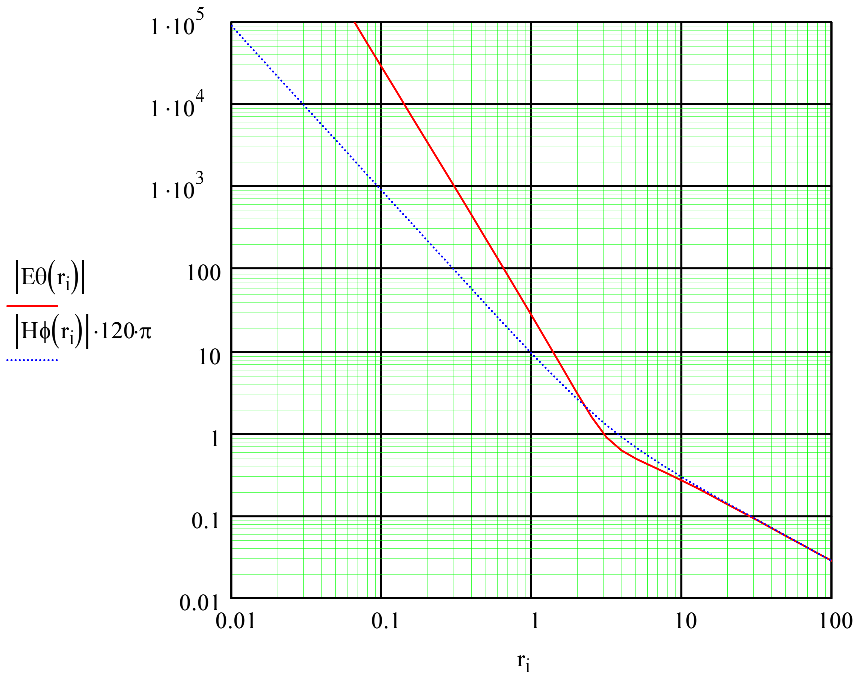
E and H fields of an elementary electric dipole

Assume our wavelength is $\lambda := 20$ m, and we have a lenght of $\delta L := 0.3$ m of wire carring an AC current $I := 1$ A. Since we are interesting eventualy in far field at its maximum, we consider $\theta := \frac{\pi}{2}$ direction and only E and H components associated with it. For a wave number $k := \frac{2 \cdot \pi}{\lambda}$ these components are:

$$E\theta(r) := j \cdot 30 \cdot k^2 \cdot I \cdot \delta L \cdot \left[\frac{1}{k \cdot r} - \frac{j}{(k \cdot r)^2} - \frac{1}{(k \cdot r)^3} \right] \cdot \sin(\theta) \cdot e^{-j \cdot k \cdot r}$$

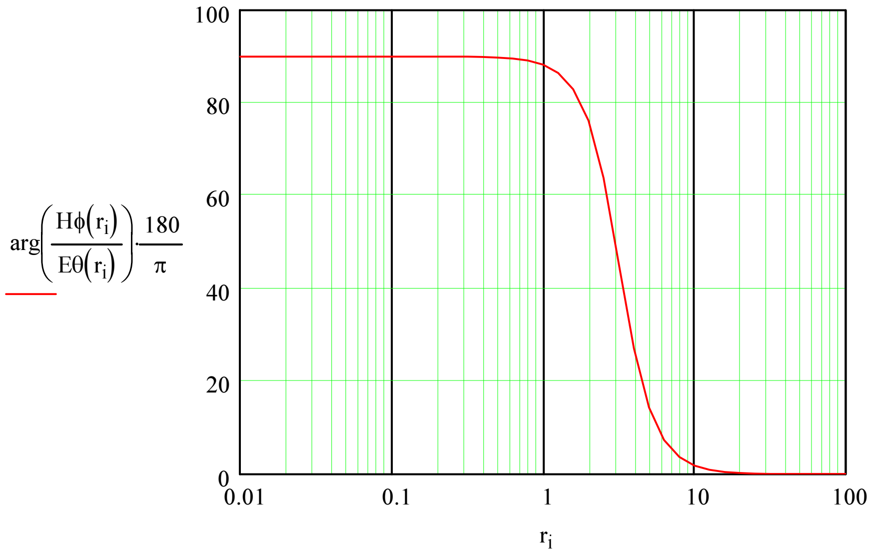
$$H\phi(r) := j \cdot \frac{k^2}{4 \cdot \pi} \cdot I \cdot \delta L \cdot \left[\frac{1}{k \cdot r} - \frac{j}{(k \cdot r)^2} \right] \cdot \sin(\theta) \cdot e^{-j \cdot k \cdot r}$$

Specifying a minimum distance from the dipole $rmin := 0.01$ m and a maximum distance $rmax := 100$ m, for $pts\_dec := 10$ (points per decade) we need $imax := \log\left(\frac{rmax}{rmin}\right) \cdot pts\_dec$ points on our graphs. Thus $i := 0 .. imax$, $r_i := rmin \cdot 10^{\frac{i}{pts\_dec}}$ and our magnitude plot is below:



Here E is in V/m, but H is multiplied by $120 \cdot \pi = 376.991$ Ohm to get the same value in the far field area. Obviously the plot is what one may expect: the 1/(r^3) (for E) and 1/(r^2) (for H) components dominate at short distances, while only 1/r component for both E and H fields presents at long distances.

The next figure is a phase plot:



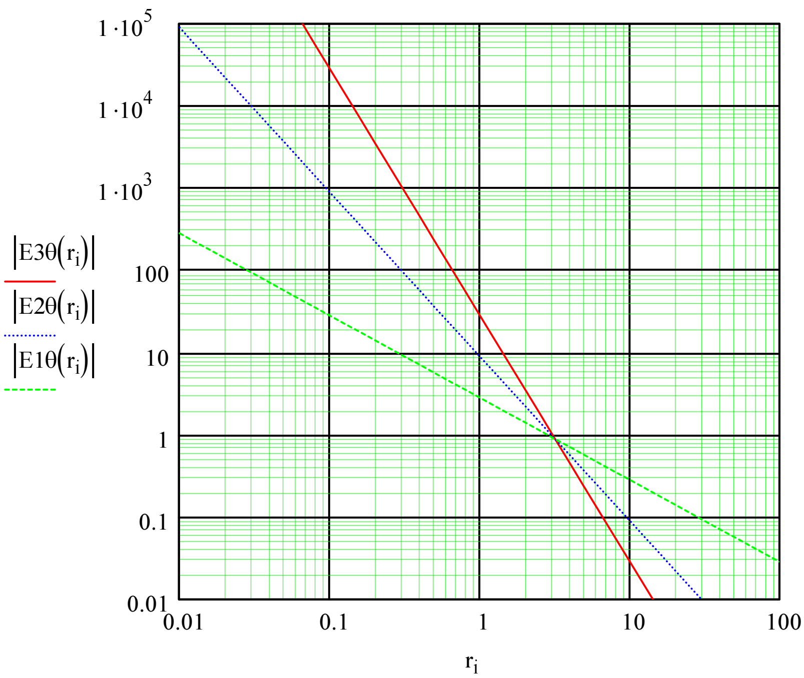
Again, as soon as near field components drop below the far field component, the total phase changes from 90 degrees to zero. Here it would be helpful to look at the components:

$$E3\theta(r) := j \cdot 30 \cdot k^2 \cdot I \cdot \delta L \cdot \frac{1}{(k \cdot r)^3} \cdot \sin(\theta) \cdot e^{-j \cdot k \cdot r}$$

$$E2\theta(r) := j \cdot 30 \cdot k^2 \cdot I \cdot \delta L \cdot \frac{j}{(k \cdot r)^2} \cdot \sin(\theta) \cdot e^{-j \cdot k \cdot r}$$

$$E1\theta(r) := j \cdot 30 \cdot k^2 \cdot I \cdot \delta L \cdot \frac{1}{k \cdot r} \cdot \sin(\theta) \cdot e^{-j \cdot k \cdot r}$$

Obviously plotting $H1\phi(r)$ and $H2\phi(r)$ multiplied by $120*\pi$ is of no help, since $H1\phi(r)*120*\pi=E1\Theta(r)$ and $H2\phi(r)*120*\pi=E2\Theta(r)$.



As expected, all the E components are of equal magnitude at a distance where k*r=1 or r=(1/k)=$\lambda/(2*\pi)$. For much smaller distance the observed E to H phase shift is the phase difference between $E3\Theta$ and $H2\phi$ components, which is 90 degrees. For much larger distance the observed phase shift is between $E1\Theta$ and $H1\phi$ components, which is zero.

Each complex wire antenna from the classical theory can be represented as a set of elementary dipoles discussed above. Its field is a vector sum of partial fields produced by each dipole, and this statement holds true for both near and far fields. Thus there is no special E and H "interaction" starting beyond the near field margin. Just the near field drops below the far field componet and makes the latest visible.