The Electromagnetic Wave Electric Field Force Thruster with The New Understanding of Electromagnetic Momentum Conservation Equation

Author:　　　Zhixian Lin

November 15, 2015

Contents

Abstract

We know that on the electromagnetic wave propagation path, the direction of electric field at a point changes periodically. If there is a charged object at the point also changes its charge property periodically with the same frequency, then the electric field force direction on the object will not change. Therefore, the object will do directional movement. Based on this, it is possible to design a spacecraft without propellant. And the calculation suggests that the thrust can be much higher than radiation pressure. With the Electromagnetic Momentum Conservation Equation, this paper also proved that in a limited space, momentum can be not conserved although it is still conserved in the whole universe. Also with the Electromagnetic Momentum Conservation Equation, this paper explained why in quantum mechanics at the particle level, particles usually do not follow Newton's second law.

Key words: propellant-less propulsion, electromagnetic wave propulsion, electromagnetic propulsion, electromagnetic wave force, propulsion, electromagnetic momentum conservation

1. The Principle of Electromagnetic Wave Electric Field Force Thruster

We know that on the electromagnetic wave propagation path, the direction of electric field at a point changes periodically. If there is a charged object at the point also changes its charge property periodically with the same frequency, then the electric field force direction on the object will not change. Based on this, I designed the Electromagnetic Wave Electric Field Force Thruster (EWEFFT).

We assume that the polarization direction of the electromagnetic wave and the thruster are on the same plane. And the electromagnetic wave is a directional wave. The AC power U has the same frequency with the electromagnetic wave.

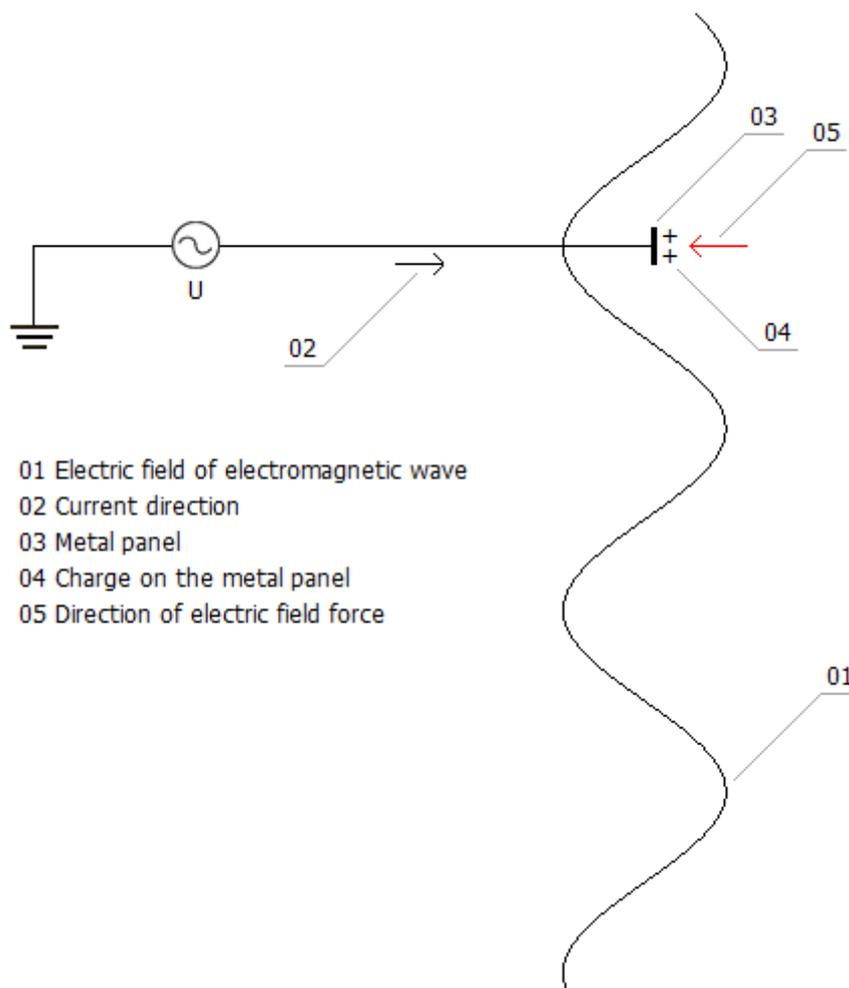Figure 1: The Left Half of the Electromagnetic Wave Cycle.

01 Electric field of electromagnetic wave
02 Current direction
03 Metal panel
04 Charge on the metal panel
05 Direction of electric field force

Figure 2: The Right Half of the Electromagnetic Wave Cycle.

01 Electric field of electromagnetic wave
02 Current direction
03 Metal panel
04 Charge on the metal panel
05 Direction of electric field force
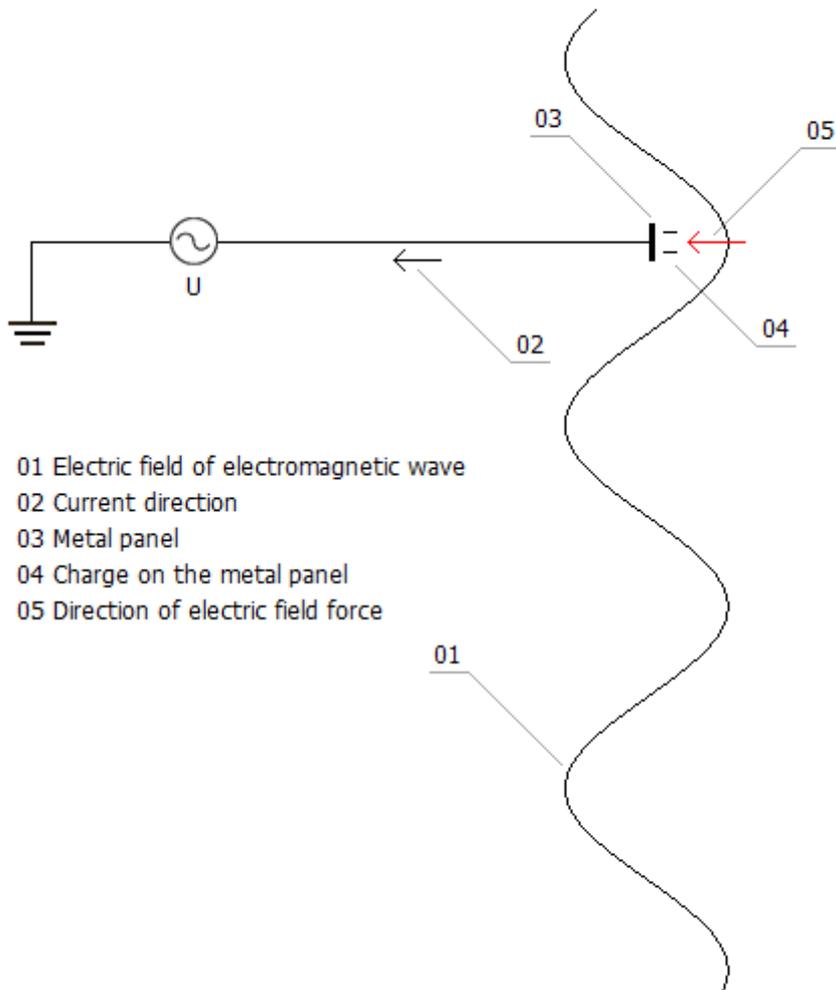
From the figure 1 and 2, we can see that the direction of electric field force can keep the same if the charge on the metal panel synchronizes with the electromagnetic wave. Because the direction of electric field force on the metal panel does not change, so the thruster will do directional movement.

2. The Force on Electromagnetic Wave Electric Field Force Thruster

We assume that electric field of the electromagnetic wave at the metal panel changes according to the following formula:

$$E(t) = E_0 \times \sin(\omega \times t) \qquad (2\text{-}1)$$

E_0 is the amplitude of E. ω is the angular frequency of the electromagnetic

wave. t is the time.

Declare the electromagnetic wave cycle is T, then we have:

$$T = \frac{2 \times \pi}{\omega} \qquad (2\text{-}2)$$

Assume that the current in the inductor L changes according to the following formula:

$$i(t) = I0 \times \sin(\omega \times t + \frac{\pi}{2}) \qquad (2\text{-}3)$$

$I0$ is the amplitude of i. $\frac{\pi}{2}$ is the phase difference for synchronizing $E(t)$ and $C(t)$.

Then quantity of electric charge on the metal panel will be:

$$C(t) = \int i(t)\,dt \qquad (2\text{-}4)$$

Assume the initial quantity of charge on the metal panel is 0, then we have:

$$C(t) = \frac{I0 \times \sin(\omega \times t)}{\omega} \qquad (2\text{-}5)$$

Then electric field force on the metal panel is:

$$f(t) = C \times E \qquad (2\text{-}6)$$

The average electric field force on the metal panel is:

$$F = \frac{\int_0^T f(t)\,dt}{T} \qquad (2\text{-}7)$$

Solve (2-7), then we have:

$$F = \frac{E0 \times I0}{2 \times \omega} \qquad (2\text{-}8)$$

3. Performance of the Electromagnetic Wave Electric Field Force Thruster

If the Poynting's vector of the electromagnetic wave is 1000 W/m2, then $E0$ is 868 V/m. If the wavelength of the electromagnetic wave is 10 m, then ω is 1.884E8. And if $I0$ is 100 A, then we can figure out F is 2.3E-4 N. F can be much higher

4

than radiation pressure if I_0 is high enough and the wavelength of the electromagnetic wave is long enough. And we can make the electromagnetic wave beam narrower to increase the Poynting's vector without increasing power of the electromagnetic wave source, and then the F is increased.

4. The New Understanding of Electromagnetic Momentum Conservation Equation

The following equation is the Electromagnetic Momentum Conservation Equation.

$$f = -\nabla \bullet \overset{\leftrightarrow}{T} - \frac{\partial g}{\partial t} \qquad (4\text{-}1)$$

$$\overset{\leftrightarrow}{T} = -\varepsilon_0 EE - \frac{1}{\mu_0} BB + \frac{1}{2}(\varepsilon_0 E^2 + \frac{1}{\mu_0} B^2)\overset{\leftrightarrow}{I} \qquad (4\text{-}2)$$

$$g = \varepsilon_0 E \times B \qquad (4\text{-}3)$$

f is the Lorentz force density.

And we have the Newton's second law:

$$F = \frac{\partial p}{\partial t} \qquad (4\text{-}4)$$

Compare (4-1) with (4-4), if f match F and $-\frac{\partial g}{\partial t}$ match $\frac{\partial p}{\partial t}$, then (4-4) is missing one item to match $-\nabla \bullet \overset{\leftrightarrow}{T}$. So (4-4) should be the special case of (4-1) when $-\nabla \bullet \overset{\leftrightarrow}{T}$ tends to zero.

Do integral for (4-1) in region V, then we have its integral form:

$$\int_V fdV = -\int_V \nabla \bullet \overset{\leftrightarrow}{T} - \frac{d}{dt}\int_V gdV \qquad (4\text{-}5)$$

$\int_V fdV$ should match F and $-\frac{d}{dt}\int_V gdV$ should match $\frac{\partial p}{\partial t}$. We know

that when V is the whole space, $-\int_V \nabla \bullet \overset{\leftrightarrow}{T}$ will tend to zero. So when V is a large enough space, $-\int_V \nabla \bullet \overset{\leftrightarrow}{T}$ can be considered as zero. That means Newton's second law is the special case of Electromagnetic Momentum Conservation Law when we use a large enough space to contain the system.

But when V is a limited space which is not large enough and it is not in a static field, then $-\int_V \nabla \bullet \overset{\leftrightarrow}{T}$ can not be considered as zero, Newton's second law does not work in this case. So in a limited space which is not large enough, momentum can be not conserved. When we enlarge the space to the whole universe, it will always be large enough. So momentum will always be conserved in the whole universe.

Einstein's special theory of relativity proves that Newton's law does not work for high speed object, Electromagnetic Momentum Conservation Equation proves that Newton's law also does not work in a limited space which is not large enough.

In (4-1) we can see that f is composed by $-\nabla \bullet \overset{\leftrightarrow}{T}$ and $-\dfrac{\partial g}{\partial t}$. $-\dfrac{\partial g}{\partial t}$ is the radiation pressure. So we can understand why the thrust of EWEFFT can be much higher than radiation pressure, because its thrust has more $-\nabla \bullet \overset{\leftrightarrow}{T}$, but less $-\dfrac{\partial g}{\partial t}$.

As we know, in quantum mechanics at the particle level, particles usually do not follow Newton's second law. And we know the smaller the volume is, the higher probability that $-\int_V \nabla \bullet \overset{\leftrightarrow}{T}$ will not be zero, then the higher probability that particles do not follow Newton's second law. This can explain why in quantum mechanics, particles usually do not follow Newton's second law.

EWEFFT does not violate the Electromagnetic Momentum Conservation Law, but it violates Newton's second law in a limited space which is not large enough. But in the whole universe, it still does not violate Newton's second law.

5. Design a Spacecraft with EWEFFT

We assume that the distance between the electromagnetic wave source and

EWEFFT is very long. Because the electromagnetic wave is a directional wave, then the electric field force on EWEFFT can be much higher the radiation pressure. Although EWEFFT may also generate some electromagnetic wave, but its wave is not directional wave, just need the distance is long enough, the reaction force from EWEFFT to the source can be very week, much weaker than the force from the source to EWEFFT. So the action force and the reaction force are not the same.

If the distance between the electromagnetic wave source and EWEFFT "D" is very long, and because the electromagnetic wave is a directional wave, then the force on EWEFFT can be much higher than the reaction force from EWEFFT to the source. So we can put EWEFFT and the source on the same spacecraft, just need their distance is long enough. And even though there maybe a little reaction force between EWEFFT and the wave source, their reaction force can only be perpendicular to the electric field force on the metal panel of EWEFFT. So the reaction force from EWEFFT to the source will not offset the electric field force on the metal panel of EWEFFT.

Figure 3: Electromagnetic Wave Electric Field Force Spacecraft.

01 A spacecraft with EWEFFT
02 Electromagnetic Wave Electric Field Force Thruster(EWEFFT)
03 Directional electromagnetic wave source
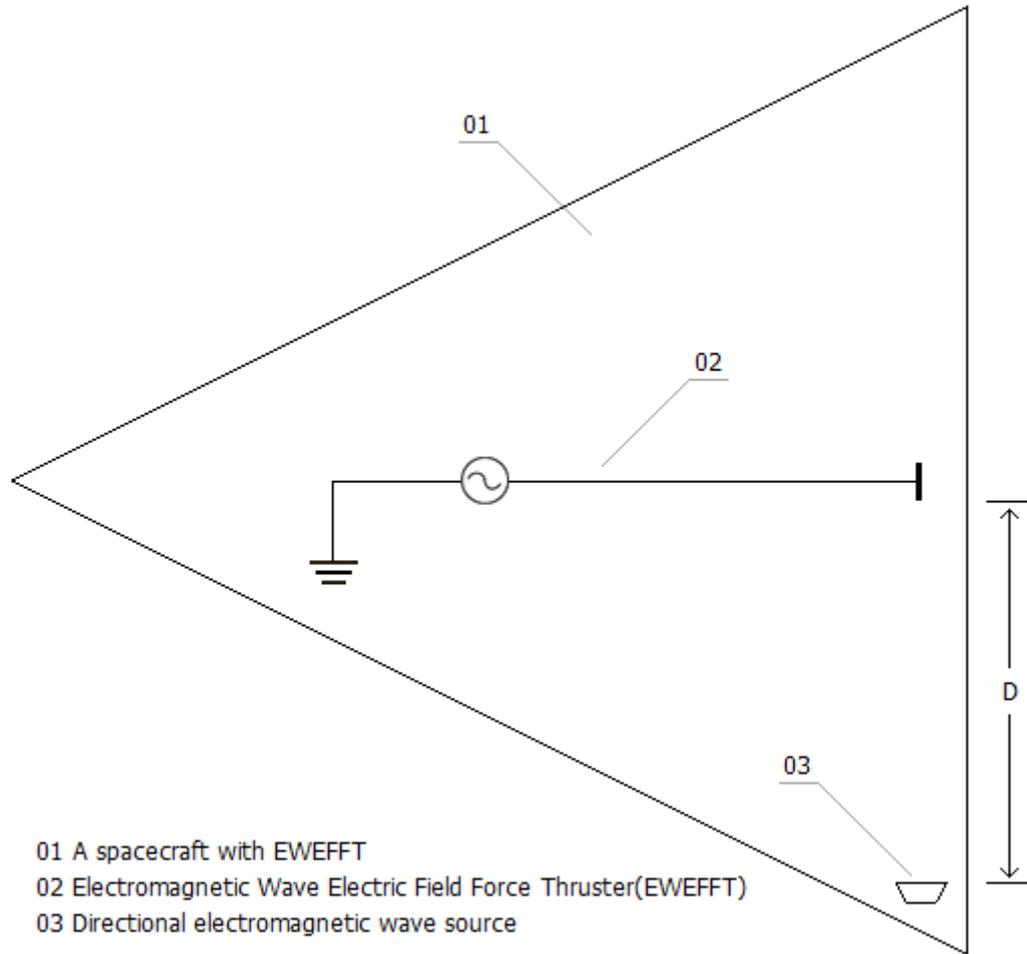
6. Conclusion

Although EWEFFT looks like a violation of Newton's Law, but it does not violate any principle of electromagnetism. And the calculation suggests that the thrust of EWEFFT can be much higher than radiation pressure. Based on EWEFFT, it is possible to design a spacecraft without propellant. And the Electromagnetic Momentum Conservation Equation proves that in a limited space, momentum can be not conserved although it is still conserved in the whole universe.