

# Propulsion Physics under the Changing Density Field Model

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**Abstract:** To grow as a space faring race, future spaceflight systems will require new propulsion physics. Specifically a propulsion physics model that does not require mass ejection without limiting the high thrust necessary to accelerate within or beyond our solar system and return within a normal work period or lifetime. In 2004 Khoury and Weltman produced a density dependent cosmology theory they called Chameleon Cosmology, as its nature, it is hidden within known physics. This theory represents a scalar field within and about an object, even in the vacuum. Whereby, these scalar fields can be viewed as vacuum energy fields with definable densities that permeate all matter; having implications to dark matter/energy with universe acceleration properties; implying a new force mechanism for propulsion physics. Using Chameleon Cosmology, the author has developed a new propulsion physics model, called the Changing Density Field (CDF) Model. This model relates to density changes in these density fields, where the density field density changes are related to the acceleration of matter within an object. These density changes in turn change how an object couples to the surrounding density fields. Whereby, thrust is achieved by causing a differential in the coupling to these density fields about an object. Since the model indicates that the density of the density field in an object can be changed by internal mass acceleration, even without exhausting mass, the CDF model implies a new propellant-less propulsion physics model.

## INTRODUCTION

As mankind grows toward a space faring race, it is apparent that future spaceflight systems will require new propulsion physics; specifically a propulsion physics model that does not require mass ejection. Such a propellant-less system should not limit the high thrust necessary to accelerate and de-accelerate within or beyond our solar system in order to return its crew within a normal work period or lifetime. The model presented in this paper is one such propulsion physics model that could provide new paths in propulsion toward this end. This model is based on Chameleon Cosmology a dark matter theory; introduced by Khoury and Weltman in 2004<sup>1, 2</sup> and accounts for Universe expansion, which acts against gravity. Chameleon as it is hidden within known physics

Chameleon Cosmology<sup>1, 2</sup> implies that the Universe is composed of density dependent scalar fields with definable spherical densities down to the Universe's critical density far from any large body (*i.e.*, galaxy). That is, given a region or density field with a defined spherical radius, the density of the density field is dependent on the sum of the total mass within its radius with its center equivalent to the center of the distribution of the gravitational mass in the density field. Whereby, as the radius approaches the universe radius, the density field's density approaches the Universe's critical density.

The Universe can then be divided in a multitude of smaller density fields down to the laboratory scale. Then for an object placed between two (near static) density fields of different densities, the *field force* on the object is a function of the change in the gradient between the two density fields. Whereby, the *field force* can add or subtract from the Newtonian gravitational model. However, under static or free fall conditions, the *field force* is much-much smaller than the gravitational force and does not contradict measured gravitational forces.

It is however known that Universe expansion acts against the gravitational force of the masses in the Universe. And since rocket propulsion also works against the gravitational force of the earth's gravitation, one should expect that a new propulsion physics rocket model can be developed using the concept of Chameleon Cosmology.

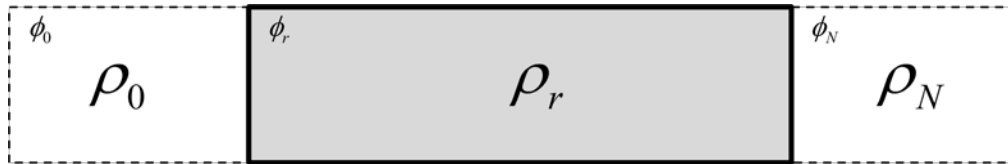
Using Chameleon Cosmology, the author has developed a new propulsion physics model, called the Changing Density Field (CDF) model. The CDF model is developed in Appendix A and further refined to just an acceleration equation in Appendix B. Appendix C develops some of the CDF model parameters for a solid rocket needed in the following acceleration model, which is followed by a new propellant-less propulsion model.

## A NEW PROPULSION PHYSICS ROCKET MODEL

The new propulsion physics rocket model is discussed in the following through first looking at the static conditions (no accelerating internal mass) and then at the non-static conditions (accelerating internal mass) of a rocket.

### Static Rocket CDF Model

The “static rocket” CDF model (*i.e.* no exhausted mass) is illustrated in Figure 1 for a rocket with potential to move away from a dominating Newtonian density field, *i.e.*, the highest gravitational object. In Figure 1, the dotted box of density  $\rho_0$  represents the density of the ambient density field  $\phi_0$  (*e.g.*, the atmosphere), the gray box of density  $\rho_r$  represents the density of the rocket’s density field  $\phi_r$ , and the dotted box of density  $\rho_N$  represents the dominating Newtonian density field  $\phi_N$  (*e.g.*, the earth). Since the “static rocket” CDF model of Figure 1 is not moving, the height of the boxes are taken to be the diameter of the rocket. That is the radial interfaces between the fields are equal to the rocket’s radius  $r_{rocket}$ , even though the ambient and Newtonian density fields are much-much larger than the rocket. Any force due to the density field perpendicular to the direction of motion can be assumed small enough to ignore.

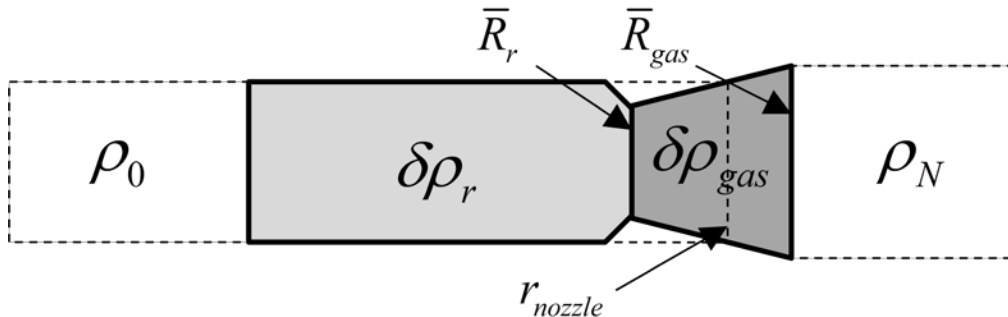


**Figure 1.** Static Rocket CDF Model.

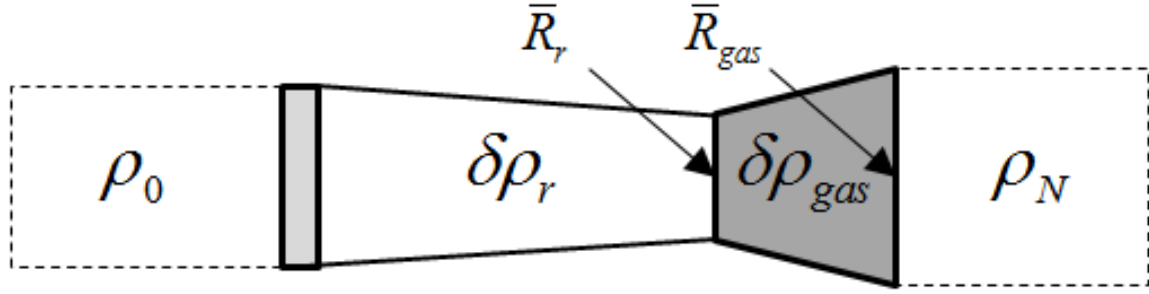
### Non-Static Rocket CDF Model

The “Non-static or accelerating rocket” CDF model is illustrated in Figure 2. In Figure 2, the density  $\delta\rho_r$  represents the rocket’s changing density field and the density  $\delta\rho_{gas}$  represents the accelerated gas’s density field (darker gray) in the rocket’s nozzle, where the density field takes on the shape of the rocket-nozzle. In fact in this model, the radial interface  $\bar{R}_r$  between the rocket and nozzle is approximately the throat diameter and the nozzle to external density field radial interface  $\bar{R}_{gas}$  is approximately  $\sqrt{2}$  time the rocket nozzle exit radius  $r_{nozzle} \leq r_{rocket}$ .

The nozzle shape is also reflected back on the combustion chamber, where as the propellant is exhausted, the large end of the nozzle shape moves in the forward direction as shown in figure 3.



**Figure 2.** Accelerating Rocket CDF model at Start.



**Figure 3.** Accelerating Rocket Density Field Model near end of burn

Like normal rocket propulsion the thrust is given as

$$T_r = -m'_r a_r, \quad (1)$$

where  $a_r$  is the rocket's acceleration at propellant burnout and  $m'_r$  is the rocket's mass at propellant burnout, given by

$$m'_r \approx m_r - m_{ex} \quad (2)$$

or the launch mass  $m_r$  minus the exhausted mass  $m_{ex}$ .

The acceleration  $a_r$  under the CDF Model (Appendix A-C) is given from equation (44) as

$$a_r \approx 6\alpha \left( \frac{\varphi^3}{\sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right)} \right)^{1/2} g_N. \quad (3)$$

where the factor  $\alpha$  is a correction needed due to the omission of the ambient and Newtonian density field interactions on the rocket (see Appendix D),  $l_p \approx 1.62 \times 10^{-35} m$  is the Planck length,  $g_N$  is the Newtonian acceleration of gravity of the dominating density field  $\phi_N$  ( $g_N = 9.81 m/s^2$  for the earth),  $\varphi$  is the rocket's phase factor (discussed in the next section),

$$\bar{R}_r = \left( \frac{\varphi^3}{\sqrt{l_p} \left( 6\alpha \left( \frac{g_N}{a_r} \right) \right)^2 + \frac{1}{\sqrt{\bar{R}_{gas}}} \right)^{-2} \approx r_{throat} \quad (4)$$

is the rocket to nozzle radial interface from equation (45), but has been shown to be about the throat radius  $r_{throat}$ , and

$$\bar{R}_{gas} \approx r_{nozzle} \sqrt{2} \quad (5)$$

is the nozzle to environment radial interface from equation (57).

### Phase Factor

The rocket model represents a time varying density system with phased coupling between the density fields. The phase is due to time dilation and retardation associated with the motion of the exhausted mass<sup>3</sup>. This implies a phase factor

$$\varphi = \frac{\tau}{\tau + \Delta\tau} \ll 1, \quad (6)$$

where  $\tau$  is the relaxation time of the exhausted mass (*i.e.*, leaving the nozzle) and  $\Delta\tau$  is the retardation time of the rocket's mass flow into the nozzle.

For a rocket, the hot gas relaxation time

$$\tau \approx \frac{\bar{R}_{gas}}{v_{gas}}, \quad (7)$$

where  $v_{gas}$  is the hot gas velocity, and the rocket's mass flow retardation time

$$\Delta\tau \approx \frac{m_{ex}}{\dot{m}}, \quad (8)$$

where  $\dot{m}$  is the propellant mass flow rate crossing the throat.

Combining equations (6), (7) and (8) yields a rocket phase factor

$$\varphi \approx \left( 1 + \left( \frac{v_{gas}}{\bar{R}_{gas}} \right) \left( \frac{m_{ex}}{\dot{m}} \right) \right)^{-1}. \quad (9)$$

which represents the time retardation of the rocket's density change with respect to the mass flow into the nozzle, which inherently changes the both the rocket's and the nozzle's field densities.

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**Example 1:** This example uses the data from example 2-1 in Sutton and Ross<sup>4</sup> converted to metric units. The example appears to be a Sidewinder, AMRAM or Similar Missile. Table I shows the given parameters, the parameters surmised (guessed) from a like missile, and the parameters calculated from these values. Although both the throat and nozzle radius are a bit of a guess, they are within expected values for like missiles. However of note is the sensitivity to five decimal places of the throat parameter to getting the exact thrust value.

**Table I.** The given, surmised and calculated values for the rocket with  $\alpha = 1$ .

Given	Surmised	Calculated
$m_r = 90.72 \text{ kg}$	$r_{nozzle} \approx 0.051 \text{ m}$	$m'_r \approx 58.97 \text{ kg}$ (eqn. 2)
$m_{ex} = 31.75 \text{ kg}$	$r_{throat} \approx 0.01293 \text{ m}^*$	$\bar{R}_{gas} \approx 0.0718 \text{ m}$ (eqn. 5)
$v_{gas} \approx 2355.49 \text{ m/s}$		$\varphi \approx 1.02 \times 10^{-5}$ (eqn. 9)
$\dot{m} = 10.58 \text{ kg/s}$		
$F_{N_{80}} \approx 578.74 \text{ N}$		$a_r \approx 422.25 \text{ m/s}^2$ (eqn. 3)
$T \approx 2.49 \times 10^4 \text{ N}$		

\*Adjusted to give the same value as  $a_r = T/m'_r \approx 422.25 \text{ m/s}^2$  (eqn. 1), but is close to the expected throat radius.

## THE PROPELLANT-LESS PROPULSION MODEL

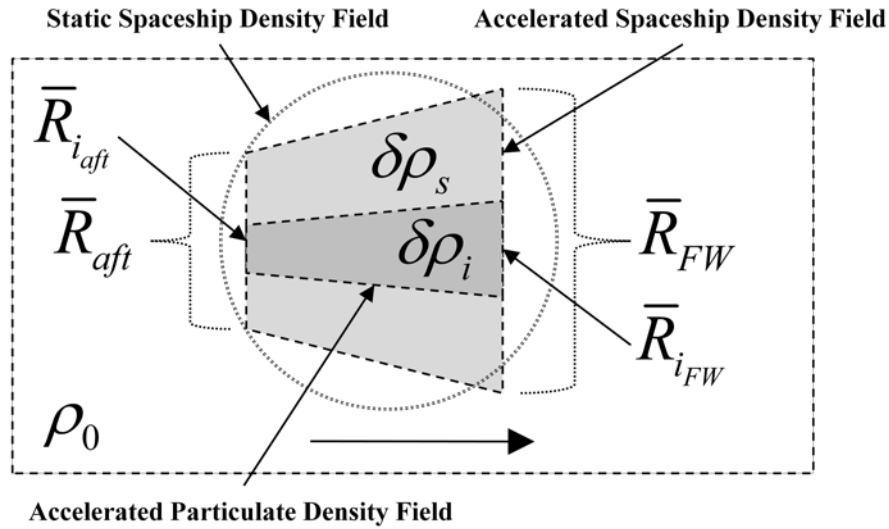
Propellant-less propulsion implies the non-existence of on board propellants (*e.g.*, solar sails) or *no exhausted propellant* (*e.g.*, Mag-Lev). Propellers or turbines and wings which act on the atmosphere to create a field pressure differential can also be included in the no exhausted propellant as their fuel by-products are typically only exhausted as waste. It is understood that systems using *no exhausted propellant* do not imply free energy exchange, *i.e.*, violation of energy conservation.

Field pressure differentials can also exist in a gravitational field, but is not always presented as such. The most famous gravitational field pressure differential theory is Warpdrive (and similar concepts), but we will not go there in this paper. Warpdrive is pointed out to instill in the reader that vacuum field interaction is not a new theory, only one that to date these types of models have not been found to fit any engineering propulsion model. The CDF model presented in this paper may possibly be a first.

In the CDF model, the density of a density field can change by accelerating mass inside the field [equation (46)]. This occurs for the density field of a solid object (a rocket) or the density field of a region of empty space (inside the rocket nozzle). Whereby, a propellant-less propulsion system with *no exhausted propellant* should be doable by creating a net differential in the forward and reverse mass acceleration inside an object.

In a solid object, the accelerated mass needs to be very small, probably down to subatomic particles to insure the inertial force can be managed during motion reversal. Electrons are the prime candidate as they are known to move freely in many materials. The electron CDF model will be explored in the next section.

The general propellant-less propulsion CDF model is derived from Figures 2 & 3 as shown in Figure 4. The exception is that, like Universe expansion, the direction of motion is in the direction of particulate motion with density  $\delta\rho_i$  and the dynamic spaceship density field of density  $\delta\rho_s$  is only representative and not actual as the spaceship does not change shape. However, the nozzle like shape are a direct result of the forward and aft radial interfaces or factors  $\bar{R}$ , which are know or can be calculated and provide a nice link back to the nozzles in the standard rocket propulsion model as shown in Figure 2, where the large arrow at the bottom is the direction of motion.



**Figure 4.** Accelerating Particulate Mass CDF Model.

The spaceship acceleration  $a_s$  is given by equation (3) as

$$a_s \approx 6\alpha \left( \frac{\hat{\phi}^3}{\sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_{aft}}} - \frac{1}{\sqrt{\bar{R}_{FW}}} \right)} \right)^{1/2} g_N = 6\alpha \left( \frac{\hat{\phi}^3}{\sqrt{l_p} \left( \frac{1}{\sqrt{\eta \bar{R}_{ift}}} - \frac{1}{\sqrt{\eta \bar{R}_{iFW}}} \right)} \right)^{1/2} g_N, \quad (10)$$

the phase  $\hat{\phi}$  is used here as it is subject to the type of experimental system exploited. The  $\eta$  factor is a geometric factors, such that,

$$\begin{aligned} \bar{R}_{aft} &\approx \eta \bar{R}_{ift}; \\ \bar{R}_{FW} &\approx \eta \bar{R}_{iFW}. \end{aligned} \quad (11)$$

This of course assumes the phase  $\hat{\phi}$  and  $\alpha$  are the same, and that the spaceship radial factors  $\bar{R}_{aft}$ ,  $\bar{R}_{FW}$  and the accelerated particulate radial factors  $\bar{R}_{ift}$ ,  $\bar{R}_{iFW}$  are symmetrically equivalent.

The spaceship density field change is given from equation (46) as

$$\delta\rho_s \approx \rho_s + \left(\frac{a_s}{g_N}\right)\rho_s = \frac{3m_s}{4\pi R_s^3} \left(1 + \frac{a_s}{g_N}\right) \approx \frac{3}{4\pi} \frac{m_s}{\bar{R}_{aft}^3}, \quad (12)$$

where  $\rho_s$  is the field density of the spaceship and  $m_s$  is the spaceship mass with radius  $R_s$  and similarly, the accelerated particulate field density change is given by

$$\delta\rho_i \approx \rho_i + \left(\frac{a_i}{g_N}\right)\rho_i = \frac{3m_i}{4\pi R_i^3} \left(1 + \frac{a_i}{g_N}\right) \approx \frac{3}{4\pi} \frac{m_i}{\bar{R}_{i,aft}^3}, \quad (13)$$

where  $m_i$  is the total particulate mass with coherent acceleration  $a_i$ .

Equations (11), (12) and (13) yield

$$\begin{aligned} \bar{R}_{aft} &\approx \left(\frac{g_N}{g_N + a_s}\right)^{1/3} R_s \rightarrow \left(\frac{g_N}{a_s}\right)^{1/3} R_s \\ \bar{R}_{i,aft} &\approx \left(\frac{g_N}{g_N + a_i}\right)^{1/3} R_i \rightarrow \left(\frac{g_N}{a_i}\right)^{1/3} R_i \end{aligned}, \quad (14)$$

for  $a_s$  &  $a_i \gg g_N$ , which yields

$$g_N \approx \left(\frac{\bar{R}_{aft}}{R_s}\right)^3 a_s \approx \left(\frac{\bar{R}_{i,aft}}{R_i}\right)^3 a_i. \quad (15)$$

Now by assuming that the density changes  $\delta\rho_i \approx \gamma\delta\rho_s$ , equations (12) and (13) yields

$$\frac{\bar{R}_{i,aft}}{\bar{R}_{aft}} \approx \left(\frac{m_i}{\gamma m_s}\right)^{1/3}, \quad (16)$$

which when equated to equation (11) yields

$$\eta \approx \left(\gamma \frac{m_s}{m_i}\right)^{1/3} \quad (17)$$

or combined with equations (15)

$$R_s = \left(\gamma \frac{m_s a_s}{m_i a_i}\right)^{1/3} R_i \Rightarrow a_s \approx \frac{1}{\gamma} \left(\frac{m_i}{m_s}\right) \left(\frac{R_s}{R_i}\right)^3 a_i, \quad (18)$$

which when combined with equation (14) yields

$$\bar{R}_{aft} \approx \left(\gamma \frac{m_s g_N}{m_i a_i}\right)^{1/3} R_i = \left(\gamma \frac{W_s}{F_i}\right)^{1/3} R_i, \quad (19)$$

where  $W_s = m_s g_N$  is the weight of the spaceship and  $F_i = m_i a_i$  is the force on the accelerated particulates.

Now noting that equation (11) yields

$$\bar{R}_{FW} \approx \left( \frac{\bar{R}_{aft}}{\bar{R}_{i_{aft}}} \right) \bar{R}_{i_{FW}}, \quad (20)$$

which when combined with equation (10) gives

$$a_s \approx 6\alpha \left( \frac{\hat{\phi}^3 \sqrt{\bar{R}_{aft}}}{\sqrt{l_p} \left( 1 - \sqrt{\frac{\bar{R}_{i_{aft}}}{\bar{R}_{i_{FW}}}} \right)} \right)^{1/2} g_N. \quad (21)$$

Then letting

$$\alpha \approx 1 - \sqrt{\frac{\bar{R}_{i_{aft}}}{\bar{R}_{i_{FW}}}} \approx 1 - \sqrt{\left( \frac{m_i}{\gamma m_s} \right)^{1/3}} \Rightarrow \gamma \approx \frac{m_i}{m_s} (1 - \alpha)^{-6}; \quad (22)$$

using equations (16) and (19), the spaceship acceleration can be simply estimated by

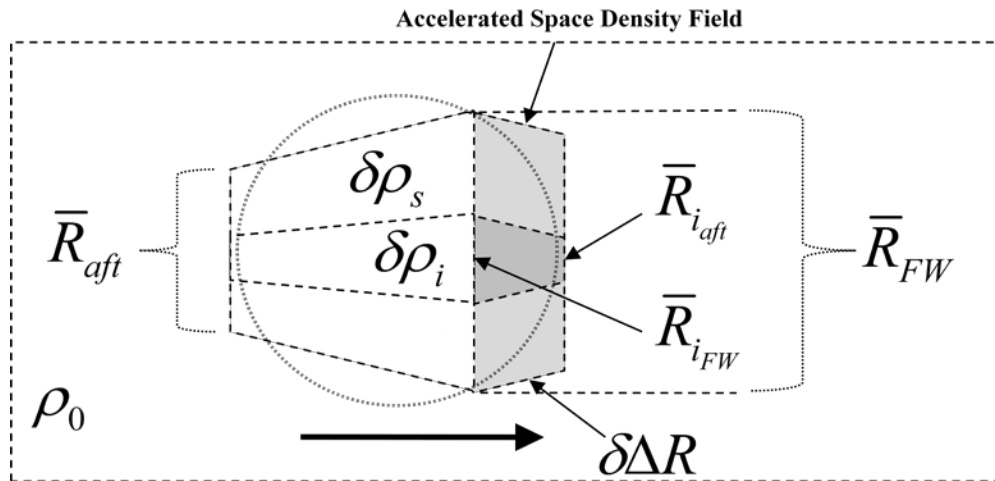
$$a_s \approx 6\sqrt{\alpha} \left( \hat{\phi}^3 \sqrt{\frac{\bar{R}_{aft}}{l_p}} \right)^{1/2} g_N = 6\sqrt{\alpha} \left( \hat{\phi}^3 \sqrt{\left( \frac{\tau \times W_s}{F_i} \right)^{1/3} \frac{R_i}{l_p}} \right)^{1/2} g_N; \quad (23)$$

using equation (19).

It is noted that using the values in Table I, the first part of equation (23) gives the same thrust value of the example when  $\sqrt{\alpha} \approx 0.85868$ . Where it is found for this model that

$$\sqrt{\alpha} \approx \sqrt{1 - \sqrt{\frac{\bar{R}_{i_{aft}}}{\bar{R}_{i_{FW}}}}} = \sqrt{1 - \sqrt{\frac{r_{nozzle}}{\bar{R}_{gas}}}} \approx 0.85644.$$

That is, under the propellant-less propulsion model only coupling distance changes  $\delta\Delta R$  [equation (31)] due to the particulate acceleration is important as there is no nozzle, per say. This can be represent as a change to the model of Figure 4 with respect to an Accelerated Space Density Field as



**Figure 5.** Corrected Accelerating Particulate Mass CDF Model

As shown, the Accelerated Space Density Field takes the place of the nozzle extension of Figure 2. With the difference from Figure 2 being that, in Figure 2, the nozzle extension is composed of accelerate exhaust mass, where, in Figure 5, the extension is composed of accelerated vacuum energy. The accelerated vacuum energy produces a squeezed vacuum state that the spaceship fall or accelerate into<sup>5</sup>.

In standard engineering propulsion terms, the Accelerated Space Density Field mimics the effect of a rocket nozzle to produce acceleration force on the spaceship, *i.e.*, we do not need to know the underlying physics, just model it as a nozzle and use it.

## Electron Mass Acceleration

Since the particulates have to be small to prevent destruction of the object, electron acceleration can be assumed, where the electron acceleration  $a_e \rightarrow v/\Delta t$ , where  $\Delta t = d/v$  is the acceleration time,  $v$  is the electron velocity and  $d$  is the acceleration distance. The accelerated electron's total kinetic energy  $\xi_k = \frac{1}{2}Nm_e v^2 \approx NeV_A \approx F_e \times d$ , where  $m_e = 9.11 \times 10^{-31} \text{ kg}$  is the electron mass,  $V_A$  is the applied voltage,  $e \approx 1.6 \times 10^{-19} \text{ coulombs}$  is the electron charge and  $N$  is the number of electrons efficiently (coherently) accelerated. Then the electron acceleration force

$$F_e \approx \frac{\xi_k}{d} = \frac{\frac{1}{2}Nm_e v^2}{d} = \frac{NeV_A}{d}. \quad (24)$$

Now combining equations (19) and (24) with  $F_i = F_e$  and  $R_i = R_e$  (the radius of the total electron cloud) yields

$$\bar{R}_{aft} \approx \left( \gamma \frac{W_s \times d}{\xi_k} \right)^{1/3} R_e = \left( \gamma \frac{W_s \times d}{NeV_A} \right)^{1/3} R_e \quad (25)$$

and combining equations (23) and (24) yields

$$a_s \approx 6\sqrt{\alpha} \left( \hat{\phi}^3 \sqrt{\left( \gamma \frac{W_s \times d}{NeV_A} \right)^{1/3} \left( \frac{R_e}{l_p} \right)} \right)^{1/2} g_N. \quad (26)$$

The author suspects that for electron acceleration in (or related to) the Type II superconductor YBCO gives a phase  $\hat{\phi}$  of the form

$$\hat{\phi} \approx \begin{cases} 0 & \text{for } V_A \leq 512 \text{ kV} \\ \varphi \left( \frac{V_A}{512 \text{ kV}} - 1 \right)^{1/3} & \text{for } V_A > 512 \text{ kV} \end{cases} \quad (27)$$

to account for why such phenomena has not already been observed; 512 kV is the electron annihilation/creation voltage; the obvious threshold voltage required to allow electrons to interact with the density field. A similar pattern was reported by Maker and Robertson<sup>6</sup> to account for data seen in the high voltage superconductor experiments<sup>7</sup>. Whereby, the second parameter only establishes the phase profile under different voltages as reported by the author<sup>8</sup>.

**Example 2:** In an experiment reported by Podkletnov and Modanese<sup>7</sup> where helium gas in a vacuum was condensed near a YBCO superconductor ( $\sim 10^{28}$  coherent electrons per square meter) with a superconductor radius  $R_{sc} \approx 0.05 \text{ m}$  and accelerated as a single body, the reported acceleration time was between  $10^{-5} \text{ s}$  and  $10^{-4} \text{ s}$  with an acceleration distance of 1 m to give an acceleration between  $10^5 \text{ m/s}^2$  and  $10^4 \text{ m/s}^2$ .

To get similar values on the acceleration, let  $\sqrt{\alpha} \approx 0.90$  and  $\varphi \approx 2 \times 10^{-3}$ . Then given a spaceship of radius  $R_s = 10 \text{ m}$  and weight  $W_s = 98,100 \text{ N}$  with an effective radial ratio  $\kappa = R_e/R_s = 0.005$  and assuming the propulsion system can produce  $10^{28}$  coherent electrons per square meter with a total electron cloud radius  $R_e = \kappa R_s = 0.05 \text{ m}$  and thickness  $Th_i = 0.001 \text{ m}$  to give



$N = 10^{28} \times \pi \times (0.05)^2 m^2 \times 0.001 m = 7.85 \times 10^{22}$  electrons at a voltage  $V_A \approx 2 \times 512 kV$  and accelerate them over a distance  $d = 1 m$  to yield an acceleration  $a_s \approx 4.43 \times 10^5 m/s^2$  using equation (26), which does not seem possible as the spaceship impulse thrust  $T = (W_s/g_N)a_s \approx 4.43 \times 10^9 N$ .

However the classical model would indicate that the thrust on the spaceship  $T = Nm_e a_s \approx 317 \times 10^{-3} N$  might be more realistic, where  $Nm_e \gg 7.85 \times 10^{22} \text{ electrons} \times 9.10938188 \times 10^{-31} kg = 7.15 \times 10^{-8} kg$ . Noting from equation (22) that

$$\gamma \approx \frac{m_i}{m_s} (1 - \alpha)^{-6} = Nm_e \left( \frac{g_N}{W_s} \right) (1 - \alpha)^{-6} \approx 7.15 \times 10^{-6}$$

On the other hand, if the electrons stay bound to the helium atoms  $\frac{1}{2}Nm_H \approx 0.5 \times 7.85 \times 10^{22} \text{ electrons} \times 6.65 \times 10^{-27} kg = 2.61 \times 10^{-4} kg$  and the thrust on the spaceship  $T = \frac{1}{2}Nm_H a_s \approx 115 N$ , where  $\gamma \approx 0.026$ .

A clue to the actual mass may lie in equation (18), where

$$a_i \approx \gamma \left( \frac{m_s}{m_i} \right) \left( \frac{R_i}{R_s} \right)^3 a_s \rightarrow c \text{ for electrons.}$$

For electrons with  $\gamma = 7.15 \times 10^{-6}$ ,  $a_s \approx 4.43 \times 10^5 m/s^2$  and  $m_i = Nm_e = 7.15 \times 10^{-8} kg$ ,  $a_e \approx 5.54 \times 10^4 m/s^2$ ; noting that for helium with  $m_i = \frac{1}{2}Nm_H \approx 2.61 \times 10^{-4} kg$  and  $\gamma \approx 0.026$ ,  $a_H \approx 5.54 \times 10^4 m/s^2$ , that is the electron and helium atoms are moving at the same speed. In which case, the thrust would be that produced by the Helium.

Since in the aforementioned experiment  $a_i \ll c$ , it would seem to indicate that it is the Helium atoms being accelerated.

#### NOTES:

It is noted that there is a capacitive relationship between the number  $N$  of electrons and the applied voltage  $V_A$ , such that, one cannot arbitrarily select the number of electrons as they come from the capacitive nature of the system, which is dependent on the applied voltage and the geometric shape.

Further, one has to also account for the relaxation velocity of any non-random electrons, *i.e.*, electron relaxing back into the material or system in opposite direction to the acceleration direction. This can be done by letting the actual acceleration

$$a'_s \approx a_s \left( 1 - \kappa_e \left( \frac{v_{relax}}{c} \right) \right). \quad (28)$$

$\kappa_e$  is a correction needed to account for random electrons relaxation (to include direction and velocity) and  $v_{relax}$  is the effective relaxation velocity of the non-random electrons. This is actually a major concern as for most materials and electron systems  $v_{relax} \rightarrow c$ . Whereby one wants a material or system design where  $\kappa_e \rightarrow 0$ . Such systems would be non-linear in relationship to the applied voltage and magnetic field changes<sup>9</sup>.

## CONCLUSION

In this paper, a new method for calculating the acceleration on a rocket is developed. This method was derived from a new cosmological theory based on changing density fields (CDF). Unlike the exhausted mass model used in current propulsion models, here the density field of in a rocket nozzle is shown to change with the acceleration of exhausted gases. Whereby, the interactions between the changing density field of the rocket due to the propellant loss and the changing density field produced by the accelerated propellant in the rocket's nozzle produce a net field

force or thrust. The new model is shown to work very well compared to an example from Sutton and Ross<sup>4</sup> - *Rocket Propulsion Elements*.

As the density field change of an object is a function of internal matter acceleration, it is conceivable that a propulsion system can be built that has no exhausted mass. Such a system would need to produce coherent particulate acceleration in one direction, while allowing the particulates to relax randomly or at a much-much less reversed coherence.

## FUTURE WORK

Future work is twofold:

- I. Further studies need to be preformed to better understand how this new model can be used to improve the current propulsion models.
- II. Experiments focused on the acceleration of coherent systems of electron without ejection should be conducted with thrust measurement taken and compared to the CDF model.

Pertaining to item II above:

1. Anomalous force measurements using an EM system have been reported by Woodward<sup>10</sup>, Brito<sup>11</sup> and others<sup>12</sup> using experimental devices similar to the device reported in the 1949 *Electromagnetic Space-Ship*<sup>13</sup> article. Although none of these works own up to the similarity. Of note, all these experimental devices used the dielectric, Barium Titanate; developed in 1960s. The near decade separation between the 1949 article and the development of new dielectrics may warrant why the *Electromagnetic Space-Ship* fell out of favor - as no proper non-linear dielectrics existed at the time. Experiments using the *Electromagnetic Space-Ship* device with similar but different dielectric materials warrant investigation.
  2. The author suspects that coherent matter, as a *Bose condensate of electrons*, accelerated in a vacuum could produce a useable changing density field. An experiment was reported by Podkletnov and Modanese<sup>7</sup> where helium gas in a high vacuum was condensed near a YBCO superconductor and accelerated as a single body. However, in their experiment, the coherent helium gas cloud was allowed to hit the anode; causing damage. It is expected that a method to randomly dispersing the coherent helium gas cloud back to a de-coherence state before hitting the anode or vacuum chamber wall would need to be implemented for the CDF model to work properly using this method. However of note, the accelerated condensate of electrons inside the YBCO superconductor may produce similar effects without damaging the experimental apparatus and may be why the (presumably neutral) coherent helium gas cloud accelerated.
- III. The author notes that the CDF model also applies to ZPE models of propulsion<sup>5</sup>. Therefore correlation to this and other models and experiments need to be conducted.

## REFERENCES

1. Khoury J. and Weltman A., *Chameleon cosmology*, *Phys. Rev. D*, **69**, (2004), p. 044026.
2. Khoury J. and Weltman A., *Chameleon Fields: Awaiting Surprises for Tests of Gravity in Space*, *Phys. Rev. Lett.*, **93**, (2004), p. 171104.
3. Robertson, G. A., *Engineering Dynamics of a Scalar Universe, Part II: Time-Varying Density Model & Propulsion*, Lecture Series paper in the proceedings of *Space, Propulsion & Energy Sciences International Forum* (SPESIF-09), edited by Glen A. Robertson, AIP **CP1103**, Melville, New York, (2009).
4. Sutton, G. P. and Ross, D. M., *Rocket Propulsion Elements*, 4<sup>th</sup> Ed., (1976).
5. Davis, E. W. and Puthoff, H. E., *Experimental Concepts for Generating Negative Energy in the Laboratory*, in the proceedings of the *Space Technology and Applications International Forum* (STAIF-06), edited by M. S. El-Genk, AIP **CP813**, Melville, New York, (2005), pp. 1362-1373.
6. Maker, D. and Robertson, G. A., *Very Large Propulsive Effects Predicted for a 512 kV Rotator*, in the proceedings of the *Space Technology Applications & International Forum*, edited by M.S. El-Genk, AIP **CP654**, Melville, NY, (2003).

7. E. Podkletnov and G. Modanese in *Investigation of High Voltage Discharges in Low Pressure Gases through Large Ceramic Superconducting Electrodes*, *Physics and Astronomy, Journal of Low Temperature Physics*, Volume 132, Numbers 3-4, (2003), pp. 239-259.
8. Robertson, G. A., *Quantum Effects in the Type II Superconductor that Lead to Power Radiated in Gravitational Waves*, to be in the ebook *Gravity-Superconductors Interaction: Theory and Experiment*, edited by G. Modanese and G. A. Robertson, Bentham Science Publishers Ltd., 2010
9. Robertson, G. A., *Electromagnetic Nonlinearity in the Dielectric Medium of Experimental EM Impulse-Momentum Systems*, in the proceedings of the *Space Technology and Applications International Forum (STAIF-06)*, edited by M. S. El-Genk, AIP **CP813**, Melville, New York, (2006), pp. 1333-1340.
10. Woodward, James F., *Investigation of Propulsive Aspects of Mach Effects*, in *Space, Propulsion and Energy Sciences International Forum (SPESIF-09)*, edited by G. A. Robertson, AIP **CP1103**, Melville, New York, (2009); and earlier work.
11. Brito, Hector H. and Elaskar, Sergio A., *Overview of Theories and Experiments on Electromagnetic Inertia Manipulation Propulsion*, in the proceedings of the *Space Technology and Applications International Forum (STAIF-05)*, edited by M. S. El-Genk, AIP **CP746**, Melville, New York, (2005), pp. 1395-1402.
12. Walker, G. B., Lahoz D. G. and Walker, G., *Measurement of the Abraham Force in Barium Titanate Specimen*, *Canadian J. of Physics* 53, pp. 2577-2586 (1975); Walker G. B. and Walker, G., *Mechanical forces in a dielectric due to electromagnetic fields*, *Canadian J. of Physic* 55, pp. 2121-2127(1977).
13. Slepian, J., *Electromagnetic Space-Ship*, *Electrical Engineering*, March, 1949, pp. 145-146; J. Slepian, "Answer to Previous Essay," *Electrical Engineering*, p. 245, April (1949).
14. Robertson, G. A., *The Chameleon Solid Rocket Propulsion Model*, in the proceeding of Space, Propulsion & Energy Sciences International Forum (SPESIF-10), edited by Glen A. Robertson, AIP **CP1208**, Melville, New York, (2010).
15. Robertson, G. A. and Pinheiro, M. J., *Vortex Formation in the Wake of Dark Matter Propulsion*, in the proceeding of Space, Propulsion & Energy Sciences International Forum (SPESIF-11), edited by Glen A. Robertson, *Physics Procedia*, Elsevier Science, (2011).

The following Appendices are derived from reference<sup>14</sup>.

## APPENDIX A

### CHANGING DENSITY FIELD MODEL

The CDF model present forces attributed to changes in the density fields in or about an object. A key factor in this model is that density changes in the scalar field densities arise from the acceleration of the particulate matter in or about an object. Whereby, net changes in the density field of an object can occur without mass ejection.

The field  $F_\phi$  force attributed to the density field changes in the CDF model, is given by

$$F_\phi \approx 6\delta\beta_m \left( \sum \delta\beta_i \right)^2 \sqrt{\frac{l_p}{R_m}} F_N \quad , \quad (29)$$

where:

- $\delta$  denotes a change from static conditions (*i.e.*,  $\delta \equiv$  motion).
- The subscript  $m$  denotes the object subject to the field force.
- The subscript  $i = n, N, 0$  denote the environmental density fields, where the subscript  $n$  denotes other adjacent density field(s), the subscript  $N$  denotes the dominating Newtonian (*i.e.*, gravitation) density field and the subscript 0 denotes the ambient density field.
- $l_p \approx 1.62 \times 10^{-35} m$  is the Planck length.
- $\bar{R}_m$  is the radial factor or common radius between adjacent density fields.
- The dominate gravity force

$$F_N = mg_N \quad , \quad (30)$$

where  $g_N$  is the acceleration of gravity of the dominating Newtonian density field.

## Coupling Factors

The coupling factors, denoted by  $\beta$ , reflect how the density fields in and about an object affect the coupling distance  $\Delta R_m$  about an object. There are basically four coupling factors:

- The mass coupling factor  $\beta_{m,n}$ ,
- The Newtonian (*i.e.*, dominate gravity field) coupling factor  $\beta_N$ ,
- The ambient coupling factor  $\beta_0$ , and
- The motion coupling factor  $\hat{\beta}_C$

In like to Einstein Physics:

*The coupling factors  $\beta$  tell the coupling distances  $\Delta R_m$  how to conform or shape and the coupling distances tell the object how to move.*

Whereby, the density field contours associated with the coupling distances  $\Delta R_m$  about an object then, in effect, represents contours in spacetime, *i.e.*, gravity wells or hills as associated with warp-drive physics<sup>15</sup>. The *big news* is that the CDF model tells us how to reshape spacetime through density field changes in and about an object, which represents a major engineering tool toward the development of space-drives.

The coupling distance (at a given point about an object) is given by

$$\Delta R_m \approx \frac{1}{3} \left( \frac{M_E^2}{\rho_m R_m} \right) \left( \frac{2M_{PL}^4}{\rho_0} \right)^{1/3} + \delta \Delta R_i \approx \beta_m^2 \sqrt{l_p \cdot R_m} + \delta \Delta R_i,$$

where:

- $M_E \approx 10^4 m^{-1}$  is the cosmological energy scale factor.
- $M_{pl} \equiv \sqrt{\hbar c / 8\pi G}$  is the reduced Planck mass.
- $\rho_m$  is the object's density.
- $R_m$  is the object's radius.
- $\rho_0$  is the density of the ambient density field.

which by similarities imply

$$\delta \Delta R_i \approx \sum \frac{1}{3} \left( \frac{M_E^2}{\hat{\beta}_{C_i} \delta \rho_i \bar{R}_i} \right) \left( \frac{2M_{PL}^4}{\delta \rho_0} \right)^{1/3} \approx (\sum \delta \beta_i)^2 \sqrt{l_p \cdot \bar{R}_i} \quad (31)$$

and, by symmetries, gives the change in the coupling factors as

$$\delta \beta_i \approx \left( 1/3 \left( \frac{M_E^2}{\hat{\beta}_{C_i} \delta \rho_i \sqrt{l_p \bar{R}_i^3}} \right) \left( \frac{2M_{PL}^4}{\delta \rho_0} \right)^{1/3} \right)^{1/2}. \quad (32)$$

The density change in an object's density field is

$$\delta \rho_i \approx \rho'_r + \left( \frac{F_r}{F_{N_r}} \right) \rho'_r \approx \rho'_i + \left( \frac{a_i}{g_N} \right) \rho'_i = \frac{3}{4\pi} \frac{m'_i}{R_i^3} \left( 1 + \frac{a_i}{g_N} \right) \approx \frac{3}{4\pi} \frac{m'_i}{\bar{R}_i^3}, \quad (33)$$

to give the change in an object's density field radius

$$\bar{R}_i \approx \left( \frac{g_N}{g_N + a_i} \right)^{1/3} R_i \rightarrow \left( \frac{g_N}{a_i} \right)^{1/3} R_i, \quad (34)$$

where the super-script ' denotes that the object's mass  $m_i$  can be changing as is the case for ejected mass.

### Time Varying Density Mass Coupling Factors

The coupling factor of an object having a time varying density is phased due to time dilation and retardation associated with the motion of the internal particulate matter that result in the time varying density<sup>3</sup>. This implies a changing mass coupling factor

$$\delta\beta_m \approx \frac{1}{6\varphi} \left( \frac{a_k}{g_N} \right), \quad (35)$$

where the phase  $\varphi$  is given by equation (6),  $a_k$  is the acceleration of the phased system  $k$ . Noting that equation (35) allows for the calculation of the motion coupling factor by setting equations (35) equal to equation (32) for the respective object.

### Thrust

The field force of equation (29) can be given in the formed  $F = (1 - \theta_m)F_N$  used in fifth force searches<sup>6</sup> by letting the fifth force coefficient

$$\theta_m \approx \frac{F_\phi}{F_N} = 6\delta\beta_m \left( \sum \delta\beta_i \right)^2 \sqrt{\frac{l_p}{R_m}}, \quad (36)$$

and applying the gradient  $\nabla$  of equation (29), which allows the thrust  $T_k$  on an object to be defined by the linear sum (*i.e.*, ignoring perpendicular density field effects) of the fifth force coefficients about an object as

$$T_k = F_{\nabla\phi} = -\sum \theta_m F_N = -\sum \theta_m \times m'_k g_N = m'_k a_k \quad (37)$$

and where the minus sign indicates upward thrust and  $m'_k$  is the burn out weight of the object or phased system subjected to the field force. Equations (36) and (37) assume that the forces on the ambient and dominating Newtonian density fields are small enough to ignore. Again, the super-script ' denotes that the object's mass  $m_i$  can be changing as is the case for ejected mass.

## APPENDIX B

### ROCKET ACCELERATION

The solid rocket motor example implies that the ambient and Newtonian coupling factors play minor roles in the thrust calculation. Whereby, they can be ignored in equation (36) to give the rocket and nozzle fifth force coefficients as

$$\theta_r \approx 6\delta\beta_r \delta\beta_{gas}^2 \sqrt{\frac{l_p}{R_r}}; \quad (38)$$

$$\theta_{gas} = -6\delta\beta_{gas} \delta\beta_r^2 \sqrt{\frac{l_p}{R_{gas}}}. \quad (39)$$

Due to the close coupling between the rocket and the nozzle,  $\delta\beta = \delta\beta_r = \delta\beta_{gas}$ , such that,

$$\sum \theta_r = \theta_0 + \theta_r + \theta_{gas} + \theta_N \approx \frac{1}{\alpha^2} \left( 6\delta\beta^3 \sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right) \right), \quad (40)$$

where the effects of the ambient and Newtonian fifth are replaced by the correction factor  $\alpha^2$ ; see Appendix D.

Combining equations (37) and (40) yields

$$T_r = -\frac{1}{\alpha^2} \left( 6\delta\beta^3 \sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right) \right) m'_r g_N \approx -m'_r a_r; \quad (41)$$

to give

$$a_r \approx \frac{1}{\alpha^2} \left( 6\delta\beta^3 \sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right) g_N \right). \quad (42)$$

Now combining equations (42) back with equation (35) with  $a_k = a_r$  yields

$$\delta\beta \approx \alpha \left( \frac{\varphi}{\sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right)} \right)^{1/2}, \quad (43)$$

which when combined back with equation (42) yields

$$a_r \approx 6\alpha \left( \frac{\varphi^3}{\sqrt{l_p} \left( \frac{1}{\sqrt{\bar{R}_r}} - \frac{1}{\sqrt{\bar{R}_{gas}}} \right)} \right)^{1/2} g_N. \quad (44)$$

which yields the complex form of the rocket to nozzle radial interface as

$$\bar{R}_r = \left( \frac{1}{\sqrt{l_p}} \left( \varphi^3 \left( 6\alpha \left( \frac{g_N}{a_r} \right) \right)^2 \right) + \frac{1}{\sqrt{\bar{R}_{gas}}} \right)^{-2}. \quad (45)$$

## APPENDIX C

### CHANGING DENSITIES IN THE ROCKET MODEL

Under the CDF model and as represented by Figure 1-3, a solid rocket constitutes a changing two density field system, *i.e.*, the changing density field  $\delta\rho_r$  of the rocket and the changing density field  $\delta\rho_{gas}$  of the accelerated gas in the rocket's nozzle. Whereby, the interactions between these systems cause a differential coupling to the local gravity environment represented by the ambient and the dominating Newtonian density fields.

Using equation (33), the changing rocket field density

$$\delta\rho_r \approx \rho'_r + \left(\frac{F_r}{F_{N_r}}\right)\rho'_r \approx \frac{m'_r}{R_r^3} \Rightarrow \frac{m'_r}{R_r^3} + \left(\frac{a_r}{g_N}\right)\left(\frac{m'_r}{R_r^3}\right) \approx \frac{m'_r}{R_r^3}, \quad (46)$$

where the normal rocket density change

$$\rho'_r = \frac{m'_r}{R_r^3} \quad (47)$$

and the changing hot gas field density

$$\delta\rho_{gas} \approx \frac{4\pi}{3}\left(\frac{F_{gas}}{F_{N_{gas}}}\right)\rho'_{gas} \approx \frac{m'_{gas}}{R_{gas}^3} \Rightarrow \left(\frac{a_{gas}}{g_N}\right)\left(\frac{m'_{gas}}{R_{gas}^3}\right) \approx \frac{m'_{gas}}{R_{gas}^3}, \quad (48)$$

where the hot gas density change

$$\rho'_{gas} \approx \frac{3m'_{gas}}{4\pi R_{gas}^3}, \quad (49)$$

using a spherical approximation, and where  $m'_{gas}$  is the gas field mass.

Equation (46) gives the rocket's changing radial factor as

$$\bar{R}_r \approx \left(\frac{F_{N_r}}{F_{N_r} + F_r\left(\frac{m_r}{m'_r}\right)}\right)^{1/3} R_r = \left(\frac{g_N}{g_N + a_r\left(\frac{m_r}{m'_r}\right)}\right)^{1/3} R_r \quad (50)$$

and equation (48) gives hot gas radial factor as

$$\bar{R}_{gas} \approx \left(\frac{F_{N_{gas}}}{F_{gas}}\right)^{1/3} R_{gas} = \left(\frac{g_N}{a_{gas}}\right)^{1/3} R_{gas}. \quad (51)$$

where the gas acceleration

$$a_{gas} \approx \frac{v_{gas}^2}{2R_{gas}} \quad (52)$$

The hot gas density in the nozzle with respect to a constant (average) gas pressure  $P_{gas}$  on the nozzle and constant (average) hot gas velocity  $v_{gas}$  is given as

$$\rho'_{gas} \approx \frac{3}{4}\left(\frac{P_{gas}}{v_{gas}^2}\right) \times 100, \quad (53)$$

where the factor 100 is a correction factor needed to convert the field's density to human units in order to equate the density of equation (53) back to equation (49) to give the gas field mass

$$m'_{gas} \approx \pi\left(\frac{\bar{R}_{gas}^3}{v_{gas}^2}\right)P_{gas} \times 100 \quad (54)$$

and gas radial factor

$$\bar{R}_{gas} \approx \left( \frac{1}{100} \cdot \frac{m'_{gas} v_{gas}^2}{\pi P_{gas}} \right)^{1/3}. \quad (55)$$

Now letting

$$\frac{1}{100} P_{gas} A_{Nozzle} \approx m'_{gas} \left( \frac{v_{gas}^2}{2\bar{R}_{gas}} \right), \quad (56)$$

where  $A_{Nozzle} = \pi r_{nozzle}^2$  is the nozzle cross sectional area, which when combined with equation (55) yields

$$\bar{R}_{gas} = \left( \frac{2A_{Nozzle}}{\pi} \right)^{1/2} = r_{nozzle} \sqrt{2}. \quad (57)$$

## APPENDIX D

### AMBIENT AND NEWTONIAN FIFTH FORCE COEFFICIENTS

The ambient and Newtonian fifth force coefficients about a rocket are given by

$$\theta_0 \approx 6\beta_0 \delta\beta^2 \sqrt{\frac{l_p}{R_0}} \approx 6\delta\beta^2 \sqrt{\frac{l_p}{R_0}}; \quad (58)$$

$$\theta_N = -6\beta_N \delta\beta^2 \sqrt{\frac{l_p}{R_N}} \approx -6\delta\beta^2 \sqrt{\frac{l_p}{R_N}}. \quad (59)$$

The assumption is that the ambient and Newtonian density fields are large enough not to be effected by the changing rocket density fields, whereby there coupling factors and radial factors are unchanged.

However, the sum of the equations (58) and (59) yields

$$\theta_0 + \theta_N \approx 6\delta\beta^2 \sqrt{\frac{l_p}{R_0}} - 6\delta\beta^2 \sqrt{\frac{l_p}{R_N}} = 6\delta\beta^2 \sqrt{l_p} \left( \sqrt{\frac{1}{R_0}} - \sqrt{\frac{1}{R_N}} \right) \rightarrow -6\delta\beta^2 \sqrt{\frac{l_p}{R_N}} \neq 0; \quad (60)$$

for  $R_0 \gg R_N$ , *i.e.*, universe radius verse the earth radius. Although, close to the Newtonian object  $R_0 \approx R_N$ , whereby the sum is  $\sim 0$  and far from any object  $R_N \approx R_0$ , whereby again the sum is  $\sim 0$ . Therefore, one needs to assume that conditions could exist where  $R_N \neq R_0$ . For this reason, the  $\alpha^{-2}$  factor is added in equation (40).

The factor “-2” is done for convenience leading to the definition of  $\alpha$  in equation (22).

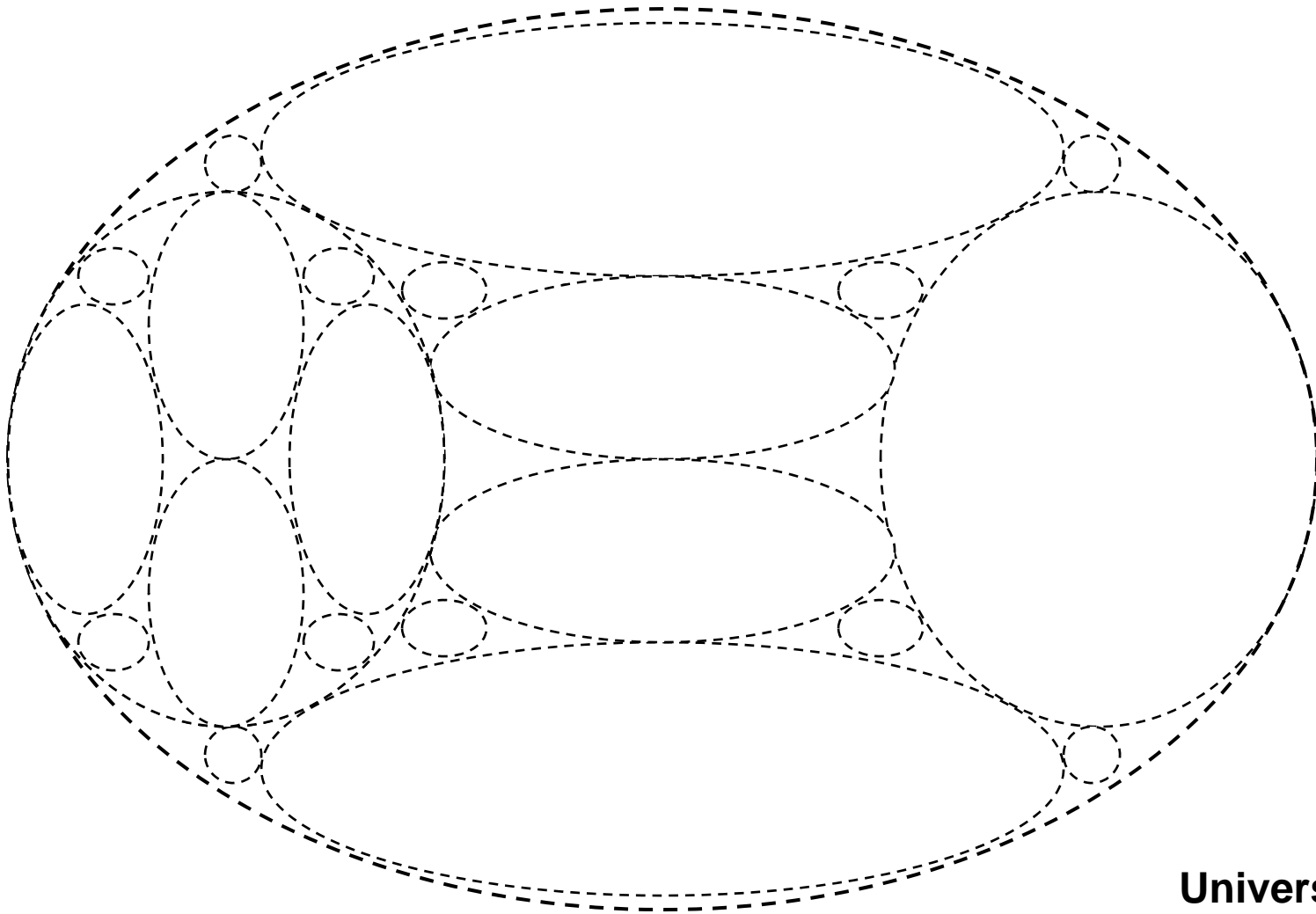


# **Propulsion Physics under the Changing Density Field Model**

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**A Density Field is any region of space where a density of particulate matter can be logically defined.**



# Fundamental Theory

PHYSICAL REVIEW D **69**, 044026 (2004)

## Chameleon cosmology

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The evidence for the accelerated expansion of the Universe and the time dependence of the fine-structure constant suggests the existence of at least one scalar field with a mass of order  $H_0$ . If such a field exists, then it is generally assumed that its coupling to matter must be tuned to unnaturally small values in order to satisfy the tests of the equivalence principle (EP). In this paper, we present an alternative explanation which allows scalar fields to evolve cosmologically while having couplings to matter of order unity. In our scenario, the mass of the fields depends on the local matter density; the interaction range is typically of order 1 mm on Earth (where the density is high) and of order  $10\text{--}10^4$  AU in the solar system (where the density is low). All current bounds from tests of general relativity are satisfied. Nevertheless, we predict that near-future experiments that will test gravity in space will measure an effective Newton's constant different by order unity from that on Earth, as well as EP violations stronger than currently allowed by laboratory experiments. Such outcomes would constitute a smoking gun for our scenario.

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PACS number(s): 04.50.+h, 04.80.Cc, 98.80.-k

# Fundamental Theory

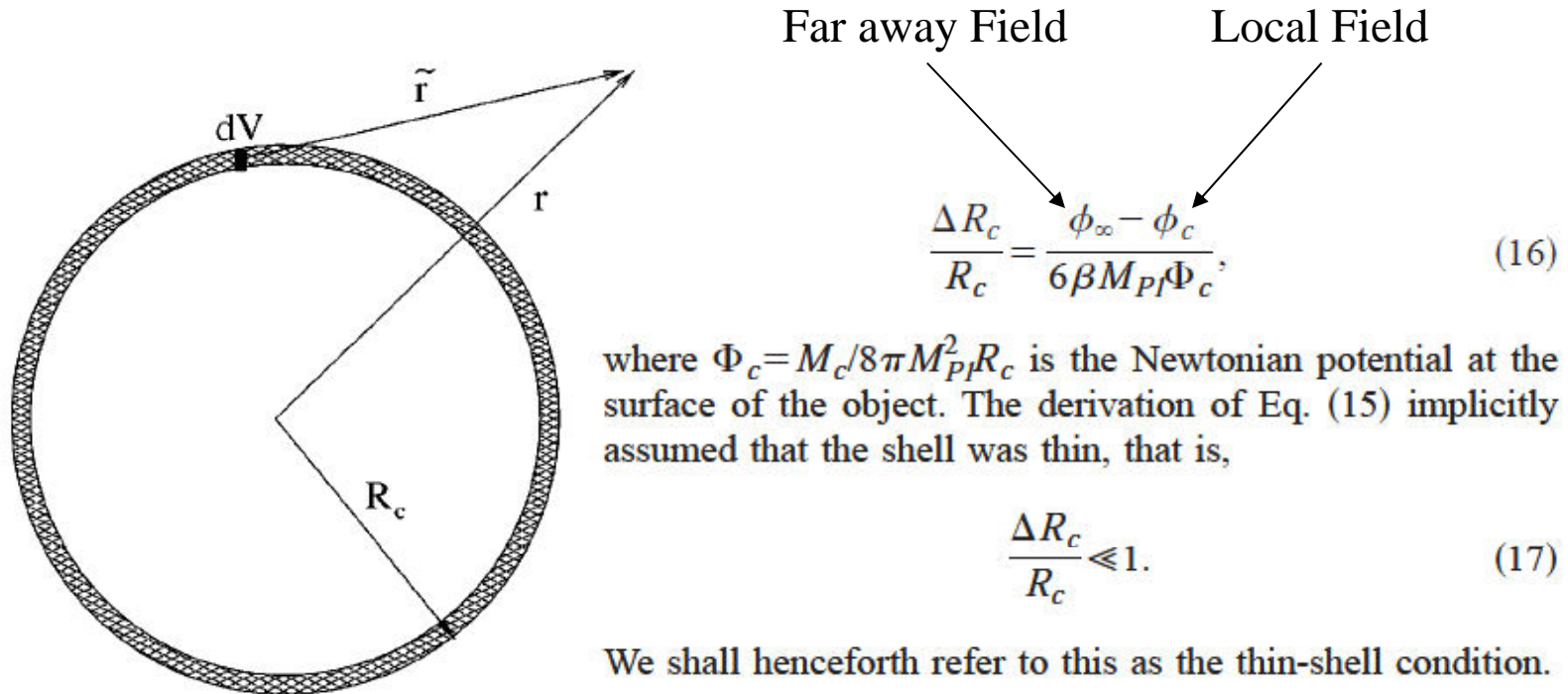


FIG. 4. For large objects, the  $\phi$  field a distance  $r > R_c$  from the center is to a good approximation entirely determined by the contribution from infinitesimal volume elements  $dV$  (dark rectangle) lying within a thin shell of thickness  $\Delta R_c$  (shaded region). This thin-shell effect suppresses the resulting chameleon force.

# Fundamental Theory

that the resulting chameleon force on a test particle of mass  $M$  and coupling  $\beta$  is given by

$$\vec{F}_\phi = -\frac{\beta}{M_{Pl}} M \vec{\nabla} \phi. \quad (20)$$

which is recognized as the Yukawa profile for a scalar field of mass  $m_\infty$ . Note that Eqs. (15) and (18) differ only by a thin-shell suppression factor of  $\Delta R_c/R_c$ . To summarize, the exterior solution for a compact object is given by

$$\begin{aligned} \phi(r) &\approx -\left(\frac{\beta}{4\pi M_{Pl}}\right) \frac{M_c e^{-m_\infty r}}{r} + \phi_\infty \quad \text{if } \frac{\Delta R_c}{R_c} > 1, \\ \phi(r) &\approx -\left(\frac{\beta}{4\pi M_{Pl}}\right) \left(\frac{3\Delta R_c}{R_c}\right) \frac{M_c e^{-m_\infty r}}{r} + \phi_\infty \\ &\quad \text{if } \frac{\Delta R_c}{R_c} \ll 1, \end{aligned} \quad (19)$$

with  $\Delta R_c/R_c$  defined in Eq. (16).

*Thick-shell regime:*  $\phi_I \geq \phi_c$ . In this case, the field is initially sufficiently displaced from  $\phi_c$  that it begins to roll almost as soon as it is released at  $r=0$ . Hence there is no friction-dominated regime in this case, and the interior solution for  $\phi$  is most easily obtained by taking the  $R_{roll} \rightarrow 0$  limit of Eq. (24) and replacing  $\phi_c$  by  $\phi_I$ . Matching to the exterior solution as before, we obtain

$$\phi(r) = \frac{\beta \rho_c r^2}{6 M_{Pl}} + \phi_I \quad \text{for } 0 < r < R_c \quad (29)$$

**In these equations  $\hbar$  and  $c = 1$**

## Fundamental Theory

$$\vec{F}_\phi = mc^2 \left( \frac{\beta_m}{M_{Pl}} \right) \nabla \phi(r_x) \hat{r}$$

$$\approx 2\beta_m \left( 3 \frac{\Delta R_m}{R_m} \right) m \vec{g}_N$$

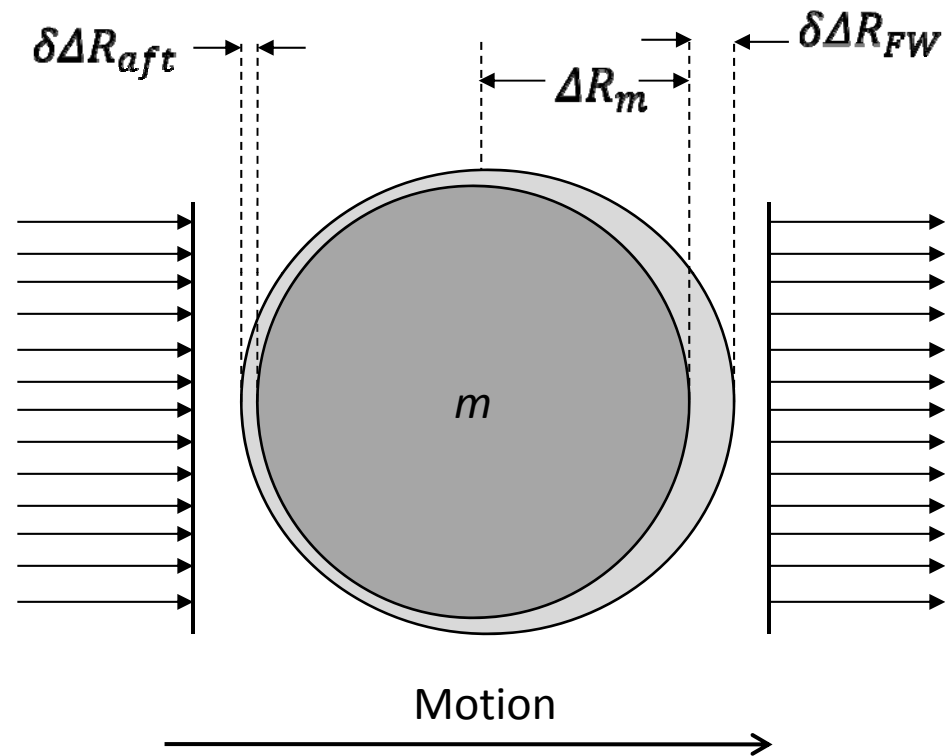
$$= 6\beta_m \left( \frac{\Delta R_m}{R_m} \right) \vec{F}_N$$

$$\Delta R_m \approx \frac{1}{3} \left( \frac{M_E^2}{\beta_c \rho_m R_m} \right) \left( \frac{2M_{PL}^4}{\rho_0} \right)^{1/3}$$

$$\beta_c = 1$$

# Modified Theory

## Based on Universe Expansion\*



\*Robertson, Glen A., "Engineering Dynamics of a Scalar Universe, Part I: Theory & Static Density Models," in the proceeding of Space, Propulsion & Energy Sciences International Forum, edited by Glen A. Robertson, AIP Conference Proceedings, Melville, New York, (2009a).

## Modified Theory

**For the earth**


$$\Delta R_m \approx \frac{1}{3} \left( \frac{M_E^2}{\rho_m R_m} \right) \left( \frac{2M_{PL}^4}{\rho_0} \right)^{1/3} \approx \sqrt{l_p R_m}$$

**For the other planets**

$$\Delta R_m \approx \frac{1}{3} \left( \frac{M_E^2}{\rho_m R_m} \right) \left( \frac{2M_{PL}^4}{\rho_0} \right)^{1/3} \approx \beta_i^2 \sqrt{l_p R_m}$$



## Modified Theory

$$\delta\Delta R_m \approx \sum \frac{1}{3} \left( \frac{M_E^2}{\hat{\beta}_c \delta\rho_m \bar{R}_m} \right) \left( \frac{2M_{PL}^4}{\rho_0} \right)^{1/3} = \left( \sum \delta\beta_i \right)^2 \sqrt{l_p \cdot \bar{R}_m}$$


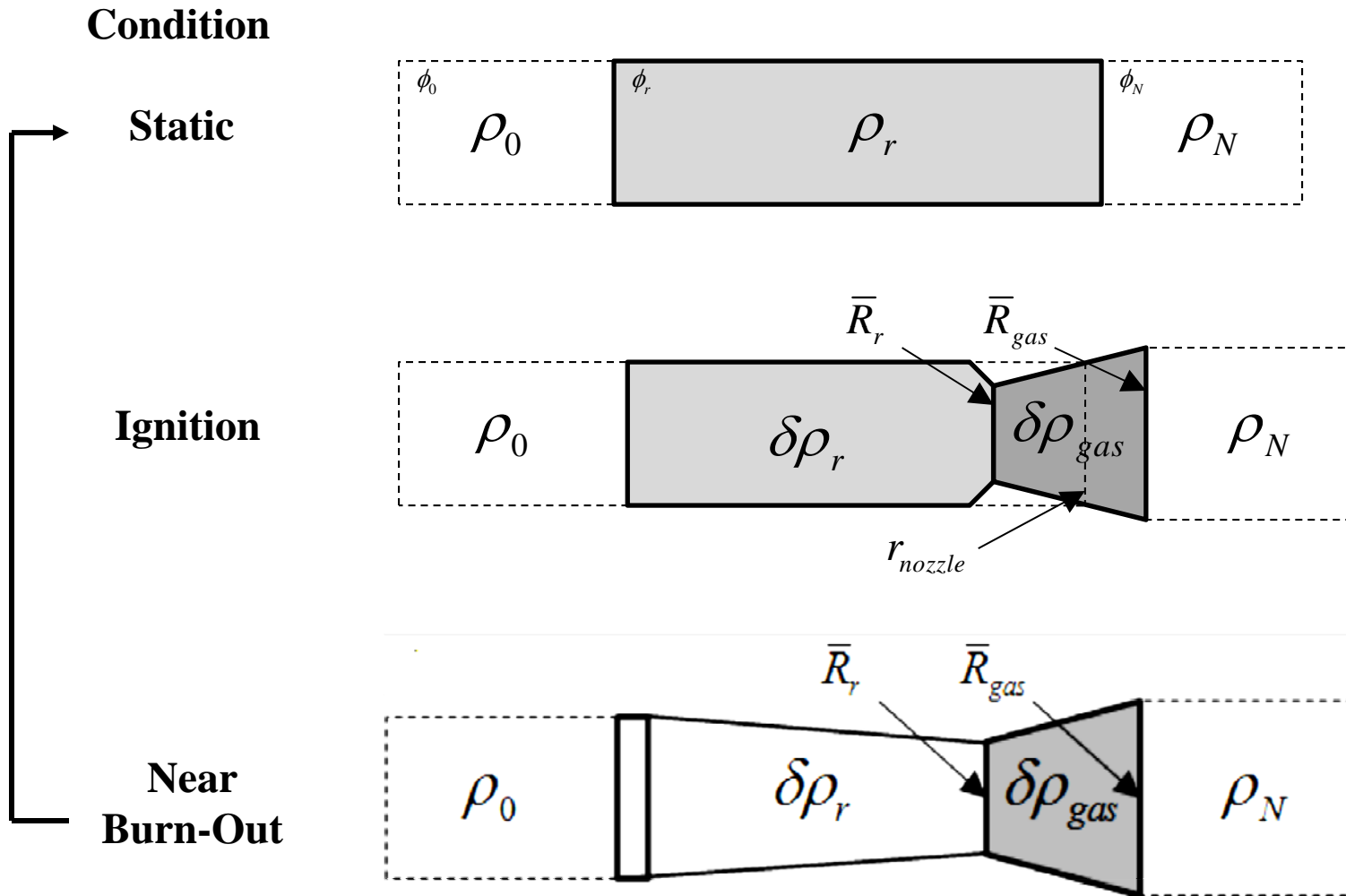
$$\hat{\beta}_c \neq 1$$

Bit complex as all the near fields have to be considered.

$$F_\phi \approx 6\delta\beta_m \left( \sum \delta\beta_i \right)^2 \sqrt{\frac{l_p}{\bar{R}_m}} F_N$$

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model



**The field density is only equal to the object density when static – not moving.**

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model

### Changing Field Densities

$$\delta\rho_r \approx \rho'_r + \left( \frac{F_r}{F_{N_r}} \right) \rho'_r \approx \frac{m'_r}{\bar{R}^3} \Rightarrow \frac{m'_r}{R_r^3} + \left( \frac{a_r}{g_N} \right) \left( \frac{m'_r}{R_r^3} \right) \approx \frac{m'_r}{\bar{R}^3}$$

$$\delta\rho_{gas} \approx \frac{4\pi}{3} \left( \frac{F_{gas}}{F_{N_{gas}}} \right) \rho'_{gas} \approx \frac{m'_{gas}}{\bar{R}_{gas}^3} \Rightarrow \left( \frac{a_{gas}}{g_N} \right) \left( \frac{m'_{gas}}{R_{gas}^3} \right) \approx \frac{m'_{gas}}{\bar{R}_{gas}^3}$$

$$m'_{gas} \approx \pi \left( \frac{\bar{R}_{gas}^3}{v_{gas}^2} \right) P_{gas} \times 100$$

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model

Thrust  $\longrightarrow T_r = -m'_r a_r$

Burnout Mass  $\longrightarrow m'_r \approx m_r - m_{ex}$

Acceleration  $\longrightarrow a_r \approx 6\alpha \left( \frac{\text{Phase Factor } \varphi^3}{\sqrt{l_p} \left( \frac{1}{\sqrt{R_r}} - \frac{1}{\sqrt{R_{gas}}} \right)} \right)^{1/2} g_N$

Planck Length  $l_p \approx 1.62 \times 10^{-35} \text{ m}$

Gravitational Constant ?

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model

Exhausted Mass velocity

Phase Factor

$$\varphi \approx \left( 1 + \left( \frac{v_{gas}}{\bar{R}_{gas}} \right) \left( \frac{m_{ex}}{\dot{m}} \right)^{-1} \right)$$

Total Exhausted Mass

Mass Flow Rate

$$\bar{R}_{gas} \approx r_{nozzle} \sqrt{2}$$

$$\bar{R}_r = \left( \frac{\varphi^3}{\sqrt{l_p}} \left( 6\alpha \left( \frac{g_N}{a_r} \right) \right)^2 + \frac{1}{\sqrt{\bar{R}_{gas}}} \right)^{-2} \approx r_{throat}$$

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model

**Example 1:** This example uses the data from example 2-1 in Sutton and Ross<sup>4</sup> converted to metric units. The example appears to be a Sidewinder, AMRAM or Similar Missile. Table I shows the given parameters, the parameters surmised (guessed) from a like missile, and the parameters calculated from these values. Although both the throat and nozzle radius are a bit of a guess, they are within expected values for like missiles. However of note is the sensitivity to five decimal places of the throat parameter to getting the exact thrust value.

**Table I.** The given, surmised and calculated values for the rocket with  $\alpha=1$ .

Given	Surmised	Calculated
$m_r = 90.72 \text{ kg}$	$r_{nozzle} \approx 0.051 \text{ m}$	$m'_r \approx 58.97 \text{ kg}$ (eqn. 2)
$m_{ex} = 31.75 \text{ kg}$	$r_{throat} \approx 0.01293 \text{ m}^*$	$\bar{R}_{gas} \approx 0.0718 \text{ m}$ (eqn. 5)
$v_{gas} \approx 2355.49 \text{ m/s}$		$\varphi \approx 1.02 \times 10^{-5}$ (eqn. 9)
$\dot{m} = 10.58 \text{ kg/s}$		
$F_{N_{BD}} \approx 578.74 \text{ N}$		$\alpha_r \approx 422.25 \text{ m/s}^2$ (eqn. 3)
$T \approx 2.49 \times 10^4 \text{ N}$		

\*Adjusted to give the same value as  $\alpha_r = T/m'_r \approx 422.25 \text{ m/s}^2$  (eqn. 1), but is close to the expected throat radius.

# Propulsion Physics under the Changing Density Field Model

## Field Density Rocket Model

**Conventional Rockets**

**Not in Paper**

$$T \approx \dot{m} v_{gas} \left( \frac{1}{1 + \varphi} \right); \varphi \ll 1$$

**Mass Flow Rate** →  $\dot{m}$

**Exhausted Mass velocity** →  $v_{gas}$

**Phase Factor** →  $\varphi$

**For conventional Rockets** →  $\varphi \ll 1$

Further studies need to be preformed to better understand how this new model can be used to improve the current propulsion models.

# Propulsion Physics under the Changing Density Field Model

**OK – What does this mean?**

**It means that propulsion can be achieved without mass ejection!**

**How?**

**By changing the density of an object in a linear fashion.**

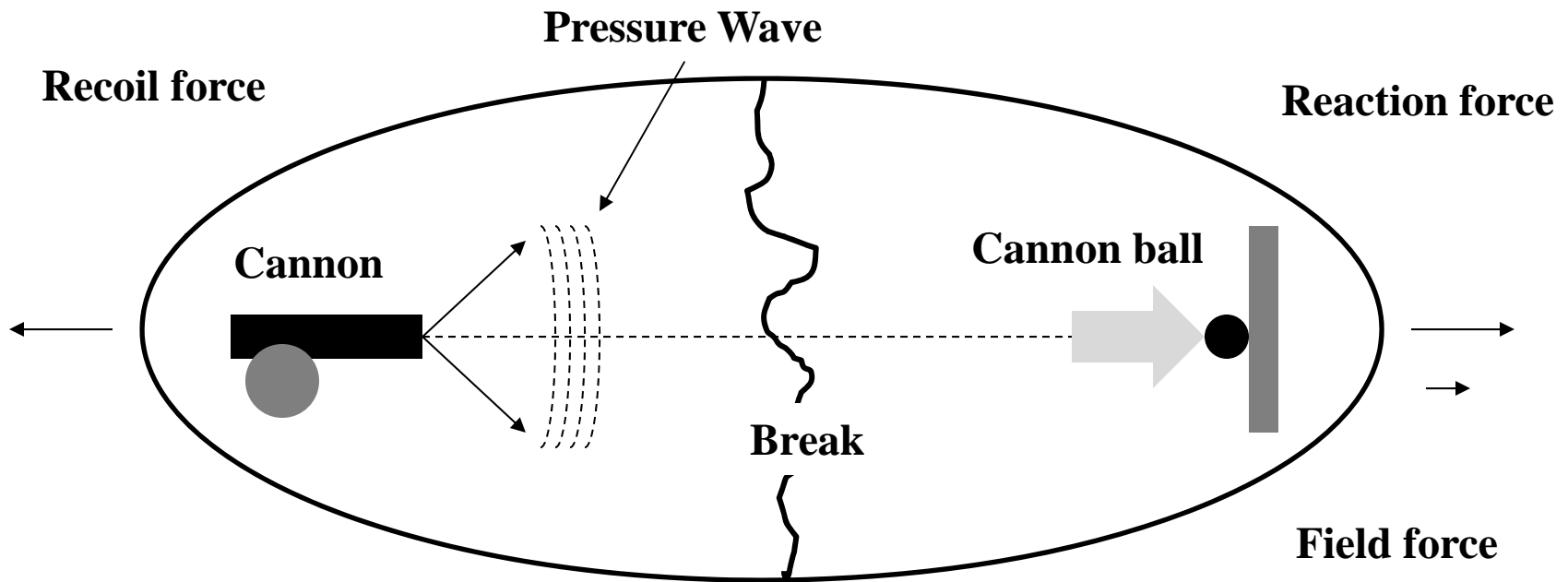
**But there is a catch ?**

- 1. The density change must be a product of the motion of coherent subatomic particles inside the object being accelerated, and**
- 2. The forward acceleration must be “GREATER THAN” the reverse acceleration.**

- 1. Done by nozzling atomic particles**
- 2. Reversed for ejected mass**



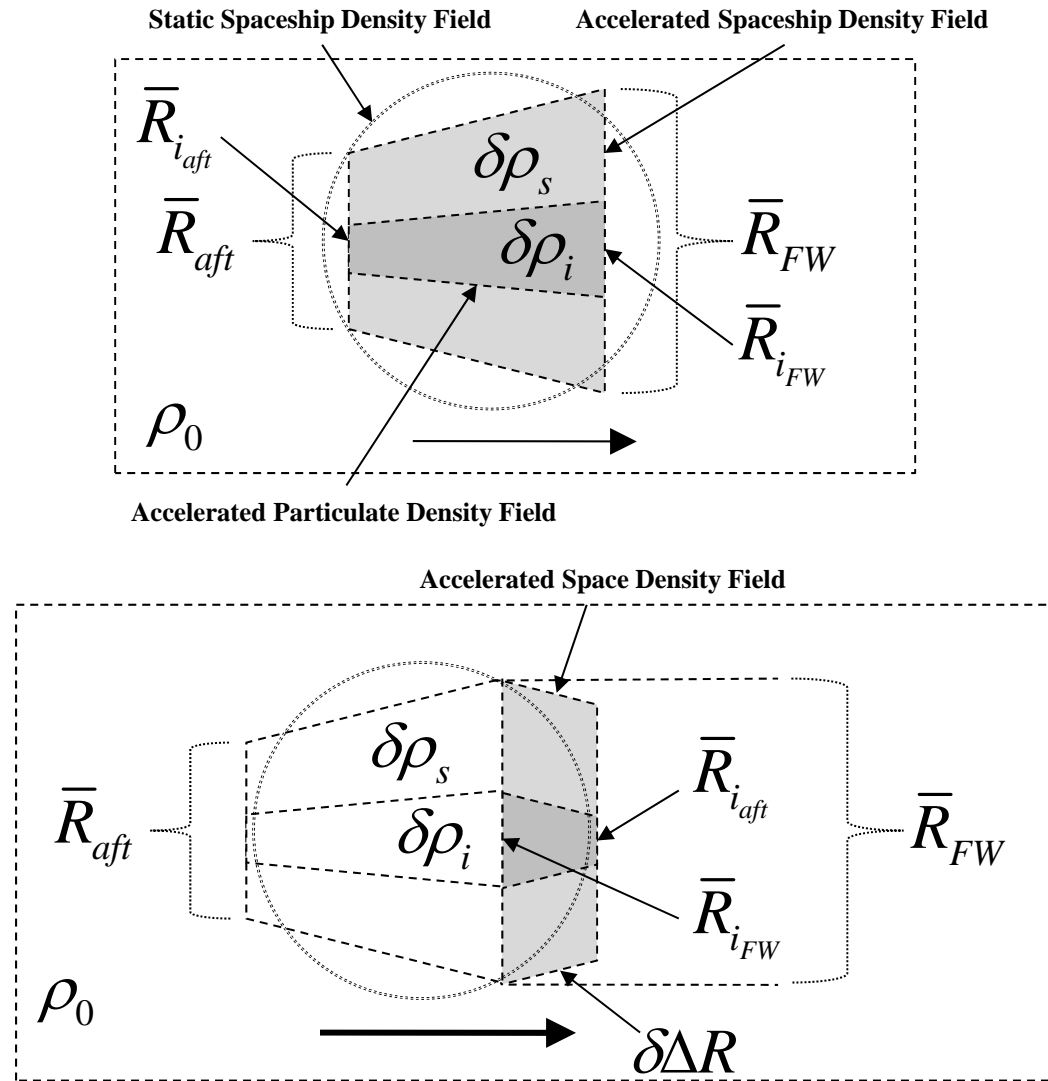
# Problem with “Marco Particles” inside an object.



[Video](#)

# Propulsion Physics under the Changing Density Field Model

## Propellant-less Model



# Propulsion Physics under the Changing Density Field Model

## Propellant-less Model

$$T_s \neq -m_\gamma a_\gamma \approx F_{\phi?} \Rightarrow T_s \approx \frac{m_\gamma}{m_s} F_{\phi?}$$

$$a_\gamma \approx 6\alpha \left( \frac{\hat{\phi}^3 \sqrt{\bar{R}_{aft}}}{\sqrt{l_p} \left( 1 - \sqrt{\frac{\bar{R}_{i_{aft}}}{\bar{R}_{i_{FW}}}} \right)} \right)^{1/2} \quad g_N \approx 6 \left( \alpha \hat{\phi}^3 \sqrt{\frac{\bar{R}_{aft}}{l_p}} \right)^{1/2} g_N$$

What is being accelerated?

$$\alpha \approx 1 - \sqrt{\frac{\bar{R}_{i_{aft}}}{\bar{R}_{i_{FW}}}}$$

# Propulsion Physics under the Changing Density Field Model

## Propellant-less Model

Not in Paper

$$m_{\gamma} = \frac{\dot{m}v_{gas}}{a_{\gamma}} = m_i \left( \frac{d}{\Delta t^2} \right) \left( \frac{1}{a_{\gamma}} \right) \approx \frac{m_i a_i}{a_{\gamma}}$$

$$T_s \approx \frac{m_{\gamma}}{m_s} F_{\phi?} = \frac{(m_{\gamma})^2 a_{\gamma}}{m_s} = \frac{(m_i a_i)^2}{m_s a_{\gamma}}$$

$$T_s \approx \frac{(m_i a_i)^2}{m_s a_{\gamma}} = \frac{(10^{-3} m_s \times a_{\gamma} / 10)^2}{m_s a_{\gamma}} = (10^{-8}) m_s a_{\gamma} \sim 20N$$

2000 kg      10<sup>6</sup> m/s

# Propulsion Physics under the Changing Density Field Model

## Propellant-less Model – Coupling Constant

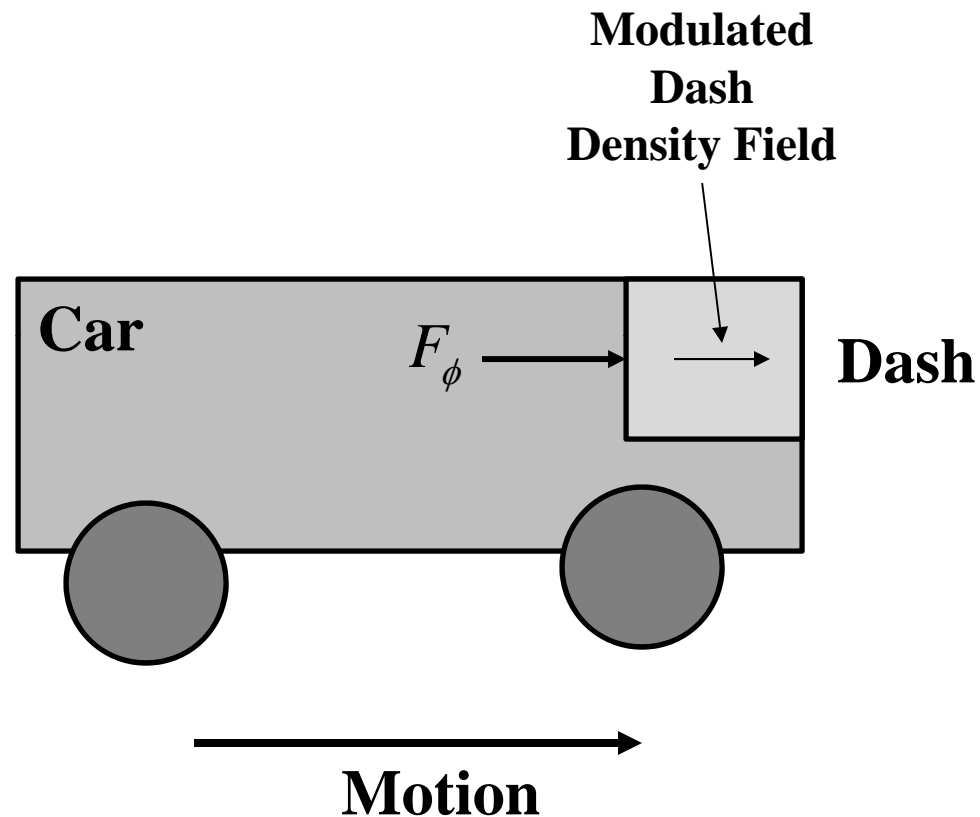
$$F_{\phi} \approx 6\delta\beta_m \left( \sum \delta\beta_i \right)^2 \sqrt{\frac{l_p}{R_m}} F_N$$

$$\delta\beta_m \left( \sum \delta\beta_i \right)^2 \approx \frac{1}{l_p} \left( \alpha \hat{\phi}^3 R_m \sqrt{l_p \bar{R}_{aft}} \right)^{1/2}$$

$$\Rightarrow \delta\Delta R \rightarrow \frac{\sqrt{R_m \bar{R}_{aft}}}{\delta\beta_{aft}} \left( \alpha \hat{\phi}^3 \sqrt{\frac{\bar{R}_{aft}}{l_p}} \right)^{1/2} \approx \frac{1}{6} \sqrt{R_m \bar{R}_{aft}} \left( \frac{a_7}{g_N} \right)$$

Further studies need to be preformed to better understand how this new model can be used to develop new propulsion systems.

You cannot push on the dash of you car to make it move – **UNLESS?**



Further studies need to be preformed to better understand how this new model can be used to develop new propulsion systems.