FTs x Termo

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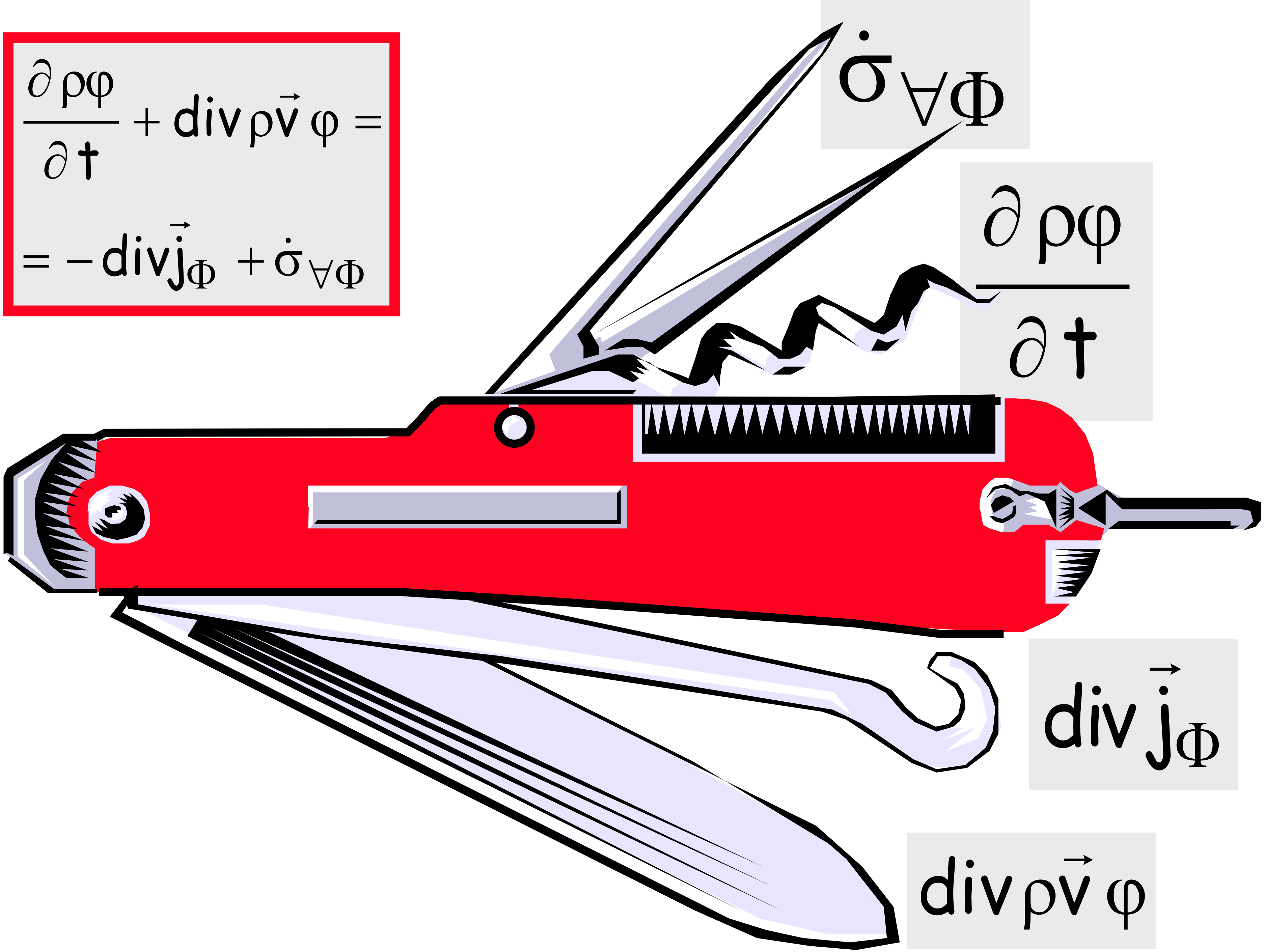
linguagem

$$\rho\frac{D\varphi}{Dt} = -\,\mathrm{div}\,\vec{j}_{\Phi} + \dot{\sigma}_{\forall_{\Phi}} = \frac{\partial\rho\varphi}{\partial t} + \mathrm{div}\,\rho\vec{v}\varphi$$

$$\Phi = \quad m; \quad m_i; \quad m\vec{v}; \quad \frac{m}{2}\vec{v}.\vec{v}; \quad mgh; \quad H; \quad \frac{m}{2}\vec{v}'.\vec{v}'; \quad \dot{\sigma}_{K'}; \quad \varepsilon; \quad S; \quad \ldots$$

$$\varphi = \quad 1; \quad x_i; \quad \vec{v}; \quad \frac{v^2}{2}; \quad gz; \quad c_p T; \quad K'; \quad \dot{\varepsilon}'; \quad \rho_{\varepsilon}; \quad s; \quad \ldots$$

$$\frac{\partial \rho\varphi}{\partial t} + \operatorname{div} \rho\vec{v}\,\varphi = -\operatorname{div}\vec{j}_{\Phi} + \dot{\sigma}_{\forall\Phi}$$



canivete

Table 11.4-1 Equations of Change for Pure Fluids in Terms of the Fluxes

Eq.	Special form	In terms of D/Dt		Comments
Cont.	—	$\frac{D\rho}{Dt} = -\rho(\nabla \cdot \mathbf{v})$	Table 3.5-1 (A)	For ρ = constant, simplifies to $(\nabla \cdot \mathbf{v}) = 0$
Motion	General	$\rho \frac{D\mathbf{v}}{Dt} = -\nabla p - [\nabla \cdot \boldsymbol{\tau}] + \rho \mathbf{g}$	Table 3.5-1 (B)	For $\boldsymbol{\tau} = 0$ this becomes Euler's equation
	Approximate	$\rho \frac{D\mathbf{v}}{Dt} = -\nabla p - [\nabla \cdot \boldsymbol{\tau}] + \bar{\rho}\mathbf{g} - \bar{\rho}\mathbf{g}\bar{\beta}(T - \bar{T})$	11.3-2 (C)	Displays buoyancy term
Energy	In terms of $\hat{K} + \hat{U} + \hat{\Phi}$	$\rho \frac{D(\hat{K} + \hat{U} + \hat{\Phi})}{Dt} = -(\nabla \cdot \mathbf{q}) - (\nabla \cdot p\mathbf{v}) - (\nabla \cdot [\boldsymbol{\tau} \cdot \mathbf{v}])$	— (D)	Exact only for Φ time independent
	In terms of $\hat{K} + \hat{U}$	$\rho \frac{D(\hat{K} + \hat{U})}{Dt} = -(\nabla \cdot \mathbf{q}) - (\nabla \cdot p\mathbf{v}) - (\nabla \cdot [\boldsymbol{\tau} \cdot \mathbf{v}]) + \rho(\mathbf{v} \cdot \mathbf{g})$	— (E)	
	In terms of $\hat{K} = \frac{1}{2}v^2$	$\rho \frac{D\hat{K}}{Dt} = -(\mathbf{v} \cdot \nabla p) - (\mathbf{v} \cdot [\nabla \cdot \boldsymbol{\tau}]) + \rho(\mathbf{v} \cdot \mathbf{g})$	Table 3.5-1 (F)	From equation of motion
	In terms of $\hat{U}$	$\rho \frac{D\hat{U}}{Dt} = -(\nabla \cdot \mathbf{q}) - p(\nabla \cdot \mathbf{v}) - (\boldsymbol{\tau}:\nabla \mathbf{v})$	11.2-2 (G)	Term containing $(\nabla \cdot \mathbf{v})$ is zero for constant ρ
	In terms of $\hat{H}$	$\rho \frac{D\hat{H}}{Dt} = -(\nabla \cdot \mathbf{q}) - (\boldsymbol{\tau}:\nabla \mathbf{v}) + \frac{Dp}{Dt}$	11.2-3 (H)	$\hat{H} = \hat{U} + (p/\rho)$
	In terms of	$\rho \hat{C}_p \frac{DT}{Dt} = -(\nabla \cdot \mathbf{q}) - T\left(\frac{\partial p}{\partial T}\right)(\nabla \cdot \mathbf{v}) - (\boldsymbol{\tau}:\nabla \mathbf{v})$		

BIRD table 11.4-1

$$\rho \frac{D\varphi}{Dt} = -\operatorname{div} \vec{j}_\Phi + \dot{\sigma}_{\forall\Phi}$$

$$\frac{\partial \rho\varphi}{\partial t} + \mathrm{div}\,\rho\vec{v}\varphi = -\,\mathrm{div}\,\vec{\dot{j}}_{\Phi} + \dot{\sigma}_{\forall_{\Phi}}$$

Moti	Approximate	$\frac{\partial}{\partial t}\rho\mathbf{v} = -[\nabla\cdot\rho\mathbf{v}\mathbf{v}] - \nabla p - [\nabla\cdot\boldsymbol{\tau}] + \bar{\rho}\mathbf{g} - \bar{\rho}\mathbf{g}\bar{\beta}(T-\bar{T})$	— (M)	Displays buoyancy term
Energy	In terms of $\hat{K}+\hat{U}+\hat{\Phi}$	$\frac{\partial}{\partial t}\rho(\hat{K}+\hat{U}+\hat{\Phi}) = -(\nabla\cdot\rho(\hat{K}+\hat{H}+\hat{\Phi})\mathbf{v}) - (\nabla\cdot\mathbf{q}) - (\nabla\cdot[\boldsymbol{\tau}\cdot\mathbf{v}])$	11.1-9 (N)	Exact only for Φ time independent
	In terms of $\hat{K}+\hat{\Phi}$	$\frac{\partial}{\partial t}\rho(\hat{K}+\hat{\Phi}) = -(\nabla\cdot\rho(\hat{K}+\hat{\Phi})\mathbf{v}) - (\mathbf{v}\cdot\nabla p) - (\mathbf{v}\cdot[\nabla\cdot\boldsymbol{\tau}])$	3.3-2 (O)	Exact only for Φ time independent From equation of motion
	In terms of $\hat{K}+\hat{U}$	$\frac{\partial}{\partial t}\rho(\hat{K}+\hat{U}) = -(\nabla\cdot\rho(\hat{K}+\hat{H})\mathbf{v}) - (\nabla\cdot\mathbf{q}) - (\nabla\cdot[\boldsymbol{\tau}\cdot\mathbf{v})] + \rho(\mathbf{v}\cdot\mathbf{g})$	11.1-7 (P)	
	In terms of $\hat{K}=\frac{1}{2}v^2$	$\frac{\partial}{\partial t}\rho\hat{K} = -(\nabla\cdot\rho\hat{K}\mathbf{v}) - (\mathbf{v}\cdot\nabla p) - (\mathbf{v}\cdot[\nabla\cdot\boldsymbol{\tau}]) + \rho(\mathbf{v}\cdot\mathbf{g})$	3.3-1 (Q)	From equation of motion
	In terms of $\hat{U}$	$\frac{\partial}{\partial t}\rho\hat{U} = -(\nabla\cdot\rho\hat{U}\mathbf{v}) - (\nabla\cdot\mathbf{q}) - p(\nabla\cdot\mathbf{v}) - (\boldsymbol{\tau}:\nabla\mathbf{v})$	11.2-1 (R)	Term containing $(\nabla\cdot\mathbf{v})$ is zero for constant ρ
	In terms of $\hat{H}$	$\frac{\partial}{\partial t}\rho\hat{H} = -(\nabla\cdot\rho\hat{H}\mathbf{v}) - (\nabla\cdot\mathbf{q}) - (\boldsymbol{\tau}:\nabla\mathbf{v}) + \frac{Dp}{Dt}$	— (S)	$\hat{H} = \hat{U} + (p/\rho)$
Entropy	—	$\frac{\partial}{\partial t}\rho\hat{S} = -(\nabla\cdot\rho\hat{S}\,\mathbf{v}) - \left(\nabla\cdot\frac{\mathbf{q}}{T}\right) - \frac{1}{T^2}(\mathbf{q}\cdot\nabla T) - \frac{1}{T}(\boldsymbol{\tau}:\nabla\dot{\mathbf{v}})$	11D.1-1 (T)	Last two terms describe entropy

BIRD eq 24.1-1

modelos

BIRD cap 24

$$\vec{j}_{\Phi} = -\rho \lambda_{\Phi} \, \mathrm{gr\vec{a}d} \, \varphi$$

$$\vec{j}_{\Phi} = -\rho \vec{\vec{\lambda}}_{\Phi} \bullet \mathrm{gr\vec{a}d} \, \mu_{\Phi}$$

compósitos

$$\vec{j}_{\Phi} = -\rho \sum_{\Psi} \vec{\vec{\lambda}}_{\Phi\Psi} \bullet \mathrm{gr\vec{a}d} \, \mu_{\Psi}$$

acoplamentos

$$\vec{j}_{\Phi} = -\rho \sum_{\Psi} \left[\vec{\vec{\lambda}}_{\Phi\Psi} \bullet \mathrm{gr\vec{a}d}^{n} \mu_{\Psi} + \vec{\vec{\aleph}}_{\Phi\Psi} \bullet \mathrm{gr\dot{\vec{a}}d}^{m} \mu_{\Psi} + \ldots \right]$$

?

unificação

$$\rho\frac{D\varphi}{Dt} = -\operatorname{div}\vec{j}_\Phi + \dot{\sigma}_{\forall\Phi}$$

$$\rho\frac{De_c}{Dt} = -\vec{v}.\operatorname{d\vec{i}v}\vec{\vec{P}} + \rho\,\vec{v}.\vec{f}$$

$$\rho\frac{De_p}{Dt} = -\rho\vec{v}\bullet\vec{f}$$

+

$$\rho\frac{De_m}{Dt} = -\vec{v}.\operatorname{div}\vec{\vec{P}}$$

+

$$\rho\frac{Du}{Dt} = T\rho\frac{Ds}{Dt} + \frac{p}{\rho}\frac{D\rho}{Dt} + \sum_i \mu_i\rho\frac{Dx_i}{Dt}$$

=

$$\rho\frac{De}{Dt} = -\operatorname{div}\left[\sum_i \mu_i\vec{j}_i + \mu_S\vec{j}_S + \vec{\vec{P}}.\vec{v}\right]$$

$$\vec{j}_e = \sum_\psi \mu_\psi\vec{j}_\psi$$

$$-\operatorname{div}\vec{\vec{P}}.\vec{v} - \operatorname{div}T\vec{j}_S - \operatorname{div}\sum_i \mu_i\vec{j}_i = -\vec{v}.\operatorname{div}\vec{\vec{P}} + T\rho\frac{Ds}{Dt} + \frac{p}{\rho}\frac{D\rho}{Dt} + \sum_i \mu_i\rho\frac{Dx_i}{Dt}$$

$$\frac{D\rho}{Dt} = -\rho\operatorname{div}\vec{v}$$

$$\rho\frac{Dx_i}{Dt} = -\operatorname{div}\vec{j}_i + \sum_j \nu_{ij}M_i\frac{D\xi_j}{Dt}$$

$$A_j = -\sum_i M_i\nu_{ij}\mu_i$$

$$T\rho\frac{Ds}{Dt} = T\operatorname{div}\vec{j}_S - \vec{\vec{\zeta}}:\operatorname{gr\vec{a}d}\vec{v} + \vec{j}_S\bullet\operatorname{gr\vec{a}d}T + \sum_i \vec{j}_i\bullet\operatorname{gr\vec{a}d}\mu_i - \sum_j A_j\frac{D\xi_j}{Dt}$$

$$\rho\frac{Ds}{Dt} = -\operatorname{div}\vec{j}_S + \dot{\sigma}_{\forall S}$$

$$\dot{\sigma}_{\forall S} = -\frac{\operatorname{gr\vec{a}d}\mu_\varepsilon}{T}\bullet\vec{j}_\varepsilon - \frac{\operatorname{gr\vec{\vec{a}}d}\vec{v}}{T}:\vec{\vec{\zeta}} - \frac{\operatorname{gr\vec{a}d}T}{T}\bullet\vec{j}_S - \sum_i\frac{\operatorname{gr\vec{a}d}\mu_i}{T}\bullet\vec{j}_i - \sum_j\frac{A_j}{T}\frac{D\xi_j}{Dt}$$

$$\rho \frac{Ds}{Dt} = -\operatorname{div} \vec{j}_S + \dot{\sigma}_{\forall S}$$

$$\dot{\sigma}_{\forall S} = -\frac{\overrightarrow{\overrightarrow{grad}}\,\vec{v}}{T} : \overrightarrow{\overrightarrow{\zeta}} - \frac{\overrightarrow{grad}\,T}{T} \bullet \vec{j}_S - \sum_i \frac{\overrightarrow{grad}\,\mu_i}{T} \bullet \vec{j}_i - \sum_j \frac{A_j}{T} \frac{D\xi_j}{Dt}$$

$$-\frac{\overrightarrow{grad}\,\mu_\varepsilon}{T} \bullet \vec{j}_\varepsilon$$

dedução

Irreversibilidades

$$\dot{\sigma}_{\forall S} =$$

$$-\frac{\overrightarrow{grad}\,\mu_\varepsilon}{T} \bullet \vec{j}_\varepsilon$$ **condução elétrica não resistida**

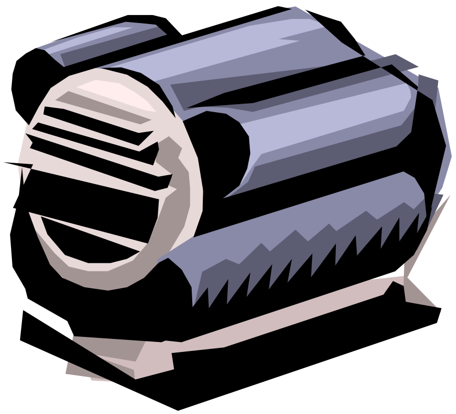
$$-\frac{\overrightarrow{\overrightarrow{grad}}\,\vec{v}}{T} : \overrightarrow{\overrightarrow{\zeta}}$$ **escoamento não resistido (atrito)**

$$-\frac{\overrightarrow{grad}\,T}{T} \bullet \vec{j}_S$$ **calor não resistido**

$$-\sum_i \frac{\overrightarrow{grad}\,\mu_i}{T} \bullet \vec{j}_i$$ **difusões não resistidas**

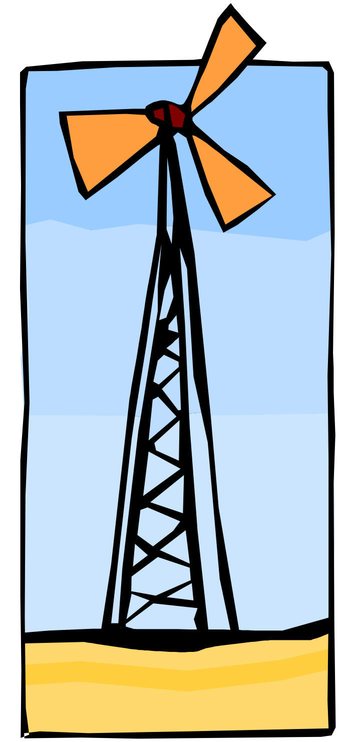
$$-\sum_j \frac{A_j}{T} \frac{D\xi_j}{Dt}$$ **reações químicas não resistidas**

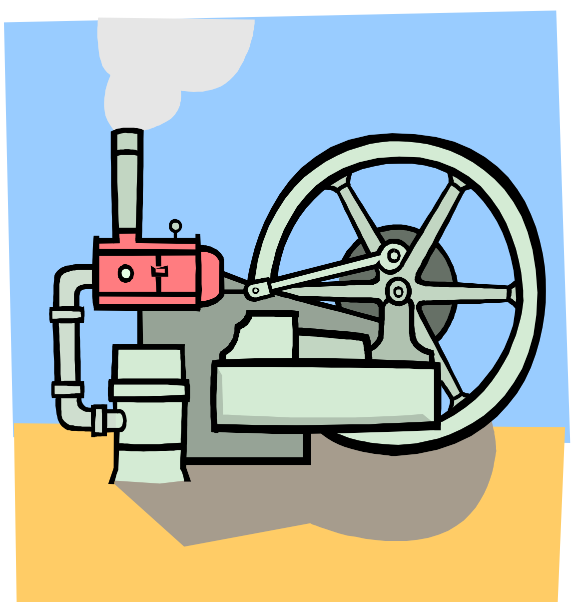
resistir -> reversir



elétrico

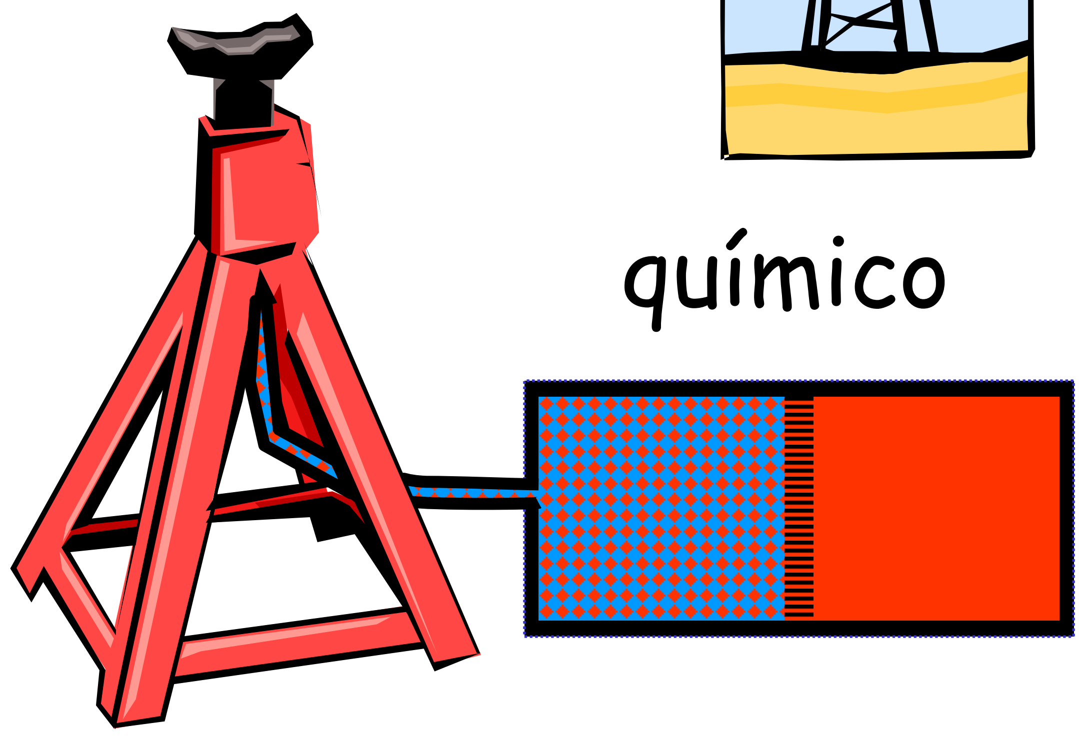
momentum

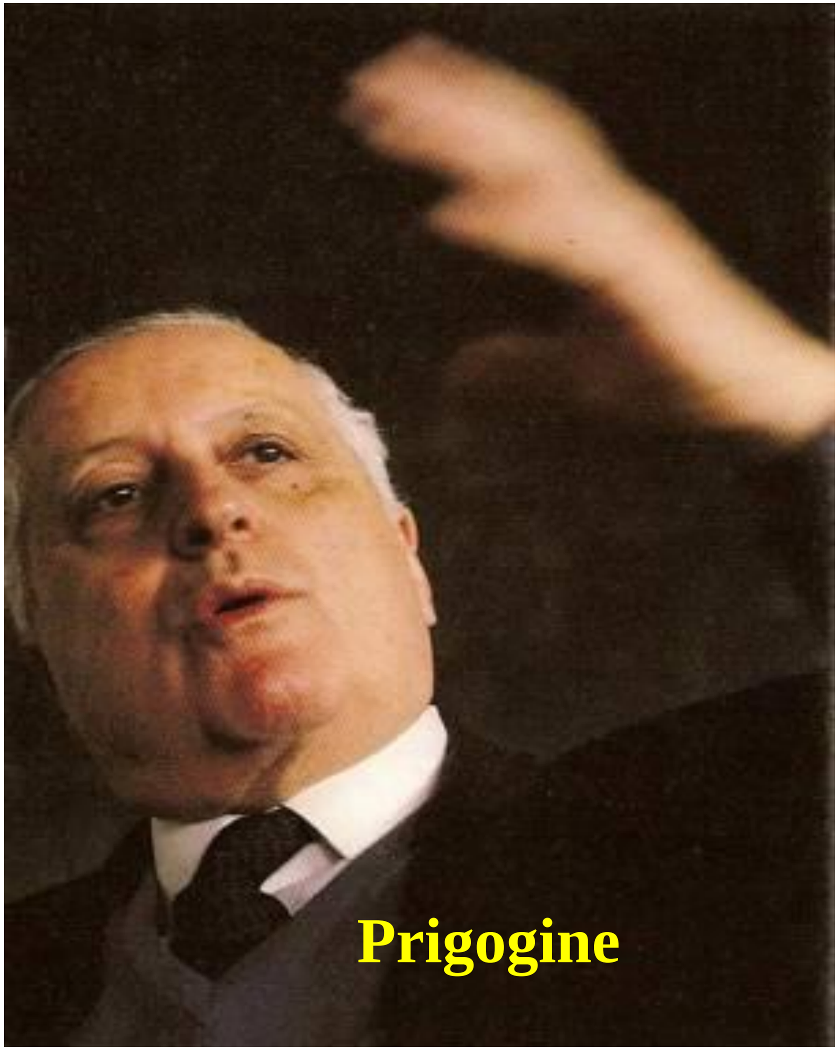




térmico

químico





1ª Generalização

$$\dot{\sigma}_{\forall S} = -\sum_{\Phi} \vec{j}_{\Phi} \bullet \frac{\overrightarrow{grad}\,\mu_{\Phi}}{T} > 0$$

$$\dot{\sigma}_{\forall S} = -\sum_{\Phi} \vec{j}_{\Phi} \bullet \frac{\vec{grad}\,\mu_{\Phi}}{T} > 0$$

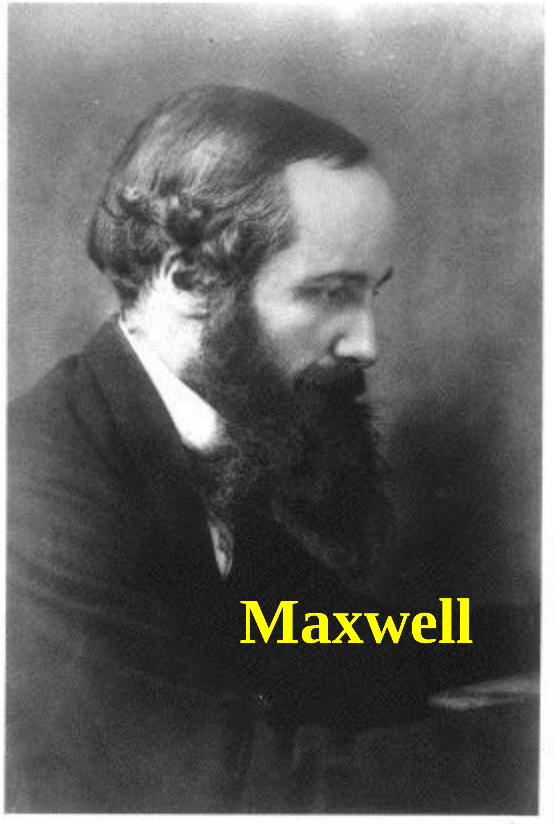
2ª Generalização

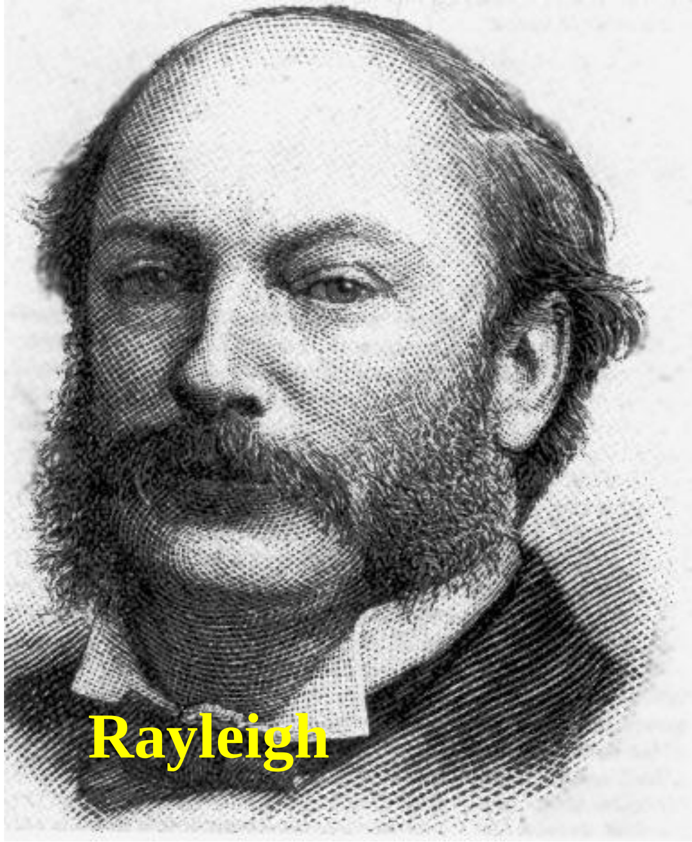
$$\vec{j}_{\Phi} = -\rho \sum_{\Psi} \vec{\vec{\lambda}}_{\Psi\Phi} \bullet \vec{grad}\,\mu_{\Psi}$$

$$\vec{j}_{\Phi} = \sum_{\Psi} L_{\Phi\Psi}\, \vec{grad}\,\mu_{\Psi}$$

$$T\dot{\sigma}_{\forall S} = -\sum_{\Phi}\sum_{\Psi} L_{\Phi\Psi}\, \vec{grad}\,\mu_{\Psi} \bullet \vec{grad}\,\mu_{\Phi} \approx L_{\Phi}\left(\vec{grad}\,\mu_{\Phi}\right)^2$$

Dissipações





$$\dot{P}_{\varepsilon} = T\,\dot{\sigma}_{\forall_{\varepsilon}} =$$

$$= \frac{1}{R_{\varepsilon}}\, \mathrm{gr}\vec{\mathrm{a}}\mathrm{d}\,\mu_{\varepsilon} \bullet \mathrm{gr}\vec{\mathrm{a}}\mathrm{d}\,\mu_{\varepsilon} =$$

$$= \frac{U_{\varepsilon}^{2}}{R_{\varepsilon}}$$

$$\Phi_{v} = T\,\dot{\sigma}_{\forall_{\vec{v}}} =$$

$$= \mu\, \mathrm{gr}\vec{\mathrm{a}}\mathrm{d}\,\vec{v} : \mathrm{gr}\vec{\mathrm{a}}\mathrm{d}\,\vec{v} =$$

$$= \mu \left(\frac{\partial v_{x}}{\partial y} \right)^{2}$$

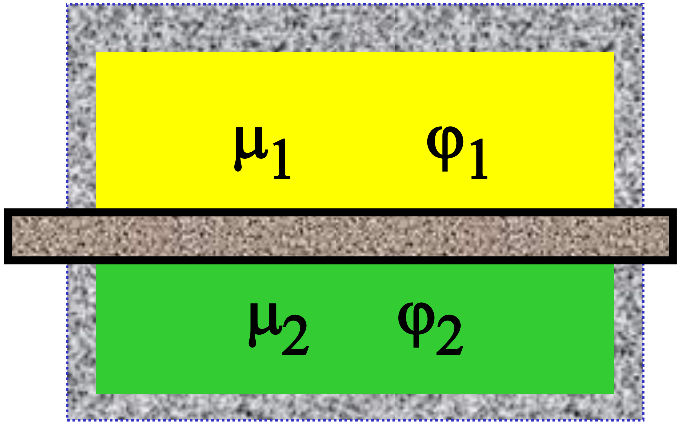
sistema composto

$$\rho\frac{Du}{Dt} = T\rho\frac{Ds}{Dt} + \frac{p}{\rho}\frac{D\rho}{Dt} + \sum_i \mu_i \rho \frac{Dx_i}{Dt}$$

$$DU = TDS - pDV + \sum_i \mu_i DN_i$$

$$dS = \frac{dU}{T} + \frac{p}{T}dV - \sum_i \frac{\mu_i}{T} dN_i$$

vínculos

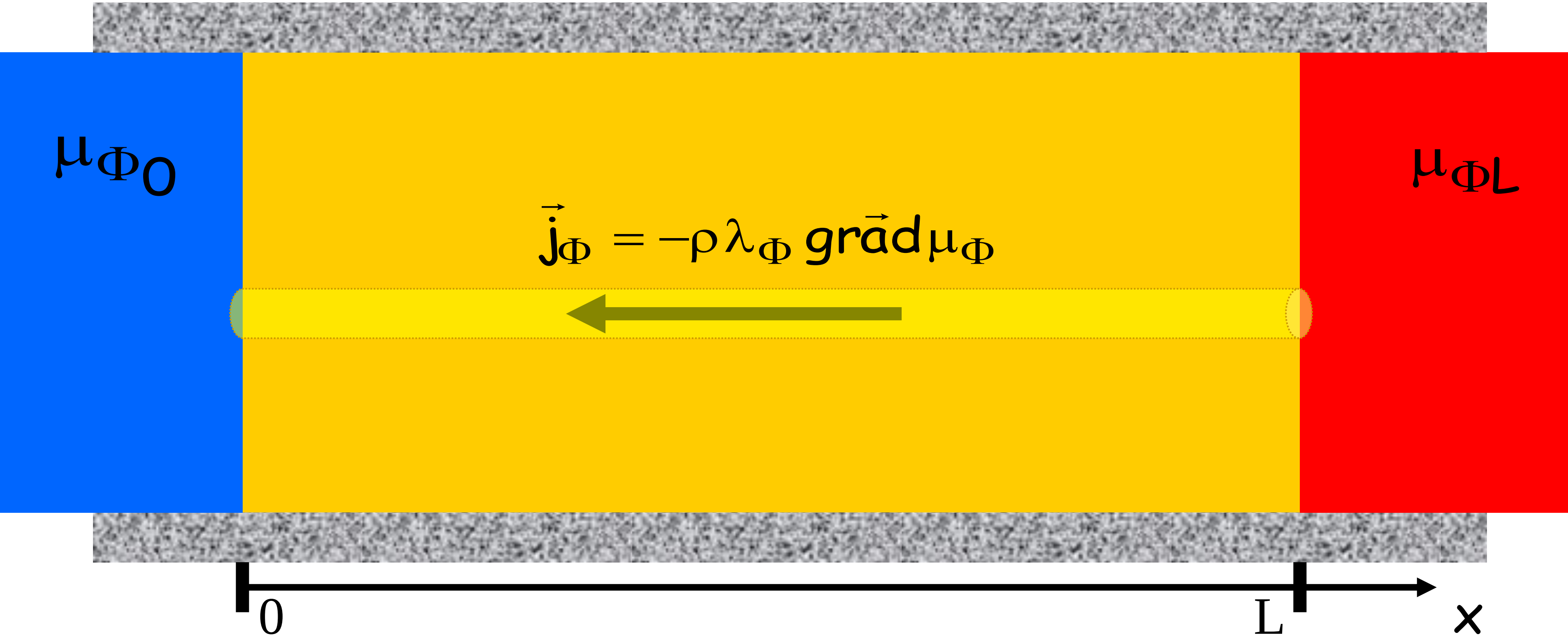


$\mu_1 > \mu_2$

restrições
adiabática,
impermeável
indeformável

$$dS = \left(\frac{1}{T_1} - \frac{1}{T_2}\right)dU_1 + \left(\frac{p_1}{T_1} - \frac{p_2}{T_2}\right)dV_1 - \left(\frac{\mu_{A_1}}{T_1} - \frac{\mu_{A_2}}{T_2}\right)dN_{A1} - \left(\frac{\mu_{B_1}}{T_1} - \frac{\mu_{B_2}}{T_2}\right)dN_{B1}$$

um exemplo de FT



$$\dot{\sigma}_{\forall S} = -\sum_{\Phi} \vec{j}_\Phi \bullet \frac{gr\vec{a}d \, \mu_\Phi}{T}$$

$$\vec{j}_\Phi = -\rho \sum_{\Psi} \vec{\vec{\lambda}}_{\Psi\Phi} \bullet gr\vec{a}d^m \, \mu_\Psi$$

$$\dot{\sigma}_{\forall S} = -\vec{j}_\Phi \bullet \frac{gr\vec{a}d \, \mu_\Phi}{T}$$

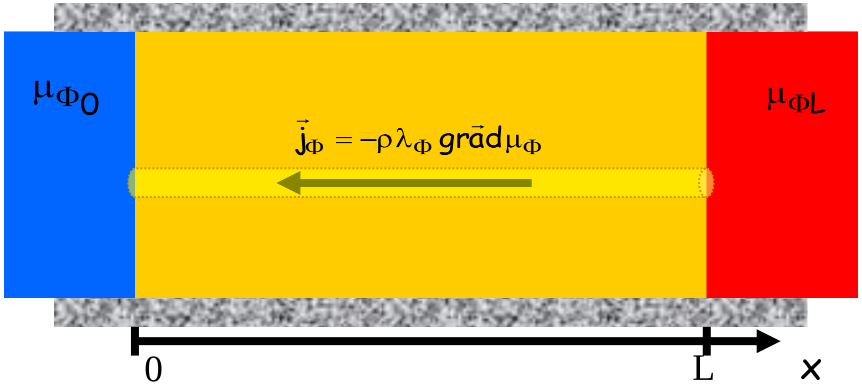
$$\vec{j}_\Phi = -\rho \lambda_\Phi \, gr\vec{a}d^m \, \mu_\Phi$$

$$\dot{\sigma}_{\$S} = -\int_0^L -\frac{\rho \lambda_\Phi}{T} \left(gr\vec{a}d \, \mu_\Phi \right)^{m+1} dx$$

variacional

$$\dot{\sigma}_{\$S} = -\int_0^L -\frac{\rho\lambda_\Phi}{T}\left(\vec{\text{grad}}\,\mu_\Phi\right)^{m+1} dx$$

$$\frac{\dot{\sigma}_{\$S}}{\rho} = \int_0^L \frac{\lambda_\Phi}{T}\left(\frac{\partial\mu_\Phi}{\partial x}\right)^{m+1} dx$$



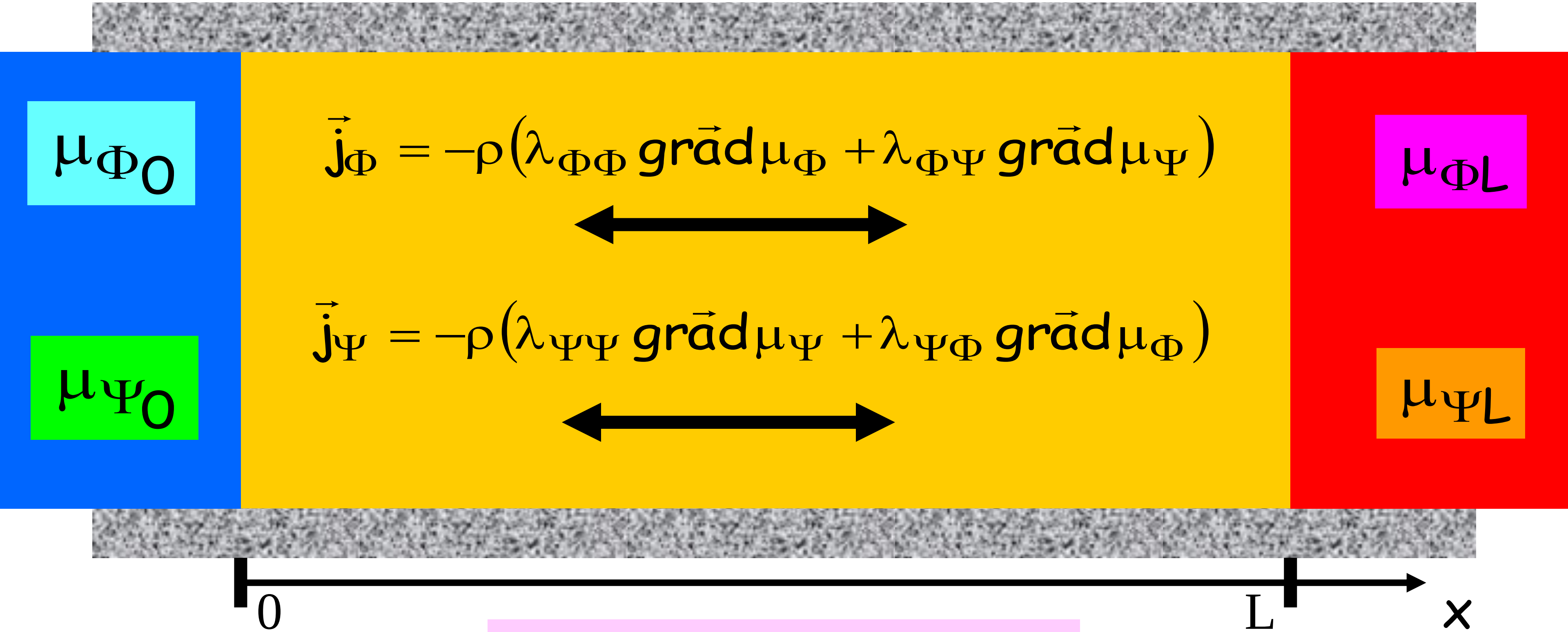
$$T(x) = f = ?$$

$$I = \int_0^L \Lambda\left(f, \frac{\partial f}{\partial x}\right) dx$$

$$\frac{d}{dx}\frac{\partial\Lambda}{\partial f/\partial x} - \frac{\partial\Lambda}{\partial f} = 0$$

$$T(x) = ax + b$$

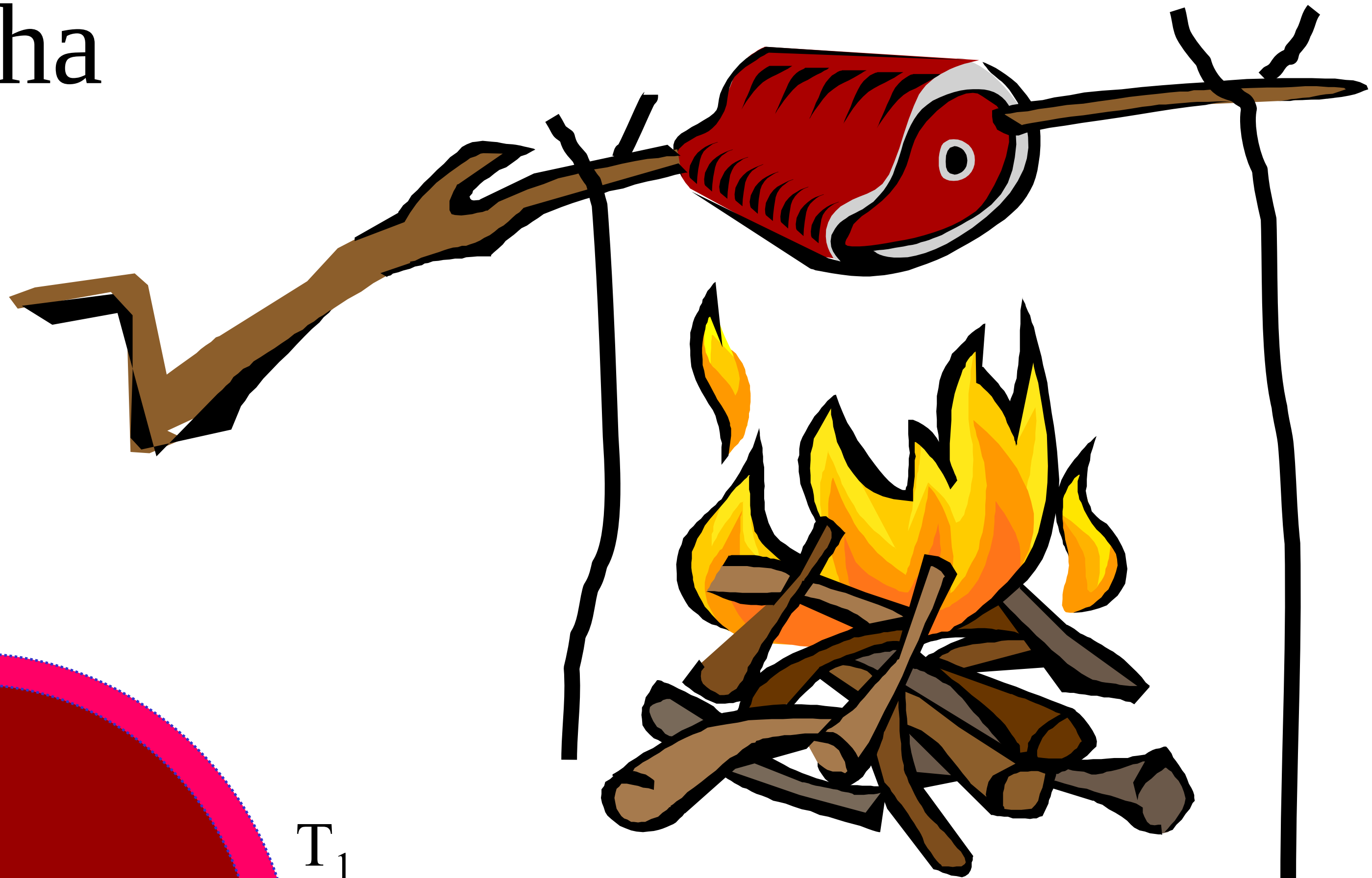
outro exemplo acoplamento de fts

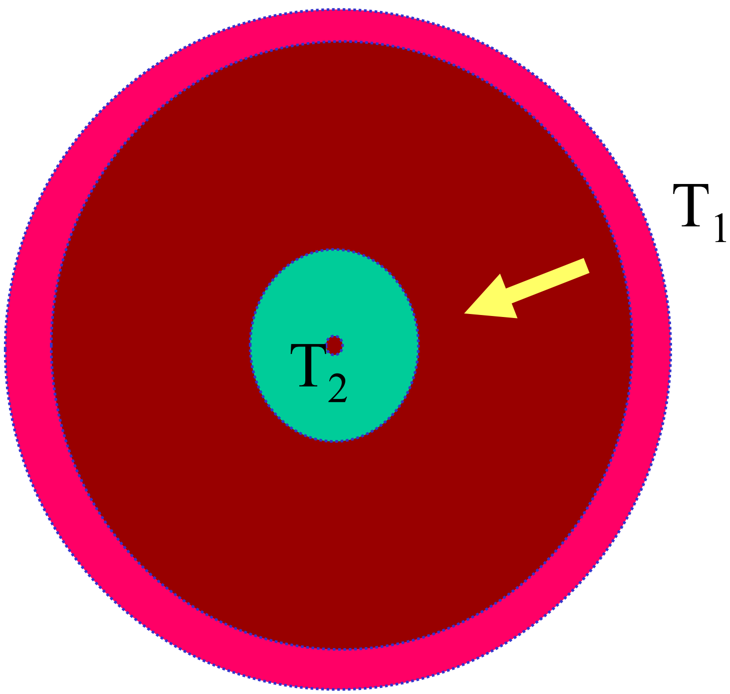


$$\dot{\sigma}_{\forall S} = -\sum_{\Phi} \vec{j}_{\Phi} \bullet \frac{\vec{grad}\,\mu_{\Phi}}{T}$$

$$\frac{T\,\dot{\sigma}_{\forall S}}{\rho} = \left\{ \begin{array}{l} \left(\lambda_{\Phi\Phi}\,\vec{grad}\,\mu_{\Phi} + \lambda_{\Phi\Psi}\,\vec{grad}\,\mu_{\Psi}\right) \bullet \vec{grad}\,\mu_{\Phi} + \\ + \left(\lambda_{\Psi\Psi}\,\vec{grad}\,\mu_{\Psi} + \lambda_{\Psi\Phi}\,\vec{grad}\,\mu_{\Phi}\right) \bullet \vec{grad}\,\mu_{\Psi} \end{array} \right\}$$

picanha



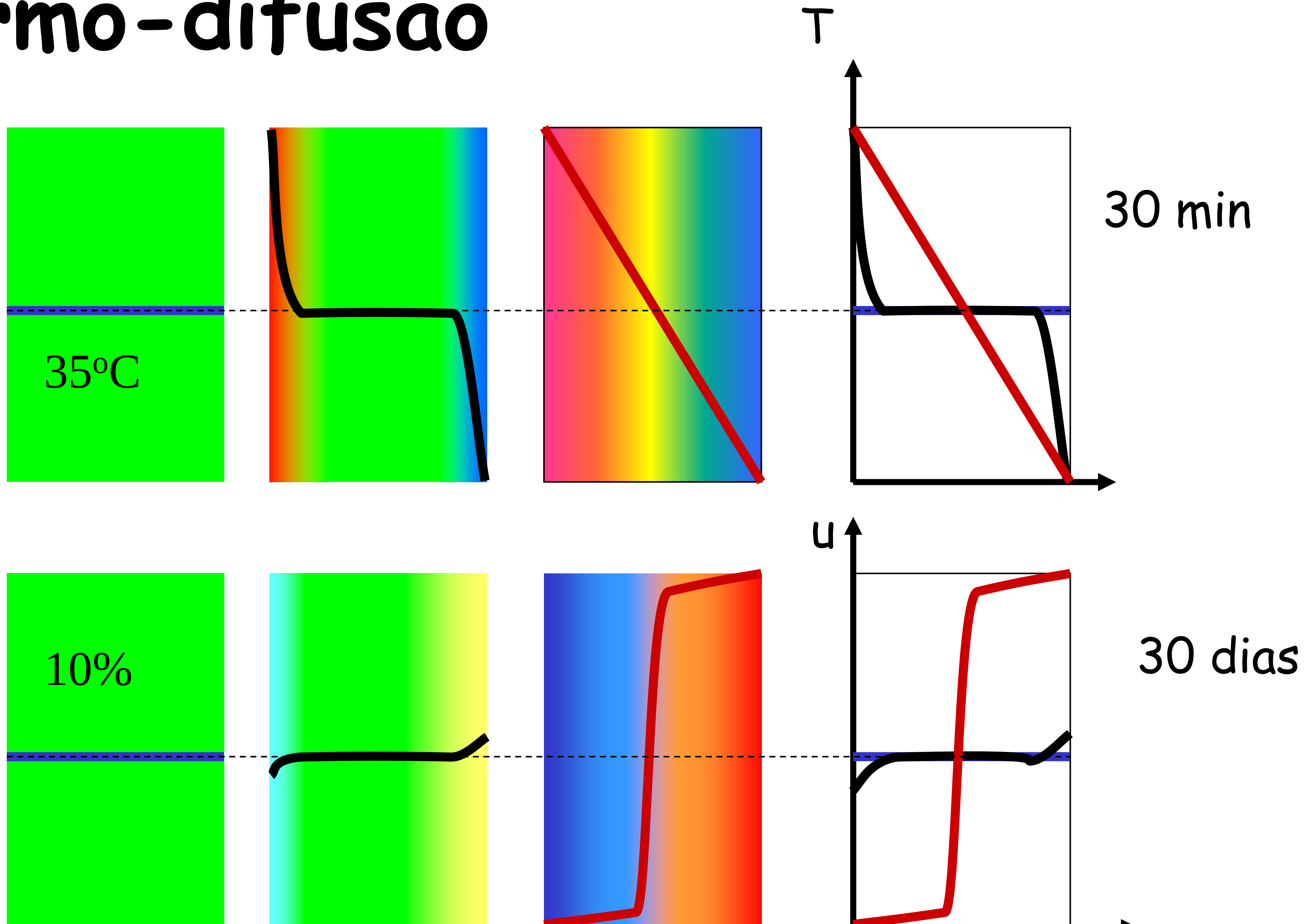


$T_1 > T_2$

$\mu_{A1} > \mu_{A2}$

$x_{A1} < x_{A2}$

termo-difusão

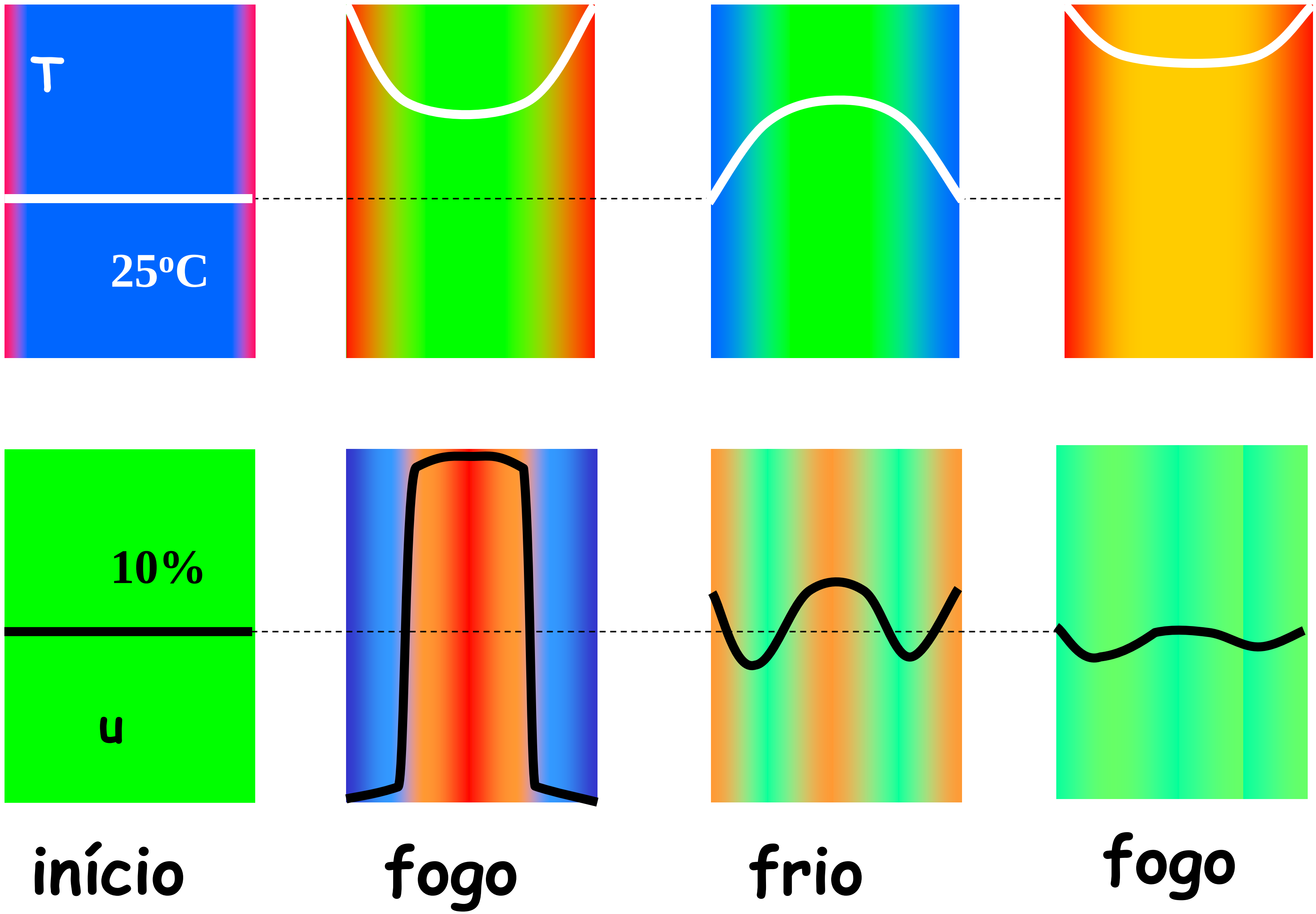


$$\vec{j}_u = -D_u\, \vec{grad}\, u$$

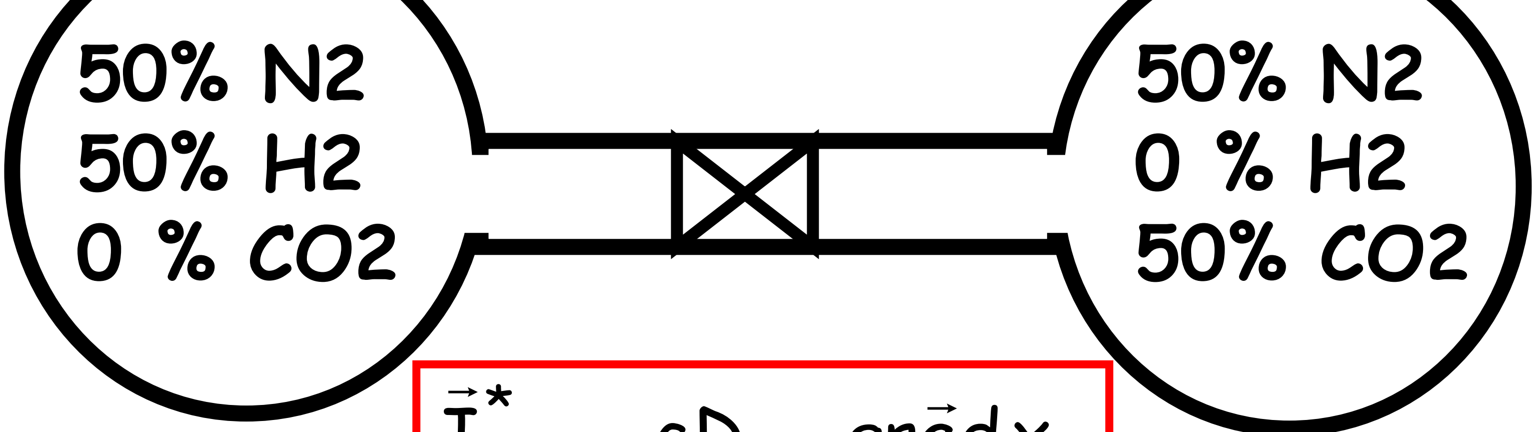
$$\vec{j}_u = -D_{uu}\, \vec{grad}\, u + D_{Tu}\, \vec{grad}\, T$$

picanha

$$\vec{j}_u = -D\left(\vec{\mathrm{grad}}\,u - \delta\,\vec{\mathrm{grad}}\,T\right)$$

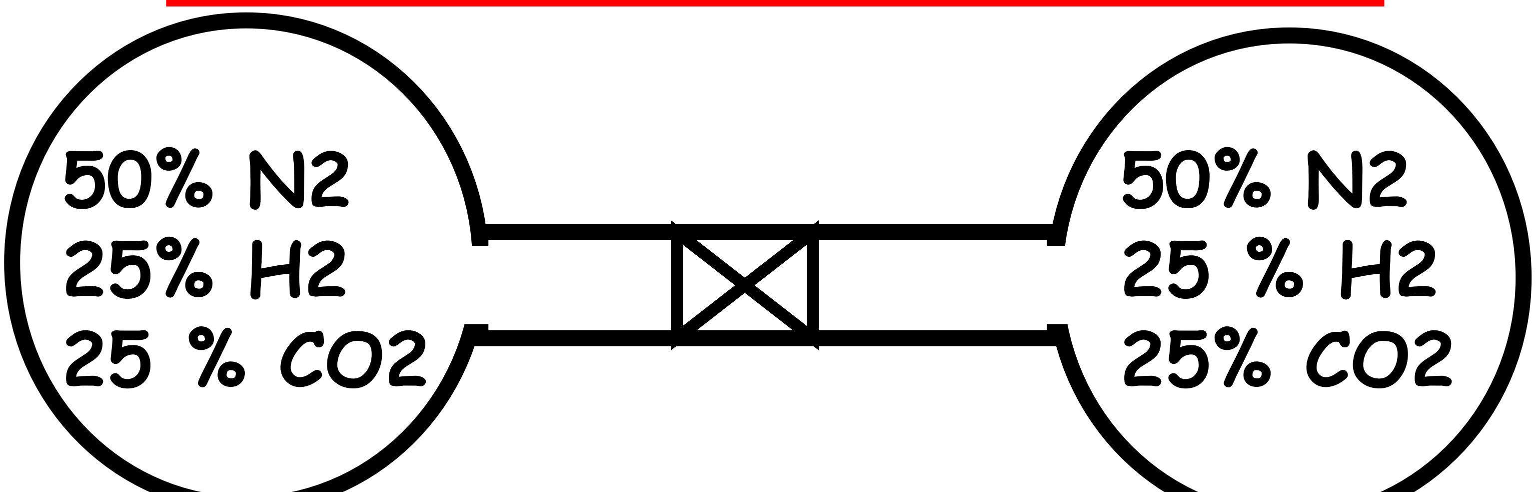


Sistema Ternário



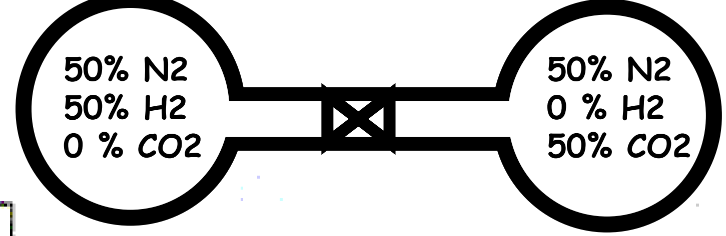
$$\vec{J}_A^{\,*} = -cD_{AB}\,\vec{\text{grad}}\,x_A$$

$$\rho\frac{D\omega_A}{Dt} = \frac{\partial \rho_A}{\partial t} + \text{div}\,\rho_A\vec{v} = \rho D_{AB}\,\text{lap}\,\omega_A + \dot{r}_A$$



BIRD (binário) ex 24.6-1

Difusão Multicomponente



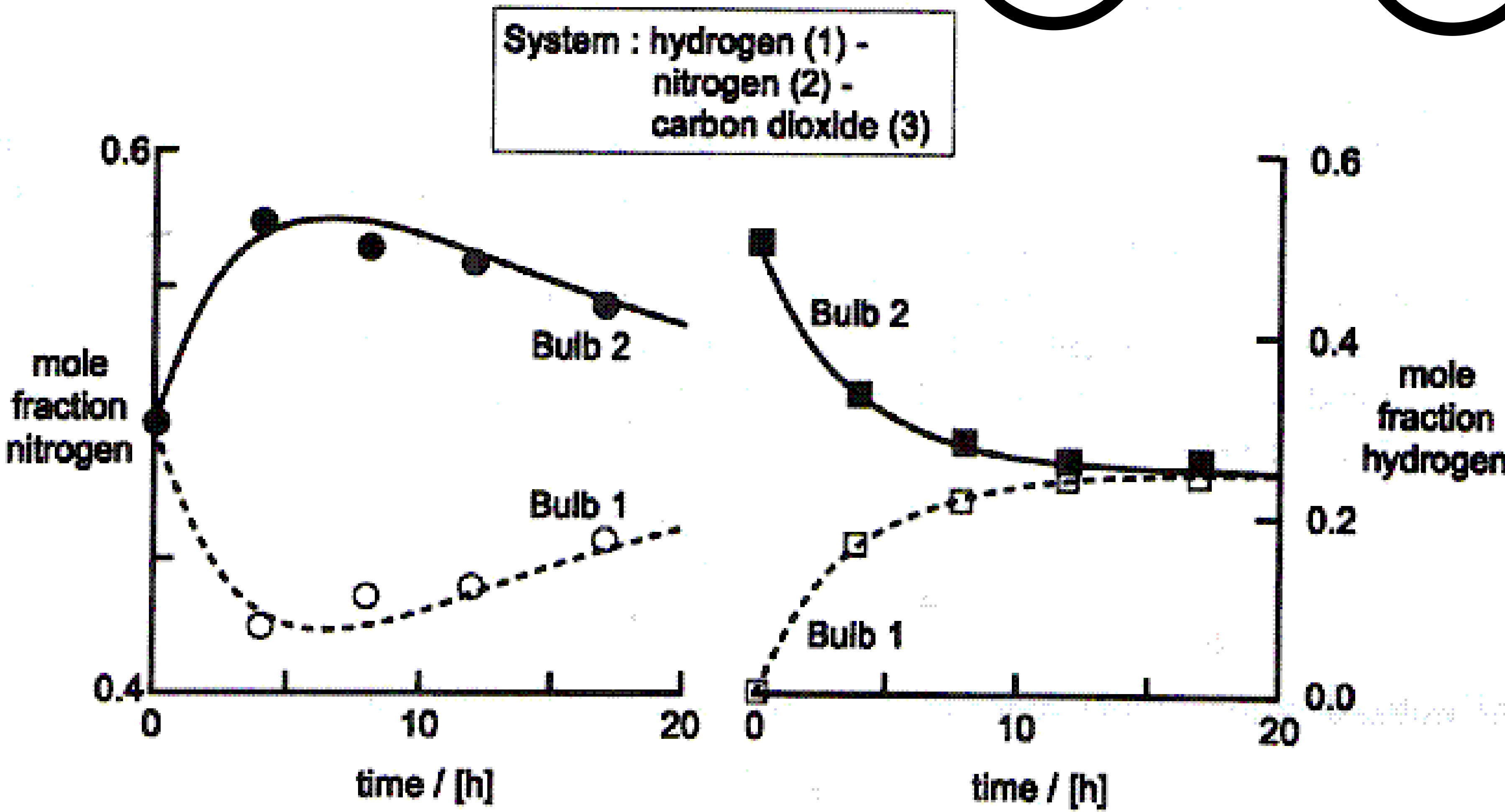


Figure 5.4. Composition–time history in two bulb diffusion cell. Experimental data from Duncan (1960).

$$\vec{J}_A^{*} = -c D_{AB}\,\vec{grad}\,x_A$$

Lei de Fick Generalizada – Sistema Ternário

Dois fluxos e duas forças independentes

$$\vec{J}_1^* = -cD_{11}\, gr\vec{a}d\, x_1 - cD_{12}\, gr\vec{a}d\, x_2$$

$$\vec{J}_2^* = -cD_{21}\, gr\vec{a}d\, x_1 - cD_{22}\, gr\vec{a}d\, x_2$$

$D_{12} \neq D_{21}$ e diferentes das difusivdiade binárias (podem ser negativos)

Lei de Fick Generalizada – Sistema Multicomponente (i =1, 2, ..., n)

$$\vec{J}_1^* = -cD_{11}\, gr\vec{a}d\, x_1 - cD_{12}\, gr\vec{a}d\, x_2 \cdots\cdots - cD_{1,n-1}\, gr\vec{a}d\, x_{n-1}$$

$$\vec{J}_2^* = -cD_{21}\, gr\vec{a}d\, x_1 - cD_{22}\, gr\vec{a}d\, x_2 \cdots\cdots - cD_{2,n-1}\, gr\vec{a}d\, x_{n-1}$$

.

$$\vec{J}_i^* = -cD_{i1}\, gr\vec{a}d\, x_1 - cD_{i2}\, gr\vec{a}d\, x_2 \cdots\cdots - cD_{i,n-1}\, gr\vec{a}d\, x_{n-1}$$

.

$$\vec{J}_{n-1}^* = -cD_{n-1,1}\, gr\vec{a}d\, x_1 - cD_{n-1,2}\, gr\vec{a}d\, x_2 \cdots\cdots - cD_{n-1,n-1}\, gr\vec{a}d\, x_{n-1}$$

$$\vec{J}_i^* = \begin{pmatrix} \vec{J}_1^* \\ \vec{J}_2^* \\ \vdots \\ \vec{J}_{n-1}^* \end{pmatrix} \qquad \sum_{i=1}^{N} \vec{J}_i^* = 0 \qquad \vec{grad}\,x = \begin{pmatrix} \vec{grad}\,x_1 \\ \vec{grad}\,x_2 \\ \vdots \\ \vec{grad}\,x_{n-1} \end{pmatrix}$$

$$[D] = \begin{pmatrix} D_{11} & D_{12} & \cdots & D_{1,n-1} \\ D_{21} & D_{22} & \cdots & D_{2,n-1} \\ \vdots & & & \vdots \\ D_{n-1,1} & D_{n-1,2} & \cdots & D_{n-1,n-1} \end{pmatrix}$$

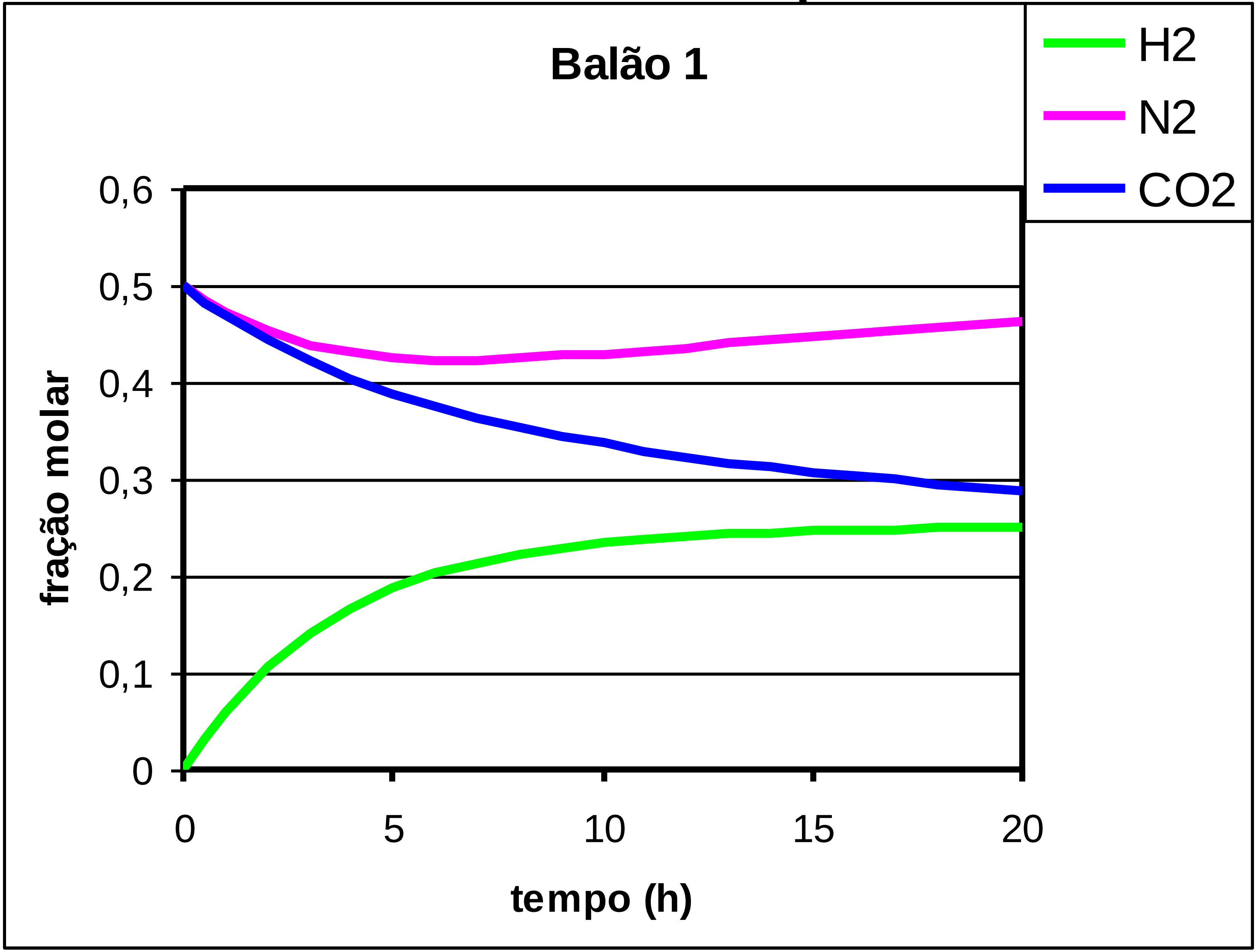
$$\left[\vec{J}^*\right] = -c[D]\left[\vec{grad}\,x\right]$$

BIRD p.718

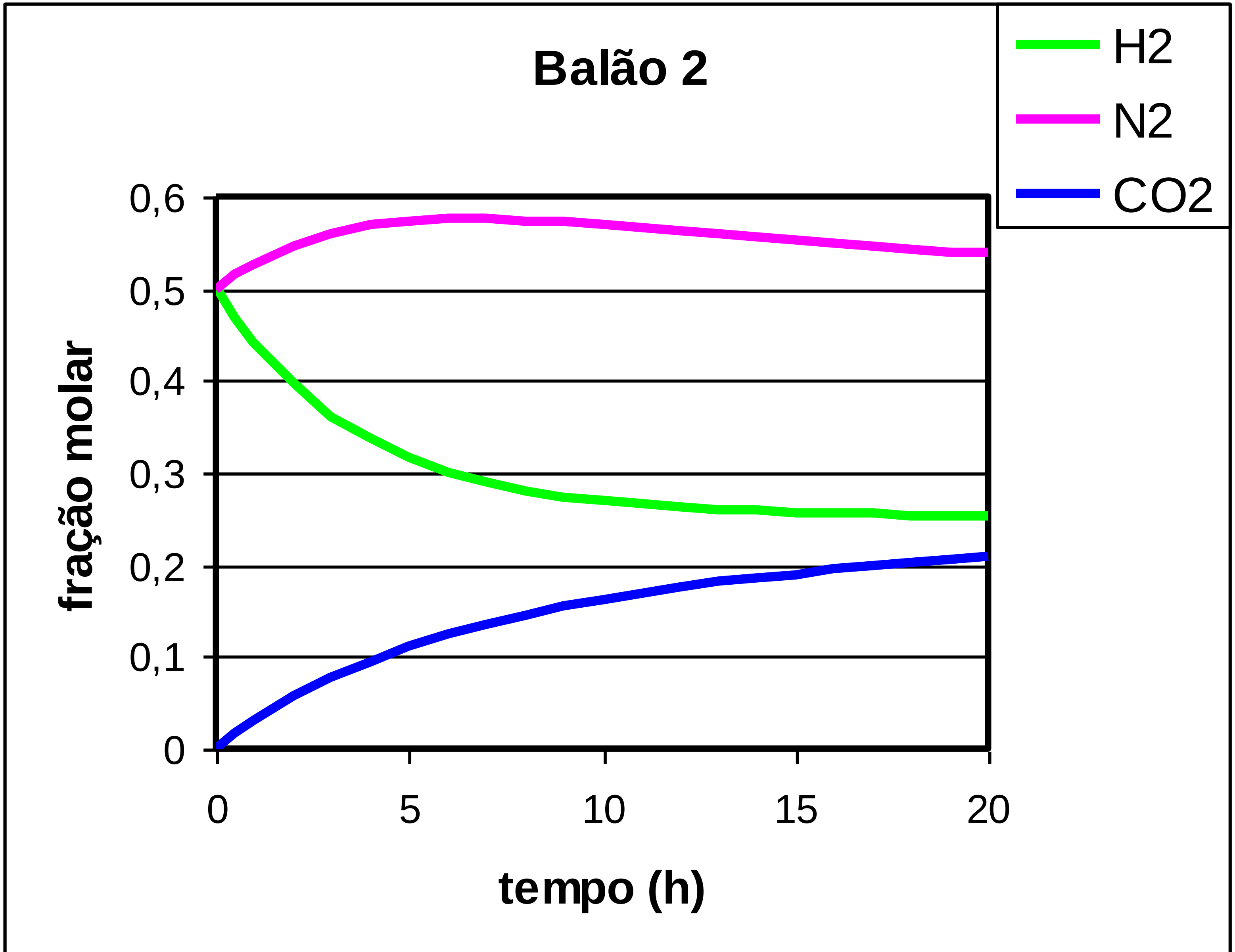
Difusão Multicomponente

tempo (h)	X10	X20	X30	X1L	X2L	X3L
0,0	0,000	0,501	0,499	0,501	0,499	0,000
0,5	0,032	0,485	0,483	0,469	0,514	0,016
1,0	0,060	0,472	0,468	0,442	0,527	0,031
2,0	0,106	0,452	0,442	0,396	0,547	0,056
3,0	0,141	0,438	0,421	0,362	0,561	0,078
4,0	0,167	0,430	0,403	0,336	0,569	0,095
5,0	0,187	0,425	0,388	0,316	0,574	0,111
6,0	0,202	0,423	0,374	0,301	0,576	0,124
7,0	0,214	0,423	0,363	0,289	0,576	0,135
8,0	0,223	0,424	0,353	0,280	0,575	0,145
9,0	0,229	0,427	0,344	0,274	0,572	0,154
10,0	0,234	0,429	0,336	0,269	0,570	0,162
11,0	0,238	0,433	0,329	0,265	0,567	0,169
12,0	0,241	0,436	0,323	0,262	0,563	0,175
13,0	0,244	0,439	0,317	0,260	0,560	0,181
14,0	0,245	0,443	0,312	0,258	0,556	0,186
15,0	0,247	0,446	0,307	0,257	0,553	0,190
16,0	0,248	0,450	0,303	0,256	0,550	0,195
17,0	0,248	0,453	0,299	0,255	0,547	0,199
18,0	0,249	0,456	0,295	0,254	0,543	0,202
19,0	0,249	0,459	0,292	0,254	0,541	0,206
20,0	0,250	0,461	0,289	0,253	0,538	0,209

Difusão Multicomponente



Difusão Multicomponente



Difusão Multicomponente

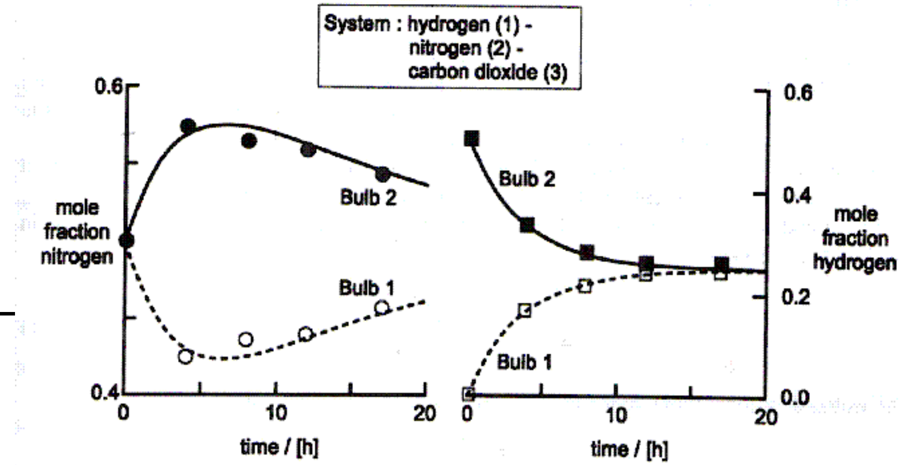


Figure 5.4. Composition–time history in two bulb diffusion cell. Experimental data from Duncan (1960).