Universität Bielefeld

Formation of particle cluster from rotating particle chains

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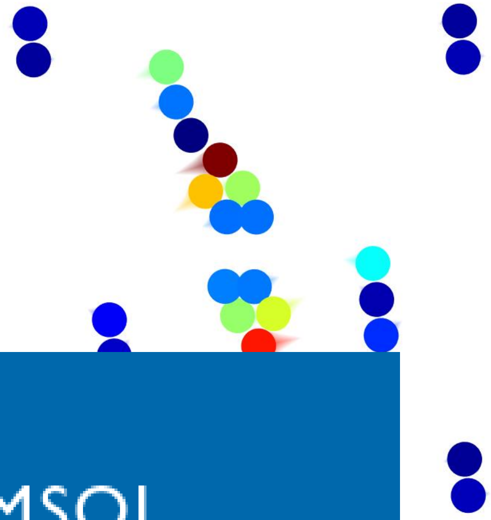

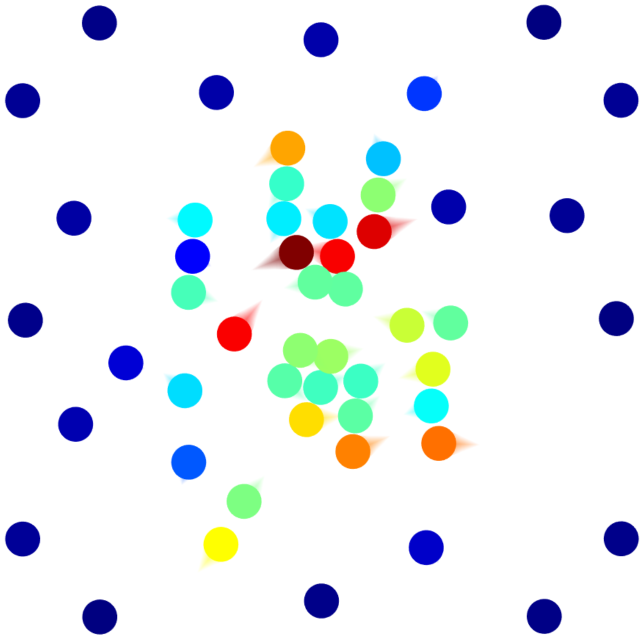

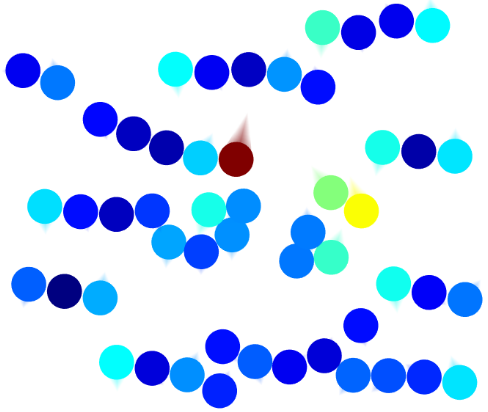

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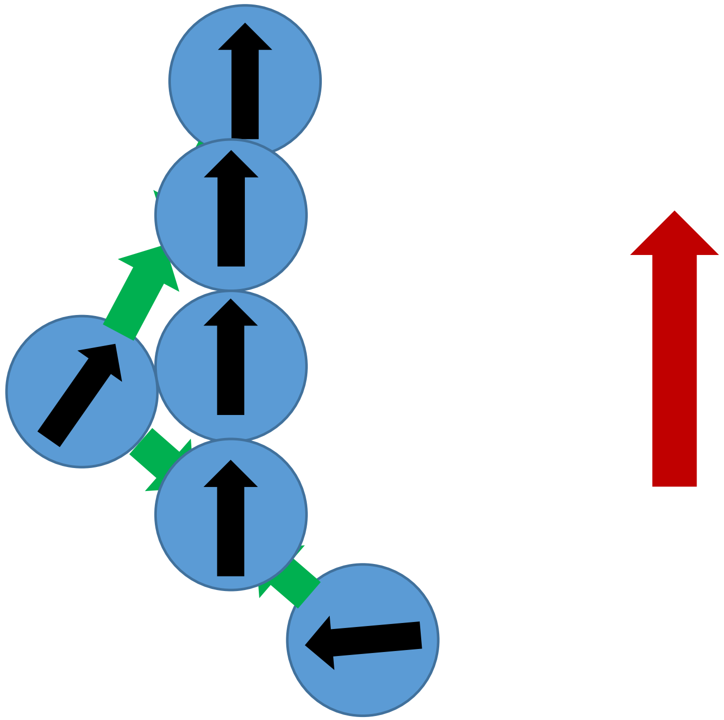
D2 Physics www.spinelectronics.de

Magnetized particles in a homogeneous magnetic field

1. Magnetic moments align
2. Particles Interact and form chains
3. Chains follow the rotation of the applied field



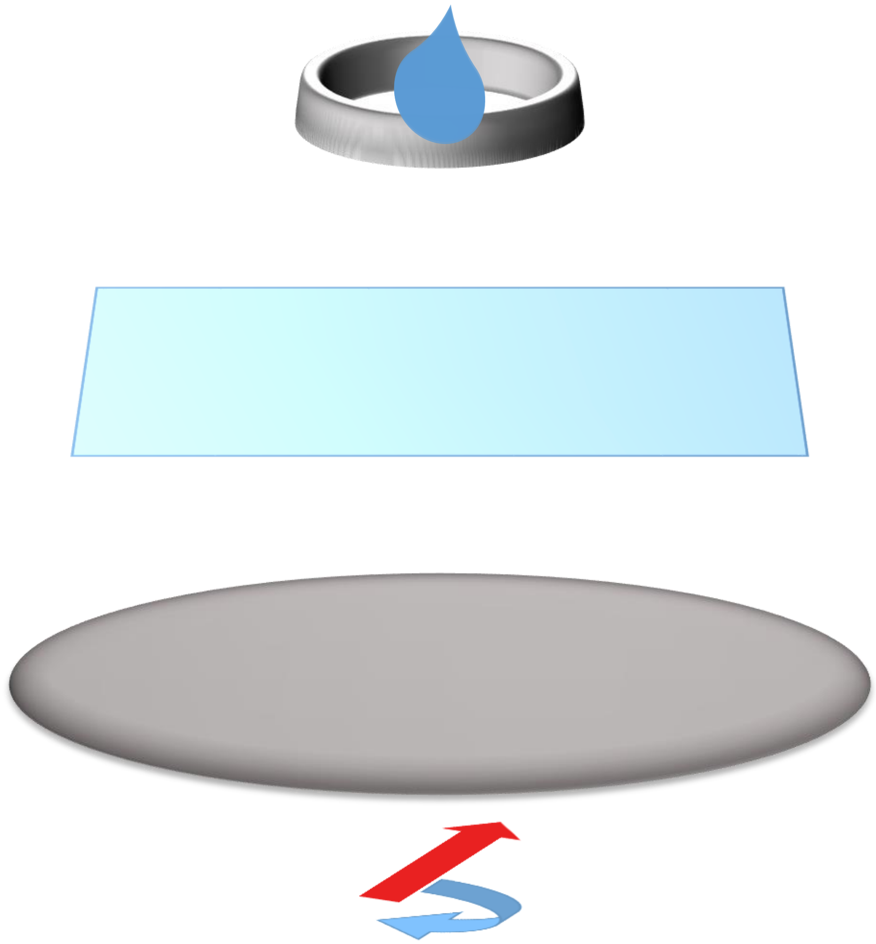
Experimental Setup and Results

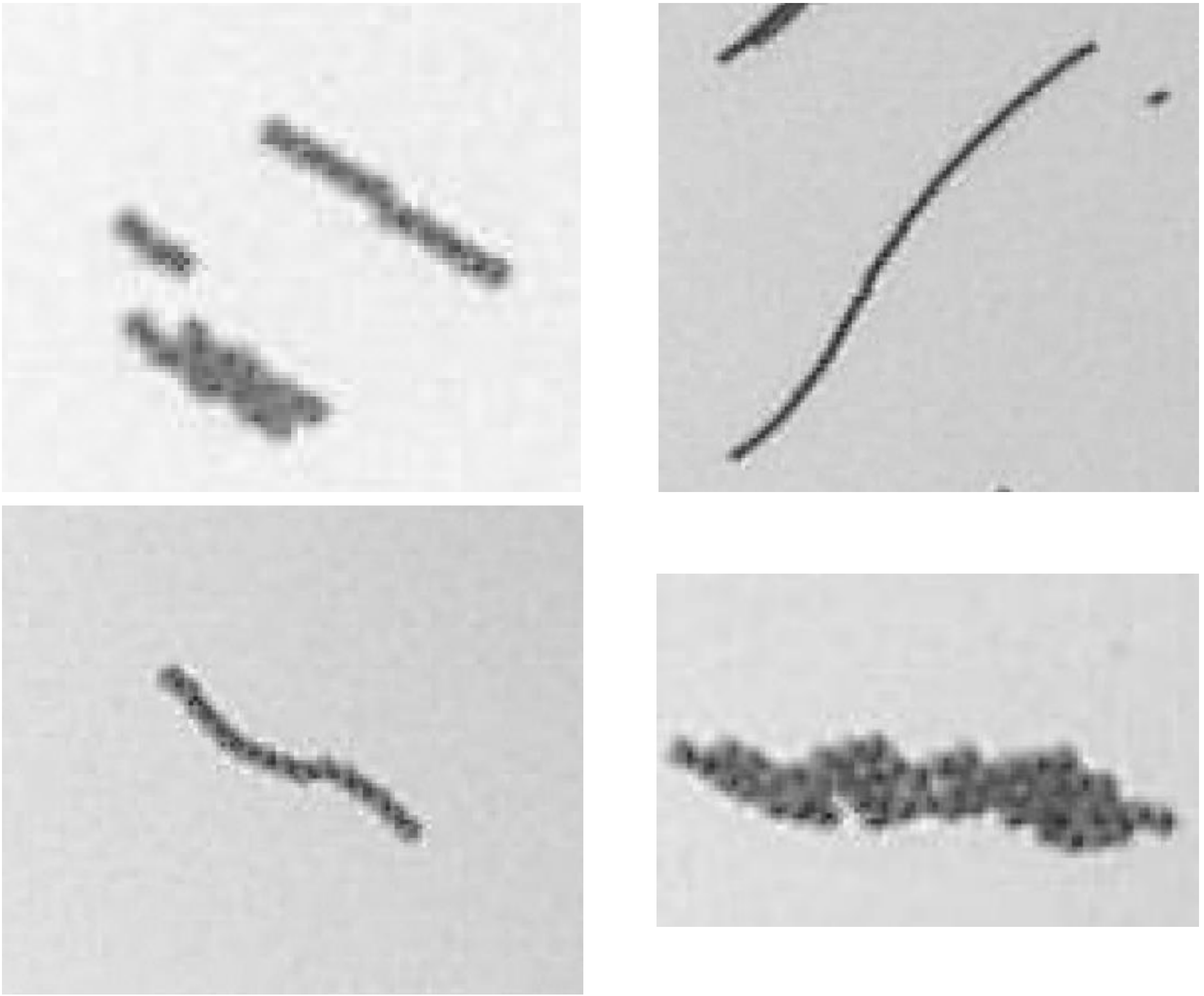
Sample with magnetic particles

Well made of PDMS

Glass object plate

Magnetic stirring device





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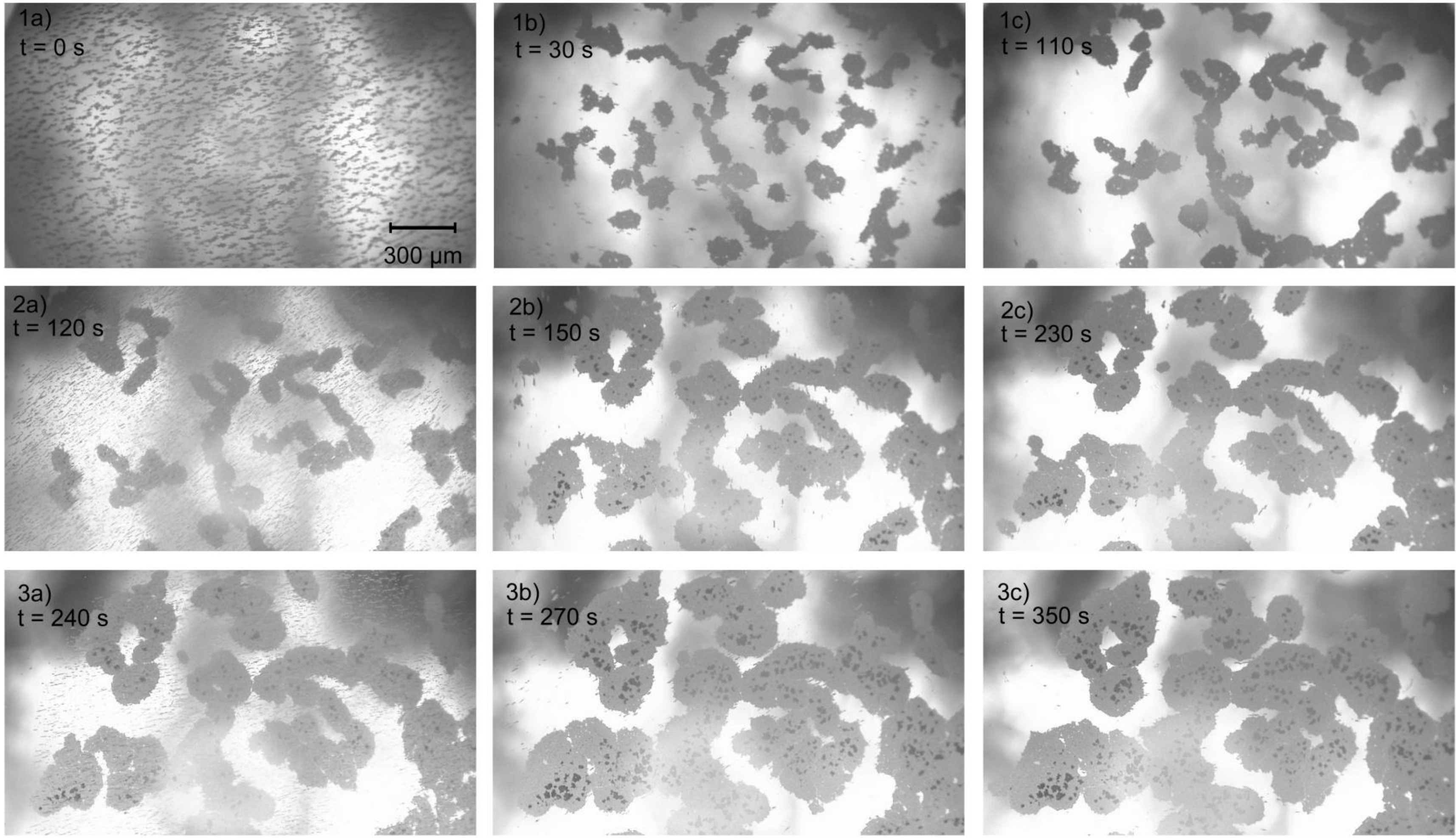
Experimental Setup and Results

Superparamagnetic particles form into highly ordered patches

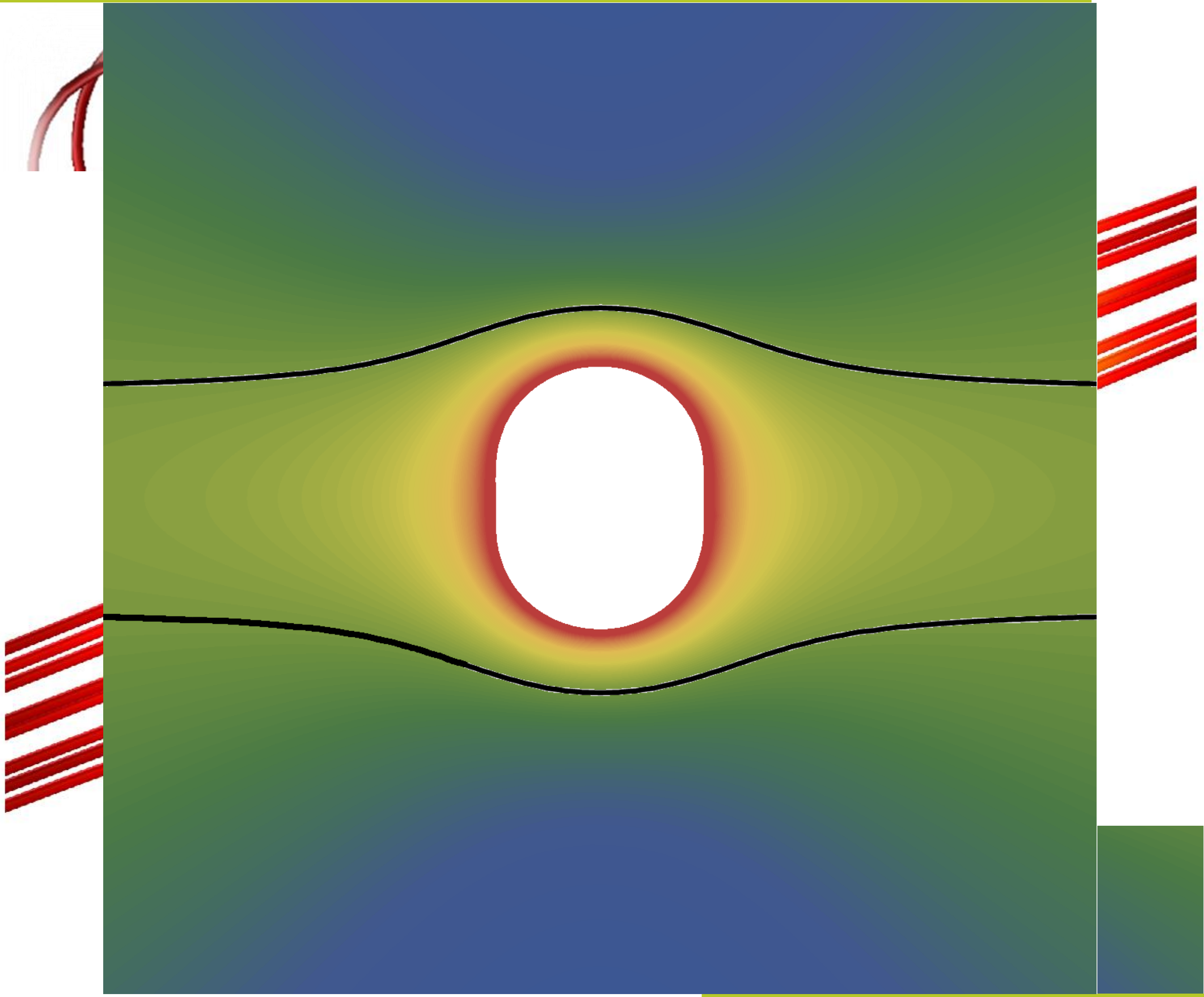
Every 2 minutes a new droplet is added

Added particles quickly attach to existing patches



Theoretical description

- Particles interact with each other, due to their inhomogeneous stray fields.
- Fluid hinders particle movement.
- Particles cannot overlap.



Theoretical description

- Particles interact with each other, due to their inhomogeneous stray fields.

$$\vec{F}_m = \frac{3\mu_0}{4\pi}\frac{m_i m_j}{r_{ij}^4}[(1 - 5(\widehat{m} \cdot \hat{r})^2)\hat{r} + 2(\widehat{m} \cdot \hat{r})\widehat{m}]$$

- Fluid hinders particle movement.

$$\vec{F}_S = 6\pi\nu_{viscosity}R\left(\vec{v}_{fluid} - \vec{v}_{particle}\right)$$

- Particles cannot overlap.

$$\vec{F}_r = \frac{24\epsilon}{\sigma}\left(\frac{\sigma^7}{r_{ij}^7} - \frac{2\sigma^{13}}{r_{ij}^{13}}\right)\hat{r}$$

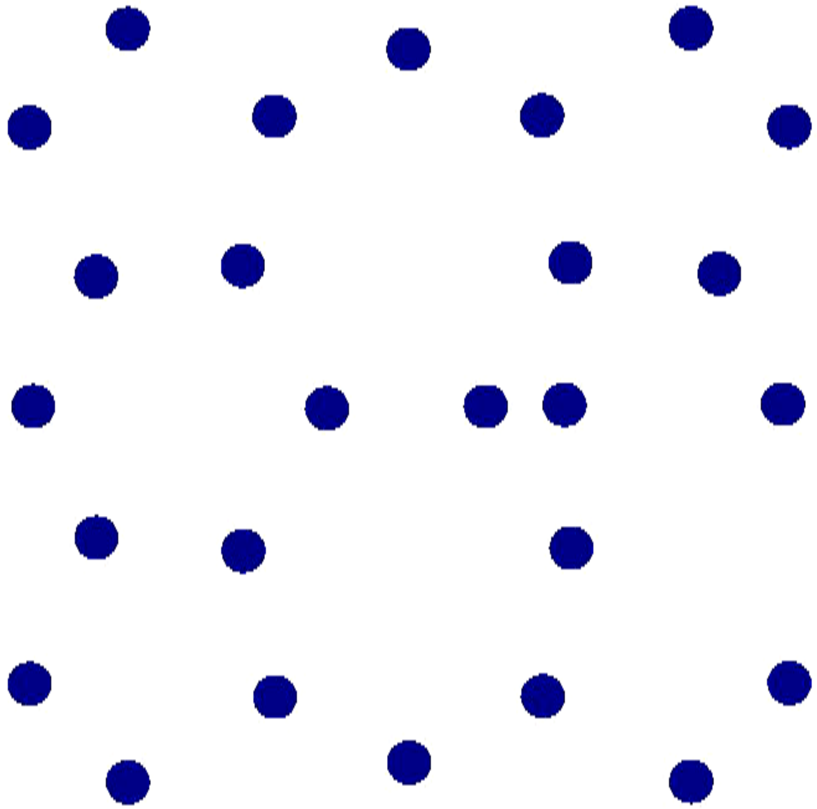
Why do particles form a cluster?

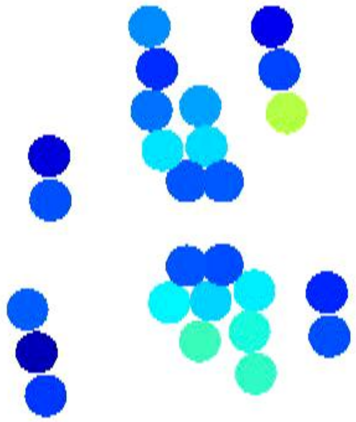
$$\vec{F}_m = \frac{3\mu_0}{4\pi}\frac{m_i m_j}{r_{ij}^4}\left[\left(1 - 5(\hat{m}\cdot\hat{r})^2\right)\hat{r} + 2(\hat{m}\cdot\hat{r})\hat{m}\right]$$

$(\hat{m}\cdot\hat{r}) \rightarrow \cos\theta$ $\qquad$ $(\hat{m}\cdot\hat{r}) \rightarrow \cos\theta$

→ No force contribution for one full turn!

Simulation results





Thank you for your attention

Any questions unanswered?