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ERBECK-MERZKIRCH INTEGRAL TRANSFORM FOR TURBULENT MICROSTRUCTURE ANALYSIS

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ABSTRACT: In addition to the velocity distribution, combustion and/or mixing processes are characterized by the distribution of the scalar quantities like temperature, density or concentration [1]. The turbulence of the scalar field is superimposed to the turbulent velocity field. While particle image velocimetry provides information about the velocity fields [2], the line-of-sight speckle technique can be used for quantitative measurements of the instantaneous density (temperature) fields in flows. A light beam passing through the test field is disturbed due to the inhomogeneous distribution of the refractive index in the flowing fluid. Speckle photography method is sensitive to the light deflection from its original direction. The line-of-sight speckle photography is very advantageous for quantitative determining of refractive index fields in turbulent flows [3]. The aim of the experiments presented herein is to investigate the changes of statistics of turbulence in the gas flow downstream of a turbulence grid caused by high heating rate due to interaction with a shock wave.

Fig.1. contains images of nanostructures under study. Such conditions are typical for the generation of the speckle pattern in diffusely scattered light, when multiscattering processes should be taken into account. The microstructural changes in the investigated samples were diagnosed by their probing with a narrow laser beam. A speckle field was generated directly in the sample being investigated as a result of the three-dimensional interference of the multiply scattered coherent radiation and projected by the imaging optical system on a high-resolution CCD matrix in much the same way as in micro-PIV diagnostics of microfluidics devises. Using relations between density gradients and deflection angles, Erbeck and Merzkirch has formulated a connection between 3D density and 2D deflection angle correlations. For isotropic turbulence the 3D density correlation function can be expressed through the deflection angle correlation functions in the following form:

$$R_\rho(r) = \frac{1}{\pi L_1 K^2} \int_r^\infty \frac{1}{\sqrt{\tau^2 - r^2}} \left\{ \int_0^\tau R_{\varepsilon q\|}\left(\tau^*\right) d\tau^* \right\} d\tau \tag{1}$$

and

$$R_\rho(r) = \frac{1}{\pi L_1 K^2} \int_r^\infty \frac{\tau}{\sqrt{\tau^2 - r^2}} R_{\varepsilon q\perp}(\tau) d\tau \tag{2}$$

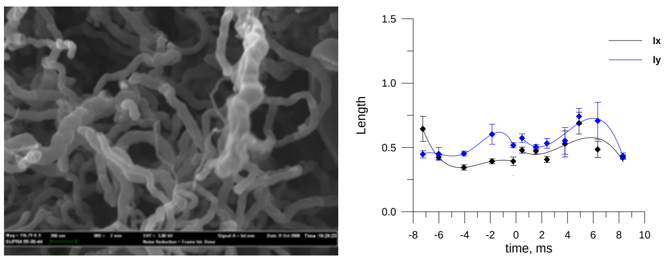

Fig. 1 Examples of nanostructures under monitoring and correlation microscales, reconstructed by statistical specklegram analysis