Karlsruher Institut für Technologie
Institut für Theorie der Kondensierten Materie

Übungen zur Theorie der Kondensierten Materie II SS 18

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1. Renormalization of the φ^3-theory (10+50+20+10+10 Points)

Consider the action

$$S = \int d^d x \varphi(x)(r - \nabla^2)\varphi(x) + \frac{v}{3}\int d^d x \varphi(x)^3 \,. \tag{1}$$

(a) Determine the upper critical dimension from the scaling behavior of the φ^3-term.

(b) Seperate the fields φ into slow and fast modes and calculate the effective action for the slow modes. Proceed analogously to the lecture or see https://www.tkm.kit.edu/downloads/ss2014_theof/Theory_F_2014.pdf, page (93-96). Assume that $\langle\varphi\rangle = 0$.
In all self-energy and vertex diagrams, set the external momenta to zero. Integration over fast modes can be performed for an infinitesimally thin shell, e.g.

$$\int_{\Lambda/b\leq k\leq\Lambda} d^d k \frac{1}{(k^2+r)^n} \simeq K_d \Lambda^d \frac{1}{(\Lambda^2+r)^n} l \,, \tag{2}$$

where K_d is the angular factor of the integration.

(c) Derive the RG-flow equations.

(d) Find the fix points.

(e) Find the critical exponents for the specific heat and the correlation length.