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Short communication

Surface aerodynamic model of the lifter

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ABSTRACT

A lifter is based on the Biefeld–Brown Effect which was first found in 1920s, and was brought to life again in 1990s. Since then, efforts were made to find its physical principle, but no satisfactory theory has been met. This paper attempts to find a solution through a simple model based on air ionization, using the surface air power to calculate its load conditions in a system, and moreover, realizing some tentative plans about the relationship between the response system operation of a generalized system and environment on its surface.

1. Introduction

An ionocraft is one of the hottest research projects nowadays whose history began with an interesting effect firstly reported by a young American physicist Thomas Townsend Brown. In 1921, Brown arranged a series of experiments based on Coolidge X-ray tube [1]. The experiments indicated that a slight vibration will occur when Coolidge X-ray tube is turned on and off. Soon, Brown found that some kind of pressure will be generated when a strong current goes through that tube [2]. After some quantitative experiments Brown's idea was confirmed: when voltage is 100 kV, 1% of weight of the object being tested will be lost. Happy as a child, Brown published his result as a "new principle". After a period of time being ignored, Swiss physicist Paul Alfred Biefeld found he was interested in Brown's research and believed his result is correct. Soon after Biefeld became Brown's supervisor they accomplished some experiments and confirmed existence of Biefeld–Brown effect [3,13].

However, this effect remained hidden until 1990s when a NASA subcontractor unfolded it [4]. Once again it became a hot topic among scientists and amateurs for its simple structure and being easy to build. At the same time, some of the scientific collaborations like NASA were also doing some rigorous researches into this effect with considerable effort. Unfortunately, after years of hard work, scientists didn't find a satisfactory explanation for the ionocrafts. Some of the attempts are as follows:

1.1. Theory of ion wind

This theory indicates that the lift on the ionocraft comes from the ion wind generates from ionization of the air by the intense electromagnetic field. But Thomas B. Bahder and Chris Fazi found in their experiments that ion wind theory can explain only a small percentage of the lift [2], in fact, the lift predicted in this theory is $10^3 \sim 10^5$ smaller than the experiments. Thus it can't be the majority of the lift on the ionocraft.

1.2. Theory of ion drift

Scientists believe that ion will play a critical but indirect role in this effect which is also the reason why the ion wind explanation failed. The ion drift theory counted in some of the indirect effect such as collision between ions. According to calculation from Thomas B. Bahder and his team, this theory gives results whose difference from experiment is smaller than 10^1, though some artificial parameters still remained to be explained [2]. However, it is generally acknowledged that ion drift is a correct explanation of Biefeld–Brown effect [5].

1.3. Lift in vacuum and zero-point energy explanation

Robert Talley's research in 1980s indicates that the lift on the ionocraft remains existing even in vacuum [3]. Although barely anyone repeats this experiment, we still see some new ideas in explaining this interesting effect. Researches by Jiang Xingliu and his team show the possibility of constructing a theory without air.

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Despite lacking of a specific method in his paper, this idea of a medium independence theory is still remarkable [6].

We may conclude that medium plays a key role in this effect because Robert Talley found that the ionocraft gives a much smaller lift in vacuum, which means that there must be interactions between the E-field and the air the lift consisting. It is necessary to take medium into account for now. We will then bring out some hypotheses and general ideas with some of the results applied in hydromechanics.

2. Hypotheses and general ideas

To get rid of any specific ionocraft, the environment they are in is the same. We have noticed that the ionocraft gives much larger lift in the air than in vacuum, so this lift must be related with the medium: air. As known to us all: the force represents the rate of momentum changing with time. Naturally enough, we will associate that lift with the similar lift on rockets which is generated via the ionizing and accelerating air downwards [7].

With the help of hydrodynamics, we will be able to analyze how the air flows in this system. We will concentrate on a specific volume in space instead of some specific particles that actually carry the momentum. The method is called 'Euler method' in hydrodynamics, which is actually a method of associating all quantities with space and time itself so that they are easy to deal with as fields [8].

Moreover, the basic principles in thermodynamics will also be introduced. In most of the cases, the thermo systems tend to stay stable in a particular status. There are some cases that the system will keep changing forever, like Benard flow between two flats with different temperature, but as is shown in Fig. 1 that after a long period of time, changes tend to be zero. Thus, with the ionocraft, we will be able to get a stable field [9].

A boundary of a system will also have a strong effect on the system. We assume an ideal environment for the ionocraft where no obstacle is in the environment because the air flows around the ionocraft is in a very small radius, as is shown in Fig. 2, thus in our specially arranged experiments it can be ignored. The effect of boundary was so obvious in some intentionally arranged cases that the ionocraft can't take off [10].

We can conclude our discussion above in mathematics as follows: $\vec{F} = \vec{F}(x, y, z, t)$ represents the idea of field; $\mathrm{d}\vec{F}/\mathrm{d}t = 0$ represents a stable field.

Based on the two principles, we set up a series of equations to solve the ionocraft problems.

3. Fundamental theories

3.1. Equations

The ionocraft in a medium is basically an electrostatic fluid problem. However, in another point of view, this problem could be

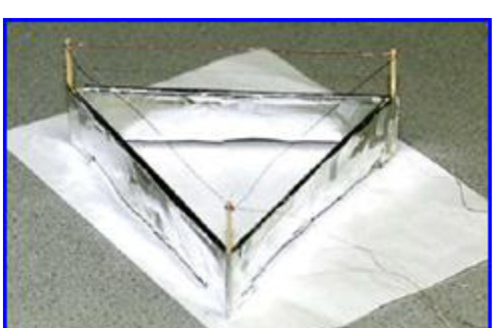

Fig. 1. Ionocraft.

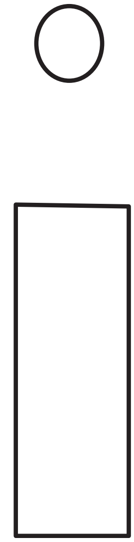

Fig. 2. Simplified structure.

solved as a problem of fields. As is mentioned above, after a long period of time, there will be three fields in space around ionocraft:

Electro field $U(P)$, where P represents a point in space;

Velocity field $\vec{u}(P)$;

Density field $\rho(P)$ and $\rho_e(P)$;

And we need to introduce another field $\sigma(P)$, its meaning will be mentioned below.

These fields could be complex because they are strongly related to each other. For example, $U(P)$ is actually the summation of E-field generated by high voltage on ionocraft and by charge density $\rho_e(P)$, and $\rho_e(P)$ is affected by E-field as well as electrons generated by ionization for electrons would cause ionization, and electrons are also affected by E-field. Instead of considering these complex processes, we focus on some basic principles that these fields follow.

We introduce the continuity equations of density fields in the first place:

$$\begin{cases} \rho \mathrm{d}\vec{u}/\mathrm{d}t + \nabla \cdot \left(\rho \vec{u}\right) = 0 \\ \rho_e \mathrm{d}\vec{u}/\mathrm{d}t + \nabla \cdot \left(\rho_e \vec{u}\right) = 0 \end{cases} \tag{3.1}$$

where is always true in every kinds of fields as is known to all.

And then we introduce the equation of E-field. Here we use the method of deriving classic Ohm's law. We see electrons as points, and their E-fields could be divided into two parts: one is the E-field that causes collision, the other is the contribution to the macroscopic E-field. And now it is a propagation–collision problem. However, the collision here is actually ionization ignoring any chemical progress [14], and the assumption of stable field tell us this ionizing progress will go to a dynamic balance.

If we focus on a small region in space, which means E-field is constant. Before collision (which is an ionization progress in fact), an electron has velocity v'_0, and velocity after collision isv_0. Between two collisions, the electron travels a distance$s = v_0 t + (1/2)q/mE\cos\theta t^2$, average speed will be$\overline{v} = v_0 + (q/m)E\cos\theta t$. For different electrons average speed will be different, but when taking average in space, we will find that:

$$\langle \overline{v} \rangle = \frac{2q}{m} E\tau \tag{3.2}$$

where τ is the average free time for electrons.

In the small region, E is constant, and ρ, ρ_e, $\vec{u}$ are all constant. Thus, in a small region, we have the following expression:

$$\vec{u} = \sigma \vec{E} \tag{3.3}$$

where σ is a constant in the small region, and for the whole space, we have:

$$\vec{u}(P) = \sigma(P)\nabla U(P) \tag{3.4}$$

And one of Maxwell equations:

$$\Delta U(P) = -\rho_e(P)/\varepsilon_0 \tag{3.5}$$

Now we have a series of equations as follows:

$$\begin{cases} \rho \mathrm{d}\vec{u}/\mathrm{d}t + \nabla\cdot\left(\rho\vec{u}\right) = 0 \\ \rho_e \mathrm{d}\vec{u}/\mathrm{d}t + \nabla\cdot\left(\rho_e\vec{u}\right) = 0 \\ \vec{u}(P) = \sigma(P)\nabla U(P) \\ \Delta U(P) = -\rho_e(P)/\varepsilon_0 \end{cases} \tag{3.6}$$

where are 6 equations in total.

Solving these equations will lead us to a known field in space, but how can we know the forces on the ionocraft via these results? As is mentioned above, the force means there is an exchange in momentum. Consider a closed surface in space which includes the ionocraft inside, and it is the boundary of a system of air and the ionocraft as a result. In a time interval delta, some momentum leaves this system, which gives the system a force. In our case of the ionocraft, this will be gained by the ionocraft itself. By letting $\Delta t \to 0$ we'll be able to calculate the lift on the ionocraft [11].

The idea above can be described in mathematics as follows

$$\begin{cases} \mathrm{d}\vec{p}/\mathrm{d}t = \left(\oint\limits_S \rho\vec{u}\,\mathrm{d}S\mathrm{d}r\right)\Big/\mathrm{d}t = \oint\limits_S\left(\vec{u}\cdot\hat{n}\right)\rho\vec{u}\,\mathrm{d}S \\ \vec{F} = \mathrm{d}\vec{p}/\mathrm{d}t - \oint\limits_S \overleftrightarrow{T}\cdot\mathrm{d}\vec{S} - \iiint\limits_V \vec{f}\,\mathrm{d}V \end{cases} \tag{3.7}$$

In which $\widehat{\vec{n}}$ is the vector perpendicular to the surface. $\overleftrightarrow{T}$ is the tension in the medium. $\vec{f}$ is the body force. Moreover, the boundary conditions are also necessary, which will be given in Section 3.3.

3.2. The completeness of equations

These the equations we get above

$$\begin{cases} \rho \mathrm{d}\vec{u}/\mathrm{d}t + \nabla\cdot\left(\rho\vec{u}\right) = 0 \\ \rho_e \mathrm{d}\vec{u}/\mathrm{d}t + \nabla\cdot\left(\rho_e\vec{u}\right) = 0 \\ \vec{u}(P) = \sigma(P)\nabla U(P) \\ \Delta U(P) = -\rho_e(P)/\varepsilon_0 \end{cases} \tag{3.8}$$

And we're now facing a problem: are these equations complete enough that we can solve all the variables?

It's easy enough to find out that field $\sigma(P)$ is unknown so that these equations is not complete, but it is a field related to specific medium so that it could be determined by some properties of medium [11].

However, a detailed discussion will be of no help here, and paying more attention to some other facts will be of more use.

Moreover, any trial to simplify these equations will lead to a conclusion that it's not easy to solve them, especially for a general boundary condition. In our issue here, we won't give any further simplification or solution; instead, we'll derive the boundary condition of the ionocraft, and make clear that the lift has nothing to do with the surface which we choose to calculate. The general conditions will be discussed after enough data is analyzed [11].

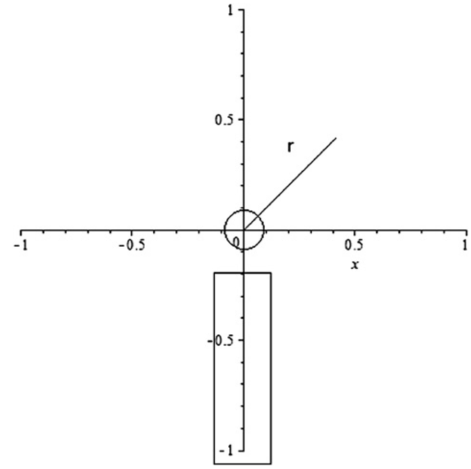

Fig. 3. Ionocraft in a polar frame.

3.3. The boundaries and boundary conditions for the ionocraft

The ionocrafts made by amateurs are in various structures with a common basic unit as is shown in Figs. 2 and 3. Practically, the metal wire (shown as a circle in Fig. 2) is 10^2 or 10^3 smaller than the aluminum sheet, so an asymmetry field could be generated [8].

To set the origin on the center of the metal wire, and the framework is set as is shown in Fig. 3. We can describe the ionocraft boundary in the following equations

$$\Omega_1 : r = r_0; \Omega_2 : \begin{cases} r\cos\theta = \pm x_0 \\ r\sin\theta = \pm y_0 \end{cases} \tag{3.9}$$

For density, a reasonable condition is that it goes to a constant when the ionocraft is far away, which is $\lim\limits_{r\to\infty}\rho(r) = \rho_0 = \mu p_0/kT$, in which p_0 is the pressure of atmosphere, T is temperature of the air (Fig. 4).

Density close to the ionocraft's surface will go to zero when the ionocraft working properly for the strong ionization and the intense electromagnetic field, which is $\lim\limits_{\Omega\to\Omega_1}\rho(r) = 0$, in which Ω is the surface we choose. Putting them together, we got the boundary condition of density

$$\begin{cases} \lim\limits_{\Omega\to\Omega_1}\rho(P) = 0 \\ \lim\limits_{r\to\infty}\rho(P) = \mu p_0/kT \end{cases} \tag{3.10}$$

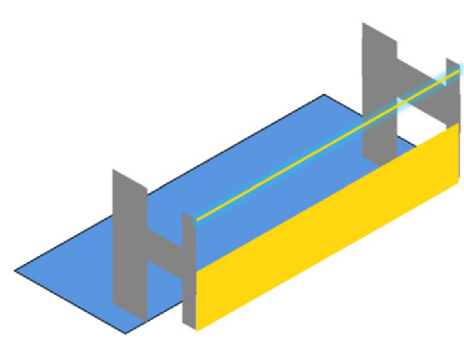

Fig. 4. Structure of the ionocraft for tests on force. The line in yellow represents the wire with high voltage, the flat in yellow represents aluminum foil connected with ground. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

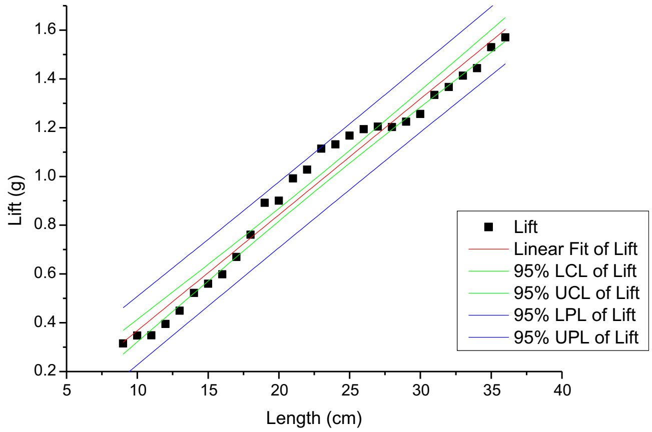

Fig. 5. Data shows good symmetry in z-axis.

Similarly, the conditions for velocity are $\lim_{r\to\infty} \vec{u}(r) = \vec{0}$. And we can't derive anything from velocity itself. However, when taking potential and charges and so on into account, we will be able to make clear the boundary condition for velocity [9] (Fig. 5).

We have these boundary conditions for potential $\begin{cases} \lim_{\Omega\to\Omega_1,\Omega_2} U(r) = U_0 \\ \lim_{r\to\infty} U(r) = 0 \end{cases}$; in which U_0 is a certain potential that is exerted on the wire, which is around 20–30 kV.

For charges, we have $\lim_{r\to\infty} \rho_e(r) = 0$; the critical point is that charges are generated from the ionizing air, considering forces on a fixed volume in space, we'll be able to know:

$(\vec{u}\cdot\nabla)\vec{u} = -\rho_e \nabla U|_{\Omega\to\Omega_1}$, where tense becomes zero because the density in the air becomes zero.

When potential is known, the charge density can be derived from Maxwell equation, and the condition above will become a condition for velocity. So we have derived a complete boundary condition of ionocraft.

4. Fundamental experiments

As is mentioned above in the introduction part, the ionocraft is a scientific project with an immense number of amateurs among the population, thus a lot of experiments have been done on it. Especially some institutes like NASA, it has also put much attention on the ionocraft so that most of the experiments can be trustable [12]. However, we didn't find any formal experiments or tests on the lift and force on the ionocraft. Our team in Gewu Zhizhi league is trying to do some researches into it. As far as July 30th, 2012, we have got results on the following subjects:

Sample machines: We have manufactured the sample machines science in the beginning to meet the need of our progressing research. We have built two types of machines, one is for demonstrating and the other is for measuring, their conditions are listed in the following Table 1.

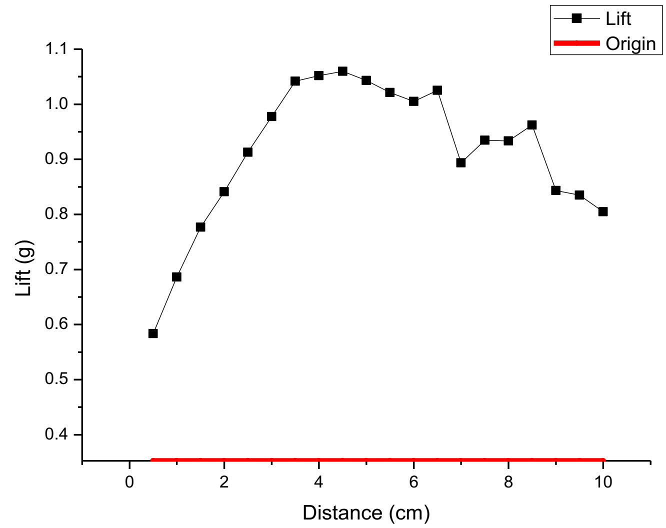

Fig. 6. Lift largely decreases when two ionocraft get too close, but still larger than the red line, which represents the lift generated by a single ionocraft. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 2
Parameters of the measurement machine.

Measurement	Distance between wire and foil	Weight	Shape of foil top
9 × 3 (cm) rectangle; 9 (cm) wire	Usually 3 (cm), and modifiable	Around 4.5 (g)	Arc

4.1. Measuring

We use lift-testers and electro scale to perform tests on forces. Results from another member of our team Guo Jia, E-field will decrease weak enough in 5 cm, and the particle thrusts are almost perpendicularly downward on the ground. Thus, we designed an ionocraft as follows, so that the ionocraft will be far enough to the electronic scale:

The line in yellow represents the wire with high voltage, the flat in yellow represents aluminum foil connected with ground (Fig. 6).

We performed tests on the effects of length, distance between two ionocrafts, distance between wire and foil and how the lift on the ionocraft distributes with time. All tests were performed under a voltage of 30 kV. We got these results (Table 2):

4.2. Effect of length to force

After some careful tests in the medium air, we find that the lift is linear related to length of the ionocraft. It shows the ionocraft has a good symmetry in this direction. Practically, the results point out that we can enlarge the lift via the longer ionocraft.

Table 1
The sample machines are not officially used in measurements.

Name	Straw 1	Little B	Test 1	Test 2
Measurement	19 × 19 × 19 (cm) 60° triangle	5 × 5 × 5 (cm) 60° triangle	17 cm	6.8 cm × 4, completed structure
Distance between wire and foil	3.6 cm	2.5 cm	3.0 cm	3.0 cm
Shape of foil top	Arc	Arc	Arc (carefully trimmed)	Arc
Weight	2.9 g	Less than 1 g	1.7 g	7.3 g
Take off or not	Stably lifted up	Stably lifted up	Took off, but not stable	Didn't take off

4.3. Effects between two ionocrafts

As shown in Fig. 6, the lift largely decreases when two ionocrafts get too close, the result indicates that the lift may be area related, and we could find a shape that gives out the most thrust so that the largest lift will be generated. We can see a great disorder occurred approximately to 6–8 cm, we surmise that the disorder is caused by a random factor; further experiments are expected to prove such conjecture.

4.4. Effect of distance between wire and foil

As shown in Fig. 7, the distance is power-related to lift, which is $y = ax^b$. It may be helpful to researches into E-fields around the ionocraft.

4.5. Distribution of the lift with time

We use quantity $Z_n = \sum_{n=1}^{N} x_n/n$ to show the distribution of the lift. Firstly, we can see a quantity whose error satisfies with normal distribution has a quantity $Z_n = \sum_{n=1}^{N} x_n/n$ changes with time as shown in Fig. 8:

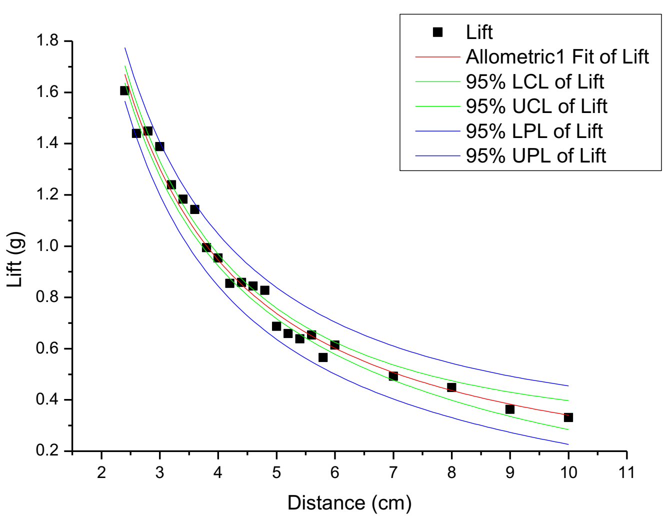

Fig. 7. Lift decreases with distance by the power 1.113, this may give us some hints about E-field around the ionocraft.

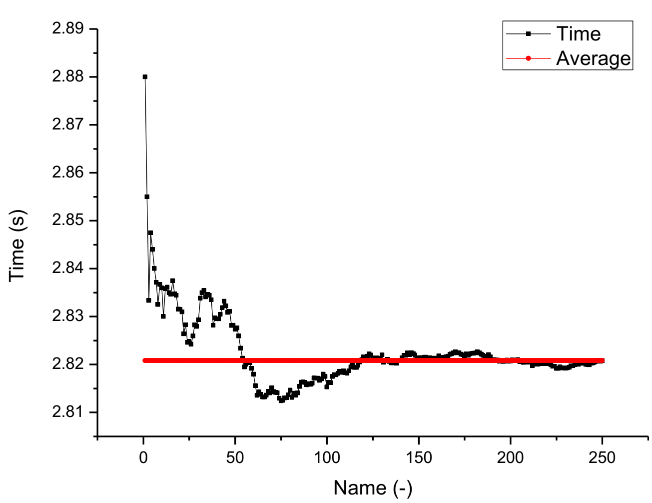

Fig. 8. The distribution of some kind of data, which satisfies the normal distribution, has a quantity Zn like this, and this should be a standard Zn to the following data.

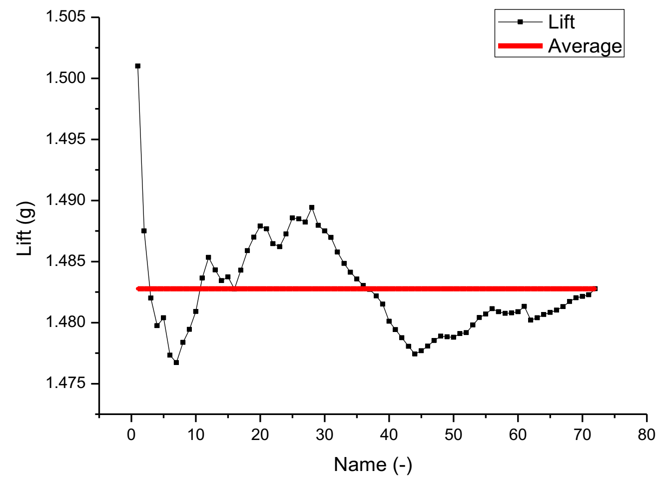

Fig. 9. The good distribution.

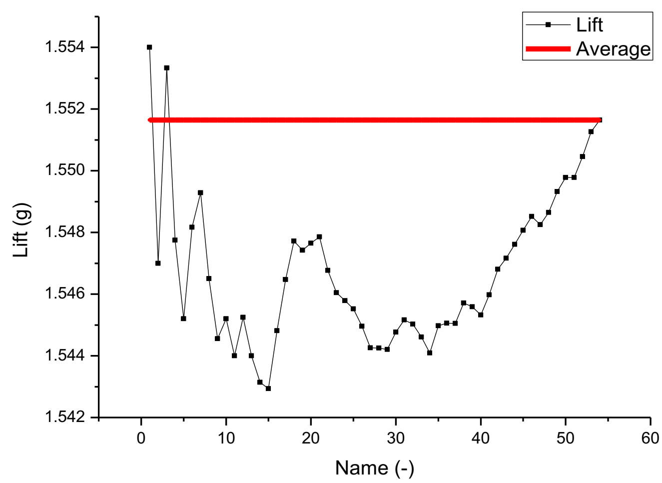

Fig. 10. The bad distribution.

And in our case, the lift distributes with time in the following forms which is very similar to the series of data without drift given above: Fig. 9

However, there is some time when this distribution doesn't look so good (Fig. 10):

These differences in distribution may be caused by effects of E-field on the scale, but it is also possible that they are caused by the ionocraft itself. We'll do more careful experiments on this later.

Unfortunately, we don't have any evidence to support our theory for now, but further experiments are to be done and tests on this theory will also be performed.

5. Conclusion

We have had our equations, but solving them will be another big problem. Here we have proved that these equations are complete, and to some degree sensible. One next step is to solve them and test them in experiments, as is mentioned in the last section.

Theoretically, the ionocraft will be a good point for new ideas. To explain this effect, one needs new ways of thinking in physics. As is mentioned in the paper by Jiang Xingliu from Beijing University of Aeronautics and Astronautics, this thrust may be caused by ZPE (zero-point-energy) [8], which indicates that this is actually a quantum effect. And many other researchers are devoting themselves into this subject [9]. Thus, it is reasonable enough to predict that ionocraft will lead to some new physics.

Practically, and more importantly, the ionocraft promises a new type of vehicle that no longer uses wheels and roads. Tests in vacuum also indicate that the ionocraft is potential to provide a method of traveling in space without rockets. The application of the ionocraft technology will change the way we live.

Moreover, we have a lot to do in this subject. As an electro-fluid effect, we haven't carefully measured the current and voltage on ionocraft when working, and other properties of ionocraft have not yet been carefully looked into. Some primary results of our experiment and others' have shown that it takes immense power to lift an approximately 5 g ionocraft [11], and this is still a big problem in realizing ionocraft as a way of transportation. What's more, some interesting effects detected in experiment have not been presented here because they are not carefully tested. Our next step will be researches into these interesting problems.

Acknowledgments

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