CBAT

IVO Ltd

Application Filed: 2021-06-07

Trademark Application Details

CBAT

Mark For: CBAT™ trademark registration is intended to cover the category of wireless chargers.

Status

2021-06-10 UTC

Refresh

LIVE APPLICATION Awaiting Examination

The trademark application has been accepted by the Office (has met the minimum filing requirements) and has not yet been assigned to an examiner.

Website	www.ivoltd.com
Research	OneLook Acronym Finder
Serial Number	90758285
Mark Literal Elements	CBAT
Mark Drawing Type	4 - STANDARD CHARACTER MARK
Mark Type	Trademark
Current Location	NEW APPLICATION PROCESSING 2021-06-10
Basis	1(b)
Class Status	ACTIVE
Primary US Classes	021: Electrical Apparatus, Machines and Supplies 023: Cutlery, Machinery, Tools and Parts Thereof 026: Measuring and Scientific Appliances 036: Musical Instruments and Supplies 038: Prints and Publications
Primary International Class	009 - Primary Class (Electrical and scientific apparatus) Scientific, nautical, surveying, electric, photographic, cinematographic, optical, weighing, measuring, signaling, checking (supervision), lifesaving and teaching apparatus and instruments; apparatus for recording, transmission or reproduction of sound or images; magnetic data carriers, recording discs; automatic vending machines and mechanisms for coin operated apparatus; cash registers, calculating machines, data processing equipment and computers; fire-extinguishing apparatus.
Filed Use	No
Current Use	No
Intent To Use	Yes
Filed ITU	Yes
44D Filed	No
44E Current	No
66A Current	No
Current Basis	No
No Basis	No

Timeline

2021-06-07	Application Filed
2021-06-10	Location: NEW APPLICATION PROCESSING
2021-06-10	Status: Live/Pending
2021-06-10	Status: New application will be assigned to an examining attorney approximately 3 months after filing date.
2021-06-10	Transaction Date

Trademark Parties (Applicants & Owners)

Party:	IVO Ltd
Address	2803 Hogan Dr Bismarck, NORTH DAKOTA UNITED STATES 58503
Legal Entity Type	Corporation
Legal Entity State	NORTH DAKOTA

Documents

Drawing	IMAGE/JPEG	2021-06-07
TEAS Plus New Application	APPLICATION/XML,IMAGE/JPEG	2021-06-07

Attorney of Record

IVO LTD
2803 HOGAN DR
BISMARCK, ND 58503

Good, Services, and Codes

International Codes:	9
U.S. Codes:	021,023,026,036,038

Type Code	Type
GS0091	Wireless chargers

Trademark Filing History

Description	Date	Proceeding Number
NEW APPLICATION ENTERED IN TRAM	2021-06-10	

Similar Marks

Mark Image	Registration | Serial	Company	Trademark Application Date
CBAT	90758285 not registered Live/Pending	IVO Ltd	2021-06-07
CBAT	78396218 2979862 Dead/Cancelled	SCIENCE APPLICATIONS INTERNATIONAL CORPORATION	2004-04-02

CHAIRMAN AND CEO

Richard Mansell

Richard Mansell is the Chief Executive Officer and co-founder of IVO Ltd. He is an experienced inventor who has worked alongside companies such as GE Health and Local Motors Industries to develop new hardware and processes. For GE, Mr. Mansell developed a compression algorithm for their CT scans as well as helped create hardware specifically for pipeline inspections.

Mr. Mansell holds multiple utility patents both individually and jointly. He is known in the automotive industry for his invention, O.S.E.M.O, which is an open-source electronic hardware and firmware suite for operating and managing equipment specifically aimed at automobile systems. Richard is the inventor of the world's first truly wireless power solution, Capacitive Based Aerial Transmission (CBAT). His extensive work with capacitive based power systems has led to multiple breakthroughs in the understanding of the electric field.

IVO, Ltd

This is the sixteenth in the series of interviews conducted by the Alleghany Highlands Economic Development Corporation about small business entrepreneurship in our area.

The Alleghany Highlands Economic Development Corporation offers entrepreneurial services, one-on-one business planning assistance, training, mentoring and operational assistance to existing local small businesses and startups.

We are located on the Dabney S. Lancaster Community College campus and can be reached at 540.862.0936 or marla@ahedc.com or terri@ahedc.com.

I recently sat down with Richard Mansell of IVO, Ltd to get his view on the life of being a small business entrepreneur in the Alleghany Highlands.

Richard Mansell can be reached by calling 704.524.7039 or preferably by email at Richard.mansell@ivoltd.com.

Richard was a pastor in North Carolina and moved here in 2011 to become the assistant pastor at Calvary Baptist Church, which is located on Mill Street in Covington, Virginia.

He does electronic hardware, research and development at his workshop at home for several companies across the states on a free lance independent contractor.

He is presently moving into the Edgemont School/Drone Zone.

What ignited the spark in you to develop IVO, Ltd?

It was the particular technology innovation of wireless power. The first part of 2018, two friends and associates of mine since 2014 Dan Telehey and Matt Silbernagel, were discussing electronic hardware for a medical device.

I started figuring out the wireless power side, so we were talking about the power supply for the medical device, I suggested that one option could be wireless power instead of a battery, USB or plug-in.

The next day they called me back wanting to talk more about the wireless power.

Since that time the actual medical device we were looking at developing actually was pushed aside completely.

We have not touched it since then and have decided to form the company IVO, Ltd concentrating on a technology innovation company but specifically pursuing the wireless power.

So up to that point I had been concentrating on developing products for other companies. We decided that we would begin developing our own technology and have pursued patents to protect our developments related to the goal of wireless power.

Since then, the electronic hardware has continued to pay the bills while figuring out how IVO should move forward with a bit of continued research for wireless power.

Tell us the reasoning behind putting the medical device aside to strictly focus on wireless power?

Because of the potential technological revolution to wirelessly power things so you do not need to plug things in anymore, we felt that this is something that must be pursued.

Being the number two winner of The Gauntlet from the Alleghany Highlands, describe your experience with that program.

For number one, The Gauntlet taught me things about business that I did not know I needed to know. That was one of the key benefits.

I wasn't sure if I should spend the time with The Gauntlet because Dan and Matt are more the business side of IVO. They do the office work, consider financial projections and I am the inventor; I am the technology side and CEO.

I said, "Well if the Alleghany Highlands Economic Development Corporation team is suggesting I need to be part of The Gauntlet, then I should probably do it."

Once I was in the class, I was given all this information within a book, a playbook (how to do a business plan), and all kinds of other materials.

Then we started having the special speakers and I started learning about stuff and realized it was not as simple as having a great idea for a product and then have folks who would want to buy it.

It just magically happens, was not really the case. Business is not magic!

So yes, learning the stuff that I did not know I needed to know about business was really good.

The second was I really enjoyed the entrepreneurial showcases, which was hearing from people who have successfully been a part of their own entrepreneurial experience. The entrepreneurs sharing their stories brought more of the academic teaching aspects to life.

So while various individuals gave their time to teach market analysis, sales pitch, etc, which is all nice, the entrepreneurial showcases was like those things in real life.

You then start to put things together and realize this is how it goes from paper to actual business experience which was really beneficial.

The third was getting to know other entrepreneurs.

I loved that; I am a people person, an extrovert for the most part.

Then you find other people who are trying to start their own business and figuring out how can I be a help to them, how can we support each other.

Now I have lots of friends and contacts in the entrepreneurial world.

Not only that but also exposure to economic development, the chamber, city and county folks, neighboring counties because it was them coming to us, the participants of the program, not us reaching out to them.

So you have already moved in to the Drone Zone, what are your plans moving forward with hiring?

With the move, I know have space to have other people and the space to take on other projects.

As of last week, I hired a part-time administrative assistant to get the office in order.

Also last week, a student summer intern started and will be learning my electronics, 3 D printing, and wireless power.

His family has signed an NDA and waiver for him to be a part of IVO.

I am really excited about this because it is like a precursor to the fall where Ed Ozols, Technology Supervisor from Bath County High School will have his classes come down as well as Joe Mayes and his class from Alleghany High School.

Once a month we will have classes from the area schools visit IVO, with the Edgemont Building providing the space. The Edgemont Building, formerly a school, is the central location for remote operations, maintenance and administration for the drone zone.

After the summer intern leaves, my goal will be to actually replace him with a technical assistant paid employee at some point.

What would you say are the top three skills needed to be a successful entrepreneur?

The obvious one is being a self starter and pushing ahead on your own without supervision.

You have to have that personal drive.

The second is the willingness to learn, a teachable spirit is very important.

You can still be an entrepreneur without the teachable spirit but to be a successful entrepreneur, I think you need to be a teachable spirit.

I wonder if this makes the difference between those entrepreneurs who are successful and those who aren't.

And/or those who are eventually successful; I think some entrepreneurs are successful because they had enough drive to get through all the hard knocks when they didn't listen to advice.

They were eventually successful but I wonder how many heartaches would have been saved if they had a teachable spirit from the beginning.

The third would be creativity; I think you have to be creative and figure out what your niche is going to be.

As an entrepreneur you are not coming in and manning an established company to make sure it runs smoothly, you actually have to come up with what is the product and who are the people.

One of the words that came up frequently in The Gauntlet was pivot; well that is creativity, being able to come up with the ideas and establish them.

It is a saturated market, what could be my niche, discovering and figuring that out, is another aspect where creativity comes into play.

To what do you most attribute your success so far?

The Lord Jesus Christ; his help and guidance from the very beginning of biblical foundation was how to do things right.

The Bible talks about how God does everything in order and that is fundamental for study, for work, relationships with other people, so the Bible is definitely the foundation in what I have been taught by other Christians.

I think people seem to like me but it is not because of whom I was as much as whom Jesus Christ has helped me to become.

Where do you see yourself in 10 years?

52 years old.

10 years is quite awhile, I have thought about the near term like 3 years or 5 years but not 10.

I would like for IVO, Ltd to be running on its own with staff. I would still be a part of the creative and inventive part.

I am concerned that the business will be so consumed with time that I will not want to do my number one thing and that is pastor and be a spiritual help to people around us.

My wife and I continue to look forward to a time where our future plans will always entail ministry.

My desire in 10 years is that IVO, Ltd is doing very well with its licensing agreements and one aspect of the business has a manufacturing facility producing products.

10 years from now I want to be pushing the limits of technology innovation because I have ideas.

The other thing is observable science, not just theoretical science, but observable science is continuing to expand what we are learning about the Universe and how God created things.

As that expands it opens up new technology possibilities.

In one word characterize your life as an entrepreneur?

Exciting!

If you could talk to one person from history who would it be and why?

Nikola Tesla.

The reason is not only was he an inventor but he was such an observer of the natural world, he learned from that and how to apply it to technology.

The other thing is he had certain frustrations and he had to overcome and deal with it and I could learn so much from him concerning that.

Think about it, he was a guy from Austria during World War I and World War II trying to develop technology in the United States.

He was also bringing into existence technology that went directly into the face of existing technology.

DC current was the thing for electricity and he was bringing in AC current. Later on he wanted to bring in pulse DC current but AC current had already been established by him.

He had to change things and because of it in his later years he was relegated to the aspects of pseudo science, kind of a mockery.

Also it seemed like he had Aspergers or something similar. He had some obsessive compulsive disorder in him as well, the way he would always have to place his napkins/forks, so there are things in history we see about him.

There are some characteristics as such that I would love to ask especially in light of what we understand concerning those things today.

Another thing about Nikola in comparison to me, we both think through technology in our heads first so by the time we put it down on paper we are pretty sure it is going to work already.

We do not design it to find out if it is going to work, we are already convinced it is going to work, and if not, we move on to something else.

Sometimes thinking through it is enough for me and I can finally sleep.

I am through asking questions unless there is something you would like to add.

The only thing I would want to add is if anyone is considering; would the time spent in Gauntlet be worth it, I would say yes, do it!

Entrepreneurs are busy and sometimes they do not know what they need to do and it's like, do I spend the time and the money to be part of the Gauntlet?

Go to The Gauntlet every Tuesday night, do it!

Alleghany Highlands Economic Development Corporation
540.862.0936
info@ahedc.com

9212 Winterberry Ave., Covington, VA 24426
Hours: Mon-Fri 8a-5p; excluding holidays

IVO Limited

0661-EX-ST-2021

Status: Pending

N/A
2021-04-27

Application Form:

FEDERAL COMMUNICATIONS COMMISSION
APPLICATION FOR SPECIAL TEMPORARY AUTHORITY

Applicant Name

Name of Applicant: IVO Limited

Address

Attention: Dan Telehey
Street Address: 4359 Fort Lincoln Rd
P.O. Box:
City: Mandan
State: ND
Zip Code: 58554
Country: United States
E-Mail Address: daniel.telehey@ivoltd.com

Best Contact

Give the following information of person who can best handle inquiries pertaining to this application:
Last Name: Mansell
First Name: Richard
Title: CEO
Phone Number: 7045247039

Explanation

Please explain in the area below why an STA is necessary:
Although our experimentation involves specifically electric fields, there is some activity within the corresponding electromagnetic field frequencies.

Purpose of Operation

Please explain the purpose of operation: Experimental testing using dynamic electric fields to transmit power to drones wirelessly at various frequencies.

Information

Callsign:
Class of Station: FX
Nature of Service: Experimental

Requested Period of Operation

Operation Start Date: 05/31/2021
Operation End Date: 10/29/2021

Manufacturer

List below transmitting equipment to be installed (if experimental, so state) if additional rows are required, please submit equipment list as an exhibit:

Manufacturer	Model Number	No. Of Units	Experimental
IVO Limited	PnPT	4	Yes

Certification

Neither the applicant nor any other party to the application is subject to a denial of Federal benefits that includes FCC benefits pursuant to Section 5301 of the Anti-Drug Abuse Act of 1988, 21 U.S.C. Section 862, because of a conviction for possession or distribution of a controlled substance. The applicant hereby waives any claim to the use of any particular frequency or electromagnetic spectrum as against the regulatory power of the United States because of the prvious use of the same, whether by license or otherwise, and requests authorization in accordance with this application. (See Section 304 of the Communications Act of 1934, as amended.) The applicant acknowledges that all statements made in this application and attached exhibits are considered material representations, and that all the exhibits part hereof and are incorporated herein as if set out in full in this application; undersigned certifies that all statements in this application are true, complete and correct to the best of his/her knowledge and belief and are made in good faith. Applicant certifies that construction of the station would NOT be an action which is likely to have a significant environmental effect. See the Commission's Rules, 47 CFR1.1301-1.1319.
Signature of Applicant (Authorized person filing form): Richard M Mansell
Title of Applicant (if any): CEO
Date: 2021-04-27 00:00:00.0

Station Location

	City	State	Latitude	Longitude	Mobile	Radius of Operation
	Covington	Virginia	North 37 75 89	West 79 99 25		0.10

Datum: NAD 83
Is a directional antenna (other than radar) used? No
Exhibit submitted: No
(a) Width of beam in degrees at the half-power point:
(b) Orientation in horizontal plane:
(c) Orientation in vertical plane:
Will the antenna extend more than 6 meters above the ground, or if mounted on an existing building, will it extend more than 6 meters above the building, or will the proposed antenna be mounted on an existing structure other than a building? No
(a) Overall height above ground to tip of antenna in meters:
(b) Elevation of ground at antenna site above mean sea level in meters:
(c) Distance to nearest aircraft landing area in kilometers:
(d) List any natural formations of existing man-made structures (hills, trees, water tanks, towers, etc.) which, in the opinion of the applicant, would tend to shield the antenna from aircraft:

Action	Frequency	Station Class	Output Power/ERP	Mean Peak	Frequency Tolerance (+/-)	Emission Designator	Modulating Signal
New	3.50000000-4.00000000 MHz	FX	20.000000 W	20.000000 WP	5.00000000 %	N1N	
New	300.00000000-1200.00000000 kHz	FX	100.000000 W	100.000000 WP	5.00000000 %	N1N	

15187

IVO LTD

CAGE CODE 869H0

Ivo Ltd has a registered in the System for Award Management for doing business with and bidding for contracts by the United States government. Cage Code 869H0 was listed as their unique company identifier. The company registered with SAM on 2018-09-15 and the registration with the below details.

Company Details

NCAGE Code	869H0	IVO LTD
CAGE Code	869H0	IVO LTD
DUNS	081330968	IVO LTD

Duns	81330968
Cage Code	869H0
Sam Extract Code	E
Purpose Of Registration	Z2
Initial Registration Date	2018-09-15
Expiration Date	2019-09-15
Last Update Date	2019-09-15
Activation Date	2018-09-25
Legal Business Name	IVO LTD
Physical Address Line 1	4359 FORT LINCOLN RD
Physical Address City	MANDAN
Physical Address Province Or State	ND
Physical Address Zippostal Code	58554
Physical Address Zip Code 4	7930
Physical Address Country Code	USA
Business Start Date	2018-02-28
Fiscal Year End Close Date	1231
Entity Structure	2L
State Of Incorporation	ND
Country Of Incorporation	USA
Business Type Counter	3
Business Type Varchar	2X~JX~XS
Primary Naics	541715
Naics Code Counter	1
Naics Code Varchar	541715E
Credit Card Usage	Y
Mailing Address Line 1	4359 FORT LINCOLN RD
Mailing Address City	MANDAN
Mailing Address Zippostal Code	58554
Mailing Address Country	USA
Mailing Address State Or Province	ND
Govt Bus Poc First Name	DANIEL
Govt Bus Poc Last Name	TELEHEY
Govt Bus Poc Title	CHIEF OPERATING OFFICER
Govt Bus Poc St Add 1	4359 FORT LINCOLN RD
Govt Bus Poc City	MANDAN
Govt Bus Poc Zippostal Code	58554
Govt Bus Poc Country Code	USA
Govt Bus Poc State Or Province	ND
Govt Bus Poc Us Phone	2147483647
Govt Bus Poc Email	daniel.telehey@ivoltd.com
Elec Bus Poc First Name	DANIEL
Elec Bus Poc Last Name	TELEHEY
Elec Bus Poc Title	CHIEF OPERATING OFFICER
Elec Bus Poc St Add 1	4359 FORT LINCOLN RD
Elec Bus Poc City	MANDAN
Elec Bus Poc Zippostal Code	58554
Elec Bus Poc Country Code	USA
Elec Bus Poc State Or Province	ND
Elec Bus Poc Us Phone	2147483647
Elec Bus Poc Email	daniel.telehey@ivoltd.com
Naics Exception Counter	1
Naics Exception Varchar	541715YYYY
Debt Subject To Offset Flag	N
End Of Record Indicator	!end

Capacitive Based Aerial Transmission (CBAT) is the ultimate power distribution method for Defense. Conduct any mission or operation with complete confidence that no device or tool goes without power. The CBAT system delivers uninterrupted power to ensure no downtime.

- Scalable Power Distribution for different sized electronics
- Minimize downtime, Maximize Security
- Reduce Waste, Reduce Risk, Reduce Costs
- Downsize batteries, upgrade mission capabilities
- Plug-n-play for on the go
- Made in the USA

WE TRANSFORM DEFENSE

CBAT Powers Mission Success

CBAT can power any mission. From a single, centralized transmitter, maintain power to all your critical tools and equipment and create your BattleSphere. Ensure no man is left behind the technology curve by adding CBAT to your tactical arsenal today.

// DOWNLOADABLES

Resources

The Future of Wireless Power

IVO's CBAT technology has a growing, successful track record across multiple applications.

Redefining Power Transmission

CBAT gives devices the ultimate advantage of utilizing wireless power, with or without a battery.

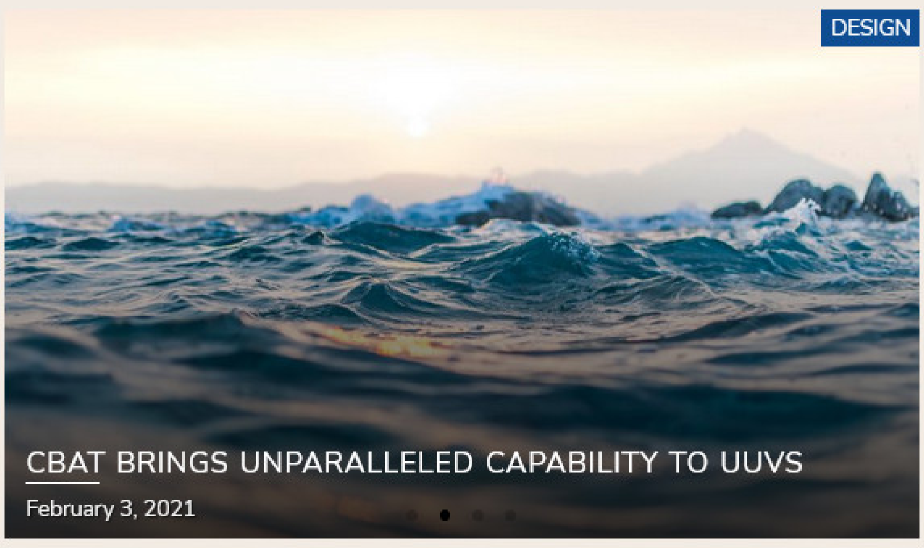
Tailored Wireless Power Solutions

CBAT is designed to wirelessly transmit true power to multiple devices from a single transmitter.

// STAY UP TO DATE

Latest News

Keep up to date with the latest news from IVO's technology advancements and company updates, including the continued development of CBAT.



Bismarck, North Dakota
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DEVELOPMENT
IVO
PRESS RELEASE: IVO LTD INTRODUCES THE WORLD'S FIRST PURE ELECTRIC THRUSTER FOR SATELLITES
March 24, 2022


DEVELOPMENT
CAPACITIVE BASED AERIAL TRANSMISSION OFFICIALLY RECEIVES NOTICE OF ALLOWANCE FROM UNITED STATE...
June 21, 2021


DESIGN
CBAT BRINGS UNPARALLELED CAPABILITY TO UUVS
February 3, 2021

Munoz

ue Operations

Paul Cejas

Technology Integration Manager

Paul Cejas's Email

Chief Engineer - Autonomous Tactical Aviation Programs @ Boeing

View Paul's Email (It's Free)

5 free lookups per month.
No credit card required.

LOCATION

St. Louis, Missouri, United States

WORK

Chief Engineer - Autonomous Tactical Aviation Programs @ Boeing

Chief Engineer Off-Boeing Programs @ Boeing

Qf-16 Chief Engineer @ Boeing

see more

EDUCATION

Georgia Institute of Technology

Bachelor of Science (BS) (Aerospace, Aeronautical and Astronautical Engineering)

University of Missouri-Saint Louis

Master of Business Administration (M.B.A.) (Finance, General)

Paul Cejas Email Address

Found 1 email address listing:

@boeing.com

View Paul's Email (It's Free)

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No credit card required.

If you need more lookups, subscriptions start at €35 (billed at $39 USD/month).

[Paul Cejas - Volotech, LLC ; Partner - Midas Consulting Group]

St Louis, Missouri, United States · President - Volotech, LLC ; Partner - Midas Consulting Group · Volotech, LLC

Recently took early retirement from **Boeing** and looking to share my experience. Successes include co-creation of the Air Combat Teaming System concept and ...

Boeing Turned An F-16 Fighter Jet Into A Drone

But what would the moral implications be of having a pilotless fighter jet?

BY ADDY DUGDALE 1 MINUTE READ

https://www.youtube.com/watch?v=dqNNAKGQd8o

Boeing has tinkered with an F-16 fighter jet and transformed it into a UAV with more capabilities than it would have with a human pilot at the controls. The adapted Lockhart-Martin aircraft, which hadn't flown in over a decade, made a solo flight above the Gulf of Mexico, while two pilots controlled its movements from the ground, reaching 7Gs of accelerations.

Two chase planes accompanied the aircraft–now renamed the QF-16, and part of a fleet of six modified jets–on its maiden flight, which went according to plan. "It was a little different to see it without anyone in it, but it was a great flight all the way round," Lieut. Col Ryan Inman, commander of the Air Force's 82nd Aerial Targets Squadron, told BBC News. Chief engineer of the project, Paul Cejas, said the plane made "probably one of the best landings I've ever seen."

Should the QF-16 have gone rogue, the controllers had a button enabling them to destroy the jet before it could either cause any harm or fall into the wrong hands. The drone, which can only take off from land, as it is too heavy to work on an aircraft carrier, will now be tested by the U.S. military in order to carry out some live-fire tests.

[*Image: Flickr user Edvard M*]

ABOUT THE AUTHOR

My writing career has taken me all round the houses over the past decade and a half--from grumpy teens and hungover rock bands in the U.K., where I was born, via celebrity interviews, health, tech and fashion in Madrid and Paris, before returning to London, where I now live. For the past five years I've been writing about technology and innovation for U.S More

Tuesday, 2 November 2021

A Thrust from 'Nothing'.

In a small lab in Plymouth, a new quantum thruster is taking shape. I have been theorising about getting thrust from quantised inertia and trying to work out how best to do it for DARPA (see ref 1). With Prof Perez-Diaz we managed to get a few microNewtons out, and I had considered asymmetric plates, but engineer Frank Becker read my papers, remembered a capacitor-based Biefeld-Brown-type experiment he had done, and with a few discussion with me, he and Ankur Bhatt tried it and produced milliNewtons of thrust (see ref 2). This test made my year. Even DARPA emailed me saying something like "What the heck is this!?". One problem was that they had used a high voltage with a digital balance so there was a potential for glitches. Then Richard Mansell of IVO Ltd tried it with an analogue method and agreed with them. This new Mansell group has also blazed the path in innovation as well.

In its simplest form, anyone, with a little care for safety, can try this experiment. If you have a humble desk and a power socket then the cost is £800. I know because I've just spent that much on it! Not bad for a technology that promises to revolutionise just about every industry we have: satellites, rockets, cars, energy...etc. The trick is to ensure no artefacts, and that we hope to do at Plymouth.

The method is to setup a potential difference of 5kV between the plates of a capacitor, and separate them by about 10 micron with a dielectric. You then allow electrons to quantum tunnel across the gap at a very low current (1 microAmp) but at a massive acceleration. The theory of quantised inertia says that they will see a field of nice hot Unruh radiation everywhere, except between the capacitor plates, as for the old Casimir effect. There will be then a quantum void between the plates that will pull the electrons out of the cathode faster than expected and this will add momentum to the system which will thrust towards the anode. A thrust from 'nothing'. As you can see in the theory paper below (ref 3), QI predicts the results of Becker and Bhatt and Mansell exactly, even the changes as you vary the plate separation.

I'm glad that my openness about QI theory and its possible applications, partly in this blog, encouraged talented engineers to contribute because in my opinion they have shaved years off the path to QI application. This includes the above-mentioned folk, but also many on twitter and many who made comments here. My question is, what is my role now? Of course, I will continue to develop the QI theory, and I have two novels describing it written, and a second text book in the works, but my DARPA funding ends at the end of 2022. I hope to give DARPA a quantum thrust of 10 mN by then. What then?

What I'd like to do is to maintain freedom to continue to develop QI, to write about it, to not starve (!) and not have to be too distracted with business! One possibility would be to setup a Horizon Institute (HÎ)? Perhaps more like a Federation of Labs. The idea would be to use crowd funding or Venture Capital funding to provide support to labs developing QI thrusters, space & interstellar tests and new energy sources based on it, provide advice based on QI, and also a testing facility. In the present era it might be best outside academia? There are already two university labs (In California and Texas) crying out at me for money to start their experiments. As usual, I can see the horizon but not the detailed path to get there! Please make comments below - you might get us to Proxima Centauri quicker!

References

McCulloch, M.E., 2018. Propellant-less propulsion from quantised inertia. J Space Explo, Volume: 7(3). https://www.tsijournals.com/articles/propellantless-propulsion-from-quantized-inertia-13923.html

Becker, F. and A., Bhatt, 2018. Electrostatic accelerated electrons within symmetric capacitors during field emission condition events exert bidirectional propellant-less thrust. https://arxiv.org/abs/1810.04368

McCulloch, M.E., 2020. Thrust from symmetric capacitors using quantised inertia. https://www.researchgate.net/publication/353481953_Thrust_from_Symmetric_Capacitors_using_Quantised_Inertia (Submitted to JPC).

Posted by Mike McCulloch at 10:58

Blog Archive

Electrostatic accelerated electrons within symmetric capacitors during field emission condition events exert bidirectional propellant-less thrust

Becker, F. M. Bhatt, Ankur S.

June 18, 2019

Abstract

During internal discharge (electrical breakdown by field emission transmission) thin symmetric capacitors accelerate slightly towards the anode; an anomaly that does not appear obvious using standard physics. Various thicknesses of discharging capacitors have been used to demonstrate and better characterize this phenomenon. It was observed that it is possible to reverse the force by adding conductive materials in the immediate proximity of the cathode when physically separated from the anode (thus not galvanically connected). Conversely, the addition of conductive materials in the area surrounding the anode did not alter the original force observed. The data gathered seems to confirm a phenomenon that could be exploited for propulsion purposes, in particular for fuel-less applications in a vacuum. The results could be correlated to an external cause which appear to be influenced by the particles' acceleration. Overall, the preliminary results are encouraging for practical engineering purposes.

Keywords: electric propulsion, electron discharge thrust, quantum vacuum thruster, QVT, field emission force, propellant-less propulsion, Unruh radiation

1 Introduction

It was experimentally observed (Becker F.M. 1990) that a thinly charged parallel plate capacitor, supplied with high voltage values of 5 kV DC - 10 kV DC, exerted an unexpected observable force towards the anode. This anomaly was only detected while using dielectrics with low dielectric breakdown strength. However, it progressively disappeared when increasing the dielectric breakdown voltage (and the material thickness). Such phenomenon was initially disregarded as a likely artifact, but a few years later, additional considerations led to the speculation that electric discharge could have been the cause of the anomaly. However, no further testing was conducted. The initial observations suggested that stronger dielectrics, with their enhanced performance in withstanding voltage, would not lead to an observable effect while the electric discharge (breakdown of insulation leading to partial/full discharge or field emission) could be responsible for the appearance of the phenomenon. In addition, Talley R.L. [9] had described a comparable anomalous observation which might have been caused by accelerating electrons or electric charges, further reducing the likelihood of a simple artifact.

While conducting a variety of capacitive discharge experiments in 2017/2018 and additional battery powered wireless experiments in 2019, data was collected during field emission and insulation breakdown discharge events of parallel capacitive charged plates. Data was collected for very short capacitor plate distances. Additionally, the collected data investigated any correlation between any anomalous force and the accelerated mass and any anomalous force and the decrease of the capacitor electrode distance, while keeping the accelerated mass constant.

2 Method

Experimental setup and test apparatus

2.1

Electrons are an easy-to-control option to achieve high acceleration of particles. Also with reference to the anomalies characterized by Talley R.L. [9], such conditions are observed as potentially relevant. The high field strength achieved in the thin electrode separation can provide constant electron accelerations in the magnitude of 10^{19} [m s^{-2}] (particle acceleration equals the fundamental electric charge divided by mass of an electron multiplied with voltage divided by the electrode distance). The strong electric field releases electrons through the field emission effect [4]. With the objective of achieving higher force values, the material was heated so that the energy value required by the electric field for electron transmission could be lowered [6] (Schottky effect): in other words, warming the material allowed an increase in the discharge of electrons using the same strength of the electric field. The application of heat enables thermionic emission as well as supplying some electrons with at least the minimal energy required to overcome the barrier force holding them in the material structure (reference to the concept of work functions of materials).

2.2

Capacitors were designed with polyethylene dielectric materials. Other materials, such as paper, glycerin, and porous plastics, were also tested but this resulted in discharges involving ionic charge flow which traveled in the opposite direction of the electron flow hindering the effect. Furthermore, some materials are prone to cavities (atmospheric voids) that introduce partial discharges [3] where electron avalanches generate ion current contribution inside the hollow space. Additionally, paper insulators were ineffective in generating measurable thrust effect since the atmospheric electron avalanches (see Paschen law [2] for breakdown voltage vs distance) would release secondary electrons but also induce ionization as well. Overall, the experimental data seem to validate that, for the design and manufacturing of a thruster device using the observed phenomenon, a vacuum propagation of the accelerated electrons, or the application of semiconductor cathode arrays, could be the most effective method to obtain a controllable effect.

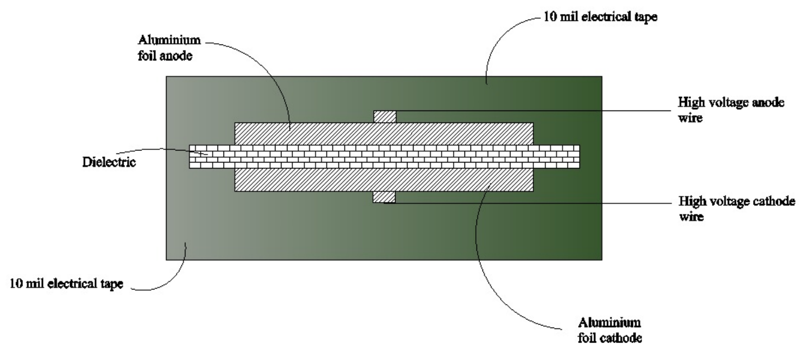

Figure 1: General prototype construction

Remark: Depending on the actual insulator thickness (as described in this document) it can be assumed that currents slightly below 1 μA are essential to generate thrust forces to trigger the load sensor (i.e. LEADZM B300T digital scale with typical sensitivity of 0.001 mg and error of 0.003 mg).

Considering the available power sources (5 kV DC, 10 kV DC), the electric field strength between the capacitor plates would be estimated to be below the actual effective tunneling field strength required to provide a sufficiently reliable current density to support the effect. Therefore, the homogeneous field character had to be enhanced into a partial inhomogeneous field to increase the field strength by altering the smooth flat shape of the emitting surface and adding sharper edges (reduced radius of an emitting surface corresponds to increase in the electric field strength as similar to a concept of a needle cathode). This was done by cutting into the electrode or by using sandpaper on the cathode surface to facilitate field emission. This was done using a precision knife applying a high number (hundreds) of small cuts on the electrode or by surface treatment with a fine sandpaper. Obtaining a sharp edge contributes to a higher field strength through the creation of inhomogeneous electric fields, in analogy with a needle electrode. If only homogenous fields are used, this (cold) emission would need an electric field strength to begin on the order around 10^7 to 10^8 [V/m].

For some tests, typically associated with higher thrust force values, the overall capacitor was preheated for testing up to approximately 50 °C before placing the device onto the measurement apparatus. This also denotes that testing attempts at low ambient temperatures without pre-heating may lead to a thrust force too low to be detected.

2.3

Confirmation tests in soft vacuum were conducted by placing the capacitor inside a sealed container, shielded by wrapping it in a conductive (grounded) outer layer. Such tests yielded results comparable, in terms of average, with the set-up of open air. Nonetheless the corresponding spread standard deviation of the data points recorded was lower for the soft vacuum (∼20 torr) during experimental tests.

2.4

The supply wires had been twisted [1] to reduce electromagnetic effects (Lorentz force etc.). This operation was performed very carefully to prevent the generation of torque onto the system. Nevertheless, the order of magnitude of theoretical torque contribution was estimated to be sufficiently low for not altering the observable phenomenon, reducing the concerns related to any possible residual torque. Moreover, the supply conductors were routed to an adequate distance (∼200 mm) to prevent electromagnetic field disturbances on the load cell of the digital scale. Field disturbances to the load cell leading to the corruption of displayed measurements were observed in the range less than ∼50 mm around the digital scale. The metal film shunt resistors used for voltage measurements to determine the electric current had a 1 % error tolerance while the probes used were approximately 2 %. The scope used for electric current measurements was a Keysight DSO1052B Oscilloscope-2 Channel-50 MHz.

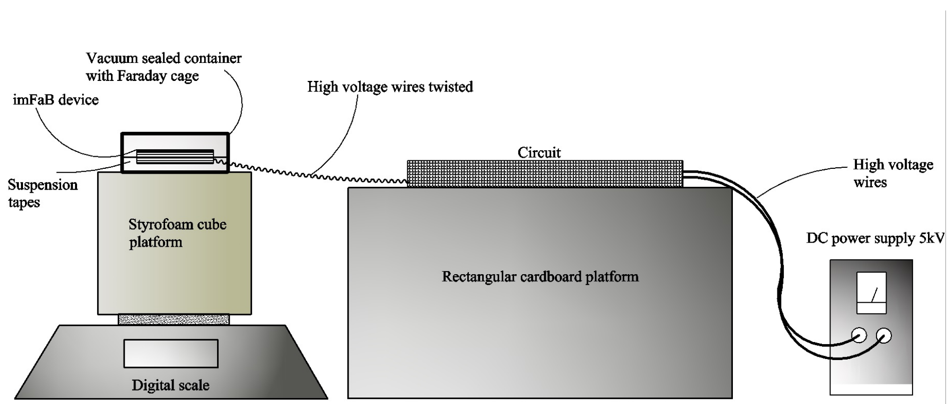

Figure 2: Experiment setup

2.5

The dielectrics had been tightly fit between the conductive surfaces to minimize the air presence. If a considerable air layer is present, in fact, this could lead to ions traveling in the opposite direction of the electrons due to avalanche processes by direct arcing, dampening the amplitude of observed thrust. As previously explained, this might also occur in certain materials when the high-field strength introduces partial internal discharges in material porosites where electrons as well as secondary avalanche electrons can generate positive charged ions. Furthermore, when glow-discharge/stronger arcing occurs, the acceleration voltage over the capacitor would decrease significantly, down to a typical ∼30V typical arc voltage level. In this condition particles, instead of being linear accelerated, would be subject to Langmuir waves, thus (plasma) rapid oscillations of the electron density related to the instability in the dielectric function. The experiment was consequently set up to minimize the risk of these occurrences (which sometimes had been observed with the test device accelerating slightly towards the earth regardless of the polarity).

2.6

It was essential to protect the measurement tools/devices of the circuit from the influences of voltage transients that could occur in a situation where the insulation resistance of the capacitor would drop significantly. In such cases, the shunt resistor would carry a higher voltage due to the voltage divider characteristic of the circuit (more precisely, this is related to the capacitor insulator experiencing a reduced resistance). The circuit, see Fig. 4, does not employ any preventive measures for such phenomena, with regards to the application of transient surge protective devices. However, a large resistor (compared to the shunt resistive value) in series with the shunt could be introduced to serve as a voltage divider in case of insulation failure. Such transient effects are seen more likely when the field emission current increases. In addition, heating the dielectric insulation material could potentially reduce the insulation resistance of the dielectrics.

2.7

An alternative to the 5 kV DC commercial power source was also used. A conventional flyback transformer with a maximum output slightly above 10 kV DC has been utilized for voltage sweeping during the experiments to vary the electron's acceleration. The flyback transformer was supplied in the primary winding by a conventional DC power supply. The output voltage characteristic has been interpolated by the input/output data specifications of the flyback manufacturer for computations. Additionally, the electric circuit was rectified (smoothed) by a tank capacitor to provide a stable supply voltage to the capacitor.

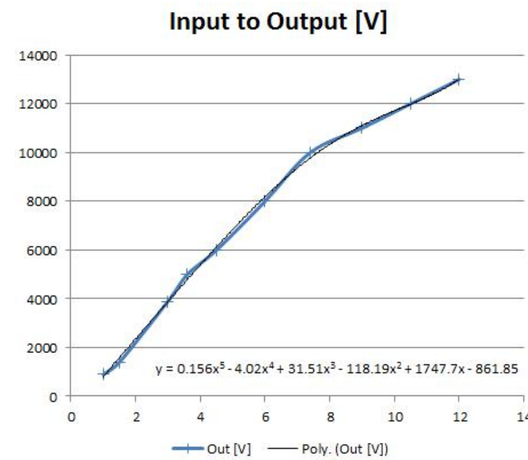

Figure 3: Interpolated output function for flyback supply source

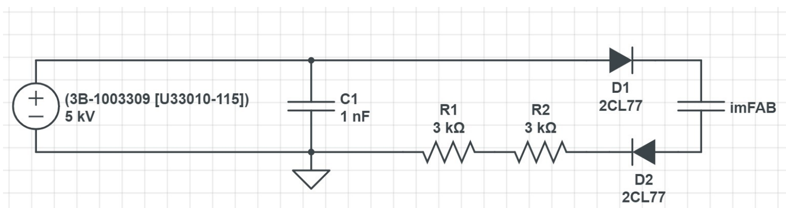

Figure 4: Functional circuit

2.8 Wireless Setup

During additional testing in January 2019, the entire thruster system was placed inside a grounded faraday cage with an inner insulation barrier. Only DC supply wires exited the cage and were connected to a battery-onboard. These low voltage DC supply wires ran vertically and twisted until terminal connections at the flyback transformer. All high voltage components were located inside the cage without any atmospheric exposed HV supply conductors. The thruster box, including the battery power supply and high voltage source, was placed on the scale and the center of gravity effects were addressed before measurement. Additionally, a wireless relay was installed on the top of the cage to turn the system on and off remotely without physical access. Signal conductors were routed to the measurement circuit (shunt to the oscilloscope). The effect device ON voltage level was fixed to around 5kV which was measured from the output of the flyback transformer with smoothing capacitor in parallel.

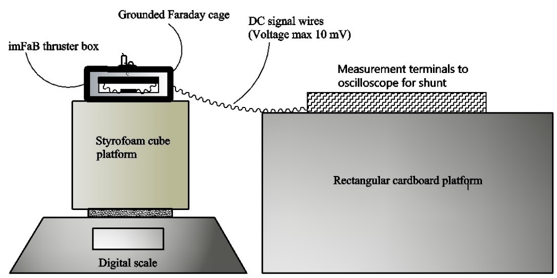

Figure 5: Wireless setup

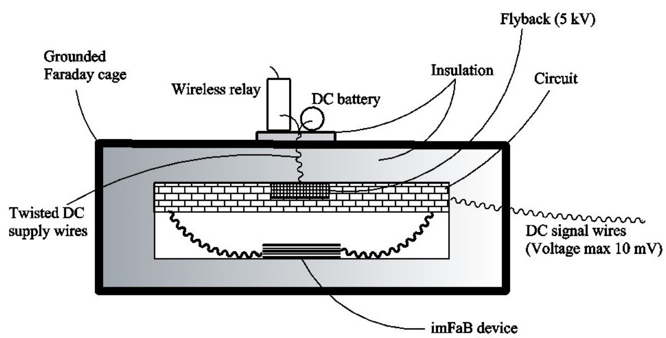

Figure 6: Thruster device

3 Results

3.1 Thrust observation versus electrode distances

The electrode distance had been varied and the force monitored. Since the discharge current is dependent on the Schottky effect (field enhanced thermionic emission), which is determined not only by the electric field strength but also by the heat of the surface, the actual current for each data point statistically fluctuates. Consequently the graphs illustrating the results of the current measurements are normalized to a constant set-up (same charge amount, same accelerated mass).

If a constant current (accelerated mass of electrons) is provided, the reduction of the distance between the electrodes causes the thrust force effect to exponentially increase in value. The electrodes distance is equivalent to the dielectric insulation thickness, and in the remainder of the paper the two dimensional characteristics are used interchangeably being equal in value.

The first sub-experiment was conducted with different insulator thicknesses, between 13 μm to 80 μm, which influenced the acceleration experienced by the electrons. The diameters of the capacitors ranged from 2.5 μm to 5 μm and a total of 266 data points were collected. The measured current value was standardized (as fluctuating under the effect of field emission) to a normalized current level of an arbitrary 10 μA. The accelerated voltage was tuned to 5 kV for all measurement points while testing different insulation thicknesses. The acceleration voltage of approximately 5 kV corresponds to an electric acceleration inside the insulator thicknesses on the order of 10^{18} to 10^{19} [m s^{-2}].

While altering the electrode's distance, it is observed that the recorded force follows a linear trend in a logarithmic view when the current is stablized to a normalized value. Hence the trend is attributed to an exponential increase of force by a linear reduction of the electrodes distance.

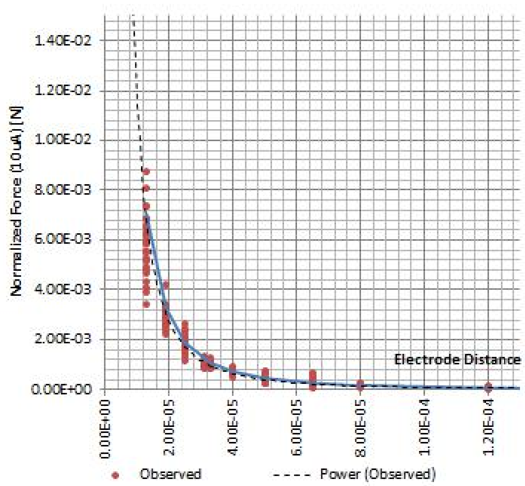

Figure 7: Normalized Force versus electrode distance

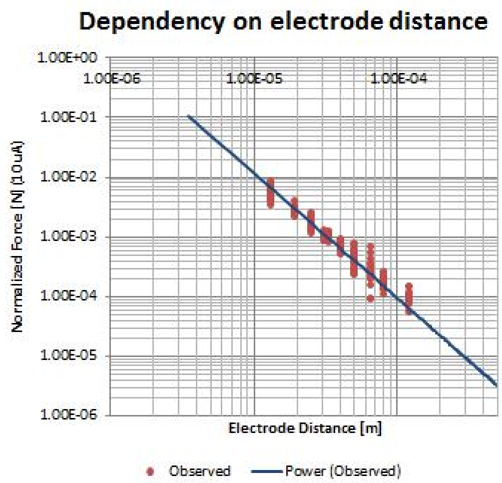

Figure 8: Normalized Force versus electrode distance (log)

Unless otherwise specified, data points of individual graphs are considered an absolute value since these points correspond to both directional scenarios (force towards measurement scale and opposite). The anode of the capacitor pointing upwards was associated to an upward acceleration while the anode pointing downwards was associated to a downward acceleration. This remained valid as long as no reversal force mechanism was introduced (see section 3.3 for details).

In Fig. 9 the actual force shows dependency on the accelerated electron mass indirectly measured by the value of the corresponding electric current. The symmetry of the data points illustrates that the observed force appears independent from influences of gravity, ionic winds and thermal buoyancy (for the latter, see additional clarifications in following paragraphs).

Additionally, several tests have been conducted in low vacuum using a simple sealed container (data points identified as vac in the attached graph), showing a trend line characterized by a lower standard deviation compared to the open-air tests.

Note: Vacuum measurement of the median thrust observations (conducted on the 33 μm capacitor) is associated to a $\sim$8 % standard deviation. Other non-vacuum measurements are in the range from 11 % (33 μm) to higher values of $\sim$30 % (50 μm). The vacuum appears to have stabilized the effect from 12 % ($\sigma = 1.2 * 10^{-4}$ N at mean of $1.0 * 10^{-3}$ N) down to 8 % ($\sigma = 8.7 * 10^{-5}$ N at mean of $1.1 * 10^{-3}$ N).

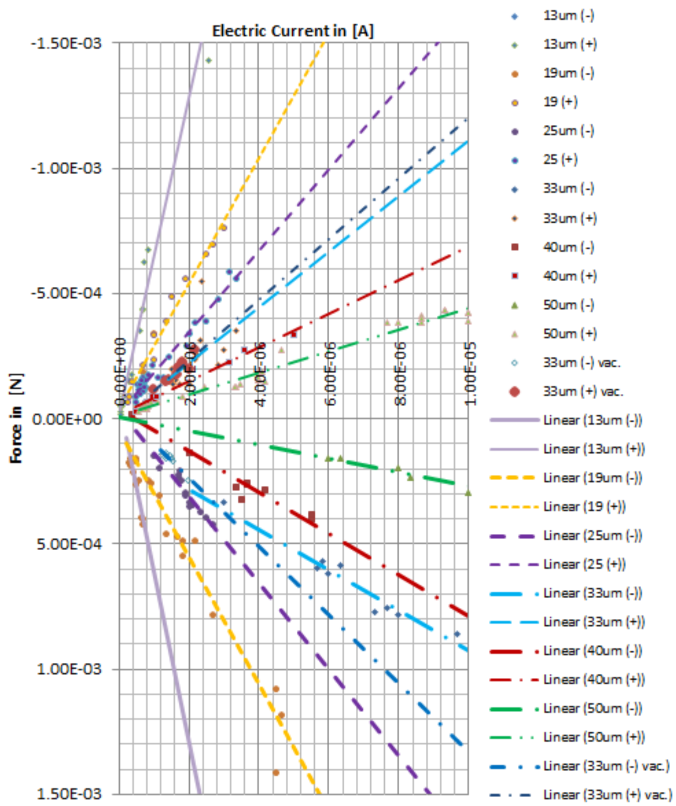

Figure 9: Force versus Current

The operational characteristic of the identified thrust effect shows a linear dependency with the amount of accelerated electron mass and increases exponentially with linear decrease of electrode distance.

Note: The graph shows that for thicker insulators the observed thrust was greater when the anode (+) was oriented on the top of the capacitor. This fact could be correlated with a slight influence of buoyancy determined by the preheating which is required to obtain higher force values.

As advised by Prof. Dr. M. Tajmar, the capacitor plates were tested in vertical position in the attempt to have a null effect that would confirm the absence of external perturbations. This verification test was conducted obtaining a null force (instead of diffuse force directions), confirming the validity of the experimental set-up and the directional attribute of the thrust.

The graph hereunder shows similar trend lines compared to the estimated power consumption.

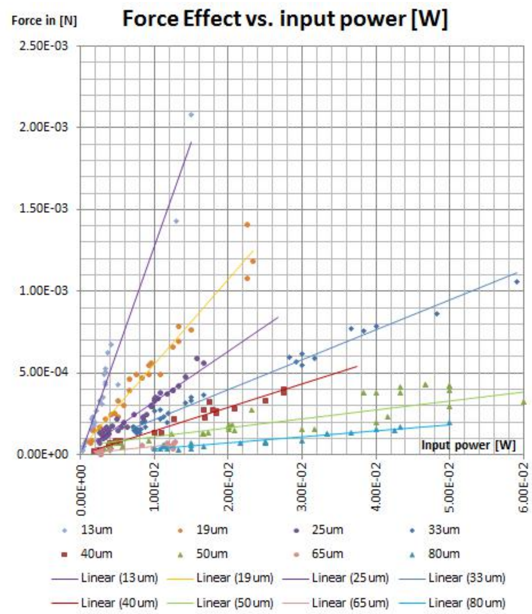

Figure 10: Force versus input power

The same graph can be extrapolated to show the force versus power ratio of a scaled-up thruster device up to 1 kW input power.

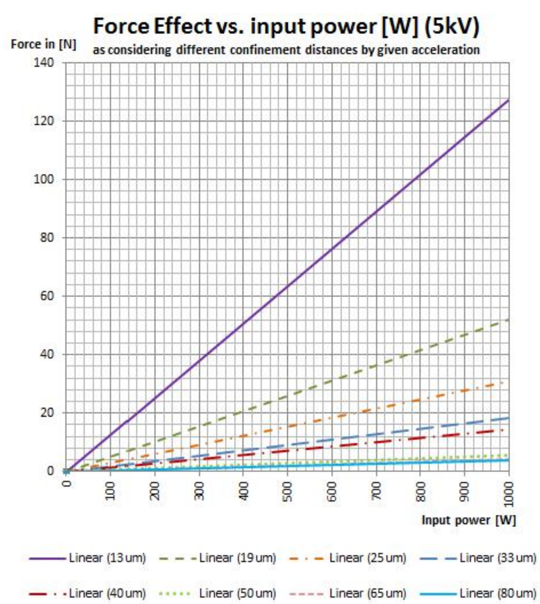

Figure 11: Force versus input power extrapolated

In addition, it was found that independent from the electrodes distance the data points line up in a log-graph. The graph highlights how lower thrust performance on thicker insulators is associated with a higher standard deviation (as visible in the lower left corner of the graph) while higher force values, with their lower standard deviation, are obtained with pre-heating in combination with shorter electrodes distance.

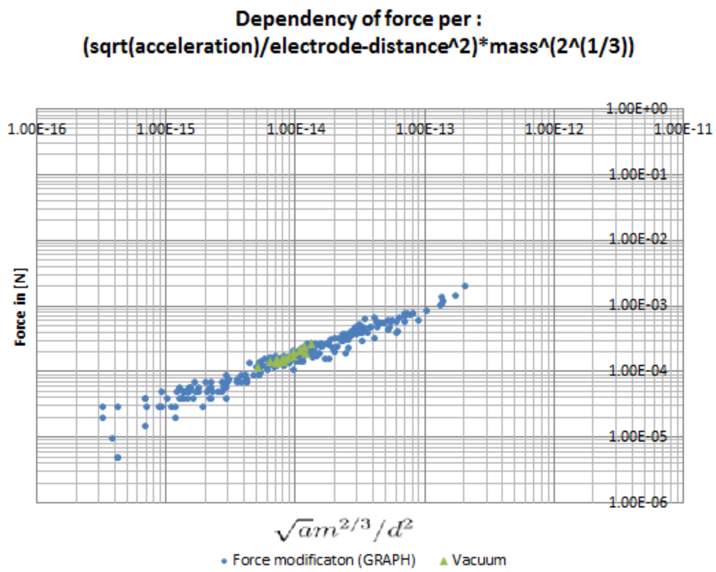

Figure 12: Force versus accelerated mass

3.2 Force versus acceleration voltage for double layer capacitor

As increased voltage was applied, a slight decrease in normalized force occurred. Voltage was swept from 1 kV to approximately 10 kV and a total of 97 data points were collected.

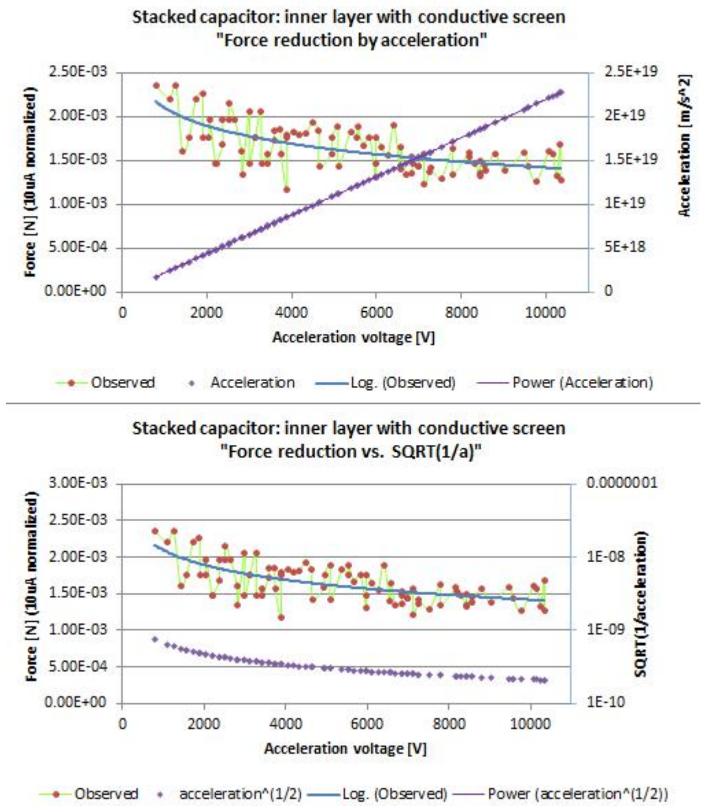

Figure 13: Stacked capacitors versus acceleration voltage

Furthermore, capacitor elements were stacked in series in the attempt to obtain a force multiplier factor. With respect to the reduction of the force with an increase in acceleration voltage, it is evident that an increase of the effect corresponds to the reciprocal of the kinetic energy of the accelerated electrons (the effect is reduced with increasing kinetic energy of the particles).

With respect to the force multiplication for these measurements, instead, the preference was to use a modified capacitor which incorporated an additional inner conductive floating material similar to the cathode/anode foil between the two insulators. Such an arrangement represents a series capacitor meaning that the voltage was approximately halved. Identifying that the supply current (see Fig. 14) yielded a comparable equivalent volume of electrons in both the single and double layer capacitor, the results also suggest that the electrons got accelerated twice. It appears that the stacked configuration provides two consecutive accelerations of the particles which have a tangible influence on the output force ($\sim$doubling).

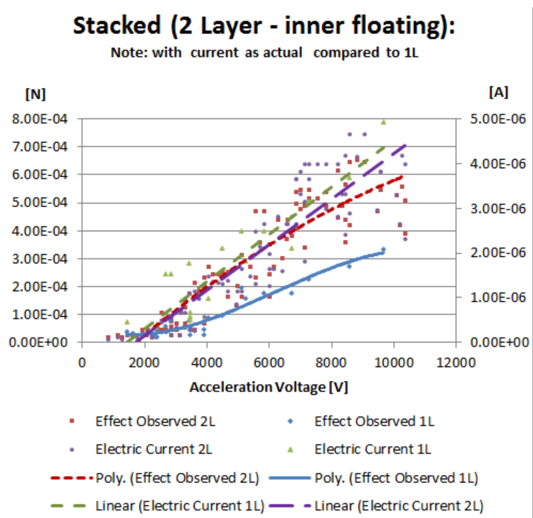

Figure 14: Force versus acceleration voltage

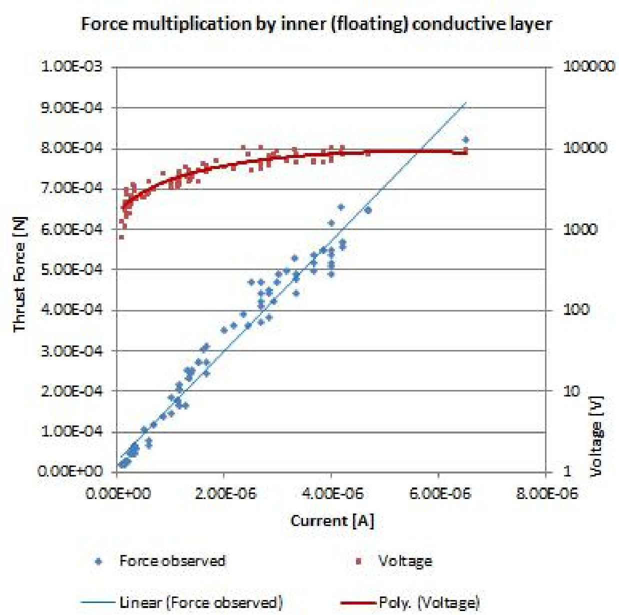

Figure 15: Force versus current

Fig. 16 illustrates the overall weight modification which was observed during the various experiments.

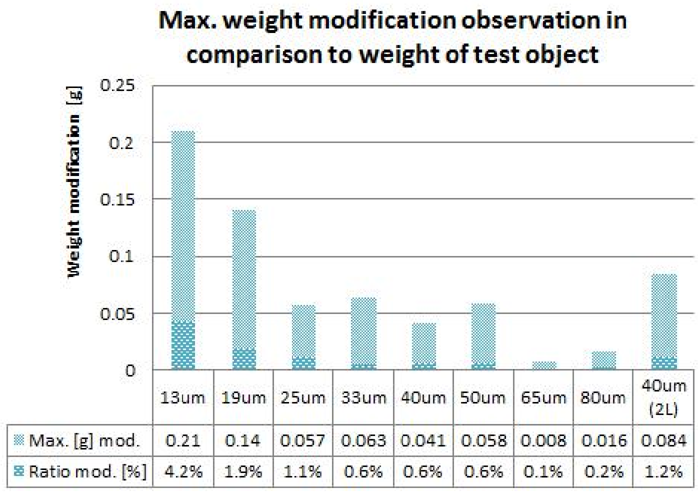

Figure 16: Maximum weight modification for all capacitors

An interesting piece of evidence was that some capacitors showed a lower performance in the number of accelerated particles: such performance was detected by measuring a lower electric current. Fig. 16 has the main purpose of illustrating the highest amount of force achieved with different electrode distances.

3.3 Altering conditions by inserting a conductive wave attenuator around the test object

Additional tests (144 data points) resulted in the identification of a reversal in directional force. Tests had been conducted to determine whether external contributors might have influenced the phenomena. Electromagnetic radiation conducting material had been utilized to dampen radiations with a wavelength lower than a centimeter.

Below is the simplified skin depth equation for good conductors.

$$\delta = \sqrt{\frac{2\rho}{2\pi f \mu_r \mu_0}} \tag{1}$$

ρ = resistivity of the conductor
f = frequency of current
μ_r = relative magnetic permeability of the conductor
μ_0 = the permeability of free space

Four different behaviors were identified:

1. When the thickness of the cathode was extended before a certain range, the thrust effect appeared to be linearly reduced (slope of $-2R$) with respect to the increased elongation of the cathode.

2. When a conductive material, electrically insulated from the cathode, was inserted into a certain area behind the cathode but before a certain range, a full force reversal (compared to the original observed effect) was observed.

3. When a conductive material, electrically insulated from the cathode, was inserted a sufficient distance behind the cathode beyond a range, a normal original effect was observed.

4. When the thickness of the cathode was extended beyond a certain range, a full force reversal (compared to the original observed effect) was observed.

Suspecting that the forces observed are somehow linked to an external radiation field experienced by the capacitor (virtual particle oscillations, vacuum quantum mechanical effect etc.) during the electron's acceleration, several additional tests were performed in the attempt to dampen shorter wavelengths thus influencing the generated force. This was done introducing an attenuation material, aluminum sheet on the order of a few tenths of a millimeter, at several distances from the surface of the cathode.

After numerous tests, it was discovered that the force could be reversed with approximately the same value of the original force at all distances less than the range, R, when the attenuator material was electrically insulated from the cathode. Speculatively, This range might correspond to the rindler horizon equation (which is equal to c^2/a) [5] since the electron experiences high acceleration and this corresponds to the range length. When placing the attenuator past the range distance R , this led to a sudden change of force direction. This change in direction, with the attenuator sheet beyond the determined range, led to the sudden recovery of the original force direction (towards anode equal to electron propagation path). The distance R within this paper is called range or simply R in the remaining part of the paper.

Furthermore it was observed that an extension in thickness of the conducting cathode does not lead to a force reversal but to a reduction of the force. This was estimated as being proportional to the covered space between original position of the cathode surface and the distance which had been identified as R. It should also be noted that there could be an exponential decrease since data points between $0.5R$ and R were not in the range of the measurement device. Finally, if the cathode thickness exceeded R a force reversal was established with the same magnitude of the full normal effect (propagation toward the anode).

The following graph shows coverage condition by the conductive material (insulated and galvanic connected to the cathode) considering previous defined length R.

Remark: The force reversal only occurred by covering areas around the cathode. No alteration in the original effect force was observable in other regions (such as in front of the anode).

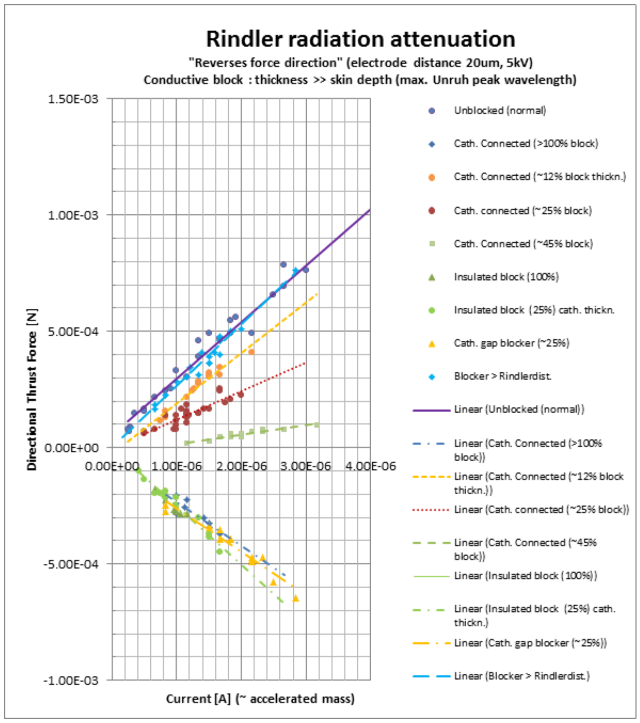

Figure 17: Force [N] versus current for various blockers

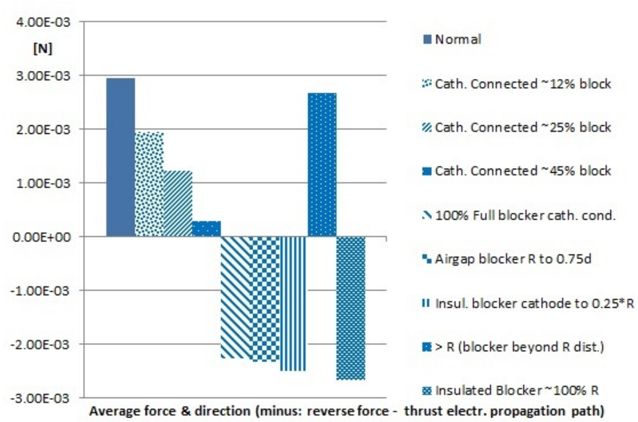

Figure 18: Force [N] for different blockers with data measurements averaged

Block	0%	12%	25%	45%
Force [mN]	2.93	1.94	1.21	0.28
Level	100%	66.21%	41.30%	9.56%

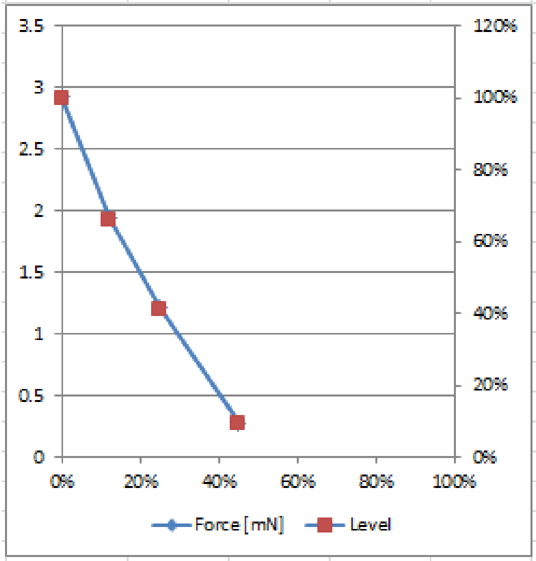

Figure 19: Force [N] reduction with blockers with data measurements averaged

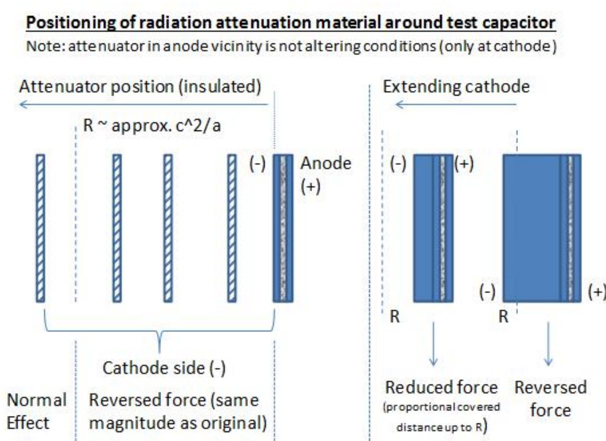

Figure 20: Strategic positioning of radiation attenuation materials

3.4 Wireless Experimental Results

The new battery-powered onboard wireless setup resulted in a convergent force trend-line with the previous data collected for 20 um distance (October 2018). Both devices had a supplied voltage of 5 kV. Generally, smaller thrust values from lower current values were found due to the lower ambient temperature conditions and lack of heat applied to the imFaB device. Artificial heating to increase electric current was avoided to prevent heat trapped inside the closed grounded Faraday cage . This could have resulted in buoyancy errors.

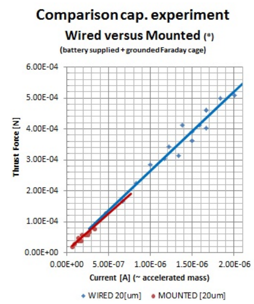

Figure 21: Wireless battery powered results

4 Discussion

While conducting a variety of capacitive discharge experiments from 2017-2019, a directional force was repeatedly observed during field emission and insulation breakdown discharge of parallel capacitive charged plates.

The collected experimental data highlighted:

1. A linear correlation between the thrust force and the accelerated mass.

2. An exponential increase in the observed force with the decrease of the capacitor electrode distance, while keeping the accelerated mass constant.

The effect was observable and repeatable under certain conditions:

1. With a very short capacitor plate separation distance.

2. Under a uniform discharge causing the acceleration of only electrons (as the charged accelerated particles).

It appears that if an electric discharge occurs, such as bridging the electrodes by arcing, this would introduce positive charges to the system which would hinder the effect. Additionally, the force appears reversible when conductive material, insulated from the cathode, is inserted right behind the cathode of the capacitor, thus behind the accelerated electrons. Additionally, placement of the conductive material below a range, R, also changes certain behaviors of directional force which depends on if the material is connected to the cathode or not. Finally, extending the cathode thickness between R and the cathode can also decrease the normal effect. Similar testing was conducted adding conductive material in front of the anode. This led to the same results as without the attenuation material (equal to original effect).

Interestingly, the force appears to correlate to the identified range R, as relevant for the force reversal mechanism, within the zone from cathode towards R. Here the observed force is plotted against the range R.

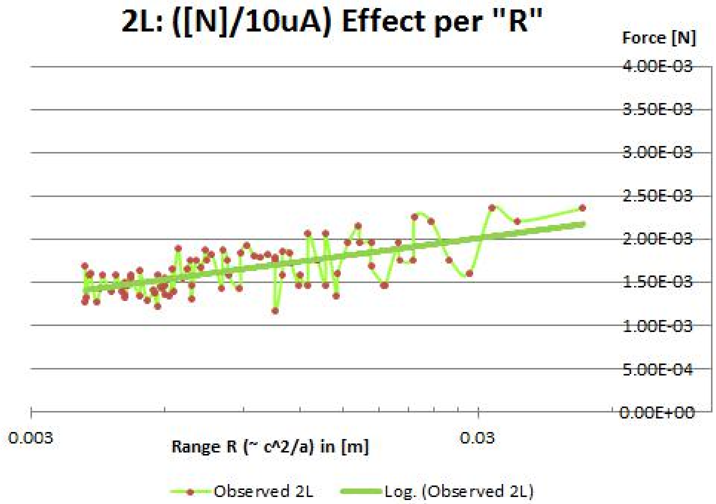

Figure 22: Force versus range distance at 10μA

Overall the illustrated results of the four different sub-experiments, with an adequately high sample size (507 data points collected) with evident trend lines, suggest that a new phenomenon, and not an artifact, has been observed. To confirm the evidence, the plan should be to repeat the experiments with a more sophisticated testing facility and equipment. This should provide new evidence and confirmation with a new paper.

It is also worth mentioning that the observed phenomenon does not seem correlated to any evidence found while testing capacitive ion lifters [8]. The thrust anomaly, as described in this paper, is assumed to be caused by electrons accelerated within a capacitor due to a field emission from a high electric field. In this experiment, the capacitor has been used mainly as the mechanism to accelerate particles, in particular, electron charges. Additionally, artifacts are considered to be of a low probability due to the merging trend lines with different experimental setups. This would exclude the fact that two different artifact disturbances could provide data points on the same curve for the device.

The observations suggest that a wave field around the capacitor is the cause of the thrust and that this field is correlated to accelerated electrons [7]. This also may suggest that this phenomenon could be a quantum mechanical effect or some relation to Unruh radiation [10]. This potentially could be confirmed with an existing theoretical framework which seems to predict the observed forces. This additional study, already on-going in 2019, is beyond the purpose of this paper. If preliminary evidence is confirmed, it would open the possibility to design and build fuel-less thrusters that could operate in vacuum, thus suitable for space applications.

Speculatively, in case a Rindler horizon is relevant to the effect, one could consider the inside zone between the cathode and anode to be correlated to the conventional Casimir effect. An electron immersed in this quantum state environment, having an acceleration and by that a Rindler horizon, would be under the influence of an additional field which corresponds to the radiation emitted by the Rindler horizon (reference to the initial hypothesis of Unruh radiation). Hence, the electron might be under the influence of two overlapping fields of quantum states. This would provide an energy/momentum gradient in the fields which, by conservation of momentum law, would initiate a resulting force effect due to the natural symmetry breaking by altering the normal natural radiation which is causing inertia. The electron floats inside a casimir scenario in between the electrodes. Here, the radiation difference around the electron is not homogenous compared to the normal Casimir effect. Rather the addition of the Rindler horizon radiation causes it to become inhomogeneous.

The new battery-powered onboard wireless setup resulted in successful for bi-directional thrust. A thrust to approximately 10 mg was commonplace for our 20um capacitor with shunt currents matching the wired setup. Earths magnetic field which was around 45uT (measured) and an overestimate max length of 0.5 m for supply wires with a draw current of 0.5A in the primary circuit (measured and specs). Additionally, the wires ran vertically and twisted so would unlikely result in any appreciable Lorentz forces. Even in a theoretical maximum scenario the influence would be in the 1 mg range and should not affect the overall plausibility of the results. Additionally, a large magnet was placed in the vicinity of the DC wires and there was no noticeable effect during operations. Seems magnetic fields do not have much of an impact as expected for the vertically twisted wires on the scale values. Furthermore, the capacitor device direction was flipped without any change to DC circuit wiring so therefore any Lorentz forces would be always in one direction.

In regards to a prototype thruster (quantum vacuum thruster), the evidence collected would support the claim that the construction of a modular capacitor system, scalable and with relatively low power consumption, could be indeed feasible. The prototypes in this paper have a performance above 0.4 N/kW. This is a performance that Dr. H. White (NASAs SSRMS Subsystem Manager) considers as a minimum requirement for a crewed mission to Titan/Enceladus [11]. Construction of modular stacked segments could also provide the advantage of individual segment shut-down in case of failure/malfunction without compromising the thrust performance of the remaining part of the capacitors. Since the thruster concept is exclusively electric, this experimental discovery could provide a first tangible mean for interstellar space exploration once an adequate source of energy is fine-tuned (see performance chart Fig. 11).

5 Conclusion

By conducting tests on capacitive systems which accelerate electrons at values on the order of magnitude of 10^{19} [m s^{-2}] during field emission, a force accelerating the overall system has been clearly identified and characterized. This thrust force, observed distinctively in capacitors with a minimized distance between the electrodes (as a mechanism for particle acceleration), is in linear correlation with the amount of accelerated matter, which corresponds to the electrons released through an electric current determined by field emission. The force is oriented in the propagation direction of the electrons, but can be reversed or attenuated placing conductive material at specific distances in the area behind the cathode (thus outside the capacitor).

Experimental tests show the force increases exponentially when distance between electrodes is decreased. Also, the force detection was confirmed in soft vacuum condition showing evidence of lower standard deviation of the collected data.

The observed thrust can be enhanced by preheating the capacitor so that the energy value required by the electric field for electron transmission can be lowered by means of Schottky/thermionic effects. In addition, the field strength can be increased by changing the field type from homogeneous to inhomogeneous. For instance using sandpaper or applying a high number of small cuts on the cathode surface can facilitate field emission. Furthermore, the force can be multiplied by using a modular design of stacking capacitors in series: this architecture, with respect to a single, higher performing capacitor, has the advantage of keeping each segment performance independent from the remaining ones.

The capacitors tested in the experiments have a performance above 0.4 [N/kW]; a benchmark often used by NASA to define a thrust ratio sufficient for interplanetary travel. This simple technology, in fact, has the advantage of being completely electric, thus suitable for fuel-less electric propulsion in vacuum. Moreover the scalability of this architecture, coupled with adequate energy source generation, might be appropriate for interstellar travel and precise maneuvering in space.

Looking into the trend results of the conducted experiments, it should be seen essential to conduct the experiment with more accurate calibrated measuring equipment. It is also suggested that next scientific efforts should focus on correlating these results with an existing theoretical framework, so that an apparent anomaly can be adequately predicted and controlled for practical engineering purposes. The preliminary correlation results are certainly encouraging. A second priority would be to test and/or prepare this apparatus in space to validate its performance in a vacuum and its performance away from a strong gravity source.

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7 Appendix: Potential Errors

The results during both the remote (battery powered unit without exposed HV conductors) and wire testing could result in Trichel pulses" by insufficient insulation. The signature of these pulses have the properties of lifted currents (offset = DC component with sharp inrush currents) as seen on the oscilloscope display. The signals look similar to field emission currents but have different attributes (spikes), and are actually a corona discharge with trichel pulses. Field emission events occur having current peaks starting from approximately zero on the display of the oscilloscope. In contrast, external located trichel impulses (in wiring etc.), which are generated outside the test capacitor, do fluctuate but are added in amplitude to the small DC component leakage current. It was found that a leakage current is likely generated from a conductive enclosure such as the Faraday shielding cage without sufficient inner insulation material near a thin high voltage charged conductor. Here, it would also be relevant to check the insulation rating when appropriate since, for example, a 500 V rating would be insufficient as a direct barrier between HV polarities. Usually, 500 V is a typical standard value rating of insulators on the market. Furthermore, an air layer with the insulation material of a conductor could become a composite capacitor (voltages distribute with each material index and per thickness involved). The electric field strength inside the air is significantly higher than inside the material. Therefore if a metallic object, such as a shielding enclosure, is connected to the negative polarity, electrons could be tunneled out the surface due to insufficient insulation and ionize the air gap to the next conductor. Additionally, using conductors not rated appropriately to the intended use could also lead to a null effect due to leakage currents. Additionally, having twisted conductor supplies inside sheeted routing should not be near the enclosure which could have a different polarity. If the field is strong enough the electrons could be pulled out of the enclosure and accelerated towards the insulator.

One can also consider the influence of possible Lorentz forces even thought the HV supply current is significantly low. One solution is the usage of twisted conductors. However, this should be done with care as twisted conductors with different polarities with longer lengths could also cause leakages. Hence it should be seen essential to provide twisting with limited/avoiding direct contact of insulation of conductors with different polarities during a high voltage scenario. During twisting, application of air loops may boost insulation distance and limit the direct contact points. Also, it is necessary to utilize conductors rated for the high voltage application. Adding tubing over high voltage conductors rated up to 500V (working voltage, insulation voltage) should be considered an insufficient insulation system if there is direct contact with one conductor (Faraday or conductive mu-metal surface connected to one HV polarity). Recreation of the Trichel pulses during were performed in January 2019 during further testing. The result usually ended in a null effect since the path of least resistance was not through the capacitor. Larger currents around 10uA were commonplace measured at the shunt. For a valid effect, values were nominally much lower in the low uA range for a large normal effect.

At the current state of research it is not yet clarified whether the quantum vacuum oscillations emerge from the local vacuum or are emitted by the cosmic horizon [5]. A mu-metal shielding might cause complications during testing so in the future it is suggested to compare the use of normal Faraday cages and mu-metal cages.

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