S22

ρ_a extenzív sűrűség $\quad j_a^i$ áramsűrűsége

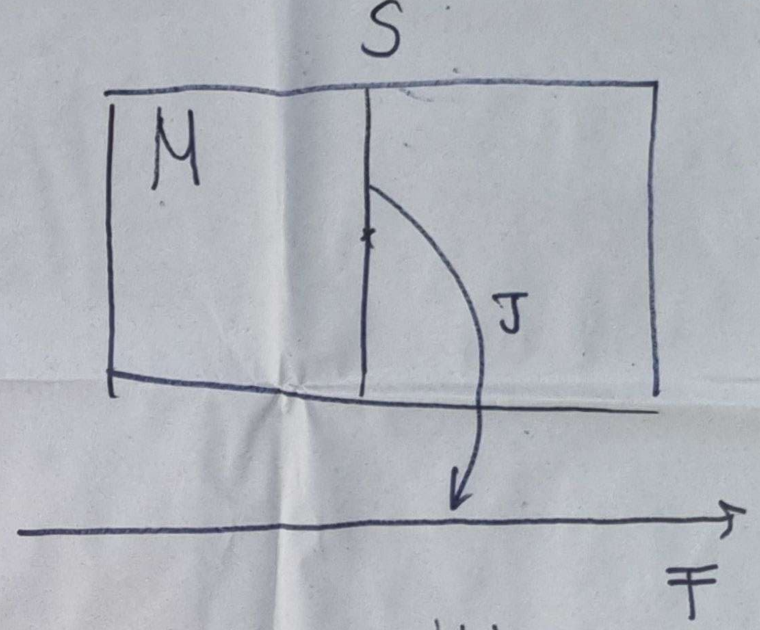
$$\partial_t \rho_a + \partial_i j_a^i = 0 \quad — \quad \boxed{\partial_a A^a = 0}$$

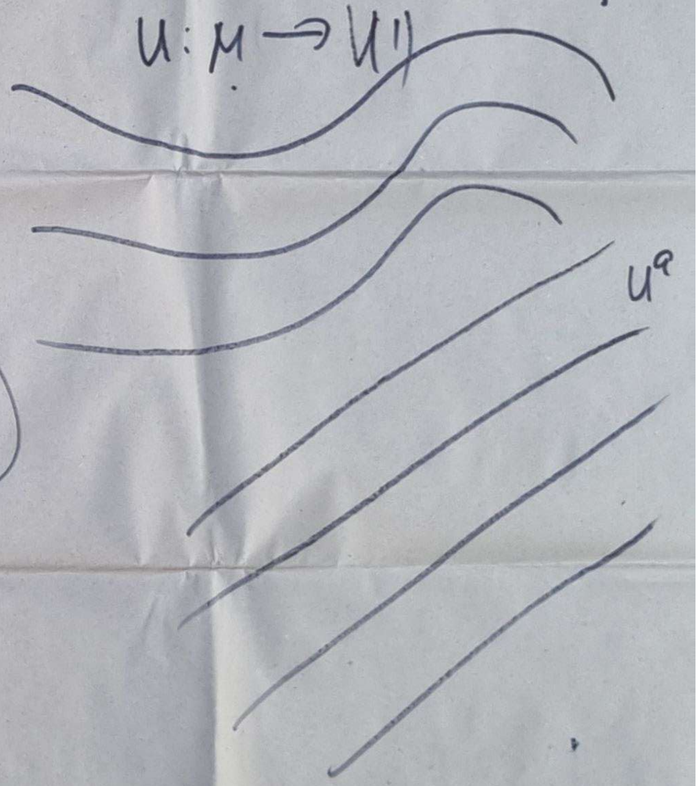
$$\text{konvektív} \leftarrow j_a^i = \rho_a v^i + \hat{j}_a^i \rightarrow \text{~~konvektív~~ konduktív}$$

$$\partial_t \rho + \partial_i(\rho v^i + \hat{j}^i) = \partial_t \rho + v^i \partial_i \rho + \rho\, \partial_i v^i +$$

$$+ \partial_i \hat{j}^i = \underbrace{(\partial_t + v^i \partial_i)}_{\dot{\rho}} \rho + \rho\, \partial_i v^i + \partial_i \hat{j}^i = 0$$

$\cancel{d}$ $u^a \partial_a$





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3) $\cancel{\rho_u = \rho}$ $\boxed{\partial_t \rho_u + \partial_i(\rho_u v^i + q^i) = \cancel{\text{hőforrás}}\ 0}$

hőáramsűrűség ?

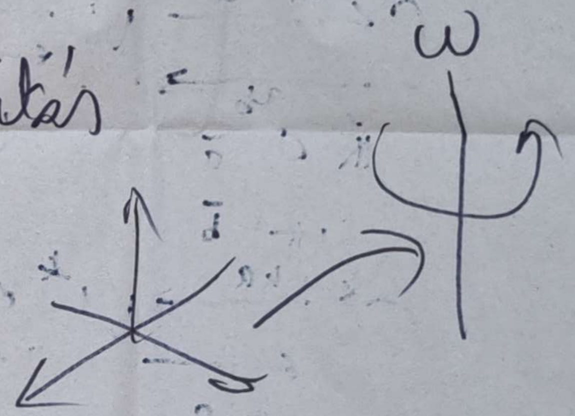
$\rho_u = \rho c T$ q^i ?

1? $\boxed{q^i = -\underline{\underline{\lambda \partial_i T}}}$ $q^i(T, \partial_i T, \dots)$

„relaxációs idő"

4) $\underline{\underline{\tau \overset{\nabla}{q^i}}} + q^i + \lambda \partial_i T = 0$

Noll-féle objektivitás



Maxwell–Cattaneo–Vernotte

1) $\partial_t \rho + \partial_i(\rho v^i) = 0$ „2. hang"

2) $\partial_t(\rho v^i) + \partial_j(\rho v^i v^j + P^{ij}) = 0^i$ Euler

$-T^{ij} = p\delta^{ij}$

(1,2,3,4) hiperbolikus $\overset{\nabla}{}$ alsóáramlásos Truesdell

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— Courant – kritériumnak : $\tau_b(\delta^b{}_a - u^a \tau_a) =$

téridő + termodinamika $\tau_a - \tau_a = 0_0$

$q^i \to$ 2.2 Miféle fizikai mennyiség?

$$\begin{tikzcd} S \arrow[r, shift right, "\delta^b{}_{\bar a}"'] & M \arrow[l, shift right, "\Pi_u{}^{\bar b}{}_a"'] \arrow[r, shift left, "\tau_a"] & T \arrow[l, shift left, "u^a"] \end{tikzcd}$$

$$\begin{tikzcd} S^* \arrow[r, shift left, "(\Pi_u)_a{}^{\bar b}"] & M^* \arrow[l, shift left, "\delta_{\bar b}{}^a"] \arrow[r, shift right, "u^a"'] & T^* \arrow[l, shift right, "\tau_a"'] \end{tikzcd}$$

$\mathrm{Lin}(M,S) \equiv \mathrm{Bilin}(S^* \times M, \mathbb{R}) \equiv S \otimes M^*$

$\Pi_u : M \to S \equiv S \otimes M^* \quad \Pi_u{}^{\bar b}{}_a$

$i : S \to M \equiv M \otimes S^* \quad \delta^b{}_{\bar a}$

$i^* : M^* \to S^* \equiv S^* \otimes M \quad \delta_{\bar b}{}^a$

$\cancel{u^*}\ M^* \to T^* \equiv T \otimes M \quad u^a$

$\cancel{\Pi_u^* : M^* \to S^* \equiv}$

$\Pi_u^* : S^* \to M^* \equiv M^* \otimes S^*$

$\tau_a u^a = 1$

$\Pi_u{}^{\bar b}{}_a = \delta^b{}_a - u^b \tau_a$

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$$\Pi_u{}^{\bar b}{}_a u^a = (\delta^b{}_a - u^b J_a)u^a = u^b - u^b \underbrace{J_a u^a}_{\Lambda} = u^b - u^b = 0^b$$

$$\Pi_u{}^{\bar a}{}_b \delta^b{}_{\bar c} = \underline{(\delta^a{}_b - u^a J_b)}\delta^b{}_{\bar c} = \delta^{\bar a}{}_b \delta^b{}_{\bar c} - u^a \underbrace{J_b \delta^b{}_{\bar c}} = \delta^{\bar a}{}_{\bar c} - 0$$

$$\underset{M}{\underset{\cap}{A^a}} \overset{u}{\prec} \left(\underbrace{J_a A^a}_{A}, \Pi_u{}^{\bar b}{}_a A^a\right) = \left(A, (\delta^b{}_a - u^b J_a)A^a\right) = (A, A^b - u^b A) = (A, A^{\bar b}_u)$$

$$(\xi_u)^{(0,1)}{}_{\bar a} : M \to \bar T \times S \equiv (\bar T \times S) \otimes M^* : \quad A^a \mapsto (A, A^{\bar a})'$$

u-formának

$$(\xi_u^{-1}) : \bar T \times S \to M \equiv M \otimes (\bar T^* \times S^*) : (A, A^{\bar a}) \mapsto \boxed{Au^a + A^{\bar a}_u = A^a}$$

$$A^a = Au^a + A^{\bar a} \overset{u'}{\prec} \left(\underbrace{J_a(Au^a + A^{\bar a})}_{A} ; \Pi_{u'}{}^{\bar a}{}_b (Au^b + A^{\bar b})\right) = \left(A, Au^a - Au'^a + A^{\bar a}\right)$$

$$(\delta^a{}_b - u'^a J_b) \qquad\qquad A^{\bar a} - A v^{\bar a}_{u'u}$$

$$\partial_a A^a = \partial_a(Au^a + A^{\bar a}) = \boxed{u^a \partial_a A + A \partial_a u^a + \partial_a A^{\bar a} = 0}$$

S26

$$\partial_t \rho + \partial_i(\rho v_i) = 0 \qquad \dot{\rho} + \rho\,\partial_i v^i = 0 \qquad \dot{\sqcup} = (\partial_t + v^i\partial_i)\sqcup$$

$$\partial_t \rho v^i + \partial_j(\rho v^i v^j + P^{ij}) = 0^i \qquad \rho\dot{v}^i + \partial_j P^{ij} = 0^i$$

? $f^i = -\rho\,\partial_i \varphi$

$$\partial_t(\rho u) + \partial_i(\rho u v^i + q^i) = -P^{ik}\partial_i v_k \qquad \rho\dot{u} + \partial_i q^i = -P^{ik}\partial_i v_k$$

$$\rho u = \rho e_T - \frac{\rho v^2}{2}$$

$$\dot{\rho} + \rho\,\partial_i v^i + \partial_i j^i = 0$$

$$\partial_c Z^{abc} = 0 \rightarrow \boxed{\dot{p}^i + \cancel{p_k}\, p^i \partial_k v^k} + \rho\dot{v}^i + j^k\partial_k v^i + \partial_k P^{ik} = 0$$

$$\cancel{\text{...}}\ (\rho e)^{\cdot} + \rho e\,\partial_i v^i + \partial_i q^i + p_i \dot{v}^i + P^{ik}\partial_i v_k = 0$$

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$$Z^{abc} \in M \otimes M \vee M \qquad J_a J_b J_c Z^{abc} = \rho$$

$$\begin{pmatrix} \rho & p^i \\ p^j & e^{ij} = \frac{e}{2}\delta^{ij} \end{pmatrix} \begin{pmatrix} j^i & p^{ik} \\ p^{jk} & q^{ijk} - \frac{1}{2} q^{i \cdot} \delta^{jk} \end{pmatrix}$$

$$\rho' = \rho \qquad j'^i = j^i + \rho v^i$$

$$p'^i = p^i + \rho v^i$$

$$e' = e + \underline{\underline{p_i v^i}} + \rho/2\, v^2$$

$$p'^{ik} = p^{ik} + \rho v^i v^k + p^k v^i + j^i v^k$$

$$q^{i'} = q^i + v^i e' + p^{ik} v_k + j^i v^2/2$$