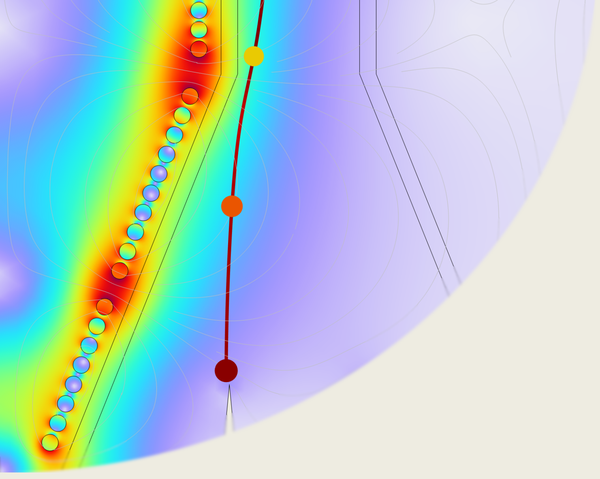

Magnetic particle separation in a liquid column based on magnetophoresis

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Abstract

In this paper, the topic of separation of sinking particles in a stationary liquid column based on magnetophoresis is studied in depth. For this purpose, the fundamentals of magnetophoresis are presented at the beginning. Subsequently, the modeling of the stationary liquid column is discussed in detail. The simulation results illustrate the vertical separation due to gravity and show the field-assisted transient horizontal deflection of the particles. Thus, a flexible method for magnetic particle separation was verified by simulations.

Magnetophoresis

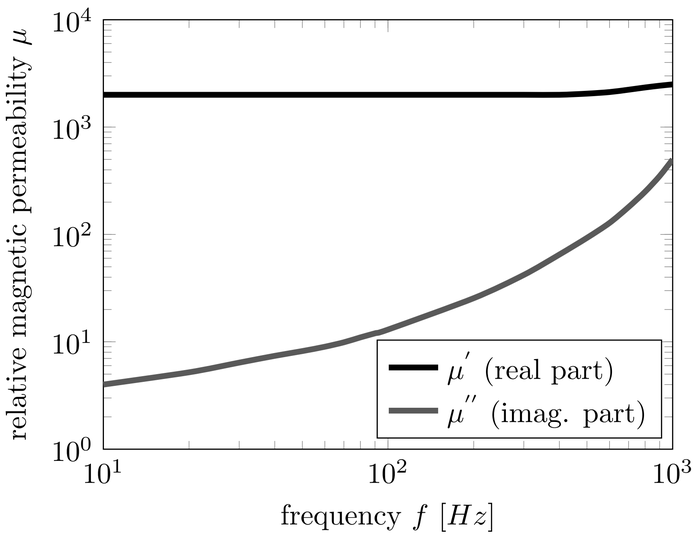
Magnetophoretic force:

$$F_m = \frac{1}{4}\pi \cdot d^3 \cdot \mu_0 \cdot \mu_m \cdot K \cdot \nabla|H|^2$$

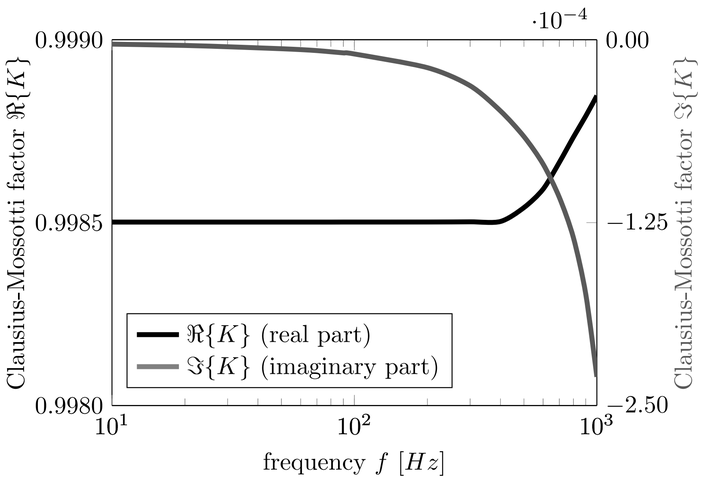
Clausius-Mossotti factor:

$$K = \frac{\mu_p - \mu_m}{\mu_p + 2\,\mu_m} \qquad \text{with} \qquad \mu = \mu^{'} - j\,\mu^{''}$$

Frequency-dependent complex permeability:

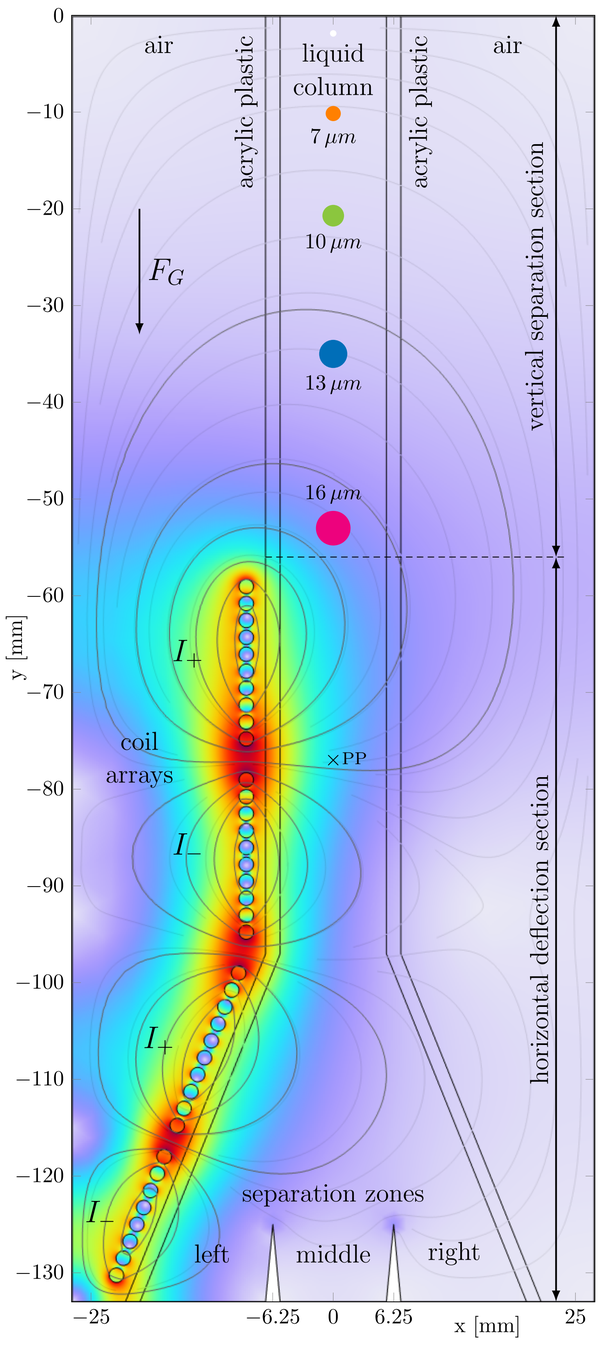


Frequency-dependent Clausius-Mossotti factor:



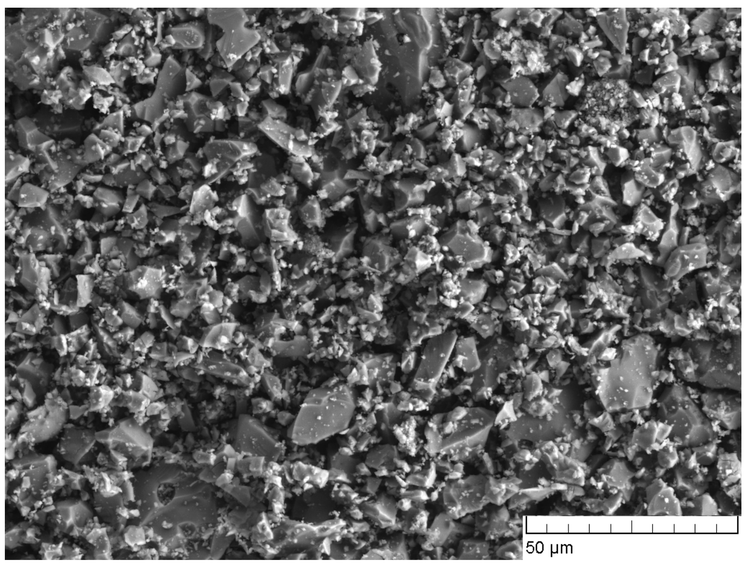
Stationary Liquid Column

Stationary liquid column with vertically separated particles during a sink time of $t = 100s$:

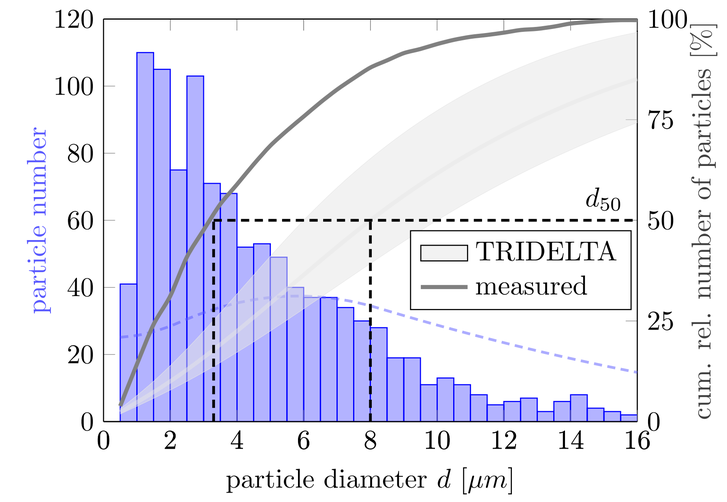


MnZn Ferrite Powder

SEM image of MnZn ferrite powder:



Particle size distribution statistics:



Vertical Separation

Force balance:

$$F_G = F_A + F_R$$

Sink velocity:

$$v = \frac{g \cdot (\varrho_p - \varrho_m)}{18\,\eta_m} \cdot d^2$$

Diameter-dependent vertical particle velocity:

Horizontal Deflection

Particle deflection trajectories of particle diameters ranging from $d = 8\mu m - 16\mu m$ (separation diameter: $d_{sep} = 12\mu m$):

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