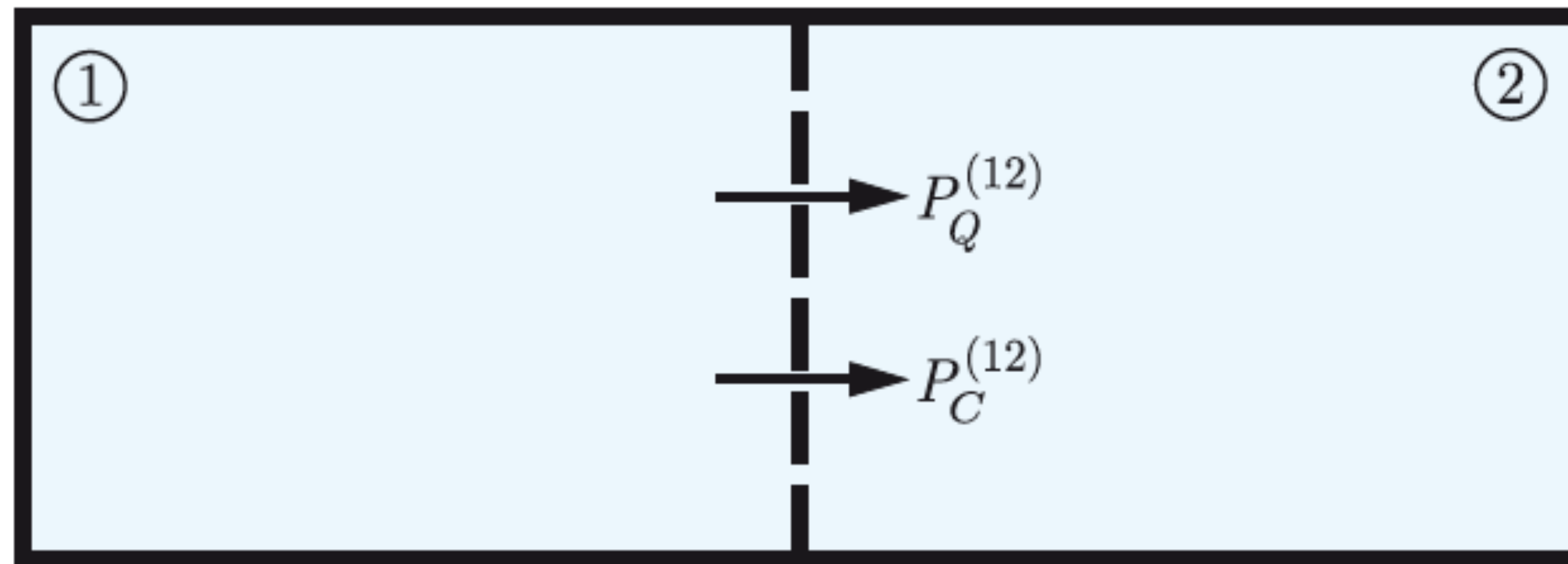


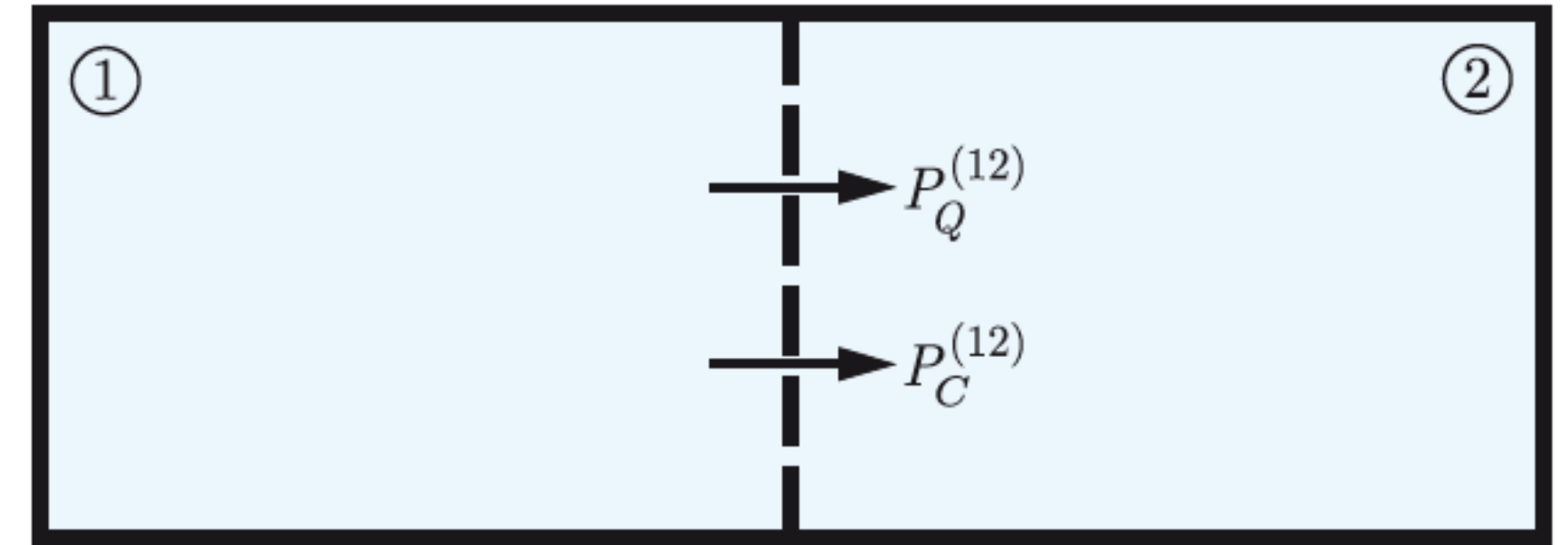
EPFL Paroi fixe, diatherme, perméable



- Système isolé
- composé de deux sous-systèmes simples
- séparés par une paroi
 - fixe
 - diatherme
 - perméable

Paroi fixe, diatherme, perméable

- **Variables d'état:** S_1, S_2
 N_1, N_2
- **Extensivité:** $S = S_1 + S_2$
 $U = U_1 + U_2 \quad N = N_1 + N_2$



$$\dot{U}_1(S_1, N_1) = T_1(S_1, N_1) \dot{S}_1 + \mu_1(S_1, N_1) \dot{N}_1$$

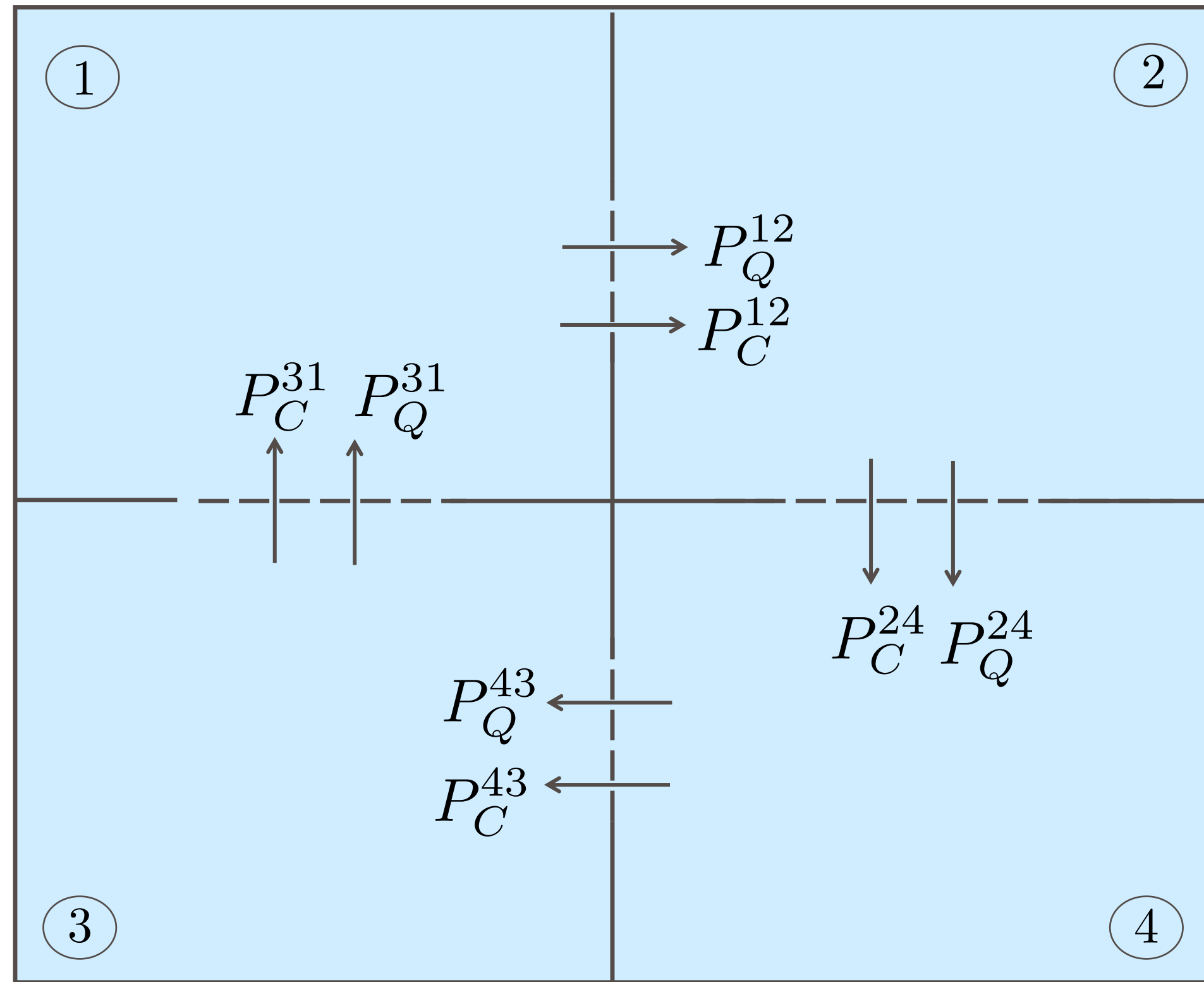
$$\dot{S}_1 = \frac{1}{T_1} \left(\dot{U}_1(S_1, N_1) - \mu_1(S_1, N_1) \dot{N}_1 \right) \quad \dot{S}_2 = \frac{1}{T_2} \left(\dot{U}_2(S_2, N_2) - \mu_2(S_2, N_2) \dot{N}_2 \right)$$

- **Système isolé:** $\dot{U}_1 = -\dot{U}_2 \quad \dot{U}_1(S_1, N_1) = P_Q^{(21)} + P_C^{(21)} \quad \dot{U}_2(S_2, N_2) = P_Q^{(12)} + P_C^{(12)}$
 $\dot{N}_1 = -\dot{N}_2 \quad \dot{N}_1 = I^{(21)} \quad \dot{N}_2 = I^{(12)}$

$$\Pi_S = \dot{S}_1 + \dot{S}_2 = \frac{1}{T_1} \left(P_Q^{(12)} + P_C^{(12)} \right) + \frac{1}{T_2} \left(P_Q^{(21)} + P_C^{(21)} \right) - \frac{\mu_1}{T_1} I^{(21)} - \frac{\mu_2}{T_2} I^{(12)}$$

$$\Pi_S = \dot{S} = \sum_i \dot{S}_i = \sum_{i,j} \frac{1}{T_i} \left(P_Q^{(ji)} + P_C^{(ji)} \right) - \sum_{i,j} \frac{\mu_i}{T_i} I^{(ji)}$$

Ensemble de sous-systèmes



- Système isolé
- composé de plusieurs sous-systèmes simples
- séparés par des parois
 - fixes
 - Diathermes
 - perméables
- une substance chimique

Ensemble de sous-systèmes

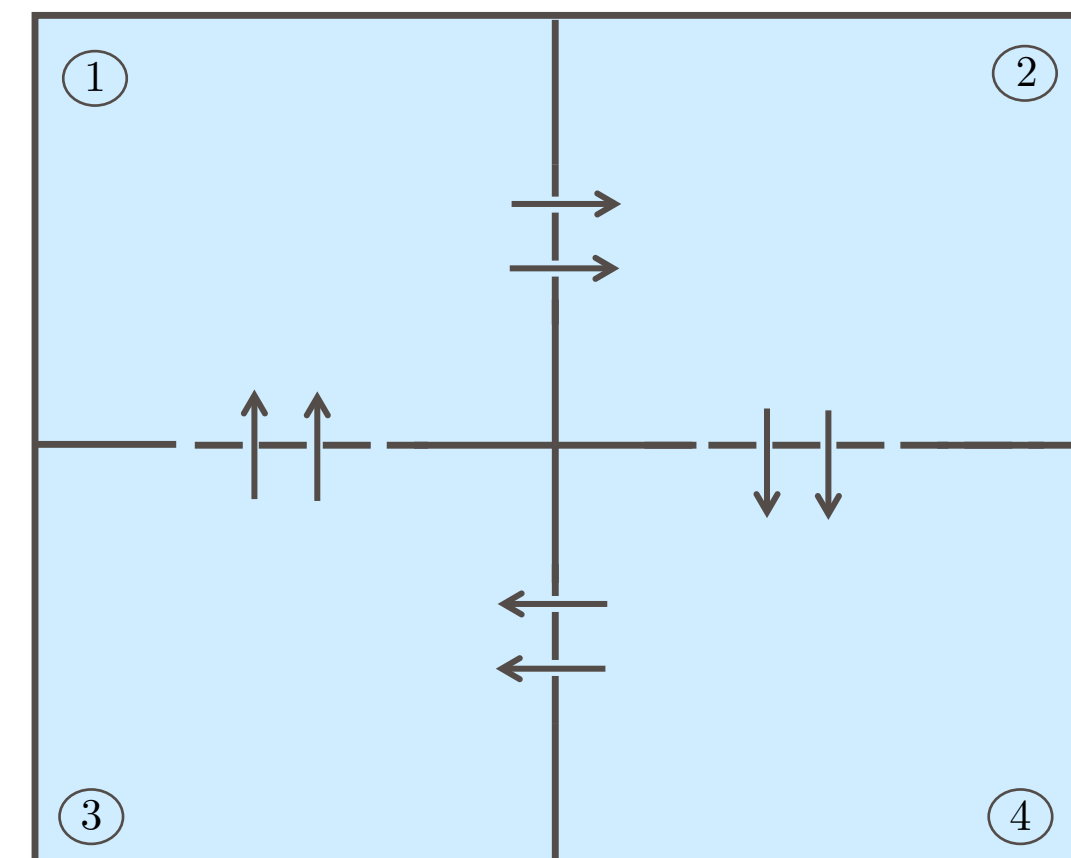
$$\Pi_S = \dot{S} = \sum_i \dot{S}_i = \sum_{i,j} \frac{1}{T_i} \left(P_Q^{(ji)} + P_C^{(ji)} \right) - \sum_{i,j} \frac{\mu_i}{T_i} I^{(ji)}$$

$$\dot{N}_i = \sum_j I^{(ji)} \quad I^{(ij)} = -I^{(ji)} \quad \dot{N} = \sum_i \dot{N}_i = \sum_{i,j} I^{(ji)} = 0$$

$$\dot{U} = \sum_i \dot{U}_i = \sum_{i,j} \left(P_Q^{(ji)} + P_C^{(ji)} \right) = 0 \quad P_Q^{(ij)} + P_C^{(ij)} = -P_Q^{(ji)} - P_C^{(ji)}$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} \left(P_Q^{(ji)} + P_C^{(ji)} \right) + \frac{1}{T_j} \left(P_Q^{(ij)} + P_C^{(ij)} \right) \right) - \frac{1}{2} \sum_{i,j} \left(\frac{\mu_i}{T_i} I^{(ji)} + \frac{\mu_j}{T_j} I^{(ij)} \right)$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) \left(P_Q^{(ji)} + P_C^{(ji)} \right) - \frac{1}{2} \sum_{i,j} \left(\frac{\mu_i}{T_i} - \frac{\mu_j}{T_j} \right) I^{(ji)}$$



Ensemble de sous-systèmes

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) \left(P_Q^{(ji)} + P_C^{(ji)} \right) - \frac{1}{2} \sum_{i,j} \left(\frac{\mu_i}{T_i} - \frac{\mu_j}{T_j} \right) I^{(ji)}$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} + \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) \mu_i I^{(ji)} - \frac{1}{2} \sum_{i,j} \left(\frac{\mu_i}{T_i} - \frac{\mu_j}{T_j} \right) I^{(ji)}$$

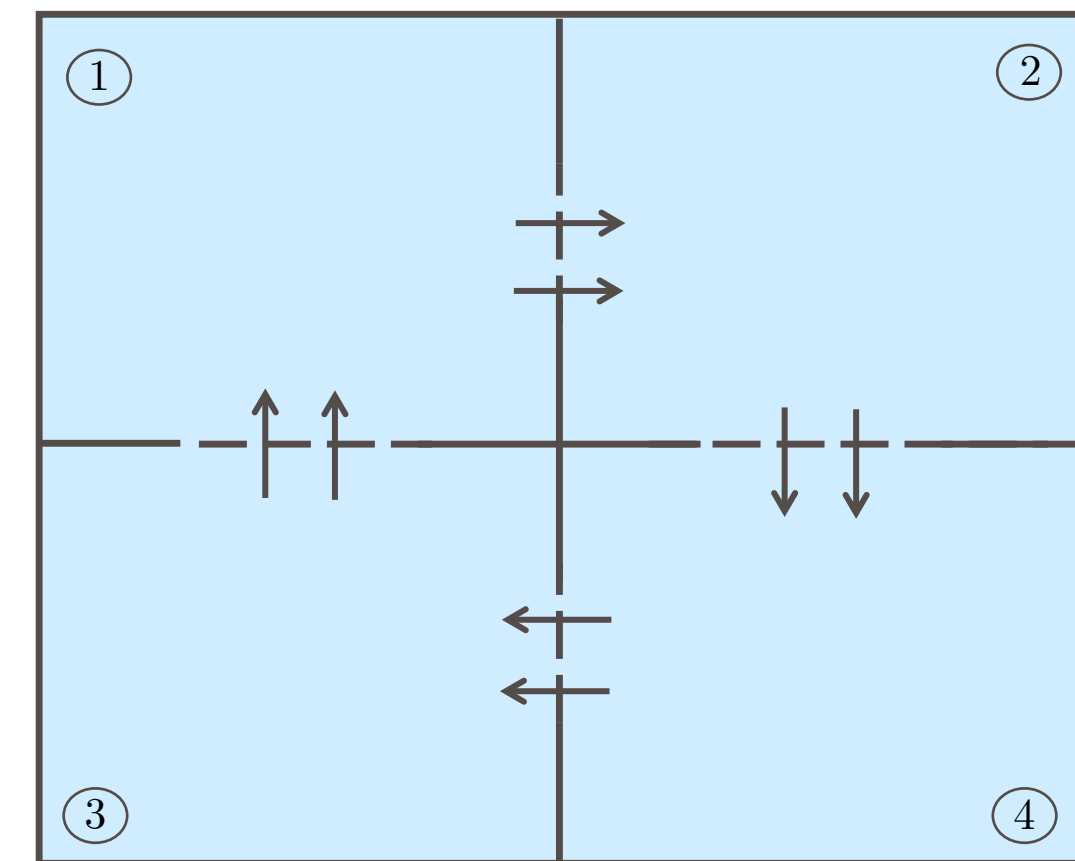
$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} - \frac{1}{2} \sum_{i,j} \frac{\mu_i}{T_j} I^{(ji)} + \frac{1}{2} \sum_{i,j} \frac{\mu_j}{T_j} I^{(ji)}$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} - \frac{1}{2} \sum_{i,j} \frac{\mu_i - \mu_j}{T_j} I^{(ji)}$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} - \frac{1}{4} \sum_{i,j} \left(\frac{\mu_i - \mu_j}{T_j} I^{(ji)} + \frac{\mu_j - \mu_i}{T_i} I^{(ij)} \right)$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} - \frac{1}{4} \sum_{i,j} \left(\frac{\mu_i - \mu_j}{T_j} + \frac{\mu_i - \mu_j}{T_i} \right) I^{(ji)}$$

$$\Pi_S = \frac{1}{2} \sum_{i,j} \left(\frac{1}{T_i} - \frac{1}{T_j} \right) P_Q^{(ji)} - \frac{1}{4} \sum_{i,j} \left(\frac{1}{T_j} + \frac{1}{T_i} \right) (\mu_i - \mu_j) I^{(ji)}$$



$$P_C^{(ji)} = \mu_i I^{(ji)}$$