Notes on Dresden SP2020+1 EmDrive paper

1.Introduction

In March 2021, Dresden Technical University gave a paper at the Space Propulsion 2020+1 conference entitled:

HIGH-ACCURACY THRUST MEASUREMENTS OF THE EMDRIVE AND ELIMINATION OF FALSE-POSITIVE EFFECTS

M. Tajmar , O. Neunzig and M. Weikert

This paper reported on their work on manufacturing and testing a replica of the original NASA thruster. SPR Ltd were requested to review the paper, resulting in these notes. They include a copy of our original correspondence with Martin Tajmar and a further technical note on the latest results.

2.Email to Martin Tajmar at Dresden University.

Subject:	NASA EmDrive Thruster
From:	sprltd@emdrive.com
Date:	Fri, October 6, 2017 15:05
To:	martin.tajmar@tu-dresden.de
Priority:	Normal
Options:	View Full Header | View Printable Version | Download this as a file | Add to Address Book | View Message Details | View as plain text

Dear Martin

I'm glad to see from your IAC17 paper that you are still working on EmDrive.

I note that you say you are going to replicate the NASA thruster.

I have been advised that two other organisations have tried and failed to produce measurable thrust using exact replicas of the NASA design. This is not surprising as the design is fatally flawed, which I have pointed out in the attached note.

I updated the note today to suggest that the cavity can still be used if the dielectric is removed and a TE013 mode used.

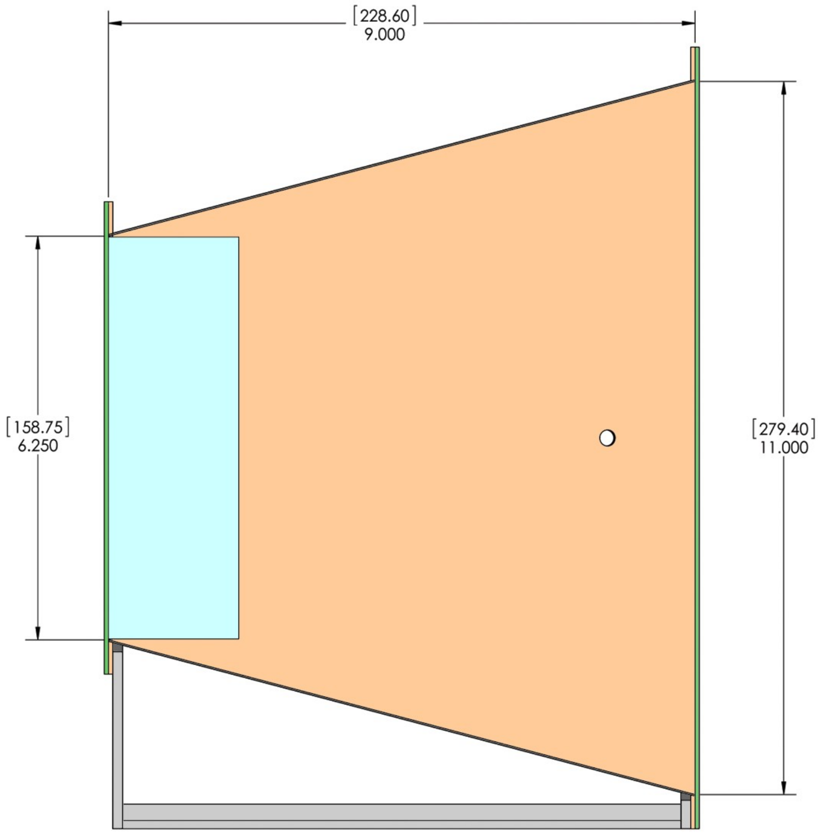
Hope this helps you as well.

Best regards

Roger

2.Note attached to 2017 email

Notes on a NASA replication thruster. Issue 2.



The following observations suggest that the above thruster design is unlikely to produce any meaningful levels of thrust.

1.In a TM212 mode K_{nm}=0.612

Thus for a resonant frequency of 1941MHz:

Cut off diameter = 252.3mm

Cut off position = 58.1mm from large end.

The cavity is therefore operating in cut-off condition.

2. For a narrow band input, a flat end plate will lead to spreading of the resonant bandwidth due to wave-front phase distortion, and thus a significant loss of unloaded Q.

3. The interface between dielectric section and air filled section of the cavity must have a good impedance match. The dielectric section must be sized accordingly and requires axial adjustment to achieve final tuning.

To achieve resonance, the dielectric section could be removed, and a TE013 mode (K_{nm}=0.82) be tried.

For the above dimensions a resonant frequency of 2,584.2 MHz is calculated for TE013 mode.

The input, whether slot, loop or dipole, should be oriented for TE modes and tuned to the resonant frequency.

For optimum results, the general design principles can be downloaded from SPR website www.emdrive.com

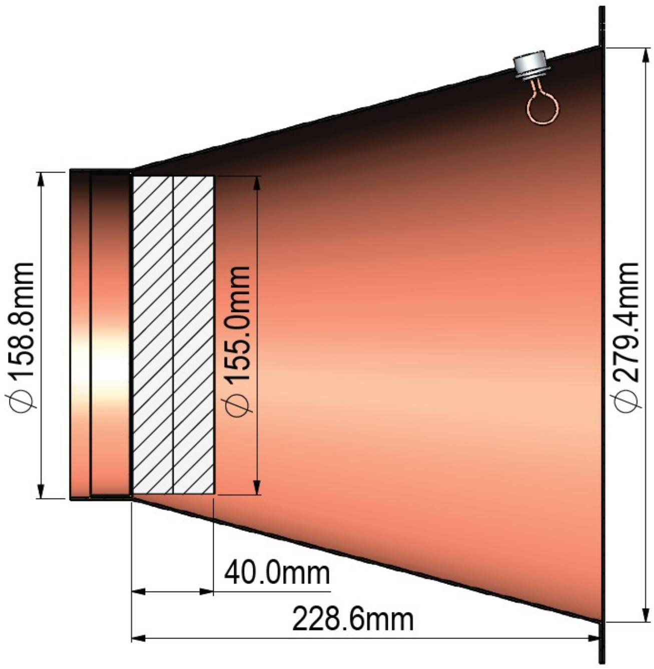
Roger Shawyer. SPR Ltd.

6 October 2017

3. Notes on 2021 paper

(a)

Fig 7 from the 2021 paper now gives the dimensions of the dielectric discs and the loop orientation, which enabled the true operating mode to be determined.



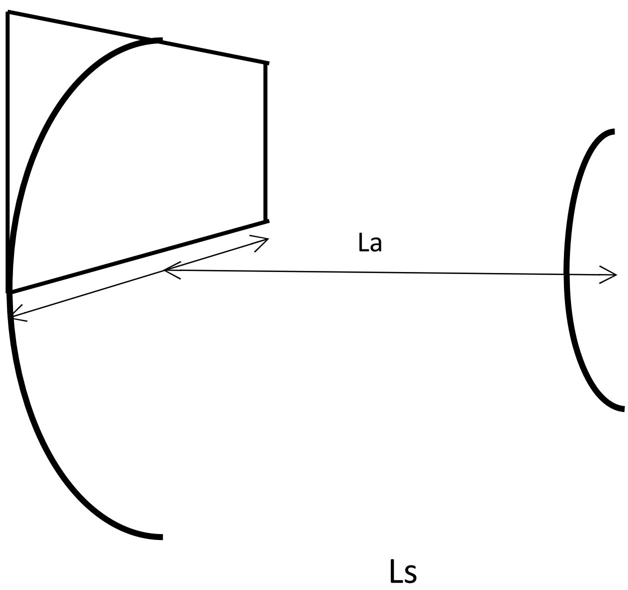
The SPR design spreadsheet, described in our IAC-20 paper, was used to calculate the resonant frequency at the interface axial length of 188.6mm using TM012 mode. (Note the loop orientation is for TM modes)

The resulting resonant frequency is 1894 MHz, compared to the measured frequency of 1914 MHz, which is a typical offset due to manufacturing tolerances.

This shows clearly that the interface between the dielectric and vacuum section is not impedance matched, as suggested to Dresden in 2017.

(b)

The actual resonant geometry is therefore a tapered cavity with two flat end plates. The problems with flat end plates were explained in the SPR seminar given at Dresden on 11 July 2018. The simple geometry shown in slide 15 of that seminar, is reproduced below.



For flat end plates

Path length error = Ls-La

Total error =Q(Ls-La) leads to wavefront phase error and reduction of Q

End plates must be shaped and aligned to minimise mean path length error.

Application of this geometry to the Dresden cavity shows that the wave-front phase error reaches half a wavelength (87.9mm), at a Q of 14, so the cavity will suffer a negligible unloaded Q. The hugely distorted wave-front will result in multiple reflections off the sidewalls rendering the cavity unable to support linear travelling waves. Any trivial forces in the end plates will be balanced by sidewall forces, resulting in zero net thrust.

(c)

In section 5.2, the paper states:

For fast and precise tuning, a single port Vector Network Analyzer (VNA) Anritsu MS46121A was used.

Therefore the apparent Qu of 23,000 and input return loss that have been measured is simply the performance of the input loop because there was no attempt at impedance matching between the loop and the cavity. This requires two port measurement using a detector probe. The importance of Impedance matching between the loop and cavity was emphasised in slide 14 of the 2018 Dresden seminar.

(d)

From Fig 8 in the paper, it appears that loop tuning merely comprised a 3 stub coaxial tuner between the circulator and input. There is no method of actually tuning the loop itself. Thus virtually all the input power is dissipated in the loop, and there is no coupling of any significant power into the cavity itself.

This is clearly shown by the reported very high return loss of 45dB, which is indicative of an input loop matched only to the source impedance. Correct coupling into the cavity usually gives a much lower return loss, typically around 20dB.

A copy of the drawing of the SPR Flight Thruster loop assembly was sent to Dresden on 10 October 2018 to illustrate the typical tuning mechanism required.

4.Conclusions

Whilst the rational for manufacturing and testing a replica NASA cavity, following our correspondence with Dresden since 2017, is not understood, the result of almost 4 years of effort has merely confirmed our original advice. The cavity, so carefully tested, clearly cannot operate as an EmDrive thruster, and should not even be described as such.

This result is also confirmed by three other organisations, NRL, Toulouse University and a private US Research organisation.

All attempts to produce working EmDrive thrusters must be carried out with a clear understanding of the theory of EmDrive, and with sufficient experience of microwave engineering to avoid the mistakes identified in these notes.