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1. Exercise sheet to the lecture "Statistical Physics Far from Equilibrium"

Exercise 1: Positivity of response functions

Be S the entropy of some thermodynamic system and A_i the extensive variables characterizing this system. As stated in the lecture, the matrix

$$\delta S_{ij}^{(2)} = \frac{\partial^2 S}{\partial A_i \partial A_j}$$

is negative definite at the equilibrium. Show, for the examples of the specific heat c_V and the compressibility κ_T:

$$c_V = \left.\frac{\partial E}{\partial T}\right|_V, \qquad \kappa_T = -\frac{1}{V}\left.\frac{\partial V}{\partial p}\right|_T,$$

that due to this property, the response functions of thermodynamic systems at equilibrium are positive.

Hint: Let S be a function of V and E alone. Write down the total differential corresponding to differentiating S twice and replace the dependence on E by a dependence on T and V. To do so it is convenient to consider the total differential of $1/T$. Identify the prefactors of $\mathrm{d}V^2$ and $\mathrm{d}T^2$.

Exercise 2: Temperature relaxation time

Consider two thermodynamic systems, Σ_1 and Σ_2, that for times $t < 0$ are kept isolated from one another at temperatures T_1 and T_2 respectively. At time $t = 0$ the systems are brought into contact by means of a thermal bridge of length L, cross section area A, and thermal conductivity λ (see Fig. 1). Calculate the relaxation time of the system.

Hint: Here we consider constant c_V.

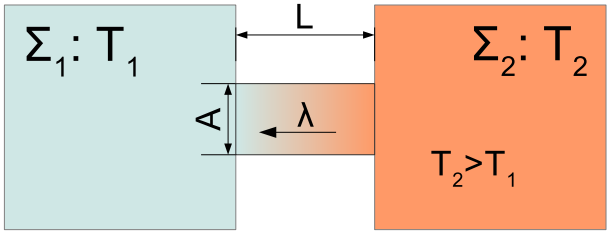

Figure 1: Thermal bridge.