

Electro Hydro Dynamic Thrusters

University Physics II Honors Project

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Lab Section 1

EHD thrusters may look weird at first due to the lack of moving parts. These devices have been found on antigravity and free energy websites and have also been sold by businesses as antigravity devices. EHD stands for Electro Hydro Dynamics which is the study of the flow of a fluid under the effect of an electric field. The principle of ionic air propulsion with corona generated charged particles has been known since the early days of electric discovery. One of the first references to sensing moving air near a charged tube appeared in 1709 in a book titled 'Physico-Mechanical Experiments on Various Subjects' by F.Hauksbee. The principles behind EHD thrusters were also studied by many famous names in physics such as Newton, Faraday, and Maxwell. Despite early interest, little was known about how exactly these devices worked until relatively recently. The most recent major scientific study done on this method of propulsion was by NASA scientists in October 2004 on what they called Asymmetrical Capacitor Thrusters or ACT's. For my project I sought to build a working EHD thruster, and through observation of my own EHD thruster and research into others, try and determine exactly how they work.

The EHD thruster I built was an extremely lightweight triangular device made from balsa wood, thin 48 gauge wire, and aluminum foil. The balsa wood makes up the frame of the thruster and separates the wire from the aluminum foil. The wire is wrapped in a single loop along the top of the thruster and the aluminum foil is wrapped around the bottom directly below the wire. EHD thrusters need very high voltages to work. The power supply I used was a 20 kilovolt supply made from a neon sign transformer and a capacitor ladder which brought the voltage from 120V AC to 20KV DC. The positive terminal of the power supply is connected to

the wire while the negative terminal is connected to the foil. The thruster will work if the polarities are switched but it seems to result in less thrust.

As stated before, until recently there was much controversy as to how these devices worked. A short list of ideas includes ionic clouds, ejected material from the surface of the wire, and even polarization of a vacuum into matter and antimatter. These ideas attempt to explain with one theory how the device works in the atmosphere as well as the observation of a very miniscule force that is initially produced when the device is turned on in a vacuum. Research done by others demonstrates that the performance of these devices decreases with decreases in atmospheric pressure and are negligible in a complete vacuum. The ionic cloud theory has been disproven mathematically by not producing enough thrust. The ejected material theory has been rejected because for the velocities of the ejected material that might be expected from thermal or electrostatic forces, the amount of material that would need to be removed from the wire is much greater than that available. The idea of the creation of antimatter is easily rejected by the fact that the energy of the system is 10^9 times too small. The best and most widely supported theory for the performance of these devices in air is the Biefeld-Brown effect otherwise known as the Electro Fluid Dynamics. I will explain this theory below as well as one theory to explain the slight force experienced in a vacuum.

The thrust mechanism for an electro fluid dynamics is provided by Coulomb's law of electrostatics acting on ions and the law of conservation of momentum. The high electric field intensity around the fine wire ionizes the air molecules with positive charge, which are in turn repelled from the same wire and attracted towards the bottom, negatively charged foil. As each positive ion is attracted toward the collector foil, it in turn attracts the foil toward it, pulling the

device up. At the same time, its repulsion from the top wire also pushes the lifter upward. By Newton's laws, the momentum that the device gains in the upward direction is equal to the net downward momentum of all the ions. If this were all that happened, when the ions collide with the foil at the bottom, the momentums would cancel out and the net thrust would be zero. This is where the air molecules come in and explains why the thruster works much better in atmosphere. As the ions travel downward toward the foil, they collide with neutral air molecules (about 10^{10} collisions per second at atmospheric pressure), transferring some of their downward momentum to the neutral air, driving the air generally downward. The ions will collide several times with different air molecules transferring most of their momentum to the neutral air before colliding with the foil and transferring their remaining momentum to foil. The neutral air however is not attracted to the foil and most will blow past it and therefore the momentum will not be cancelled out. This allows for the net upward thrust produced. Using some approximations and assumptions, the force of the thrust can be computed. Assume for now that all of the current consists of ions traveling directly from the wire to the foil and further assume that the voltage changes uniformly from the wire to the foil. Also, assume that all of the ions move from the wire to the foil. With these assumptions, the Force F may be computed in terms of the total charge, q , the Voltage applied, V , and the distance between wire and the center of the foil, d , as $F = qE = qV/d = tIV/d$. Removing many of these assumptions and approximations to more accurately calculate the force produced would be a chore. Luckily one researcher Leon Tribe has already broken down the formula for the thrust produced by an EHD thruster and has created a program for calculating the thrust using the distance between the wire and foil, area of foil, cross sectional area of the thruster, and potential difference of the

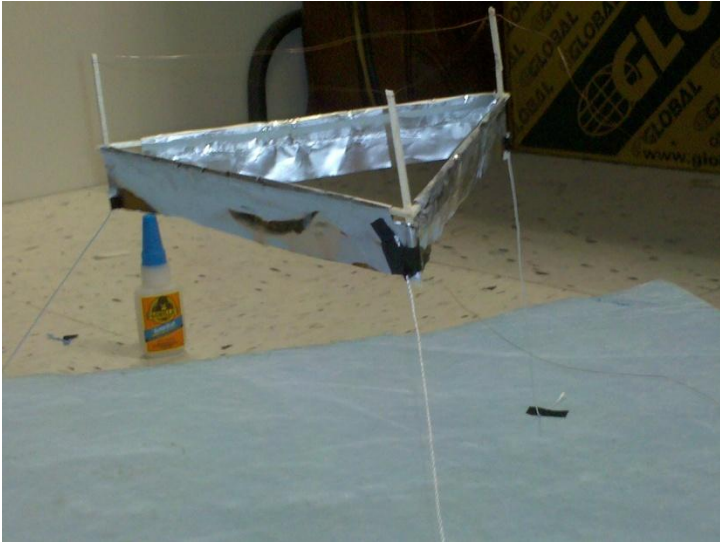
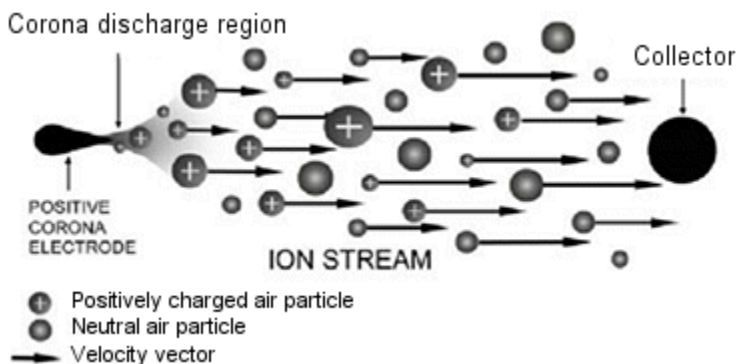
power supply. Using data for my thruster, his program calculates the output of my thruster to be a measly .042 Newtons. This explains why the thruster must be built so light to lift off the ground.

Now the main problem with this theory is how the thruster still produces a minuscule thrust in a vacuum with no air molecules to transfer momentum to. One explanation is that it is not correct to assume that all of the charged particles come into contact with the foil collector. The stray particles from the EHD thruster can cause induced charges on the interior of the vacuum container. Interaction between the charge of the thruster and the induced charge of the vacuum container can create a force. By simply grounding the vacuum chamber, the force is eliminated.

With these findings, the lift produced by these devices can finally be explained. It isn't antigravity, it isn't the creation of antimatter, and it isn't magic. It is a force created by Electro Hydro Dynamics also known as the Biefeld-Brown effect. Although very cool, thrusters like these are not very energy efficient and due to the corrosive effects of high voltages in air, they also are not very reliable. Also, without the ability to operate in a vacuum, their uses are very limited.

My Thruster on its maiden flight

Biefeld-Brown Effect Illustration



Resources

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