Peng Kuan 彭宽   titang78@gmail.com   https://twitter.com/pengkuanem

A wave that is out of phase with itself

23 August 2012

I do not think such wave exists. The electric and magnetic fields of plan wave are in phase. But that of the solution of the EM wave equation are out of phase. In the Figure 1, an element of antenna emits a wave composed of electric field **E** and magnetic field **H**. The electric and magnetic fields vectors are:

$$\mathbf{H}(\mathbf{r},t) = (0,0,H_\phi), \quad \mathbf{E}(\mathbf{r},t) = (E_r, E_\theta, 0)$$

The exact expression for these vectors are given in "Introduction to Electromagnetic Fields" (Clayton R. Paul, Keith W. Whites and Syed A. Nasar, , Mcgraw-Hill College; 3 Sub edition (December 9, 1997), p.590).
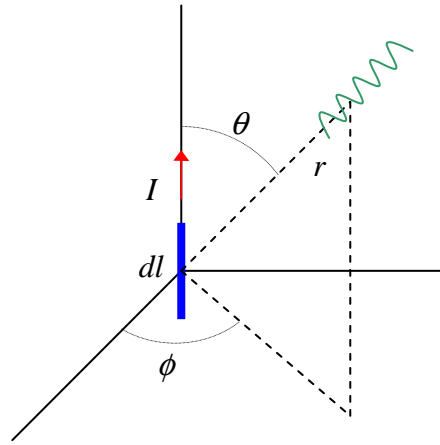

Figure 1

The emitting current being:

$$I = I_0 e^{j\omega t} \tag{1}$$

The EM wave equation gives the expressions for the magnetic field and its phase $\Phi(H_\phi)$:

$$H_\phi = \frac{I_0 dl}{4\pi r^2} \sqrt{1 + \beta_0^2 r^2} \sin\theta e^{j(\omega t - \beta_0 r + \phi)}, \ \Phi(H_\phi) = \omega t - \beta_0 r + \phi \tag{2}$$

See "Why EM wave equation does not conform to relativity?"
http://independent.academia.edu/KuanPeng/Papers/1869009/Why_EM_wave_equation_does_not_conform_to_relativity

And the expressions for the θ component of the electric field and its phase $\Phi(E_\theta)$:

$$E_\theta = \frac{I_0 dl}{4\pi r^2} \eta_0 \sin\theta \sqrt{1 + \left(\beta_0 r - \frac{1}{\beta_0 r}\right)^2} e^{j(\omega t - \beta_0 r + \varphi)}, \ \Phi(E_\theta) = \omega t - \beta_0 r + \varphi \tag{3}$$

See "Can EM wave go forward back?"
http://independent.academia.edu/KuanPeng/Papers/1875721/Can_EM_wave_go_forward_back

The expressions for the angles ϕ and φ are:

$$\phi = \arctan(\beta_0 r), \quad \varphi = \arctan\left(\beta_0 r - \frac{1}{\beta_0 r}\right) \tag{4}$$

Discuss the paradoxes and the new law, Carry the experiments out.
Let us pioneer a new physics. Pioneer Today, Master Tomorrow.

1

By expressing in terms of wave length λ,

$$\beta_0 r = 2\pi \frac{r}{\lambda}$$

The expressions for the phase of the 2 fields are:

$$\Phi(H_\phi) = \omega t - \frac{2\pi r}{\lambda} + \arctan\left(\frac{2\pi r}{\lambda}\right)$$

$$\Phi(E_\theta) = \omega t - \frac{2\pi r}{\lambda} + \arctan\left(\frac{2\pi r}{\lambda} - \frac{\lambda}{2\pi r}\right)$$

(5)

The difference between these 2 phases is:

$$\Delta\Phi = \Phi(E_\theta) - \Phi(H_\phi) = \arctan\left(\frac{2\pi r}{\lambda} - \frac{\lambda}{2\pi r}\right) - \arctan\left(\frac{2\pi r}{\lambda}\right)$$

For time t=0, the 2 phases and their difference in space are drawn in the Figure 2.
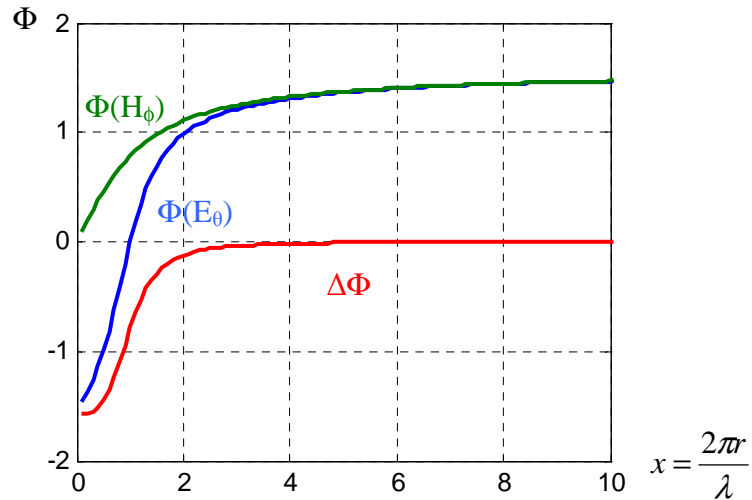

Figure 2

The curve $\Delta\Phi$ in this figure shows that the phase of the electric and magnetic fields vary differently, so the electric field wave slides with respect to the magnetic field wave. For example, if the maximums of the 2 fields coincide at a point r_1, a moment later, each will travel a different distance and the 2 will separate. In other words, the wave in terms of electric field is out of phase with itself in terms of magnetic field.

What is stranger is that the 2 components of the same electric field slide between them too. The expression for the r component is given in "Introduction to Electromagnetic Fields":

$$E_r = 2\frac{I_0 dl}{4\pi}\eta_0\beta_0^2\cos\theta\left(\frac{1}{\beta_0^2 r^2} - j\frac{1}{\beta_0^3 r^3}\right)e^{j(\omega t - \beta_0 r)}$$

By transforming it as follow:

$$E_r = 2\frac{I_0 dl}{4\pi r^2}\frac{\eta_0}{j\beta_0 r}\cos\theta(j\beta_0 r + 1)e^{j(\omega t - \beta_0 r)} = 2\frac{I_0 dl}{4\pi r^2}\frac{\eta_0}{\beta_0 r}\cos\theta\sqrt{1 + \beta_0^2 r^2}(-j)(\cos\phi + j\sin\phi)e^{j(\omega t - \beta_0 r)}$$

2

$$E_r = 2\frac{I_0 dl}{4\pi r^2}\frac{\eta_0}{\beta_0 r}\cos\theta\sqrt{1+\beta_0^2 r^2}\, e^{j(\omega t - \beta_0 r + \phi - \pi/2)}$$

We obtain the expression for its phase:

$$\Phi(E_r) = \omega t - \frac{2\pi r}{\lambda} + \arctan\left(\frac{2\pi r}{\lambda}\right) - \pi/2$$

The difference of phase between the r and θ components is:

$$\Phi(E_\theta) - \Phi(E_r) = \arctan\left(\frac{2\pi r}{\lambda} - \frac{\lambda}{2\pi r}\right) - \arctan\left(\frac{2\pi r}{\lambda}\right) + \pi/2$$

So, the components of the electric field slide with respect to each other! But, however weird the components' sliding, it is not forbidden by physical principles. Why not.

This gives us a measurable property to test experimentally. The experiment consists of comparing the electric and magnetic fields' phase that an antenna emits. The Figure 3 shows the setup. The electric field detector e_1 and magnetic field detector h_1 are placed at the same distance near the antenna and the collected signals will be compared.
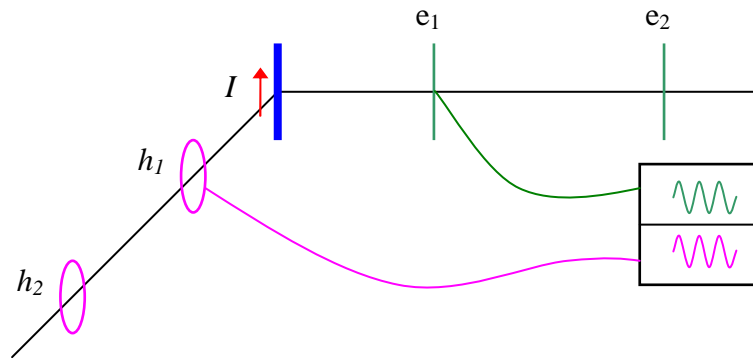

Figure 3

For example, the distance of the detectors is chosen as follow:

$$x_0 = \frac{2\pi r}{\lambda} = 0.2,\ r = 0.0318\lambda$$

If the wave length is 100m, whose frequency is 3MHz, the distance between the antenna and the detector is 3.18m.

The angles ϕ and φ corresponding to x_0 are:

$$\phi = \arctan(x_0) = 0.1974,\qquad \varphi = \arctan\left(x_0 - \frac{1}{x_0}\right) = -1.3654$$

According to the EM wave equation, the signals of the measured electric field should be proportional to this cosine function (see equation (2)):

$$Y(E_\theta) = \cos(\omega t - 1.5654)$$

And the signals of the measured magnetic field should be proportional to this cosine function (see equation (3)):

Discuss the paradoxes and the new law, Carry the experiments out.
Let us pioneer a new physics. Pioneer Today, Master Tomorrow.

3

$$Y\left(H_\phi\right)=\cos\left(\omega t-0.0026\right)$$

What will be the experiment's outcome? Because Relativity forbids any wave to travel faster then light, I'm certain that the measured signals will be identical to a light signal synchronous to the emitting current (see equation (1)), whose cosine function is:

$$Y\left(light\right)=\cos\left(\omega t-0.2\right)$$

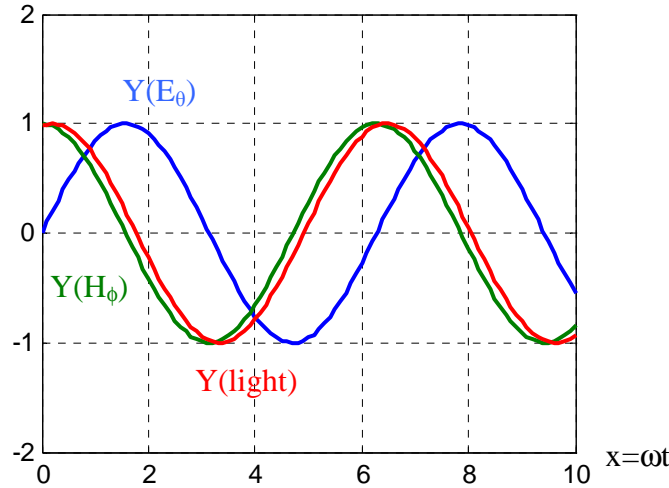The curves of these 3 cosine functions are drawn in blue, green and red in the Figure 4.

Figure 4

We have to consider the possibility if the measured signals are out of phase. In this case, the EM wave equation will be confirmed, along with variable and faster then light phase velocity, backward progressing wave, deformation of signals. For more details, please see the articles: Why EM wave equation does not conform to relativity?
http://independent.academia.edu/KuanPeng/Papers/1869009/Why_EM_wave_equation_does_not_conform_to_relativity
Can EM wave go forward back?
http://independent.academia.edu/KuanPeng/Papers/1875721/Can_EM_wave_go_forward_back
Deformation of EM wave signals
http://independent.academia.edu/KuanPeng/Papers/1868601/Deformation_of_EM_wave_signals

In the Figure 3, I have drawn supplementary electric field detector e_2 and magnetic field detector h_2 for measuring the phase shift along propagation. Between 2 positions r_1 and r_2, the phase shift of a light wave is:

$$\frac{2\pi r_1}{\lambda}-\frac{2\pi r_2}{\lambda}$$

But the phase shift for electric and magnetic fields according to the EM wave equation are (see the equations (5)):

$$E_\theta:\Phi\left(r_2\right)-\Phi\left(r_1\right)=\frac{2\pi r_1}{\lambda}-\frac{2\pi r_2}{\lambda}+\arctan\left(\frac{2\pi r_2}{\lambda}-\frac{\lambda}{2\pi r_2}\right)-\arctan\left(\frac{2\pi r_1}{\lambda}-\frac{\lambda}{2\pi r_1}\right)$$

$$H_\phi:\Phi\left(r_2\right)-\Phi\left(r_1\right)=\frac{2\pi r_1}{\lambda}-\frac{2\pi r_2}{\lambda}+\arctan\left(\frac{2\pi r_2}{\lambda}\right)-\arctan\left(\frac{2\pi r_1}{\lambda}\right)$$

These phase shift can be measured by the detectors (e_1, e_2) and (h_1, h_2) and will be compared with that of light.

Discuss the paradoxes and the new law, Carry the experiments out.
Let us pioneer a new physics. Pioneer Today, Master Tomorrow.

4

Summary

For the sake of science, I call for experimenters to do the 5 experiments I propose, the present one and that presented in:

Deformation of EM wave signals

Displacement magnetism experiment design

Non Loop EMF Experiment

Lorentz torque experiment

Discuss the paradoxes and the new law, Carry the experiments out.
Let us pioneer a new physics. Pioneer Today, Master Tomorrow.