Image-time Correlation Spectroscopy: Dynamical Events of Images

Image-time correlation spectroscopy is used to characterize the dynamics of structures of a size that permits to record spatially resolved microscopy images. The time-resolution ranges from about 0.1 seconds to many hours. Examples where we are using the technique are, the dynamics of (chiral-) nematic texture from depolarized images, the dynamics of an electric field induced dynamical state where nematic domains melt and form, and the dynamics of colloidal particles that form strings under the influence of an electric field. The idea behind this technique is as follows. A time series of images is recorded with (for example) a CCD camera (see Fig.1). An **image-time correlation function** $C_V(t)$ is constructed from these images, which is defined as,

$$C_V(t) = \frac{\left\langle \left(I(t) - \langle I(t)\rangle\right)\left(I(0) - \langle I(0)\rangle\right)\right\rangle}{\left\langle \left(I(0) - \langle I(0)\rangle\right)^2\right\rangle}$$

where *I(t)* is the intensity of a single pixel at time *t*, and where the brackets denote averaging over all pixels of the CCD camera.

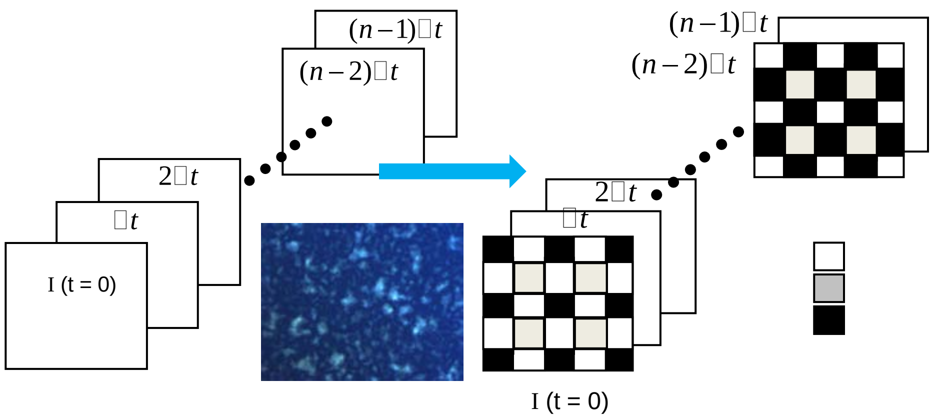
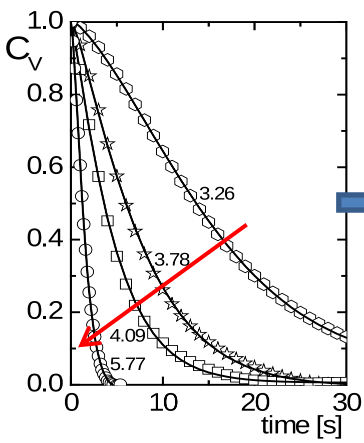


Fig.1 The principle of the image-time correlation technique. CCD-camera images are converted to grey-values, from which a correlation function is constructed. The image that is shown here, is an image of a dynamical state where nematic domains (the white areas) melt and form.

Examples of such correlation functions for an electric-field induced dynamical state in dispersions of fd-virus particles, where nematic domains melt and form, is given in Fig.2, for various electric field strengths (as indicated in the left panel). For increasing field amplitudes the melting and forming of domains becomes faster. In this case the correlation functions can be fitted with a stretched exponential (see Fig.2), where the time constant τ is a measure for how fast melting and forming occurs. Using this technique we identified a critical point in the non-equilibrium phase diagram where the characteristic time diverges.



$$F(t) = B + A\exp\left\{-\left(\frac{t}{\tau}\right)^{\beta}\right\}$$

Fitting function for dynamical images (events)

Fig.2 Left: Image-time correlation functions for the process where melting and forming of nematic domains in fd-virus suspensions is induced by the application of an electric field. The number are the electric field strength in V/mm. Right: The fitting function of the correlation functions, where the time constant τ characterizes how fast melting and forming of domains occurs. The solid lines in the left panel are the fitting results.

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