# Alternative Reflections on EmDrives and Newton's Third Law, the Conservation of Momentum

**Johann Albers**

**Formerly: Fachbereich Physik der Universität des Saarlandes**

**66041 Saarbrücken, Germany**

**e-mail: johann.albers@t-online.de**

## ABSTRACT

The EmDrive (Electromagnetic Drive) is assumed to be able to produce propulsive mechanical forces from electrical power, without the need of propellant material. On the basis of classical theories of gravitation, this idea, however, violates heavily a well-established physical law, the conservation of momentum. On the basis of the "Alternative Reflections on Gravitation" (ARG), however, such a drive is not only seen as possible without the violation of Newton's third law. It even lets expect enormous improvements for interplanetary and even interstellar flight projects.

## 1. INTRODUCTION

Podkletnov's "Impulse Gravity Generator" [1] and the so called "EmDrive" [2] are assumed by the involved researchers to be revolutionary propulsion systems for future space flights. This, because these systems don't need any heavy propellant material. According to almost every expert in the field of gravity, these ideas, as well their realization as also their peer reviewing, are hampered by the fact that they obviously violate extremely a well-established physical law: Newton's 3rd law, which describes the conservation of momentum. Indeed, it is hardly imaginable for almost everybody, that a free flying satellite can accelerate forward without expelling material, or an equivalent of electromagnetic radiation, into the opposite direction.

The EmDrive is a system wherein electrons, emitted from a heated cathode, produce microwave radiation when moving in an electromagnetic field. It is well-

known that neither electrons nor microwave radiation can pass through a metal sheet. Therefore, on the basis of classical theories, a completely shielded system like a microwave generator can't produce any directional thrust without violating the well-established experience about the conservation of momentum.

In the following it will be explained, however, that on the basis of the "Alternative Reflections on Gravitation" (ARG) [3, 4] such a scenario can very well be expected, and that it is not associated with a violation of Newton's 3rd law. How can such discrepancies be explained? To answer this question it is obviously helpful to mention a condition for the validity of Newton's 3rd law: it is valid only for closed systems. Classical theories of gravity of course consider a free flying satellite as such a closed system. On the basis of the ARG, however, an "Impulse Gravity Generator" and an "EmDrive" are not closed systems. This is due to the assumption of the ARG that Axions and axion like particles (ALPs) play an essential role in gravitational physics.

## 2. RELEVANT PRICIPLES OF THE ARG

In order to illustrate the basic ideas of the ARG in connection with the EmDrive, chapter 6 of a foregoing paper [5] about Podkletnov's "Impulse Gravity Generator" may be cited here:

"The electromagnetic radiation from the surface of the Sun, with a temperature of about 6000 K, shows its maximum at a photon energy at about 2 eV. At the center of the Sun, with a temperature of about 15 Million deg K, photon energies up to 5000 eV are typically to be expected. If under these conditions ALPs are created inside the Sun, why should they not be created under conditions, where inside the gravity generator accelerating electrical fields are created by discharges with 2 Million Volts. Therefore, from the ARG it is very reasonable to assume that this type of generator can act as a production system for ALPs. The second component, necessary for the local conversion of ALPs, a magnetic system, as discussed above with the Tampere-experiment, also exists in the gravity generator. And because production system and magnetic system exist at the same place, it can be expected that a part of the ALPs is already converted to gravitons inside the equipment, which can be detected directly behind the generator due to their repulsive forces. The small divergence of the beam along the direction of the electrical discharge is well compatible with the expectations of the ARG. Therefore, on the basis of the ARG, it is expected that future experiments with setups like the "Impulse Gravity Generator" can deliver new and extremely valuable insights into the real sources of gravity."

On the basis of the ARG the EmDrive is seen as a system, comparable to Podkletnov's "Impulse Gravity Generator": The magnetron seems to be an effective source for the production of ALPs. The second necessary component, a magnetic system which catalyzes the transformation of the ALPs into gravitons obviously also seems to exist: The electromagnetic system of microwaves, enclosed in a metallic container. If the microwaves could escape without a closed container, the intensity of their magnetic field probably would not be sufficiently high to produce a measurable effect. But if the strength of the magnetic field is increased by locking up these waves resonantly in a container with high quality-factor, the chance for a measurable effect is increased. Thus, it is not surprising that just the Cannae-Drive with a quality-factor Q of 1.1*10^7 shows one of the highest efficiencies for the production of thrust from electric power, 952 mN/kW, (Force/PowerInput), and a "Force to Power" value which is about 285500 times higher than that of a "Photon Rocket" [6] which gets its force from the radiation pressure of the electromagnetic radiation.

Two points of interest should be mentioned here to elucidate the difference between conventional gravitational theories and the ARG: Firstly, the mechanical thrust is not due to the radiation pressure of the enclosed microwaves, but due to the gravitons which are generated from ALPs by the catalyzing effect of the magnetic field of these waves. Secondly: All the effects, which due to the ARG are connected with the production of ALPs, their conversion to gravitons and their interaction with baryonic matter, produce repulsive, and not attractive gravitational forces. This corresponds to the statement, which was already written in the first paper about the ARG [3]: The primary gravitational interactions between masses are repulsive forces.

## 3. HYPOTHETICAL EMDRIVES

On the basis of the ARG the EmDrive-setups may very well be seen as such valuable experiments. These systems usually contain magnetrons which are operated at voltages of about 4kV, comparable to the above mentioned 5kV photons in the interior of stars. Therefore, EmDrive-setups with magnetrons may be seen as sources of Axions or ALPs, similar to the hot interior of stars. Without going into detail in connection with different reports about EmDrives, three hypothetical EmDrive setups may be considered in order to explain the problem with the law of the conservation of momentum.

**Spherical sources of ALPs:** The first hypothetical setup is based on sources which emit ALPs with the same intensity into every spherical direction. Although all these ALPs take away a certain amount of mechanical impulse, due to the spherical

symmetry, the resultant force on the source is zero. If these escaping ALPs, however, are traversing magnetic fields, they are partly conversed to gravitons, which adopt the mechanical impulse of these ALPs. The interaction of the gravitons with baryonic matter then leads to repulsive forces.

As described in detail in the update of the ARG [4], the hot interior of stars seem to be such sources of ALPs. And the possible repulsive forces are assumed to be responsible for effects like chromospheric heating, solar wind, solar flares, coronal mass ejection and bipolar jets.

**Unidirectional Sources of ALPs:** As a second hypothetical setup a source of ALPs may be considered which emits ALPs, highly focused into one direction, e.g. to the right. Then at the source there should be observed a repulsive force towards the left, due to the emission of these ALPs. But because the ALPs transport their impulse to the right without any remarkable interaction with baryonic matter, there obviously exists the problem with the conservation of momentum. This problem, however, only exists on the basis of traditional theories, but not on the basis of the ARG. Due to the ARG the ALPs will be transformed during their flight, without or with the support of magnetic fields, into gravitons. As a typical distance a value of about .13 pc is derived in [4] on the basis of astrophysical observations. But even at larger distances, these gravitons transfer more and more of their impulses towards baryonic matter. Therefore, there exists no boundary of a closed system. But at the source of the ALPs, the principle of the conservation of momentum is not violated.

A different situation appears, however, if an asymmetrically arranged magnetic system at the right side of the source supports the conversion of ALPs to gravitons along this direction. When these gravitons meet some matter, e.g. already inside the magnetic system, or matter belonging to the wall of a metallic shield, a part of the gravitons is absorbed by this matter, proportional to the masses of the matter. This will produce repulsive forces and a thrust-effect of the whole system. But it can also produce repulsive forces, even behind a closed metallic container, and push a book from a disk, as it is reported in connection with Podkletnov's "Impulse Gravity Generator" [1]. Podkletnov's gravity experiments were discussed in detail on the basis of the ARG in a recent paper [5]. This second hypothetical EmDrive-setup and the reports about the "Impulse Gravity Generator" seem to be very compatible.

**Bidirectional sources of ALPs:** A third hypothetical setup may be considered which contains a source of ALPs inside a closed metallic container. The source may emit ALPs with the same intensity preferably into opposite directions, to the left and to the right. Then the system does't feel any thrust. But if magnetic fields, e.g. at the

right side of the source, catalyse the production of gravitons and make possible the transfer of their momentum to the wall of the container, the whole system will feel a thrust to the right.

This scenario seems to be very similar to that of the EmDrives. But while conventional theories assume that the thrust of the EmDrives is produced by the radiation pressure of the microwaves, according to the ARG the thrust results from the absorption of gravitons and their impulses by baryonic matter. The microwave system only acts as the catalyzing magnetic system to transfer the ALPs to gravitons. The ARG don't see a problem concerning the conservation of momentum. In contrary, the use of EmDrives as revolutionary propellentless space drives is a quite well expectable possibility.

On the basis of the ARG there are seen some differences between the various types of EmDrives. Due to the low symmetry of the assembly of Shawyer's original EmDrive [2], statements about the direction of a resultant thrust seem to be very difficult. Small geometric changes may produce quite different results. No wonder that the reports about similar systems of this type with conical resonators differ so widely [6]. Fetta's Cannae Drive [2], however, possesses an axial symmetry. This lets expect a thrust along this axis and it provides a good chance for reproducible results.

### 4. EMDRIVE OR GRAVITONDRIVE?

In almost every paper about EmDrives or the Cannae-drive it is assumed that the observed thrust is created by the radiation pressure of the enclosed microwaves. As already discussed in detail in [5], Podkletnov's "Impulse Gravity Generator" produces highly focused repulsive forces far away from the place of the electrical discharge, but at positions where they hardly can be generated by microwaves. On the basis of the ARG, however, these repulsive forces can be well generated by gravitons at these places. Therefore, in the following the designation "GravitonDrive" will be used.

## 5. EXPECTATIONS FROM GRAVITONDRIVES DUE TO THE ARG

Although reports about EmDrives exist since more than 15 years [2], the possibility of their existence is still under doubt. This seems to be mainly due to the fact that the explanations on the basis of traditional gravitational theories could not lead reproducibly to positive results. In contrary, sometimes the proposed explanations turned out to be invalid. Thus, progresses in this field may be expected only by chance. As an example concerning these considerations, the assumption of the

effectivity of slots in the microwave cavity of the Cannae-drive may be mentioned. Although it turned out in the meantime that these slots are ineffective [2], this idea had a positive result: the thickness of the wall, and therefore also the mass which could absorb gravitons increased. This contributes, according to the ARG, to the high efficiency of the Cannae-Drive, compared to that of the EmDrive with their thin metal sheet walls.

## 6. PERSPECTIVES OF GRAVITON DRIVES

The possibility of GravitonDrives will have an immense influence on the planning of new space projects. If satellites are pushed by rockets cheaply into Low Earth Orbits (LEO), they can survive there for very long times due to the stabilization of the orbit by the thrust of the GravitonDrive. The first proof of this idea may be delivered very soon after the start of a cubesat satellite already in 2017 [7]. Satellites from such a low orbit can easily rise to higher orbits, e.g. to GEO (geostationary Earth orbit) without additional rocket power. Such satellites can also travel to every planet and enter into orbits around them. Even a return into an orbit around earth is possible. This is due to the fact that the GravitonDrive allows acceleration and deceleration towards any direction. All these travels can be performed with drastically reduced efforts of costs and time.

Reports about already existing EmDrives deliver data about the thrust per kWatt, which are up to 320000 times higher than that of the thrust from the radiation pressure of a source with the same radiation power [6]. Therefore, it seems to be appropriate to mention here a second source of thrust without propellent material, which is based on radiation pressure: Solar sails (also called light sails or photon sails) [8]. "LightSail 2" is a project by The Planetary Society, which starts in 2017 with this drive [9]. The "Breakthrough Starshot" program [10] is evaluating, with an enormous budget, the possibility of a travel to next stars like Alpha Centauri with the same drive. In both cases a comparison of the Sail-Drive with the GravitonDrive seems to be reasonable.

## 7. WISH FOR A CONVINCING EXPERIMENT

Although Podkletnov's experiments in 1992 [11] are known now since a quarter of a century, the reality of the curious gravitational forces remains in doubt, especially because different reports about EmDrives don't provide a definite proof of their existence. This situation would drastically change if suitable experiments could be provided which undoubtedly support the ideas of EmDrives or GravitonDrives.

Ideally, such experiments should be so simple and so cheap that they could be

reproduced with positive results by thousands of people. The observed thrust should be far above the spurious effects from disturbing sources. A measurement of a repulsive thrust at places where no microwave power exists, would furthermore allow a decision about the designations "EmDrive" or "GravitonDrive".

## 7. CONCLUSIONS

Although the idea of a propulsion without matter, as described in this paper, contradicts traditional theories about gravity, it can not be prevented from further research, due to the possible high commercial importance. Positive reports about the effect of EmDrives probably will have almost no chance to be accepted by peer-reviewed journals. But even if published somewhere else, such reports must be regarded as the most severe attacks against traditional theories of gravity.

The main problem with the acception of EmDrive papers by peer-reviewed journals is not the fact that the existence of EmDrives can't be explained by classical theories of gravitation. As a proof of this claim, the case of dark matter may be cited. Although its existence was postulated more than 80 years ago, and though the assumed appropriate particles could not be found until now, the peer-reviewed journals are flooded with papers concerning this topic. The main problem with the publication of EmDrive papers, however, is the fact, that the reports severely contradict a well-established principle, the conservation of momentum. And this fact will make the EmDrive to a more severe problem for traditional theories of gravitation than other unexpected gravitational effects, which until now are explained by concepts as dark matter and dark energy and the introduction of appropriate parameters.

## 8. REFERENCES


[1] Podkletnov, E. & Modanese, G. (2001), arXiv:physics/0108005

[2] https://en.wikipedia.org/wiki/RF_resonant_cavity_thruster

[3] Albers, J. (1997), arXiv:physics/9706002v1

[4] Albers, J. (2015), http://www.vixra.org/abs/1509.0224

[5] Albers, J. (2016), http://www.vixra.org/abs/1603.0273

[6] http://emdrive.wiki/Experimental_Results

[7] http://cannae.com/cubesat/

[8] https://en.wikipedia.org/wiki/Solar_sail

[9] http://sail.planetary.org/

[10] https://breakthroughinitiatives.org/News/4

[11] Podkletnov, E. and Nieminen, R. (1992), http://www.sciencedirect.com/science/article/pii/092145349290055H