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:

- $\sigma = 10\,\mu\mathrm{m}$
- $kT = 1.38064852 \times 10^{-23}\,\mathrm{J/K} \cdot 293.15\,\mathrm{K} = 4.04737114 \times 10^{-21}\,\mathrm{J}$
- $D = kT/(3\pi\eta\sigma) = 4.04737114 \times 10^{-21}\,\mathrm{J}/(3\pi \cdot 10^{-3}\,\mathrm{Pa\,s} \cdot 10^{-5}\,\mathrm{m}) = 4.29439415 \times 10^{-14}\,\mathrm{m^2/s}$
- $\tau_D = \sigma^2/D = 2328.61718\,\mathrm{s}$
- $m_0 = \frac{M_\rho(80\,\mathrm{kA/m}) \cdot \rho \cdot V^{\mathrm{col}}}{80\,\mathrm{kA/m}} \cdot H = \frac{1.8\,\mathrm{Am^2/kg} \cdot 1100\,\mathrm{kg/m^3} \cdot (4/3)\pi\left(5 \times 10^{-6}\,\mathrm{m}\right)^3}{80 \times 10^3\,\mathrm{A/m}} \cdot H = 1.29590697 \times 10^{-17}\,\mathrm{m^3} \cdot H$

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

- $1\,\frac{\mu\mathrm{L}}{\mathrm{min}} = 1.67 \times 10^{-8}\,\frac{\mathrm{L}}{\mathrm{s}}$
- $\overline{v}_{\mathrm{exp}} = 1.67 \times 10^{-11}\,\frac{\mathrm{m^3}}{\mathrm{s}}/(30 \times 10^{-6}\,\mathrm{m} \cdot 3000 \times 10^{-6}\,\mathrm{m}) = 1.851852 \times 10^{-4}\,\mathrm{m/s} = 4.312254 \times 10^4\,\sigma/\tau_D$

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)

- $\overline{v}_{\mathrm{sim}} = \frac{1}{h}\int_0^h v_{\mathrm{max}}\left(1 - \frac{\left(y - \frac{h}{2}\right)^2}{\left(\frac{h}{2}\right)^2}\right)\mathrm{d}y = \frac{2}{3}v_{\mathrm{max}}$
- $\overline{v}_{\mathrm{exp}} = \overline{v}_{\mathrm{sim}} \Rightarrow v_{\mathrm{max}} = 1\,\sigma/\tau_D \mathrel{\widehat{=}} 1.545982 \times 10^{-5}\,\frac{\mu\mathrm{L}}{\mathrm{min}}$