TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

DLR AIRBUS

ELECTROMAGNETIC SIMULATION AND INVERSION OF MAGNETIC FIELD DATA FROM PLANETARY AND ASTEROID ANALOGS ON THE INTERNATIONAL SPACE STATION (ISS)

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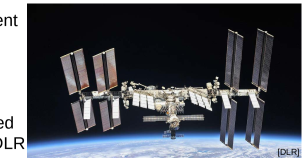
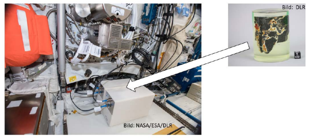
THE MFX EXPERIMENT

Experiment:

- Electromagnetic experiment on planetary and asteroid analogs exposed to the varying Earth's magnetic field aboard the ISS
- Developed and constructed by AIRBUS on behalf of DLR
- Commissioned in 2018 during Alexander Gerst's mission "horizons – knowledge for tomorrow"



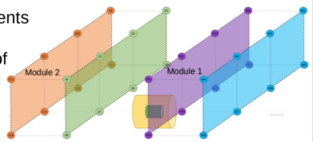
Setting on ISS



Samples:

- Meteorites, rocks, technical materials, reference materials

Test setup



Data:

- Time series of 3 components of the magnetic field measured in the vicinity of the samples

Approach:

- Individual investigation of magnetic and induction phenomena with separate simulation and inversions
- Process understanding for the magnitude of the contributions
- Possibility of upscaling to planetoids / asteroids

MAGNETOSTATICS

- **Magnetostatic reaction** of magnetizable sample to external magnetic field
- Linear problem for each point in time

$$\vec{B} = -\mu \nabla U$$

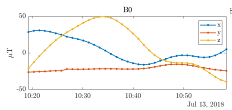
$$-\nabla \cdot (\mu \nabla U) = f$$

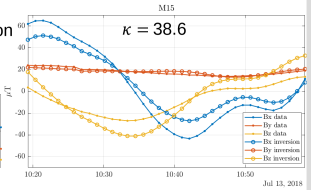
$\mu_0 (1+\kappa)$ stimulating field

- **Magnetic susceptibility κ** of sample

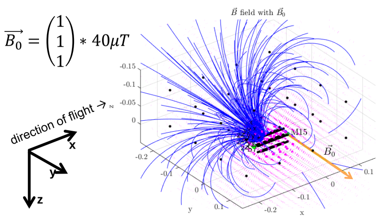
B_0 from reference sensor 13th July 2018, 3h 30min 7 subsamples

- Mesh from Gmsh, import to Matlab
- Simulation based on Bär,M.(2012) with triangulated surface
- Simultaneous linear inversion of measured data for κ





$$\vec{B_0} = \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} * 40\mu T$$



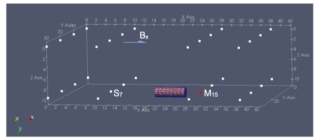
ELECTROMAGNETIC INDUCTION

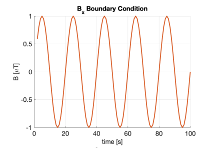
- **Aim:** Numerical simulation of electromagnetic induction in different samples of the MFX experiment due to a time-varying external magnetic field
- Nédélec finite elements on unstructured grids (Schneider et al., subm.; Schwarzbach et al., 2011)
- **Governing partial differential equation**:

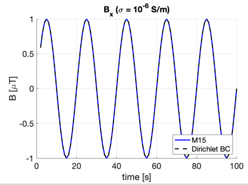
$$\nabla \times \left(\sigma^{-1} \nabla \times \left(\mu^{-1} \vec{B}\right)\right) = -\frac{\partial}{\partial t} \vec{B}$$

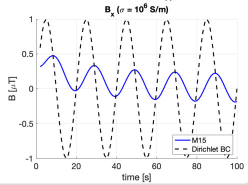
$\vec{B}$ mag. flux density, σ el. conductivity, μ magn. permeability

- **Dirichlet boundary condition**: $B_x(t) = B_0 \sin \omega t$
- **First test:** Homogeneous full-space with low ($\sigma = 10^{-6}$ S/m, lower left figure) and high electrical conductivity ($\sigma = 10^{6}$ S/m, lower right figure), test frequency $f = 0.05$ Hz and $B_0 = 1$ µT









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This work is funded by the Federal Ministry for Economic Affairs and Energy (BMWi).