Folie 47 Zfs

Gekoppelte Feldprobleme

CTD / CDKR

Wärmeleitung-Wärmetransport

Fourier

T

$$c\varrho\frac{\partial T}{\partial t} - \operatorname{div}(\lambda\nabla T) + c\varrho\vec{v}\,\nabla T + aT = f$$

+ RB + IB + AB

CSM

Festkörpermechanik

Navier-Lamé

$\vec{u}$

$$\varrho\frac{\partial^2 u}{\partial t^2} - \operatorname{div}\sigma = f$$

$$\sigma = \tilde{D}\varepsilon \ \ldots$$

$$\varepsilon(u) = \frac{1}{2}(\nabla u + \nabla u^T) \ \ldots$$

+ RB + IB + AB

CFD

Strömungsmechanik

Navier-Stokes

$\vec{v}, p, \varrho$

$$\varrho\frac{\partial v}{\partial t} + \varrho v\cdot\nabla v = \operatorname{div}\sigma + \varrho f$$

$$\frac{\partial\varrho}{\partial t} + \operatorname{div}(\varrho v) = 0$$

$$\sigma = \sigma(p, v) = \ldots$$

+ Energiegl. T

+ Zustandsgl. $p = p(\varrho, T)$

+ RB + AB

CEM

Elektrodynamik

Maxwell

$\vec{H}, \vec{B}, \vec{E}, \vec{D}$

$$\operatorname{curl} H = J + \frac{\partial D}{\partial t}$$

$$\operatorname{div} B = 0$$

$$\operatorname{curl} E = -\frac{\partial B}{\partial t}$$

$$\operatorname{div} D = \varrho$$

$$B = \mu H + \mu_0 M$$

$$D = \varepsilon E + P$$

$$J = J_c + J_i = \sigma(E + \vec{v}\times B) + J_i$$

+ RB (ASB) + IC + AB

Thermomechanik

z.B. $\sigma = \tilde{D}\varepsilon + \beta(T - T_0)$

MHD

Diffusion-Konvektion-Reaktion

$c = \vec{c}$ = Konzentrationen

$$c_p\frac{\partial c}{\partial t} - \operatorname{div}(\tilde{D}\nabla c) + c_p\vec{v}\,\nabla c + r(c) = f$$

+ RB + AB, c_p - Porositätskoeff.

z.B. inkompressible Newt. Fluide

$\varrho = \text{const}$

$\sigma = -pI + \tau$ mit

$\tau = \lambda \operatorname{div}(v) I + 2\mu\,\varepsilon(v)$

$\lambda = -\frac{2}{3}\mu, \ \nu = \frac{\mu}{\varrho}$

$$\frac{\partial v}{\partial t} - \nu\Delta v + v\cdot\nabla v + \frac{1}{\varrho}\nabla p = f$$

$$\operatorname{div}(v) = 0$$

+ RB + AB

FSI

MHD

Magnetomechanik / Piezoelektrik

$$\sigma = \tilde{D}\varepsilon(u) + \tilde{B}E$$

$$D = \tilde{B}^T\varepsilon(u) + \tilde{\varepsilon}E$$

Elektrostatik

$$\operatorname{div} D = \operatorname{div}\varepsilon E = \varrho$$

$$E = -\nabla\varphi$$

$$-\operatorname{div}(\varepsilon\nabla\varphi) = \varrho$$

Wetter / Klima

$T, \vec{c}$ — $\vec{v}, p, \varrho$