<u>**A Note on the Thrust / Load operation of an EmDrive Thruster**</u>

There are a number of theories which attempt to explain EmDrive operation. To be consistent with accepted Physics, each theory should comply with the Law of Conservation of Momentum and the Law of Conservation of Energy. Thus a successful theory should predict the following operational characteristics. These have been repeatedly observed during experimental work extending over many years, and under many different test conditions, including reports of in orbit tests.

To illustrate consistency with the classic laws of physics, assume that an EmDrive thruster is mounted on a simple beam balance as illustrated in Fig.1.

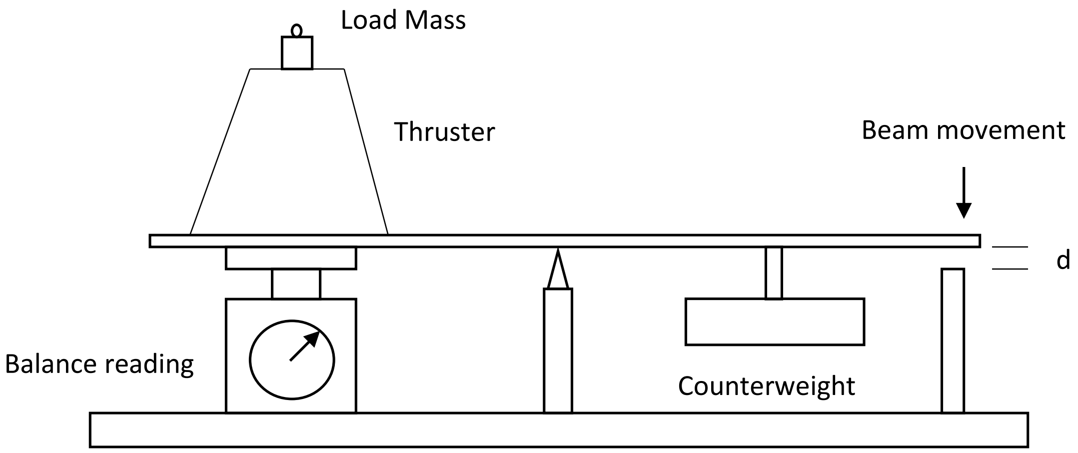

Fig.1

Assume that the thruster is a low power, first generation EmDrive thruster, producing 1 gm of thrust when power is applied. Also assume that the mass and centre of mass of the thruster plus beam, is exactly counterbalanced by the mass and centre of mass of the counterweight, and that pivot friction is zero. Assume that the balance is an ideal force feedback system and that no movement of the balance pan is necessary to record a change of balance reading.

Any theory of operation of EmDrive should predict the steady state balance readings and beam movements for the three Load masses given in Table 1, following application of power.

Test No	Load Mass (gm)	Balance reading (gm)	Beam movement (mm)
1	2	2	0
2	0.5	0	d
3	0	0	0

Table 1.

Test 1 illustrates that EmDrive complies with the Law of Conservation of Momentum. Even though there is a thrust of 1gm downwards, this is insufficient to cause acceleration of the thruster, and so there is a reaction force of 1gm upwards. Thrust and reaction force counteract and therefore the balance reading remains at 2 gm.

Test 2 illustrates “lift off”, when the thrust is higher than the load mass and the beam accelerates upwards, separating from the balance pan.

Test 3 illustrates the operation under zero load mass and is best understood by considering the transient response of the beam. Upon initial application of input energy, the stored energy starts to build up in the cavity. The resulting thrust causes initial acceleration of the beam, but the input energy is now converted to kinetic energy plus thermal losses. Stored energy, and therefore thrust, thus tends to zero. The steady state solution is that the total inertia of the beam damps out transient accelerations and the balance reading and beam movement remain at zero. This result confirms that EmDrive complies with the Law of Conservation of Energy.

These tests illustrate that EmDrive can be considered as a new class of electrical machine. As with any electrical machine, power output and efficiency will depend on the applied load. An electric motor will stall and give no useful work output if the applied load is higher than the torque produced. Similarly if the motor is under no load conditions, no useful work will be obtained. In both cases, input energy will simply be expended in electrical and mechanical losses. For an EmDrive thruster, no thrust will be measured for an overload condition, or when the thruster is under a no load condition.

These characteristics must be taken into consideration when an EmDrive thruster is operated in orbit, where true free space, i.e. no load conditions, can apply. Two thrusters, with thrust vectors having some opposing component, thus enabling each thruster to load the other, are one solution.

Clearly for ground based experiments, similar responses should be predictable for an EmDrive thruster on any type of balance such as a torsional or pendulum balance. It is recommended that a careful mathematical model, including transient analysis of the electrical and mechanical energy responses, be carried out for the actual balance, load and thruster parameters being used. This will help validate the experimental data.