

Author name

Giuliano Bettini

Title

EM drive theory

Abstract

The EM drive is an object composed by a Magnetron feeding a tapered resonant cavity whose area is greater at one end. Both ends of the cavity are sealed. When the Magnetron is turned on, the EM drive manifests a thrust toward the smaller end of the cavity.

Nothing is emitted outside.

Mainstream Physics is reluctant to recognize the EM drive as valid as it appears to break the law of conservation of momentum

For this reason EM drive caused discussions, theories more or less exotic, and skepticisms.

But the experiments seem to confirm it works.

Here I discuss a simple theory in the framework of classical physics.

1 – Premise: the jet propulsion principle of operation

The principle of operation of the jet propulsion is briefly summarized in Fig. 1: emitting a mass to the right, a thrust manifests toward the left.

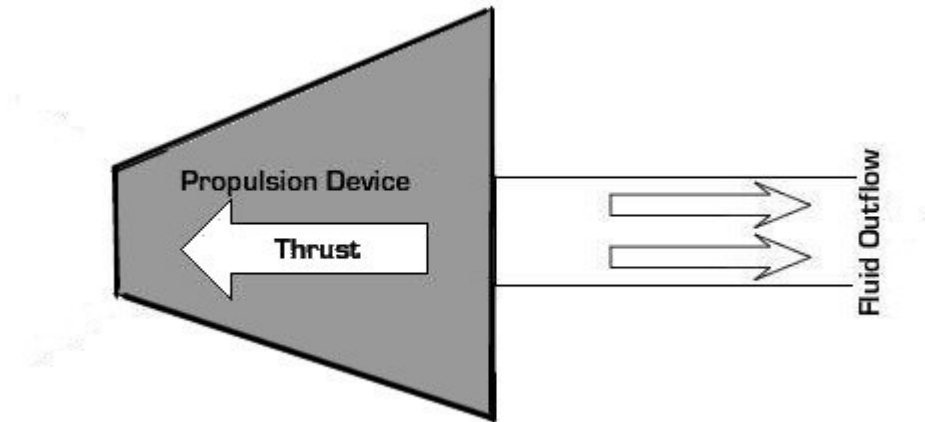


Fig. 1-Jet propulsion principle of operation

The reason is the conservation of linear momentum. This is sketched in Fig. 2. The object (the overall system) before the shot has momentum zero.

After the shot, the cannon ball has a momentum toward the right, let's say P_1 .

But according to the conservation of linear momentum the overall momentum (without external force acting on the object) has to remain zero.

(Note: if the net external force acting on an object is zero, its linear momentum is constant).

So the cannon acquires a momentum toward the left, let's say P_2

$$P_2 = -P_1, \quad (P_1 + P_2 = 0)$$

i.e. there is a thrust along P_2 .

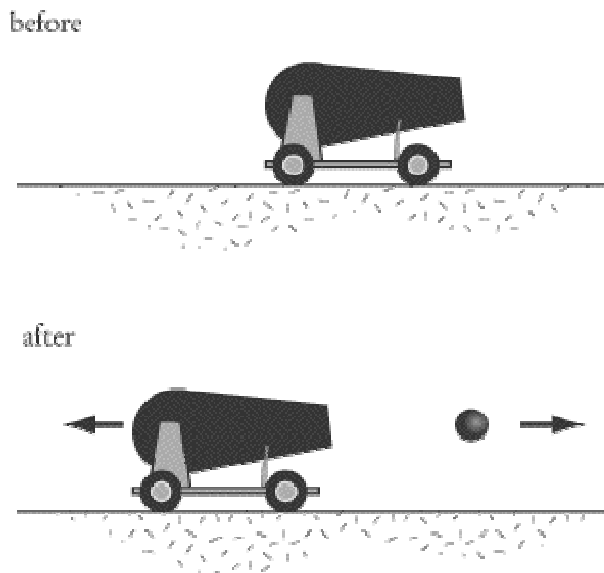


Fig. 2 – Conservation of momentum

2- The EM drive. Theory

As reminded in the abstract, EM drive is composed by a Magnetron feeding a tapered resonant cavity whose area is greater at one end.

Let's start with the Magnetron "off", Fig. 3. The overall momentum of the object is obviously zero.

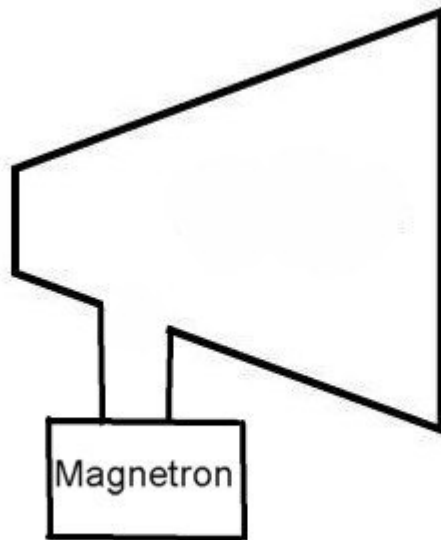


Fig. 3 – Magnetron off

What happens when the Magnetron is turned "on"?

The experiment shows that the object acquires a momentum directed toward the smaller end of the cavity (toward the left in Fig. 3).

But nothing is emitted toward the right.

How is it possible to generate momentum toward the left, without emitting something?

Evidently "something is thrown inside".

(Note. It is the same thing as if you launch a mass INSIDE of a spaceship. The system must move in the opposite direction.

In fact you have a thump but no net movement. But "a thump" is a movement.

It lasts as long as the movement of the mass within. Which of course can not last forever. But if it could last forever).

What theories are saying?

According to Shawyer (see Ref.) when the Magnetron is "on", it emits microwaves which bounce around inside the cavity pushing against its sides. Shawyer claims that thrust is caused by a radiation pressure imbalance between the two faces of the cavity.

We can say this from another point of view: the electromagnetic momentum of a travelling wave.

From the e. m. point of view the cavity (the tapered waveguide) is home to a resonant stationary wave, which is composed by two travelling waves. These travelling waves have different momentum. Due to the cavity's shape there is an imbalance between them. The wave directed toward the wider end of the cavity has a growing momentum to the right, while the wave toward the left loses momentum.

The result is a net momentum, let's say P_1 (toward the right in Fig. 4).

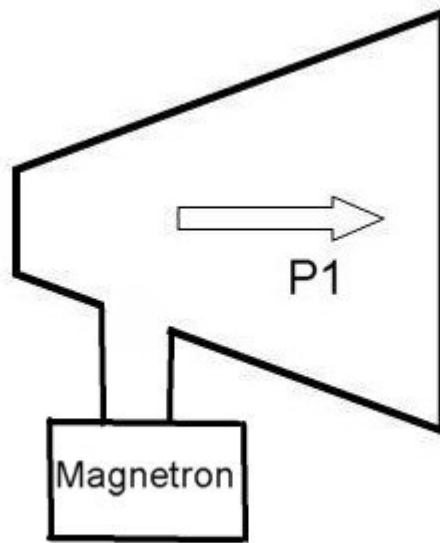


Fig. 4 – Magnetron on

Summing up, when the Magnetron on, the EM drive (Magnetron + waveguide + e.m. field) has a momentum $P1$. But before (Fig. 3) the momentum was zero. According to the conservation of linear momentum the overall momentum (without external force acting on the object) has to remain zero. This means that the EM drive acquires a momentum $P2 = -P1$, ($P1 + P2 = 0$) i.e. a thrust along $P2$ (Fig. 5).

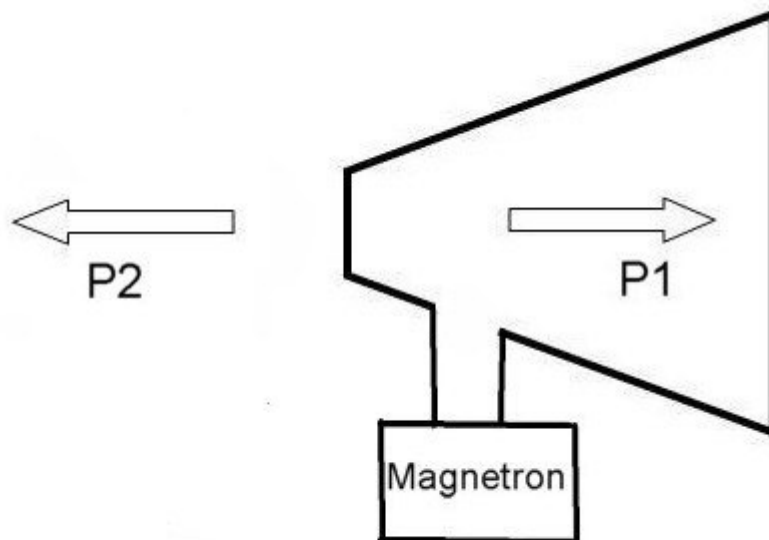


Fig. 5 – Magnetron on. Conservation of momentum. Thrust along $P2$

3 - Discussion

You have to be very accurate (this may sound like sophistry, but it is not).

Someone argues that the force unbalance on the end plates causes the thrust.

This is wrong. Forces unbalance in a closed system are not going to move the system. This would be equivalent to move your car by pushing against the dashboard , while you're inside.

Instead Shawyer, with the tapered waveguide, has "invented" the way to produce an internal momentum, P1 in the paper.

Momentum P1 is balanced by P2 because of the law of conservation of momentum. Then the thrust. So there is no such thing as "violates the law of conservation of momentum". Instead it works (if it works...) because of the law of conservation of momentum.

4 - Conclusions

The EM drive is an object that, when the Magnetron is on, produces a thrust toward one side.

The supposed reason is the balance with an electromagnetic momentum toward the other side, inside the resonant cavity

The value of the electromagnetic momentum should justify the measured thrust.

I didn't make calculation but, in the framework of the claimed experiments and the classical physics, this obviously should work.

5 - References

Many references may be found on the Internet. I just quote Shawyer

<http://emdrive.com/theory.html>