

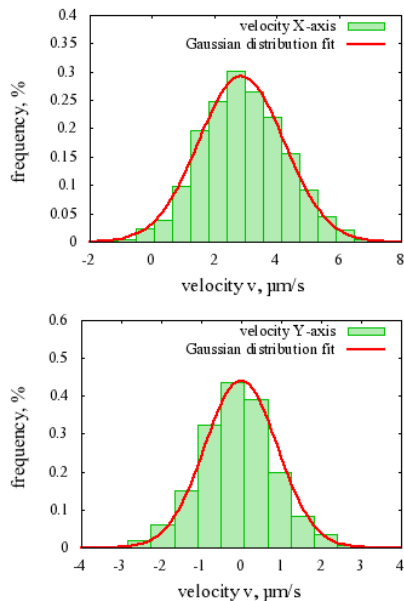
Thermal fluctuation effects in magnetophoresis of superparamagnetic microbeads

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Magnetic nanoparticles embedded in a suitable matrix are widely used in biomedicine in form of superparamagnetic beads. Here by using micro-PIV technique (Dantec) we investigate the properties of these microbeads by observation their thermal fluctuations at magnetophoresis in the nonuniform magnetic field of the permanent magnet. Our method is based on measuring the conditional probability $P(\Delta x, \Delta y; \Delta t)$ of the particle displacement $(\Delta x, \Delta y)$ in the plane of observation under the action of constant force $(m\partial B/\partial x, 0)$ (α - hydrodynamic drag coefficient):

$$P(\Delta x, \Delta y; \Delta t) = \frac{1}{(2\sqrt{\pi D\Delta t})^2} \exp(-((\Delta x - \alpha^{-1}m\partial B/\partial x\Delta t)^2 + \Delta y^2)/4D\Delta t) \quad (1)$$



which by $\Delta x = v_x\Delta t; \Delta y = v_y\Delta t$ we transform to the distribution function for the average velocity in the time interval Δt . Series of images separated by time interval Δt for diluted ensemble of microbeads are registered by micro-PIV and processed by ImageJ to get the data of the particle positions. Average velocity distributions are calculated and fitted by the Gaussian (1). The magnetic moment of the particles is determined from the magnetization curves of the diluted sample given by vibrating sample magnetometer. The results at particular value $\partial B/\partial x = 4.3 T/m$ for $1.31 \mu m$ beads are displayed in form of histograms for v_x and v_y . The data for different beads and field gradients are summarized in Table 1.

Table 1: Summary of results

Axis	Magnetic field gradient, $\partial B/\partial x$ (T/m)	Diffusion const., D ($\mu m^2/s$)	Estimated D_E ($\mu m^2/s$)	Mean velocity, v ($\mu m/s$)	Estimated v_E ($\mu m/s$)
Streptavidin Masterbeads from Ademtech, 500 nm					
x	0.0	1.09	0.86	-	-
y		1.04		-	-
x	3.6	3.61		5.3	2.2
y		1.52		-	-
Streptavidin coated magnetic particles from Spherotech, 1.31 μm					
x	0.0	0.45	0.33	-	-
y		0.46		-	-
x	3.6	0.38		2.2	5.4
y		0.23		-	-
x	4.3	0.47		2.9	6.9
y		0.20		-	-