Technische Universität München **Theoretische Physik T70**
Physik Department **B. Garbrecht, Wenyuan Ai**

Theoretische Physik 2 (Elektrodynamik)

Wintersemester 2016/17

Abgabe bis Freitag, 27.01.16, 12:00 neben PH 3218.

Übungsblatt Nr. 11 Dieses Blatt wird in den Übungen vom 30.01. - 03.02.16 besprochen.

Aufgabe 1:
Modulation of a plane wave — 2 Punkte

Consider two linearly polarized plane waves moving in the z direction with the same amplitude E_0, the same polarization direction and different frequencies $\omega + \delta\omega$, $\omega - \delta\omega$, or wave numbers $k + \delta k$, $k - \delta k$, respectively. Let $\delta\omega$ is much smaller than ω.

(a) What is the composite wave? Show that the amplitude of the composite wave is not a constant.

(b) Derive the phase velocity and group velocity of the composite wave.

Hint: The group velocity is the propagation velocity of the amplitude.

Aufgabe 2:
Plane waves propagate in a waveguide — 4 Punkte

A waveguide is a structure that guides electromagnetic waves such that a signal can propagate with minimal loss of energy by restricting its expansion to one dimension or two. The original and most common waveguide is a hollow conductive metal pipe which can be used to transfer high frequency radio waves, particularly microwaves.

Let us consider an infinite long hollow rectangular waveguide with boundaries being ideal conductors located at $x = 0, x = a; y = 0, y = b$, where $a \leq b$. Take the propagation direction to be z axis.

(a) Derive the general solution to the Helmholtz equation (*i.e.* the wave equation in absence of charges with the given boundary conditions) for electromagnetic wave with frequency ω.

(b) What is the lowest frequency ω_{min} with which an electromagnetic wave can propagate in this waveguide?

Aufgabe 3:
Cavity resonator — 4 Punkte

Let us close the rectangular waveguide in Problem 2 by adding two ideal conductors at $z = 0, z = c$ with $a \leq b \leq c$. Then we have a cavity resonator in which electromagnetic waves can be stored with specific frequencies which are called the resonant frequencies. Derive the resonant frequencies and the lowest frequency.