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Elektrodynamik, Frühjahrsemester 2019

Blatt 5

Abgabe: 2.4.19, 12:00H (Treppenhaus 4. Stock)
Tutor: Niels Lörch, Gastzimmer Treppenhaus 4. Stock

(1) $\boldsymbol{\nabla}\times\mathbf{D} = ?$ (2 Punkte)
It is tempting to think that for a linear dielectric, $\mathbf{D}$ is "just like" $\mathbf{E}$ apart from a factor ϵ. However, by considering the boundary between a polarized dielectric and the vacuum, show that (even in electrostatics) $\boldsymbol{\nabla}\times\mathbf{D} \neq 0$ in general.

(2) **Rotating cylinder with a surface charge** (3 Punkte)
A thin glass rod of radius R and length L is oriented along the z-direction; its upper and lower ends are located at $z = \pm L/2$. It carries a uniform surface charge σ and is set spinning about its axis, at an angular velocity ω. Find the magnetic field at a distance $s \gg R$ from the axis, in the xy-plane.
Hint: treat the situation as a stack of magnetic dipoles.

(3) **Mapping between homogeneously charged/polarized/magnetized objects** (5 Punkte)

(a) Show that if you know the electrical field of a uniformly *charged* object, you can immediately write down the scalar potential of a uniformly *polarized* object, and the vector potential of a uniformly *magnetized* object, of the same shape.

(b) Use this observation to obtain ϕ inside and outside a uniformly polarized sphere, and $\mathbf{A}$ inside and outside a uniformly magnetized sphere.

(c) Suppose the field inside a large piece of magnetic material is $\mathbf{B}_0$, so that $\mathbf{H}_0 = \mathbf{B}_0/\mu_0 - \mathbf{M}$ where $\mathbf{M}$ is a "frozen-in" magnetization. Now a small spherical cavity is hollowed out of the material. Find the field at the center of the cavity, in terms of $\mathbf{B}_0$ and $\mathbf{M}$. Also find $\mathbf{H}$ at the center of the cavity, in terms of $\mathbf{H}_0$ and $\mathbf{M}$.

(d) Repeat (c) for a long needle-shaped cavity running parallel to $\mathbf{M}$ and a thin wafer-shaped cavity perpendicular to $\mathbf{M}$.