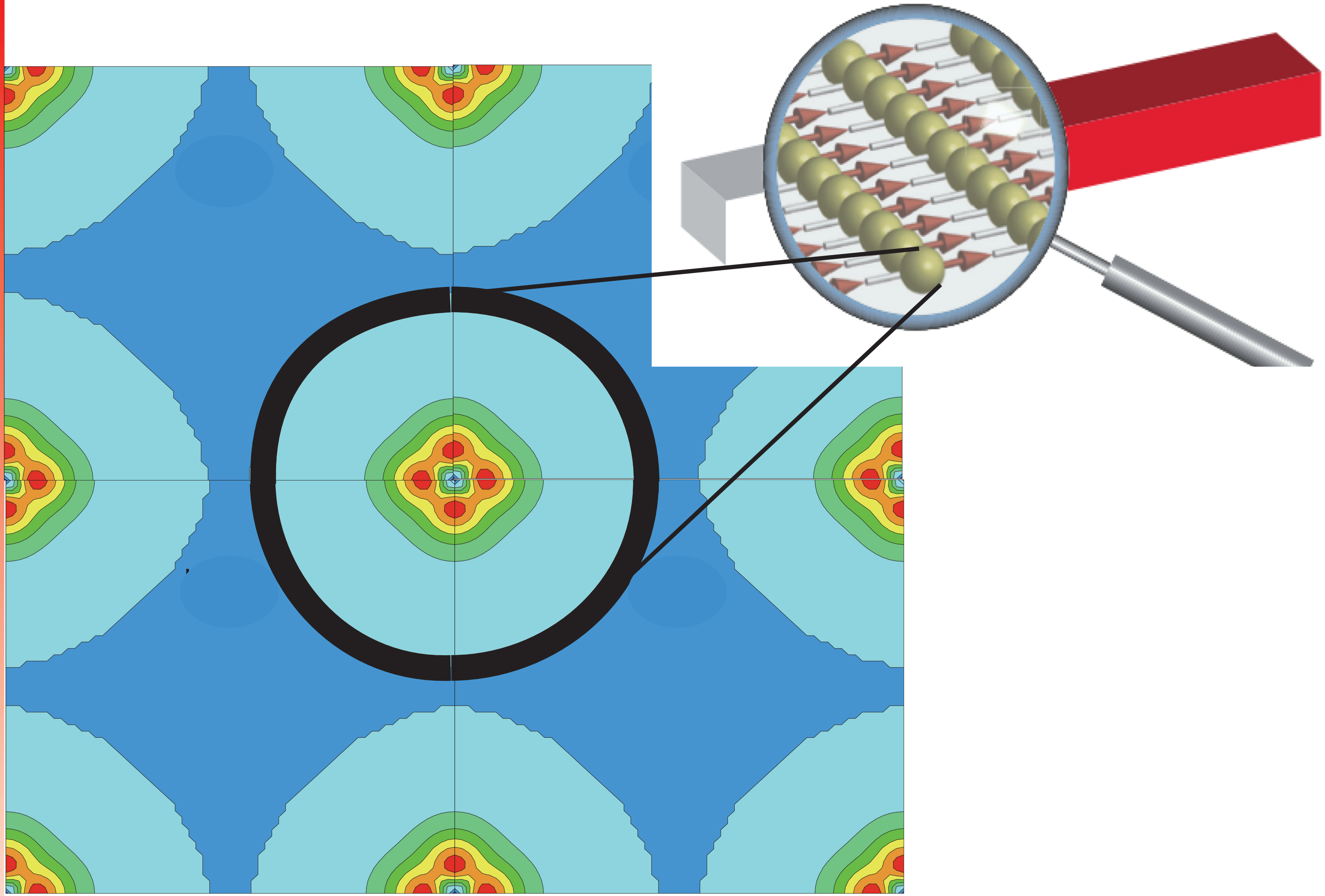
# A multiscale approach to magnetisation dynamics

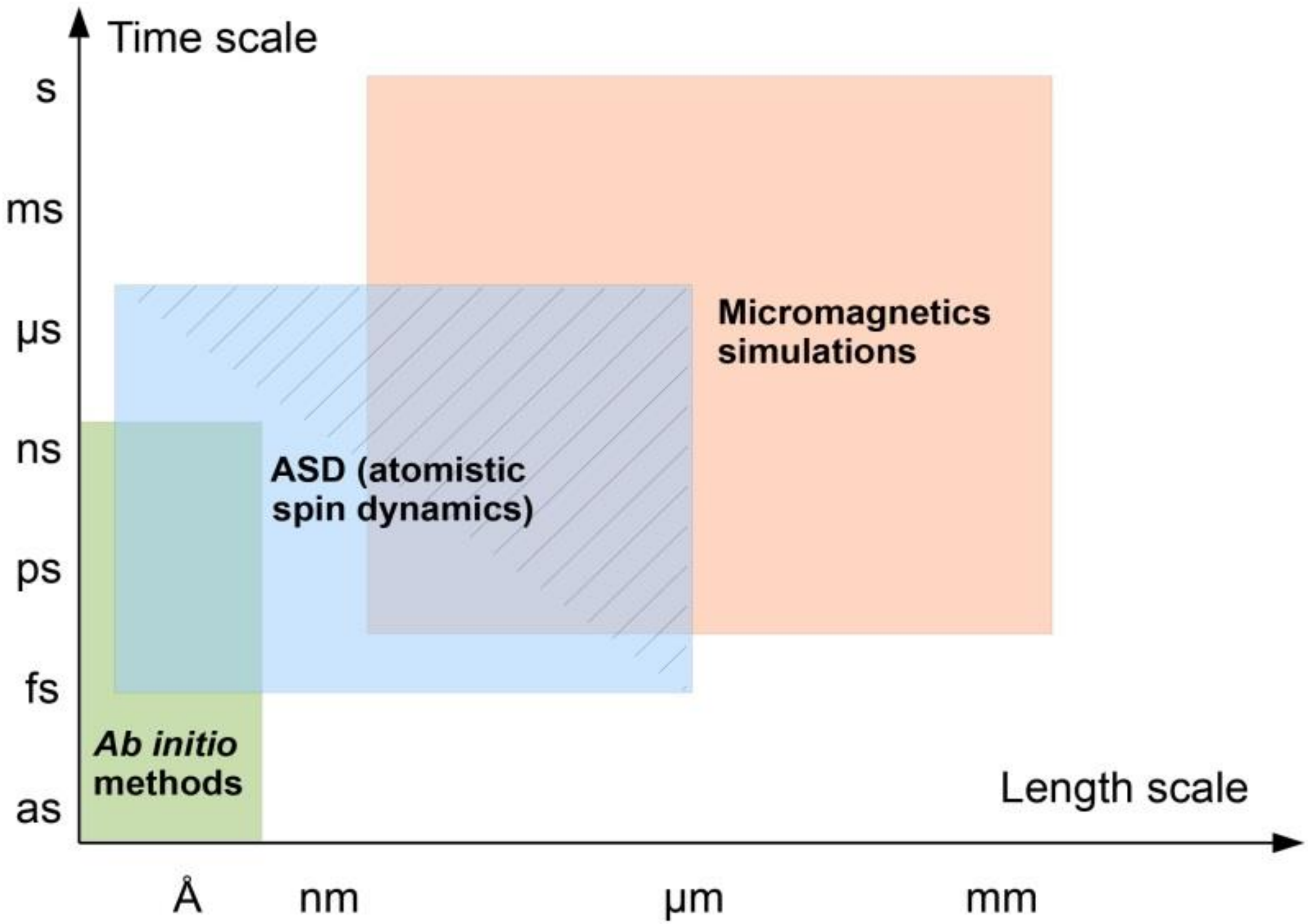
Olle Eriksson

Uppsala University
and
Örebro University

# Atomistic description



# Multiscale simulations

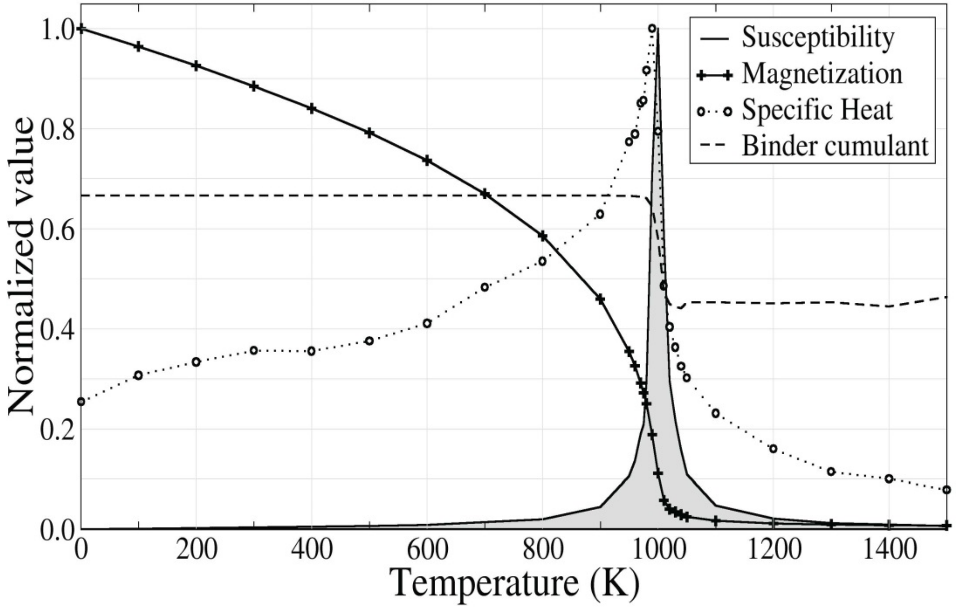


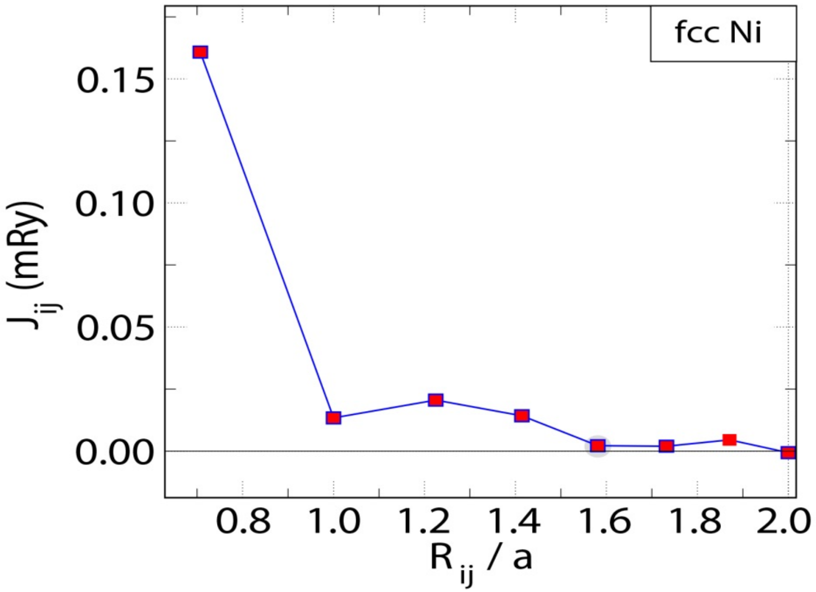
# Heisenberg spin Hamiltonian

$$H_{spin} = -\sum_{<ij>} J_{ij} \mathbf{S}_i \cdot \mathbf{S}_j$$

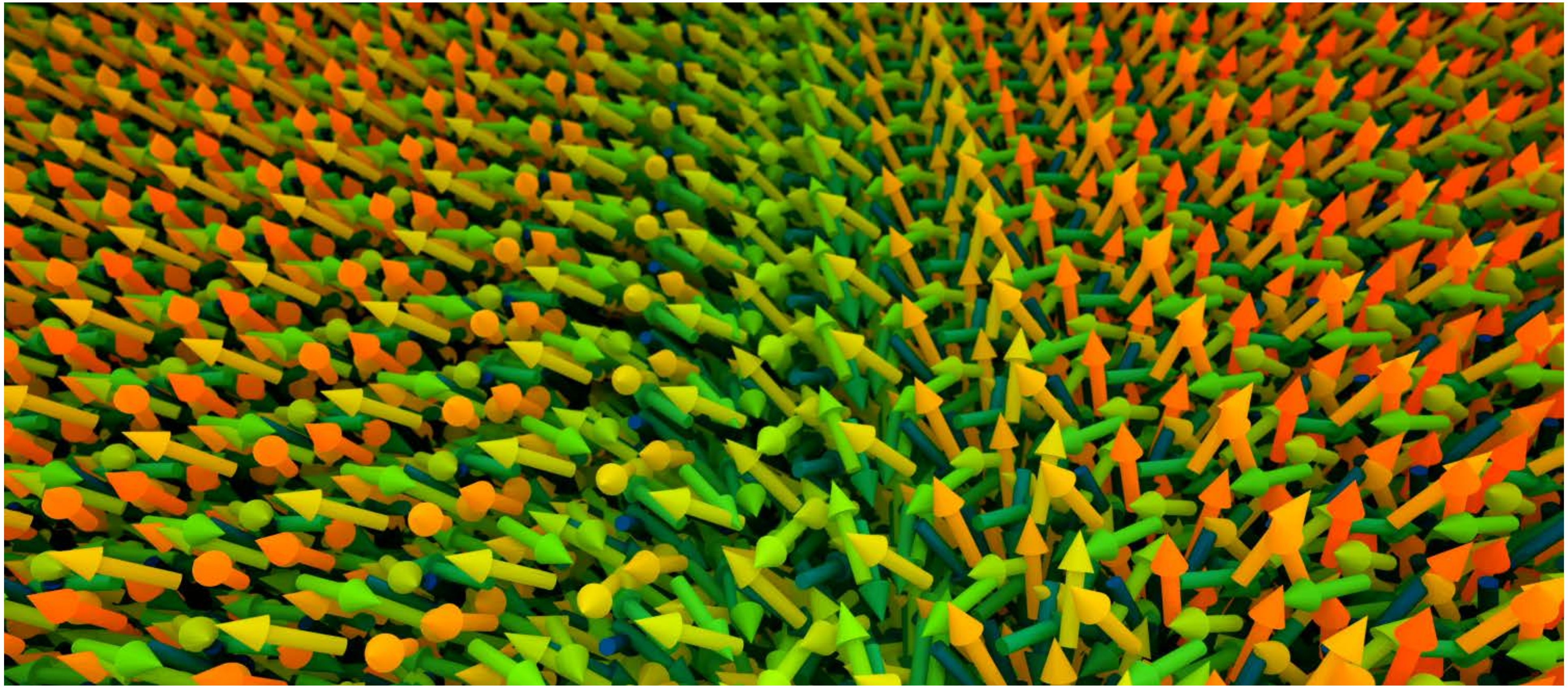
$$H_{spin} = -J \sum_{<ij>} \mathbf{S}_i \cdot \mathbf{S}_j$$

M vs T for bcc Fe



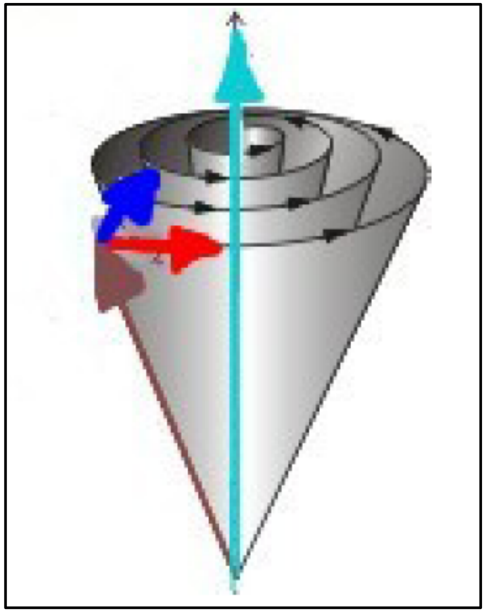
# Magnetization dynamics on the atomic scale



# Atomistic Landau-Lifshitz equation

$$\frac{d\mathbf{m_i}}{dt} = -\gamma \mathbf{m_i} \times \mathbf{B_i} - \gamma \frac{\alpha}{m_i}[\mathbf{m_i} \times [\mathbf{m_i} \times \mathbf{B_i}]]$$

Precession Damping



$$\frac{\partial \mathbf{m}_i}{\partial t} = -\gamma \mathbf{m}_i \times \mathbf{B}_i - \gamma \frac{\alpha}{m}[\mathbf{m}_i \times [\mathbf{m}_i \times \mathbf{B}_i]]$$

Prec

Energy dissipation

The e $\frac{dE}{dt} = \frac{dE}{d\mathbf{m}} \cdot \frac{d\mathbf{m}}{dt} = \mathbf{B} \cdot \frac{d\mathbf{m}}{dt}$

$$\mathbf{B} \cdot \frac{d\mathbf{m}}{dt} \propto 0 + \alpha$$

$$\frac{dE}{dt} \longleftrightarrow \alpha$$

# Calculated interaction terms

$$B_i = -\frac{dH}{dm_i}$$

$$\mathcal{H}_{iex} = -\frac{1}{2}\sum_{i\neq j} J_{ij}\mathbf{m}_i \cdot \mathbf{m}_j$$

Heisenberg exchange

$$\mathcal{H}_{DM} = -\frac{1}{2}\sum_{i\neq j} \mathbf{D}_{ij} \cdot \mathbf{m}_i \times \mathbf{m}_j$$

Dzyaloshinskii-Moriya exchange

$$\mathcal{H}_{ani} = K\sum_{i} (\mathbf{m}_i \cdot \mathbf{e}_{ani})^2$$

Uniaxial anisotropy

$$\mathcal{H}_{ext} = -\mathbf{B}_{ext} \cdot \sum_{i} \mathbf{m}_i$$

Applied magnetic field