Electrodynamics II: Assignment 4.
Due February 8 at 11:00am in class or 10:45am in the instructor's mailbox.

1. Consider a cavity with completely absorptive walls. The cavity contains homogeneous isotropic radiation with amplitude E (the radiation is unpolarized and of equal intensity in all directions). Find the normal pressure on the cavity walls. This has obvious connections to black-bodies in thermodynamics.

2. Reflection, refraction and topological insulators. Certain properties of topological insulators result from the constitutive relations $\mathbf{D}=\varepsilon\mathbf{E}-(\alpha/Z_0)\mathbf{B}$ and $\mathbf{H}=\mathbf{B}/\mu+(\alpha/Z_0)\mathbf{E}$, where α is the fine-structure constant and Z_0 is the impedance of free space. I assigned this last year and some students said it was thought provoking.
a. In a source-free region, show that the **E** and **B** field solutions to Maxwell's equations are the usual transverse plane waves.
b. If a linearly-polarized plane wave in vacuum is normally incident on this topological insulator, find the angle by which the transmitted wave is rotated in its polarization.
c. Similarly find the angle by which the reflected wave is rotated in its polarization.

3. Dirac's angular momentum decomposition. A volume contains plane waves propagating in vacuum. Show the total angular momentum in the volume is $\iiint \epsilon_0 E_i(\mathbf{r}\times\nabla)\, A_i \, dv + \iiint \epsilon_0 \mathbf{E}\times\mathbf{A}\, dv$. Because the second term is "local" (doesn't contain r), there was a temptation to treat it as the intrinsic spin of the electromagnetic wave, but this interpretation has a number of problems.

4. Energy flow with total internal reflection.
In class, we discussed the evanescent surface wave present with total internal reflection. Find the time-averaged Poynting vector of the transmitted evanescent wave parallel and perpendicular to the boundary.

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