nd*: disconnected chiral nematic phase, Ds : slow dynamical state, Df : fast, dynamical state, H : homeotropic phase at high frequency.*

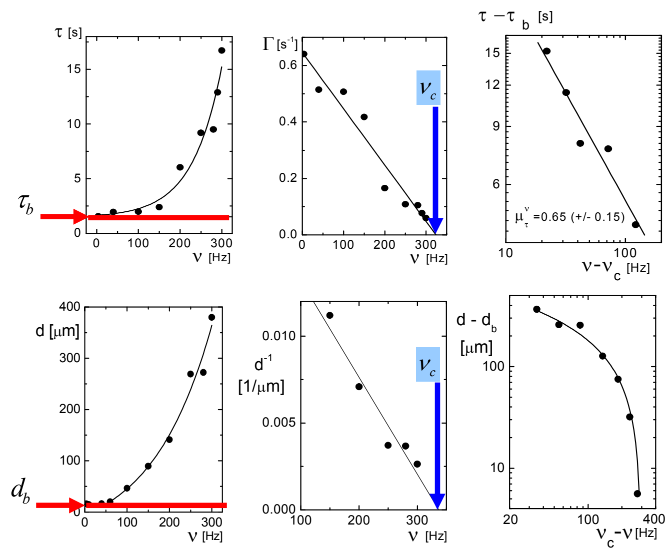
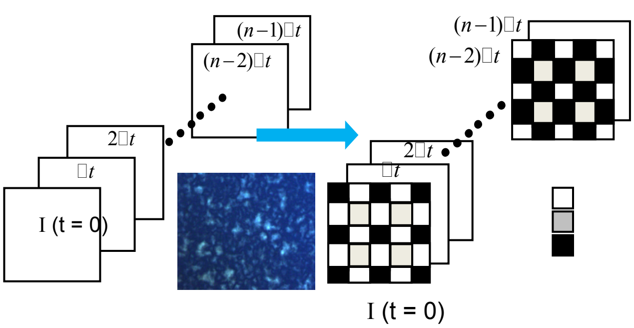


Fig.3: The determination of critical exponents from measured melting/forming times and domain sizes. The red arrows indicate non-critical contributions.



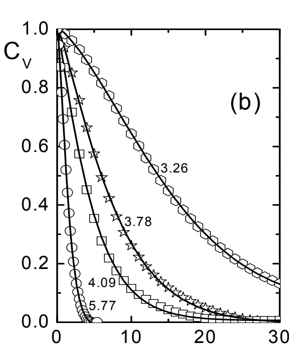


Fig.2: Upper panel: the principle of image-time correlation. A time series of CCD-images is recorded, after from which intensity-correlation functions are constructued (similar of what is done with scattered intensities in dynamic light scattering). Left panel (b): examples of correlation functions for various electric field strengths (as indicated in V/mm), together with fits to a stretched exponential.

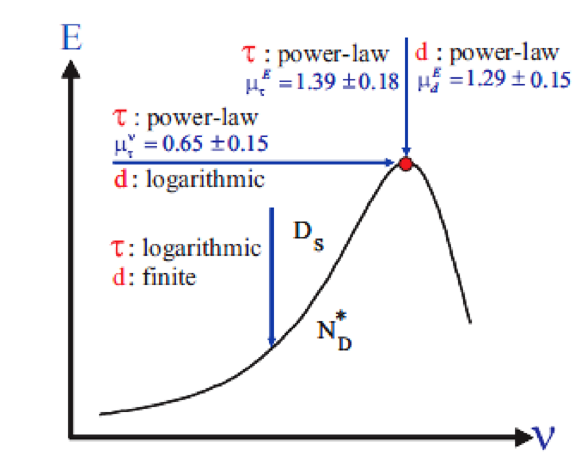


Fig.4: A summary of the critical exponents for the characteristic time of melting and forming of nematic domains and the domain size.