Karlsruher Institut für Technologie
Institut für Theorie der Kondensierten Materie

Übungen zur Theorie der Kondensierten Materie II SS 18

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1. Φ^3-interaction (40 Points)

Consider a system with a cubic interaction term given by the action

$$S[\Phi] = \frac{1}{2}\int d^dx\, \Phi(x)[r - \nabla^2]\Phi(x) + \frac{w}{3}\int d^dx\, \Phi(x)^3\,.$$

Find the expression for the self-energy of this system up to the first non-vanishing order. Evaluate this intgral for the external momentum $k = 0$ and $d = 2$.

2. Scaling relation (20 Points)

In the lecture, it was shown that the free energy density of the Φ^4-theory scales as

$$f(t, h) = b^{-d} f(b^{1/\nu} t, b^y h).$$

Derive the temperature dependence of the entropy for this system.

3. Renormalization Group analysis (40 Points)

In this exercise we want to answer the question why we only take the Φ^4-interaction into account and neglect terms such as $H_{(6)} = \frac{v}{6}\int d^dx\, \Phi(x)^6$. Go into momentum space and demonstrate that the interaction $H_{(6)}$ is irrelevant, i.e. it vanishes with growing RG-flow. Use that the momentum and the fields are rescaled by

$$\begin{aligned} p' &= bp \\ \Phi'(p') &= b^{-\rho}\Phi^<(k'/b)\,. \end{aligned}$$