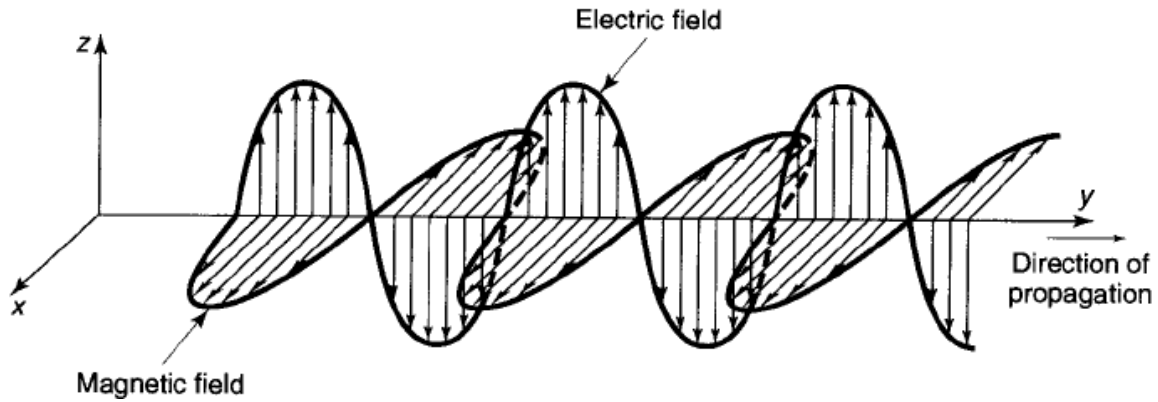


**Physics 402**  
**Prof. Anlage**  
**Discussion Worksheet**

**1. Electric quadrupole matrix element selection rules.** Suppose we relax the constraint that the electric field is uniform over the size of an atom. By expanding the traveling wave (see Fig. below) electric field  $\vec{E}(y,t) = E_0 \hat{z} \cos(ky - \omega t)$ , find the potential experienced by the electron in the atom to next order of approximation ( $ky \ll 1$ ). This is the electric quadrupole potential. Estimate how big the correction is relative to the original term for optical radiation. *Hint:*  $\cos(A - B) = \cos(A) \cos(B) + \sin(A) \sin(B)$



2. What is the form of the quadrupole matrix element? For the hydrogen atom, what selection rules on changes in the quantum number  $m$  arise from this type of matrix element?