Scalable high-throughput microfluidic separation of magnetic microparticles - Simulation parameters and reduced units

For the simulations, we use reduced units. The basic units are

- length: diameter σ

- energy: kT

- diffusion coefficient: $D = kT/(3\pi\eta\sigma)$

- Magnitude of the colloids' magnetic moment: m_0

Calculations of the units:

- $\sigma = 10\,\mu\text{m}$

- $kT = 1.38064852 \times 10^{-23}\,\text{J/K} \cdot 293.15\,\text{K} = 4.04737114 \times 10^{-21}\,\text{J}$

- $D = kT/(3\pi\eta\sigma) = 4.04737114 \times 10^{-21}\,\text{J}/(3\pi \cdot 10^{-3}\,\text{Pa s} \cdot 10^{-5}\,\text{m}) = 4.29439415 \times 10^{-14}\,\text{m}^2/\text{s}$

- $\tau_D = \sigma^2/D = 2328.61718\,\text{s}$

- $m_0 = \dfrac{M_\rho(80\text{kA/m})\cdot\rho\cdot V^{\text{col}}}{80\text{kA/m}} \cdot H = \dfrac{1.8\,\text{Am}^2/\text{kg}\cdot 1100\text{kg/m}^3\cdot(4/3)\pi\left(5\times 10^{-6}\,\text{m}\right)^3}{80\times 10^3\,\text{A/m}} \cdot H = 1.29590697 \times 10^{-17}\,\text{m}^3 \cdot H$

Calculation of the mean velocity of the flow field in the experiments:
(rounding the channel height to 3σ, which is the value used in the simulations)

- $1\,\frac{\mu L}{min} = 1.67 \times 10^{-8}\,\frac{L}{s}$

- $\bar{v}_{\text{exp}} = 1.67 \times 10^{-11}\,\frac{\text{m}^3}{\text{s}}/(30 \times 10^{-6}\,\text{m} \cdot 3000 \times 10^{-6}\,\text{m}) = 1.851852 \times 10^{-4}\,\text{m/s} = 4.312254 \times 10^4\,\sigma/\tau_D$

Calculating the mean velocity of the flow field in the simulations:
(v_{max} is the input parameter of the simulation given in the input file)

- $\bar{v}_{\text{sim}} = \dfrac{1}{h}\int\limits_0^h v_{\text{max}}\left(1 - \dfrac{\left(y-\frac{h}{2}\right)^2}{\left(\frac{h}{2}\right)^2}\right)\,\text{d}y = \dfrac{2}{3}v_{\text{max}}$

- $\bar{v}_{\text{exp}} = \bar{v}_{\text{sim}} \Rightarrow v_{\text{max}} = 1\,\sigma/\tau_D \,\hat{=}\, 1.545982 \times 10^{-5}\,\frac{\mu L}{min}$