Parameters of the Selfvariating Universe (SVU)

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Abstract

The selfvariating universe (**SVU**) is the cosmological model of the Theory of Selfvariations (**TSV**) proposed by Manousos in (Manousos 2007) and (Manousos 2013 *b*). The Theory of Selfvariations (TSV) relies on the selfvariation principle and on the zero arc length propagation principle (Manousos 2013 *b*, 2013 *d*). The selfvariation principle predicts *a* slight increase of the rest mass of material particles and of the absolute electric charge of particles of matter. The selfvariating universe (SVU) is *a* static and flat universe, where cosmological redshift is explained without the need of the expansion. It predicts an exponential law for the cosmological redshift / distance relation (Manousos 2013 *b*, 2014 *a*) and *a* variation of the fine structure constant (Manousos 2013 *c*, §9), which has been measured by Webb (2011). In this paper we investigate the consequences of *a* larger set for the SV parameters than the one used by Manousos in (Manousos 2014 *a*, §1, 3). The investigation leads to *a* narrow set of possible values. However to accurately fix all SV parameters, *a* precise determination of the distance of astronomical objects, independent of any cosmological model and *a* more accurate measurement of the variation of the fine structure constant is needed. The discovery of the variation of α, is *a* strong support for the TSV, as no other mainstream theory can explain it. We have found that in one case, the SV universe (which begun with almost zero rest masses) is heading to *a* reversal procedure where the SV rest mass unit will become infinite. After that, it enters *a* reversed phase where SV rest mass unit acquires negative values. The reversal time T_R, lies in the future and can be no less than 13 Bill years from now. We also predict an anisotropy of cosmological redshift, for objects of the same distance and peculiar velocity.

Keywords : Theory of Selfvariations (TSV), Selfvariating universe (SVU), Cosmological redshift, SV rest mass unit, SV electric charge unit, Selfvariation parameters, Non–expanding universe, Static universe, Fine structure constant

1. Introduction

1.1. The fundamental laws of the selfvariating universe (SVU)

The selfvariating universe (**SVU**) is the cosmological model of the Theory of Selfvariations (**TSV**) proposed by Manousos in (Manousos 2007) and described in detail in (Manousos 2013 *b*, 2014 *b*). The SVU is based on the following laws of the TSV :

- **Law of rest mass selfvariation**

  Every rest mass m_0, in the universe increases slightly with time, according to the equation :

$$\partial_t \left(m_0\,(t) - \frac{b\,\hbar}{c^2}\,\frac{\partial_t\, m_0\,(t)}{m_0\,(t)} \right) = 0 \qquad (1)$$

where c, is the speed of light in vacuum, $\hbar$, is the reduced Plank constant and b, is *a* dimensionless arbitrary constant (Manousos 2013 *b*, §7 .2, 2013 *d*, §3 .4). All three constants, c, $\hbar$, b, are considered by the TSV to be universal spacetime constants.

- **Law of electric charge selfvariation**

  The electric charge q, of material particles in the universe varies slightly with time, according to the equation :

$$\partial_t \left(q(t) - \frac{b_e\,\hbar}{V_e}\,\frac{\partial_t\, q(t)}{q(t)} \right) = 0 \qquad (2)$$

where, V_e, is the selfvariation electric potential which according to (Manousos 2013 *b*, §7 .2,), §3, 4, where the potential V_e, is denoted as V_0], can vary slightly, taking positive or negative values. The value of the selfvariation potential V_e, whose units are, $J\,C^{-1}$, depends on the particle involved and on the distribution of charges in the surrounding spacetime. The parameter b_e, is *a* dimensionless arbitrary universal spacetime constant. The selfvariation law requires that the absolute charge of particles of matter slightly increases with time.

The SVU model predicted by the TSV is an overall flat, static universe with overall zero energy density, where expansion is not needed to explain cosmological redshift and other cosmological data. It has immense (possibly infinite) spatial and temporal dimensions which greatly exceed the currently observed universe and has existed for an indefinite period of time (Manousos 2013 *c*, §12, 2013 *d*, §3) . In the SVU model the universe did not begun with *a* Big Bang and there is no need for an inflationary phase to explain its large scale features. In contrast it quietly begun from *a* vacuum (or nearly vacuum) state with an imperceptible increase of the rest mass of material particles.
This increase is ongoing since then. Hence cosmological redshift is explained by the implication that, particles of matter of distant astronomical objects had smaller rest mass (and absolute electric charge) in the past and therefore emitted photons with larger wavelengths on the first place. Generally it is assumed that these photons have traveled through spacetime with unaltered wavelength. The TSV also predicts that the SV potential is such that the absolute electric charge of antimatter particles decreases with time, leading to neutral particles. This (partly) explains the matter–antimatter asymmetry we observe today.

One of the most surprising results of the TSV is that there is *a* unique way according to which the selfvariations can happen (Manousos 2013 *b*, 2013 *c*). The selfvariations are quantified in the SVU model by the laws of selfvariations (1), (2), which are the only possible assuming the principles of Relativity (incorporated in the TSV as the zero arc length propagation principle). The TSV predicts that the energy increase due to the increase of *a* particle' *s* rest mass caused by the selfvariation, is counterbalanced by the continual emission of generalized photons from the particle (Manousos 2013 *b*), such that total energy is conserved.
The result is that the total energy content of the SV universe is the same at all times and overall amounts to zero energy density. For more information about matter − antimatter asymmetry see (Manousos 2013 *d*, §3). For more information about the CMBR anisotropy see (Manousos 2013 *d*, §6). For information about generalized photons see (Manousos 2013 *b*).

2. Solutions of the selfvariation equations for the SVU

2.1. The SV rest mass and SV electric charge units

In this paper we will use the notation, $log\, x \equiv log_e\, x$, for the natural logarithm.
The general solutions of equations (1), (2) which give the rest mass and electric charge are :

$$m_0(t) = \frac{b\,k\,\hbar}{c^2}\,\frac{1}{1 - e^{k(t+\mu)}} \qquad (3)$$

$$q\,(t) = \frac{b_e\,k_e\,\hbar}{V_e}\,\frac{1}{1 - e^{k_e\,(t+\mu_e)}} \qquad (4)$$

where k, k_e, and μ, μ_e, are constants of integration having units s^{-1} and s, respectively. Manousos in (Manousos 2013 *b*) investigates the consequences of eq. (3), (4). He defines the parameter, $A = e^{k(t+\mu)}$, and considers the case where, $b = 1$, $k > 0$, and, $0 < A < 1$. In (Manousos 2013 *d*) he does *a* somewhat different investigation for eq. (e4). In this paper we want to enlarge the investigation of the above equations and for this purpose we start with as few assumptions for the parameters as possible. As restrictions for the parameters follow from necessary or plausible implications of the assumptions, we will write them down as parameter conditions $(C\,n)$. At the end we will sum everything together.
To simplify our exposition we define *a* spacetime coordinate system, $\boldsymbol{x} = (r, \theta, \varphi, t) = (\mathbf{r}, t)$, centered on Earth now, hence the current cosmic time is, $t_0 = 0$.

Let, $\mu = l + \dfrac{log\, b}{k}$, $\mu_e = l_e + \dfrac{log\, b_e}{k_e}$, where l, l_e, have time units. We also define the dimensionless parameters, $A = e^{k(t+l)}$, $B_e = e^{k_e(t+l_e)}$, $A_0 = e^{k\,l}$, and, $B_0 = e^{k_e\,l_e}$. Then we have :

$$m_0(t) = \frac{b\,k\,\hbar}{c^2}\,\frac{1}{1 - b\,e^{k(t+l)}} = \frac{b\,k\,\hbar}{c^2}\,\frac{1}{1 - b\,A} \quad (5)$$

$$m_0 = m_0\,(0) = \frac{b\,k\,\hbar}{c^2}\,\frac{1}{1 - b\,A_0} \quad (6)$$

where m_0, is the current, the same everywhere in the universe. Also considering that the SV electric potential V_e, may generally depend on $\boldsymbol{x}$, we have :

$$q\,(t) = \frac{b_e\,k_e\,\hbar}{V_e}\,\frac{1}{1 - b_e\,e^{k_e\,(t+l_e)}} = \frac{b_e\,k_e\,\hbar}{V_e}\,\frac{1}{1 - b_e\,B_e} \quad (7)$$

$$q_0 = q\,(0) = \frac{b_e\,k_e\,\hbar}{V_0}\,\frac{1}{1 - b_e\,B_0} \quad (8)$$

$$q_E = \frac{b_e\,k_e\,\hbar}{V_E}\,\frac{1}{1 - b_e\,B_0} \quad (9)$$

where q_0, V_0, are the current local values of q, V_e, at position $\mathbf{r}$, and q_E, V_E, are the current Earth values of q, V_e. Notice that the earth value of the SV electric charge, depends on t :

$$q_E\,(t) = \frac{b_e\,k_e\,\hbar}{V_E\,(t)}\,\frac{1}{1 - b_e\,B_e} \quad (10)$$

The parameters b, b_e, are arbitrary dimensionless multipliers for the rest mass and electric charge, so we only consider the values, b, $b_e = \pm 1$. For these values the above equations represent rest mass and electric charge units, which from now on will be called the SV rest mass unit and the SV electric charge unit respectively. Eqs. $(5-10)$ give the SV units in various cases. In this paper we only consider particles with finite non–zero rest mass and electric charge, so we require that, k, k_e, $V_e \neq 0$. In particular we consider particles with finite non–zero current and local SV rest mass and electric charge units. All these restrictions constitute our first parameter condition (C0) :

$$\boxed{\begin{array}{ll} b,\ b_e = \pm 1 & \\ k,\ k_e,\ V_e \neq 0 & \\ \text{If, } b = 1 \Rightarrow t + l,\ l \neq 0 & \text{(C0)} \\ \text{If, } b_e = 1 \Rightarrow t + l_e,\ l_e \neq 0 & \end{array}} \Rightarrow \left(V_0,\ V_E \neq 0 \bigwedge \begin{array}{l} \text{If, } b = 1 \Rightarrow A,\ A_0 \neq 1 \\ \text{If, } b_e = 1 \Rightarrow B_e,\ B_0 \neq 1 \end{array} \right)$$

Notice that the parameters A, B_e, k_e, are not exactly the same as the A, B, k_1, parameters used by Manousos in his papers (Manousos 2013 d, §2, 4).

2.2. Derivatives of the SV units

We consider the time derivatives of the SV units $\left(\text{considering, } \partial_t\,A = k\,A,\ \partial_t\,B_e = k_e\,B_e, \text{ and, } b^2 = b_e^2 = 1\right)$, which must satisfy the requirements of the selfvariation laws :

$$\partial_t\,m_0(t) = \frac{k^2\,\hbar}{c^2}\,\frac{A}{(1 - b\,A)^2} = \frac{c^2\,A}{\hbar}\,m_0(t)^2 > 0,\ \forall\,t \Rightarrow A,\ A_0 > 0 \quad (11)$$

Sufficient (but however not necessary) conditions for (11) are : k, t, $l \in \mathbb{R}$. We also have :

$$\frac{\partial_t\,m_0(t)}{m_0(t)} = \frac{b\,k\,A}{1 - b\,A} \quad (12)$$

If we assume that the SV electric potential V_e, is time independent, we have for particles of matter :

$$\partial_t q(t) = \frac{k_e^2\,\hbar}{V_e}\,\frac{B}{(1 - b_e\,B)^2} \Rightarrow \qquad \text{(since, } q(t) \neq 0\text{)}$$

$$\frac{\partial_t q\,(t)}{q\,(t)} = q\,(t)\,\frac{V_e\,B_e}{\hbar} = \frac{b_e\,k_e\,B_e}{1 - b_e\,B_e} > 0,\ \forall\,t \quad (13)$$

As above we only consider real values of the parameters, k_e, $l_e \in \mathbb{R}$, (which in this case are neither sufficient nor generally necessary conditions to satisfy eq.(13)). Then :

$$B_e, B_0 > 0 \Rightarrow q(t)\, V_e > 0 \Rightarrow \frac{b_e\, k_e}{\frac{1}{B_e} - b_e} > 0 \Leftrightarrow \begin{pmatrix} b_e = 1 \\ \frac{k_e}{\frac{1}{B_e} - 1} > 0 \end{pmatrix} \bigvee \begin{pmatrix} b_e = -1 \\ \frac{k_e}{\frac{1}{B_e} + 1} < 0 \end{pmatrix}$$

All these restrictions constitute the parameter condition (C1a) for matter particles :

$$\boxed{\begin{array}{ll} k, k_e, t, l, l_e \in \mathbb{R} & \\ A, A_0 > 0 & \text{(C1a)} \\ B_e, B_0 > 0 & \end{array}}$$

$$\boxed{\begin{array}{l} \text{Particles of matter } - \text{ Time independent } V_e \\ \begin{pmatrix} & b_e = 1 & \\ k_e < 0 & \bigvee & k_e > 0 \\ B_e, B_0 > 1 & & 0 < B_e, B_0 < 1 \end{pmatrix} \bigvee \begin{pmatrix} b_e = -1 \\ k_e < 0 \\ B_e, B_0 > 0 \end{pmatrix} \quad \text{(C1b)} \end{array}} \Leftrightarrow \begin{pmatrix} q(t)\, V_e > 0 \\ q_0\, V_0 > 0 \\ q_E\, V_E > 0 \end{pmatrix}$$

If more generally we assume that the SV electric potential V_e, is time dependent, we have :

$$\frac{\partial_t q(t)}{q(t)} = q(t)\, \frac{V_e\, B_e}{\hbar} - \frac{\partial_t V_e}{V_e} = \frac{b_e\, k_e\, B_e}{1 - b_e\, B_e} - \frac{\partial_t V_e}{V_e} > 0, \forall\, t \qquad (14)$$

Hence the parameter conditions for matter particles are :

$$\boxed{\begin{array}{l} \text{Particles of matter } - \text{ Time dependent } V_e \\ \begin{pmatrix} b_e = 1 \\ \frac{k_e\, B_e}{1 - B_e} - \frac{\partial_t V_e}{V_e} > 0 \end{pmatrix} \bigvee \begin{pmatrix} b_e = -1 \\ \frac{k_e\, B_e}{1 + B_e} + \frac{\partial_t V_e}{V_e} < 0 \end{pmatrix} \quad \text{(C1c)} \end{array}}$$

In this case the parameter condition C1c is more complicated and will not be considered here in greater detail (it can be found online at : http : // apminstitute.org/category/physics/). In any case and for the rest of this paper, we assume only the parameter condition C1a and C1b, unless otherwise noticed.
As we work through this paper we will gather more conditions for the parameters, implied by various assumptions and observational data and we will try to estimate possible values for the parameters.

2.3. Introduction of the parameters M, and W

We define two time dependent parameters, $M, W \in \mathbb{R}$, with units s^{-1}, which satisfy the differential equations :

$$\frac{\partial_t M}{M} = k \qquad \frac{\partial_t W}{W} = k \qquad (15)\,(16)$$

$$M_0 = \frac{\partial_t m_0}{m_0} = M(0) \qquad W_0 = \frac{\partial_t q_0}{q_0} = W(0) \qquad (17)\,(18)$$

Hence :

$$M = M_0\, e^{k\, t} \qquad W = W_0\, e^{k_e\, t} \qquad (19)\,(20)$$

where as above we assume that V_e, is time–independent. These parameters are carefully chosen and connect the SVU with the SCM.In section 4.2 we will see how they are related to the Hubble parameter. From eqs. (17), (18), considering eq.(12), (13) we have :

$$M_0 = \frac{b\, k\, A_0}{1 - b\, A_0} = \frac{b\, k}{e^{-k\, \mu} - b} \qquad (21)$$

$$W_0 = \frac{b_e\, k_e}{e^{-k_e\, \mu_e} - b_e} = \frac{b_e\, k_e\, B_0}{1 - b_e\, B_0} \qquad (22)$$

$$M = M_0\, \frac{A}{A_0} = \frac{b\, k\, A}{1 - b\, A_0} = \frac{b\, k\, e^{k\, t}}{e^{-k\, \mu} - b} \qquad (23)$$

$$W = W_0 \frac{B}{B_0} = \frac{b_e k_e B_0}{1 - b_e B_0} = \frac{b_e k_e e^{k_e t}}{e^{-k_e \mu_e} - b_e} \qquad (24)$$

thus :

$$A_0 = \frac{M_0}{b(k + M_0)}, \text{ and, } B_0 = \frac{W_0}{b_e(k_e + W_0)} \qquad (25)$$

We will call M, the Manousos parameter and M_0, the Manousos constant.

From C0, C1a, we have that, M, M_0, W, $W_0 \neq 0$. Below we analyze the conditions under which eqs. (21), (22), are valid.

$$\boxed{\begin{array}{l} M_0 > 0 \Rightarrow M > 0, \text{ and, } \left(\begin{pmatrix} b = 1 \\ \begin{array}{c} 0 < A_0 < 1 \\ k > 0 \end{array} \bigvee \begin{array}{c} A_0 > 1 \\ -M_0 < k < 0 \end{array} \end{pmatrix}, \text{ or, } \begin{pmatrix} b = -1 \\ \begin{array}{c} 0 < A_0 \leq 1 \\ k \leq -2\, M_0 \end{array} \bigvee \begin{array}{c} A_0 \geq 1 \\ -2\, M_0 \leq k < -M_0 \end{array} \end{pmatrix}\right) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{or} \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{(C2a)} \\ M_0 < 0 \Rightarrow M < 0, \text{ and, } \left(\begin{pmatrix} b = 1 \\ \begin{array}{c} 0 < A_0 < 1 \\ k < 0 \end{array} \bigvee \begin{array}{c} A_0 > 1 \\ 0 < k < -M_0 \end{array} \end{pmatrix}, \text{ or, } \begin{pmatrix} b = -1 \\ \begin{array}{c} 0 < A_0 \leq 1 \\ k \geq -2\, M_0 \end{array} \bigvee \begin{array}{c} A_0 \geq 1 \\ -M_0 < k \leq -2\, M_0 \end{array} \end{pmatrix}\right) \end{array}}$$

$$\boxed{\begin{array}{l} W_0 > 0 \Rightarrow W > 0, \text{ and, } \left(\begin{pmatrix} b_e = 1 \\ \begin{array}{c} 0 < B_0 < 1 \\ k_e > 0 \end{array} \bigvee \begin{array}{c} B_0 > 1 \\ -W_0 < k_e < 0 \end{array} \end{pmatrix}, \text{ or, } \begin{pmatrix} b_e = -1 \\ \begin{array}{c} 0 < B_0 \leq 1 \\ k_e \leq -2\, W_0 \end{array} \bigvee \begin{array}{c} B_0 \geq 1 \\ -2\, W_0 \leq k_e < -W_0 \end{array} \end{pmatrix}\right) \\ \qquad\qquad\qquad\qquad\qquad\qquad \text{or} \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{(C2b)} \\ W_0 < 0 \Rightarrow W < 0, \text{ and, } \left(\begin{pmatrix} b_e = 1 \\ \begin{array}{c} 0 < B_0 < 1 \\ k_e < 0 \end{array} \bigvee \begin{array}{c} B_0 > 1 \\ 0 < k_e < -W_0 \end{array} \end{pmatrix}, \text{ or, } \begin{pmatrix} b_e = -1 \\ \begin{array}{c} 0 < B_0 \leq 1 \\ k_e \geq -2\, W_0 \end{array} \bigvee \begin{array}{c} B_0 \geq 1 \\ -W_0 < k_e \leq -2\, W_0 \end{array} \end{pmatrix}\right) \end{array}}$$

If we combine C2b with C1b (where the SV potential is assumed time independent), we see that all cases were, $W_0 < 0$, are excluded and we are left with the first part of condition C2b only :

$$\boxed{W_0 > 0 \Rightarrow W > 0 \qquad \text{(C2c)}}$$

This is *a* remarkable restriction of the parameter conditions C2b, valid for particles of matter. In the other case where the SV potential is time dependent, the combination of condition C1c with C2b, leads to roughly similar results, in the case that, $1 \gg \partial_t V_e \simeq 0$, . Thus we are almost confident that the current constant W_0, has *a* positive value in both cases.

3. The fine structure constant α

3.1. Relative SV electric potential

Manousos states in (Manousos 2013 *d*, §3) that the SV electric potential only slightly varies with position. We will confirm this in section 3.4. In this paper we will take *a* reference value to be its current Earth value V_E. Since, $V_E \neq 0$. we can define *a* relative SV electric potential, $V_R \neq 0$, generally depending on $\boldsymbol{x}$, as :

$$V_R = \frac{V_e}{V_E} \qquad (26)$$

3.2. The SV rest mass and SV electric charge units observed at distance *r*, from Earth

We cannot directly measure the current SV rest mass and SV electric charge units at any particular $\boldsymbol{x}$. This is called by Manousos (Manousos 2013 *b*, §4 .9), the internality of the universe in the measurement process. However we can find the relation between the current SV units and the SV units measured at *a* cosmological distance *r*, as observed from Earth. The look back time (in the SVU) from *a* distances r, is, $\Delta t = \frac{r}{c}$. From eqs. (5), (6), we find the value of the relative SV rest mass unit at the time of photon emission :

$$m_0(-\Delta t) = \frac{b\,k\,\hbar}{c^2}\frac{1}{1 - b\,e^{k(-\Delta t + l)}} \Rightarrow$$

$$m_0(r) = \frac{b\,k\,\hbar}{c^2}\frac{1}{1 - b\,e^{k\left(-\frac{r}{c} + l\right)}} \Rightarrow$$

$$\frac{m_0(r)}{m_0} = \frac{1 - b\,A_0}{1 - b\,A_0\,e^{-\frac{k\,r}{c}}} = \frac{1}{1 + \frac{M_0}{k}\left(1 - e^{-\frac{k\,r}{c}}\right)} \qquad (27)$$

where, $\frac{m_0(r)}{m_0}$, is the SV rest mass unit observed from Earth at distance r (in our time epoch) , relative to its current value.

In the same way we get the corresponding equations for the relative SV electric charge unit from eqs. (7), (9), (26) :

$$\frac{q(r)}{q_E} = \frac{1}{V_R}\frac{1 - b_e\,B_0}{1 - b_e\,B_0\,e^{-\frac{k_e\,r}{c}}} = \frac{1}{V_R}\frac{1}{1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e\,r}{c}}\right)} \qquad (28)$$

3.3. Distance in the SCM and SVU

We have to clarify the notion of distance we refer to in the SVU model and how this distance relates to the distances that are in use in the context of the SCM. The flat and static non–expanding SVU model is compatible with *a* unique distance notion, which does not overall change with time. In the expanding universe of the SCM, and particular in the context of the Friedmann–Lemaître–Robertson–Walker solution, we have two distances which concern us here;
the light travel (or look back) distance given by :

$$r_L = \frac{c}{H_0}\int_0^z \frac{1}{(1+v)\sqrt{\Omega_m(1+v)^3 + \Omega_k(1+v)^2 + \Omega_\Lambda}}\,dv$$

and the comoving distance given by :

$$r_c = \frac{c}{H_0}\int_0^z \frac{1}{\sqrt{\Omega_m(1+v)^3 + \Omega_k(1+v)^2 + \Omega_\Lambda}}\,dv$$

where Ω_m, is total matter density, Ω_Λ, is dark energy density and, $\Omega_k = 1 - (\Omega_m + \Omega_\Lambda)$, represents the curvature. The current Λ–CDM models sets these values at : $\Omega_\Lambda = 0.728$, $\Omega_m = 0.262$, and, $\Omega_k = 0.002$. However we will use *a* flat universe ($\Omega_k = 0$), as is predicted by the SVU model. The comoving distance of the Λ–CDM model, which is the proper distance at current time epoch, is the one that best matches the distance notion of the SVU. Thus we set :

$$r \equiv r_c$$

These relations will enable us to assign the observed cosmological data (for ex. redshift) to distances in the SVU model. Notice also that the light travel (look back) distance in the SVU, is generally the same as the distance, since light is generally assumed to be received at the same wavelength as it is emitted. Also notice that we do not restrict ourselves to the currently used set of cosmological parameters given above, but we will explore the whole interval of values : $0 \le \Omega_\Lambda \le 1$. In particular we will use four values : $\Omega_\Lambda = \{0, 0.5, 0.728, 0.99\}$. The reason is that cosmological distances are not accurately measured independently of the cosmology used. Whereas redshift is *a* direct observable, the current proper distance of an astronomical object is usually only indirectly inferred, via *a* particular choice of *a* cosmology parameter set. Thus changing the cosmology used, results in considerable differences for the 'proper' distance .

3.4. Variation of the fine structure parameter

The definition of the fine structure constant is :

$$\alpha = \frac{e^2}{4\,\pi\,\varepsilon_0\,\hbar\,c}$$

The fine structure parameter is actually *a* constant only if all quantities on the right hand side are constants. Since the SVU model predicts *a* variation of the fundamental electric charge e, it comes to no surprise that $J.K.$ Webb (Webb 2011) measured *a* variation in α,

$$\frac{\Delta\alpha}{\alpha} = \frac{\alpha(r) - \alpha}{\alpha} \lesssim \pm 10^{-5} \tag{29}$$

at light travel SCM distances ca, $r_L \lesssim 3$ Gpc. This variation can be regarded as *a* confirmation of the principles of the Theory of Selfvariations (at least of the electric charge selfvariation), since it is not predicted by the usual physical theories (Manousos 2013 *c*, §9). In the SVU model this variation is explained by the dependence of the SV electric charge unit on r, and V_e. Setting :

$$\alpha(r) = \frac{e(r)^2}{4\pi\varepsilon_0 \hbar c} \tag{30}$$

where, $e(r)$, is the fundamental electric charge observed currently from Earth at distance r, and e, is the current fundamental electric charge (*i.e.* the electron or proton charge) as measured currently on Earth. From eq. (28) we have :

$$\frac{\Delta\alpha}{\alpha} = \frac{e(r)^2}{e^2} - 1 = \frac{q(r)^2}{q_E^2} - 1 = \frac{1}{V_R^2\left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right)\right)^2} - 1 \lesssim \pm 10^{-5} \tag{31}$$

Two factors influence the value of α. The fluctuation of the (relative) SV electric potential V_R, and the selfvariation of the electric charge, expressed here by the factor, $1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right)$. If we ignore the electric charge selfvariation assuming, $\frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right) \simeq 0$, we have *a* variation in α, coupled only with the SV electric potential :

$$\frac{\Delta\alpha}{\alpha} = \frac{1}{V_R^2} - 1 \tag{32}$$

If we ignore the relative SV electric potential assuming, $V_R \simeq 1$, we have *a* variation in α, coupled only with the electric charge selfvariation :

$$\frac{\Delta\alpha}{\alpha} = \frac{1}{\left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right)\right)^2} - 1 \tag{33}$$

The total effect stems from both factors and we want to estimate their relative strength. The measurements of Webb, King et al. have found that the variation of α, has *a* large scale dipole form, where at opposite poles, $\Delta\alpha$, has opposite signs $\left(\text{approximately, } \frac{\Delta\alpha}{\alpha} \simeq \pm 10^{-5}, \text{ at light travel SCM distances ca 3 Gpc}\right)$. Also there seem to be random fluctuations at smaller scales $\left(\frac{\Delta\alpha}{\alpha} \lesssim \pm 10^{-5}, \text{ at distances } \lesssim 3 \text{ Gpc}\right)$ (Webb 2011). Both these facts are compatible with an underlying fluctuation of V_R. Contrariwise the selfvariation itself, requires an isotropic decrease of α, in all directions of the sky. In (Webb 2011), (King 2012), Webb, King et al., indicate *a* small difference between the absolute average values of $\Delta\alpha$, at the two poles :

$$\frac{\Delta\alpha_+}{\alpha} + \frac{\Delta\alpha_-}{\alpha} \simeq -0.1 \times 10^{-5}$$

Since they averaged data from *a* lot of sources, measured with two different telescopes (Keck and VLT), it is possible that this difference, is the true manifestation of the electric charge selfvariation. In any case, from these data, we estimate an upper bound for the underlying isotropic decrease caused by the electric charge selfvariation, of about

$$\delta \simeq -10^{-6}$$

(34)

for an SCM light travel distance, $r_L \simeq 3$ Gpc, which corresponds, $z = 1.5$, and thus to comoving distances of the Λ–CDM model for various values of Ω_Λ :

Ω_Λ	r_c(Gpc)
0	3.25
0.5	4.0
0.728	4.6
0.99	6.5

The comoving distance intended by Webb is, 4.6 Gpc ($\Omega_\Lambda = 0.726$, was used in (Webb 2011)). Since we consider that the actual proper SVU distance has to be measured by other means, independent of any cosmological model, we will use in this paper an even wider range of, $3 \lesssim r_1 \lesssim 8$ Gpc, as *a* possible range of SVU distances, corresponding to the SCM light travel distance, $r_L \simeq 3$ Gpc, in Webb'*s* paper. The distance uncertainty of r_1, might look huge at, $z = 1.5$, however as the uncertainty increases with z, the corresponding uncertainty at for ex., $z = 0.1$, is only 10 %, corresponding to distances between, 400 – 445 Mpc;
an uncertainty margin which might indeed seem too narrow (see Fig .3).

From eq. (33) we have :

$$0 > \frac{1}{\left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right)\right)^2} - 1 \gtrsim \delta \Leftrightarrow \begin{pmatrix} 0 < \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right) \lesssim \frac{1}{\sqrt{1+\delta}} - 1 \simeq -\frac{\delta}{2} \\ \text{or} \\ -2 + \frac{\delta}{2} \lesssim \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right) < -2 \end{pmatrix}$$

where for this and the following equations we use inequalities, since we consider that, $|\delta| \simeq -10^{-6}$, is an upper bound for the manifestation of the electric charge selfvariation.

Form condition C1b (*i.e.* $q(t)\, V_e > 0$, $q_E\, V_E > 0$) and eq. (28), we infer that, $1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right) > 0$. Hence we discard the latter condition and keep only :

$$0 < \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right) \lesssim -\frac{\delta}{2} \simeq 5 \times 10^{-7} \qquad \text{(C3)}$$

where, $r < r_1$, and, $3 \lesssim r_1 \lesssim 8$ Gpc, corresponding to SCM light travel distance, $r_L \simeq 3$ Gpc

From C3 we have :

$$0 < W_0 \lesssim -\frac{\delta\, k_e}{2}\left(1 - e^{-\frac{k_e r}{c}}\right)^{-1} \qquad (35)$$

The parameter k_e, is very close to zero and can be either positive or negative, but not exactly zero (condition C0). The graph below reflects this inequality and plots the W_0 area, against k_e.

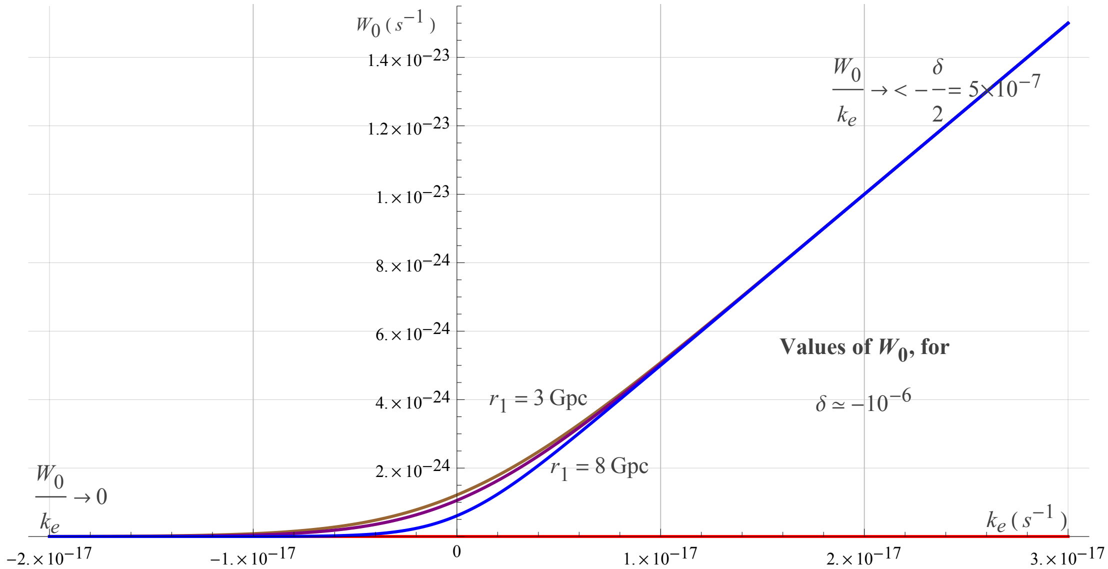

Fig. 1 : Possible values of W_0, against k_e, for, $r_1 = 3,\ 4,\ 4.6,\ 8$ Gpc (curves in descending order) according to condition C3.

From the graph we see that the uncertainty of r_1, does not affect the order of magnitude of the SV parameters W_0, and k_e. For, $k_e \simeq 0$, and various r_1, we have the values :

r_1(Gpc)	$0 < W_0 \lesssim$
3.0	1.6×10^{-24}
4.0	1.2×10^{-24}
4.6	1.05×10^{-24}
8.0	6.1×10^{-25}

A similar value is given by Manousos in (2014 *a*, §3).Theoretically the curve of Fig .1 extends on the right to much larger values for both W_0, and k_e. However the justification for the scale chosen in this figure, comes from conditions C6, C7 $\left(W_0 \ll H_0 \ll 2.2\times10^{-18}\right)$ in section 4.2. In particular :

$$k_e < 10^{-18} \Rightarrow 0 < W_0 < 2\times10^{-24} \qquad \text{(C3a)}$$

Form eq. (31) we see that the combined effect of the SV electric potential and the electric charge selfvariation on cosmological redshift, for distances up to *a* few Gpc, is very small :

$$1 - 10^{-5} \lesssim V_R^2 \left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e r}{c}}\right)\right)^2 \lesssim 1 + 10^{-5}$$

Combining with condition C3 we have

$$1 - 1.1\times10^{-5} \lesssim V_R^2 \lesssim 1 + 0.9\times10^{-5}$$

hence :

$$1 - 5.5\times10^{-6} \lesssim V_R \lesssim 1 + 4.5\times10^{-6} \qquad \text{(C4)}$$

for distances, $3 \lesssim r_1 \lesssim 8$ Gpc, corresponding to SCM light travel distance, $r_L \simeq 3$ Gpc

4. Cosmological redshift

4.1. The exponential redshift/ distance relation

The TSV predicts that in the SVU, the photon emissions of distant astronomical objects happened at *a* time when the rest mass and absolute charge of particles of matter were smaller and hence the emisssion/absorption wavelengths were larger. In this way cosmological redshift is explained in *a* flat static (non–expanding) universe, where generally we assume that radiation from distant astronomical objects is recieved at the same wavelength as it is emitted. Let, $\lambda(r)$, be the wavelength recieved today (at current time epoch) of photons emitted from atoms at position **r**. Let λ_E, be the corresponding photon wavelength in our laboratory. Cosmological redshift (measured at current time epoch t_0) is defined as :

$$z = \frac{\lambda(r)}{\lambda_E} - 1 \tag{36}$$

According to the simple Bohr model, which however is reasonably exact for simple atoms, the photon wavelength is inversely proportional to the rest mass and the 4 th power of the electric charge of the emitting particle, so we have :

$$z = \frac{m_0}{m_0(r)}\left(\frac{q_E}{q(r)}\right)^4 - 1 \tag{37}$$

Cosmological redshift depends on both the relative SV rest mass and the relative SV electric charge units. From eq. (27), (28), we have :

$$z = V_R{}^4\left(1 + \frac{M_0}{k}\left(1 - e^{-\frac{k\,r}{c}}\right)\right)\left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e\,r}{c}}\right)\right)^4 - 1 \tag{38}$$

This exponential redshift/ distance relation gives cosmological redshift (for simple atoms) in the flat non–expanding universe according to the SVU model. For small cosmological distances up to few hundred Mpc, it should be nearly coincident with the Hubble law. In the next section we will see that the derivative of z, (relative to distance) at, $r = 0$, is actually the Hubble law and this enables us to estimate some SV parameters.

From conditions C3, C4, we are motivated to define *a* mean redshift, which compensates for the fluctuations of the SV electric potential :

$$z_M = \frac{1 + z}{V_R{}^4} - 1 \Rightarrow \tag{39}$$

$$z_M = \left(1 + \frac{M_0}{k}\left(1 - e^{-\frac{k\,r}{c}}\right)\right)\left(1 + \frac{W_0}{k_e}\left(1 - e^{-\frac{k_e\,r}{c}}\right)\right)^4 - 1 \tag{40}$$

Combining eq. (40) we get condition C5 :

$$\frac{M_0}{k}\left(1 - e^{-\frac{k\,r_1}{c}}\right) \simeq z_1 = 1.5 \qquad \text{(C5)}$$
where, $3 \lesssim r_1 \lesssim 8$ Gpc

where we have assumed that in the SVU model, *a* redshift of, $z_1 = 1.5$, corresponds to distances, $3 \lesssim r_1 \lesssim 8$ Gpc. Taking the ratio with Cd3 we have :

$$0 < \frac{\frac{W_0}{k_e}\left(1 - e^{-\frac{k_e\,r_1}{c}}\right)}{\frac{M_0}{k}\left(1 - e^{-\frac{k\,r_1}{c}}\right)} \lesssim 3\times 10^{-7} \tag{41}$$

Notice that the exact value of r_1, does not affect the order of magnitude of this result, which shows how much weaker the electric charge selfvariation is relative to the rest mass selfvariation. Hence we can write the exponential redshift/ distance relation in the SVU, in *a* much simpler but nevertheless quite accurate approximation :

$$z \simeq V_R{}^4\left(1 + \frac{M_0}{k}\left(1 - e^{-\frac{k\,r}{c}}\right)\right) - 1 \tag{42}$$

$$z_M \simeq \frac{M_0}{k}\left(1 - e^{-\frac{k\,r}{c}}\right) \tag{43}$$

These are important relations because they are simple and very accurate for distances up to *a* few Gpc. From eq. (39) we have :

$$z \simeq V_R{}^4 (1 + z_M) - 1 \tag{44}$$

Since V_R, is slightly fluctuating, we expect that for *a* particular distance *r* (where z_M, is fixed), the actual measured cosmological redshift *z*, will show slight fluctuations and some anisotropic behavior over the entire sky. This can be revealed by exact measurements, especially for large redshifts. For small redshifts the peculiar velocities will cause an additional superimposed effect.

4.2. The Hubble law and its role in the SCM and SVU

From eq. (38), we have that the derivative of the cosmological redshift over distance is :

$$\partial_r z = \frac{1+z}{c} \left(\frac{k}{\left(1 + \frac{k}{M_0}\right) e^{\frac{k r}{c}} - 1} + \frac{4 k_e}{\left(1 + \frac{k_e}{W_0}\right) e^{\frac{k_e r}{c}} - 1} + 4 c \frac{\partial_r V_R}{V_R} \right) \tag{45}$$

and at the limit, $r \to 0$, we have, $V_R \to 1$, thus :

$$\partial_r z(0) = \frac{M_0 + 4 W_0}{c} + 4 \partial_r V_R(0) \tag{46}$$

From condition C4, we can assume that most probably the SV potential derivative is negligible. Thus :

$$\partial_r z(0) \simeq \partial_r z_M(0) = \frac{M_0 + 4 W_0}{c} \tag{47}$$

Since mean redshift increases with distance (in conformity with the Hubble law) we have, $M_0 + 4 W_0 > 0$, and since $W_0 > 0$ (from condition C2c), we have, $M_0 > 0$. From eq. (43) we also have :

$$\partial_r z_M(0) \simeq \frac{M_0}{c} \tag{48}$$

Combining these we get another condition for the selfvariation parameters, $W_0 \ll M_0$, based on the condition (C5), where in this paper, $\ll$, will mean ' smaller by several orders of magnitude '. Hence we have :

$$\boxed{\partial_r V_R(0) \simeq 0 \Rightarrow 0 < W_0 \ll M_0 \qquad \text{(C6)}}$$

We assume that the Hubble law refers to mean redshift (since the fluctuation of redshift is negligible for small distances and has not been noticed so far). From this law we have :

$$z_M(0) = \frac{H_0 r}{c} \Rightarrow \partial_r z_M(0) = \frac{H_0}{c} \tag{49}$$

Combining with eqs. (48 − 49) with condition C7, we get an estimate of the value of M_0 :

$$\boxed{\begin{array}{l} H_0 = M_0 + 4 W_0 \\ M_0 \simeq H_0 \simeq 2.2 \times 10^{-18}\, s^{-1} \left(\simeq 68 \, \frac{\text{km}}{s \, \text{Mpc}} \right) \end{array} \qquad \text{(C7)}}$$

Here we clearly see the roles of the parameters H_0, and W_0, M_0, in the SCM and SVU models respectively. In summary :

1. In the SCM, H_0, determines the rate of change of cosmological redshift with distance in our vicinity (via the Hubble law), whereas in the SVU, $M_0 + 4 W_0$, is the linear coefficient of the mean exponential redshift / distance relation.

2. In the SCM, H, is coupled with the expansion rate of the universe, whereas in the SVU, M, and W, are coupled with the universal rest mass and electric charge selfvariation respectively.

From conditions (C5) we have :

$$\frac{M_0}{k} \left(1 - e^{-\frac{k r_1}{c}} \right) \simeq z_1 \Rightarrow k = \frac{M_0}{z_1} + \frac{c}{r_1} \text{WL}_j \left(-\frac{M_0 r_1}{z_1 c} e^{-\frac{M_0 r_1}{z_1 c}} \right)$$

where WL_j, $j = 0, -1$, are branches of the Lambert–W function. From C8 :

$$\frac{k}{M_0} \simeq \frac{1}{z_1} + \frac{c}{M_0\, r_1} \operatorname{WL}_j\left(-\frac{M_0\, r_1}{z_1\, c}\, e^{-\frac{M_0\, r_1}{z_1\, c}}\right) \tag{50}$$

We set, $z_1 = 1.5$, and take only the real values of k, to establish condition C9 :

$$\begin{aligned} &-4.6\times 10^{-18}\, s^{-1} \lesssim (k \neq 0) \lesssim 0.47\times 10^{-18}\, s^{-1} \Leftrightarrow \\ &\qquad -2.1\ M_0 \lesssim (k \neq 0) \lesssim 0.21\ M_0 \\ &\text{where, } 3\text{ Gpc} \lesssim r_1(z = 1.5) \lesssim 8\text{ Gpc.} \end{aligned} \tag{C8}$$

For, $r_1 < 6.62$ Gpc, we have, $k < 0$, otherwise, $k > 0$. Below we give *a* graph of k.

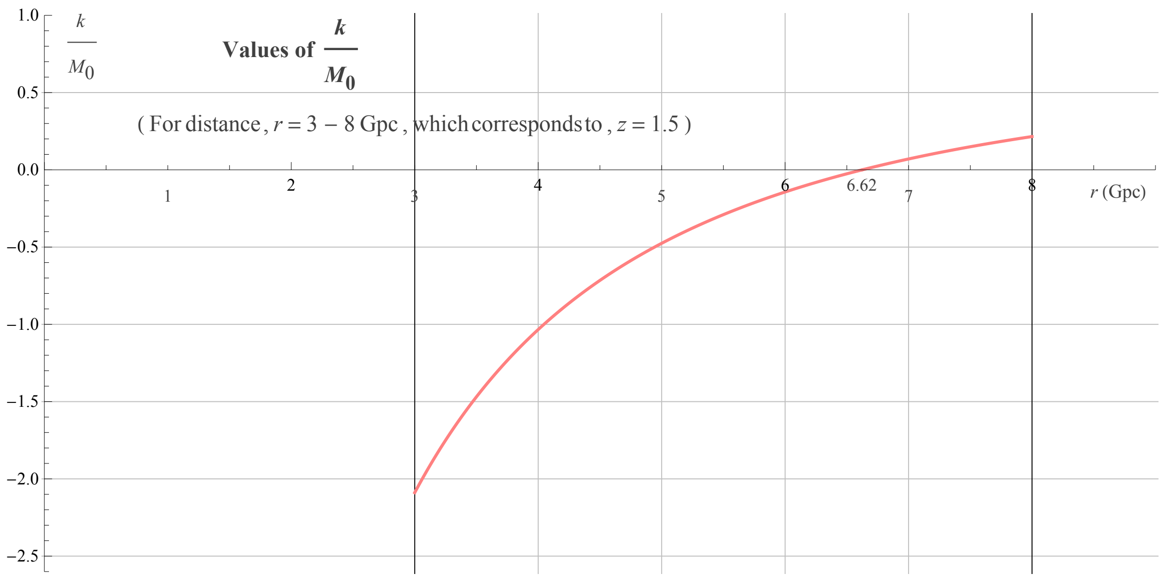

Fig. 2 : Values of k, for, $r_1 = 3 - 8$ Gpc, corresponding to, $z_1 = 1.5$.

4.3. Cosmological redshift limit as, $r \to \infty$

The long range behavior of cosmological redshift as, $r \to +\infty$, depends on the signs of the parameters in eq. (40). From condition C2c, C6 we have, W_0, $M_0 > 0$. Thus the long range behavior depends only on the signs of k, k_e :

$$\begin{aligned} &\text{For, } k,\, k_e > 0 \qquad z_M \to z_{\max} = \left(1 + \frac{M_0}{k}\right)\left(1 + \frac{W_0}{k_e}\right) - 1 \\ &\text{In all other cases} \quad z_M \to +\infty \end{aligned} \tag{51}$$

We have measured redshifts of astronomical objects in excess of 10. Also the CMBR has *a* redshift in excess of 10^3, which is quite compatible with the SVU model. Hence we conclude that in the case of finite $z_{\max}$, we have :

$$\left(1 + \frac{M_0}{k}\right)\left(1 + \frac{W_0}{k_e}\right) > 1 + z_{\max} \Leftrightarrow \frac{M_0}{k} > z_{\max},\ \text{or},\ \frac{M_0}{k} \le z_{\max} \bigwedge \frac{W_0}{k_e} > \frac{1 + z_{\max}}{\frac{M_0}{k} + 1} - 1$$

We saw in condition (C8) that for positive k, the ratio, $\dfrac{k}{M_0}$, is small. Then combining condition C8 we have::

$$\begin{aligned} &k,\, k_e > 0 \Rightarrow \\ &\text{either, } \frac{k}{M_0} < \frac{1}{z_{\max}} \\ &\text{or, } \frac{1}{z_{\max}} \le \frac{k}{M_0} \lesssim 0.21,\ \text{and},\ \frac{k_e}{W_0} < \frac{\frac{k}{M_0} + 1}{\frac{k}{M_0}\, z_{\max} - 1} \\ &\text{where, } z_{\max} > 10^3 \end{aligned} \tag{C9}$$

4.4. Comparison of the inverse redshift/ distance relations in the SVU and the Λ–CDM models

Inverting equation (43) we get the inverse mean redshift/ distance relation in the SVU model :

$$r \simeq -\frac{c}{k} \log\left(1 - \frac{k}{M_0} z_M\right) \tag{52}$$

Below we plot this equation for various values of, $\frac{k}{M_0}$, in the range given by condition C8. For comparison we also plot the comoving distance of the SCM model, based on the Robertson–Walker metric for an expanding universe as given by the Λ–CDM model. The curves reflect various values of dark energy density, $0 < \Omega_\Lambda < 0.99$, for *a* flat universe ($\Omega_k = 0$). Thus :

$$r_c = \frac{c}{H_0} \int_0^z \frac{1}{\sqrt{\Omega_m (1+v)^3 + \Omega_\Lambda}} \, dv$$

where we equate the independent variable z, with the mean redshift z_M, of the SVU model so that, $r = r_c$. The most favorite current value of dark energy density is, $\Omega_\Lambda = 0.728$. However dark energy density has not been measured directly and this value reflects the need for an almost flat universe in the context of the Λ–CDM model. In turn the Λ–CDM model is used to give comoving distances. Hence the r_c, curves heavily depend on the Λ–CDM model, as direct proper distance measurements of astronomical objects are very difficult to get and have great uncertainty, especially beyond small redshifts. So the interpretation of the r_c, is only schematical

since the Λ–CDM model is not compatible with the SVU model. What really matters is *a* correlation of redshift with proper distance measured independently of any model. From this correlation we could infer the exact values of the SV parameters.

It must not go unnoticed that the proximity of the curves of the SVU and the Λ–CDM model is remarkable for distances of many Gpc, for the particular range of the SV constants. This range has not been worked out in order to produce *a* particular shape of the distance / redshift curve, but from the selfvariation laws, the variation of the fine structure parameter, the assumption of the validity of the Hubble law for small distances and *a* possible range of distances for *a* single redshift value ($z_1 = 1.5$). From this proximity it is clear that if we are to rely on the redshift / distance data correlation in order to choose between the models, the data have to be particularly precise.

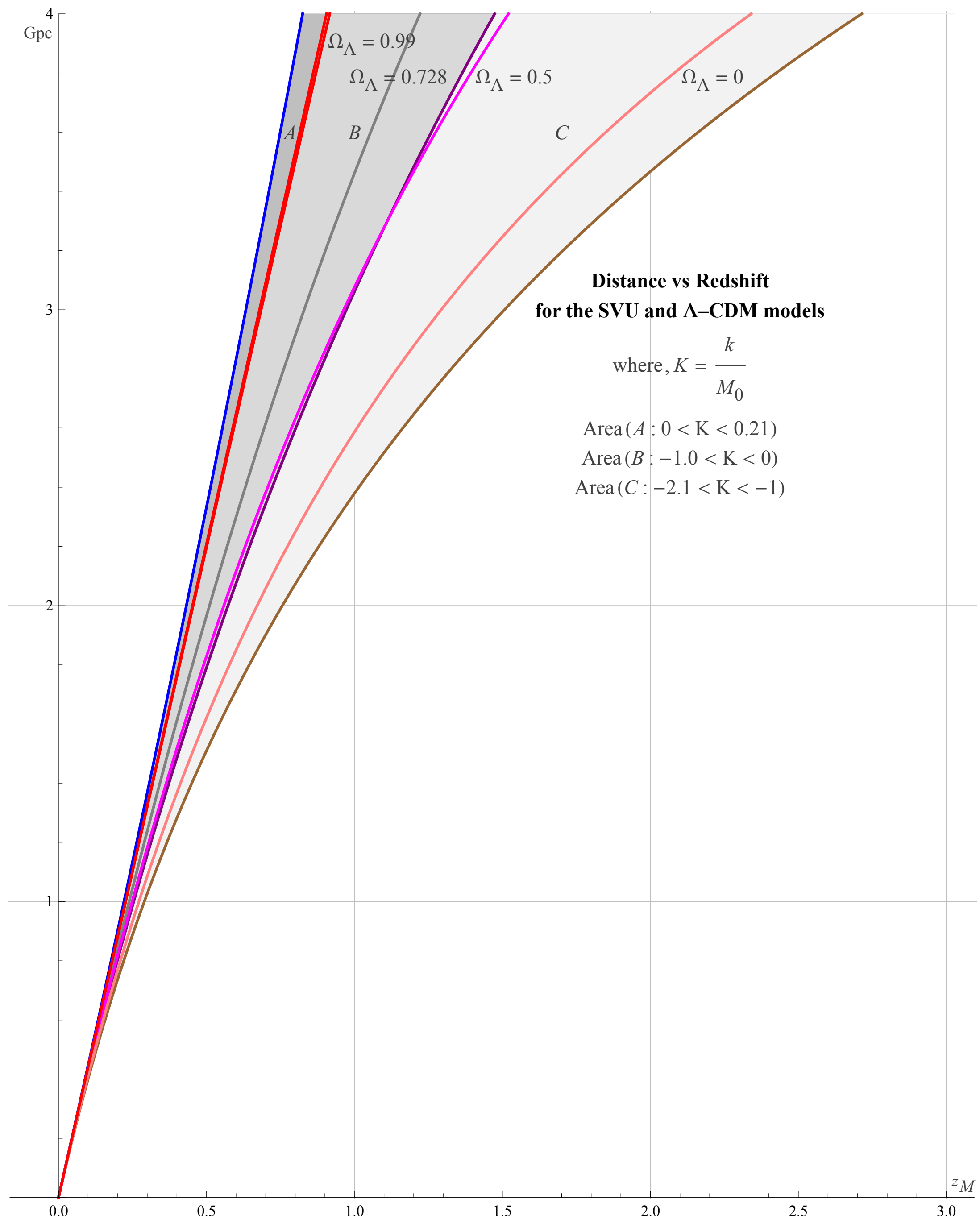

Fig. 3 : Cosmological distance vs. redshift in the SVU and the flat SCM (where the Λ–CDM are from left to right, $\Omega_\Lambda = 0.99,\ 0.728,\ 0.5,\ 0.0$). The straight line ($K = 0$) is the naive Hubble law (almost coincident with the curve, $\Omega_\Lambda = 0.99$, which is slightly to the right).

The SVU model predicts three possible areas A, B, C, where the actual distance / redshift curve can exist, depending on the value of, $\frac{k}{M_0}$. Notice also from conditions C0, C10 (section 5.1) that : $k \neq 0, -1$.

The current Λ–CDM model with, $\Omega_\Lambda = 0.728$, seems to place the comoving distance (which is simply equivalent to distance in the SVU model) in the area B. The position of this curve corresponds to, $\frac{k}{M_0} \simeq -0.6$. However area B, as we will see in section 5.1, leads to *a* negative SV rest mass unit. For comparison we give *a* curve of the Λ–CDM model with, $\Omega_\Lambda = 0.5$, which would marginally place the curve on the area C (very close to the curve, $K = -1.0$). However the current Λ–CDM model assumes the Robertson–Walker solution which explains cosmological redshift in an expanding universe. In the SVU model the cause of redshift is different and obeys *a* different relation (eq. 40). Future exact measurements of distance with redshift (independently of any model) will show which model best fits the data.

4.5. Change of SV rest mass and SV electric charge units with redshift

Inserting eq. (52) into eq.(27) we get the relative SV rest mass unit with respect to mean cosmological redshift :

$$\frac{m_0(z_M)}{m_0} \simeq \frac{1}{1+z_M} \tag{53}$$

This is *a* surprisingly simple and important equation of the SVU model, as it does not depend on any SV parameters. Many physical quantities depend on the SV rest mass unit, which directly affects the rest mass of all material particles in astronomical objects. Our equation is the same as Manousos derived in (Manousos 2013 *c*, §4), however we arrived at it under more general assumptions for the SV parameters.

This equation neglects the electric charge selfvariation. If we use the eq.(40) instead of (43), we get the exact relation between the relative SV rest mass unit and mean redshift. Unfortunately eq. (40) cannot be inverted, so we start with the inversion of eq. (27) and then we insert into eq. (40), to get :

$$1+z_M = \frac{m_0}{m_0(r)}\left(1+\frac{W_0}{k_e}\left(1-\left(1+\frac{k}{M_0}\left(1-\frac{m_0}{m_0(r)}\right)\right)^{k_e/k}\right)\right)^4 \tag{54}$$

Since this equation cannot be directly inverted we expand into series and invert. The result is :

$$\frac{m_0(z_M)}{m_0} = \frac{1}{1+b_1\, z_M + b_2\, z_M^2 + b_3\, z_M^3 + \ldots} \tag{55}$$

where the coefficients b_n, are given by the equations :

$$b_1 = \frac{1}{1+\gamma}$$

$$b_n = -\frac{1}{(1+\gamma)^{2n-1}}\left(\frac{k}{M_0}\right)^{n-2}\left(\left(\frac{1}{n-1}+\frac{k}{n\,M_0}\right)\gamma + \frac{4}{n!}\left(\frac{k}{M_0}\right)^{n+1} P_{2n-2}\left(\frac{k_e}{k}\right)\right),\ n \geq 2 \tag{56}$$

where, $\gamma = 4\,\frac{W_0}{M_0}$, and, $P_n\left(\frac{k_e}{k}\right)$, is *a* polynomial of degree n, in, $\frac{k_e}{k}$, with no constant and linear terms $\left(\textit{i.e.}\right.$ the lowest term is at least quadratic in, $\left.\frac{k_e}{k}\right)$. Manousos in (Manousos 2013 *d*, §4) implies that, $\frac{k_e}{k} \ll 1$. Although this does not necessarily follow from the parameter conditions gathered so far, it is compatible with the slow rate of the electric charge selfvariation and is most probably true. We call this assumption A1 :

$$\boxed{\frac{k_e}{k} \ll 1 \qquad \text{(A1)}}$$

The exact form of the polynomials, $P_n\left(\frac{k_e}{k}\right)$, is available online at, http :// apminstitute.org/category/physics /. Under assumption (A1) we have that, $P_{2n-2}\left(\frac{k_e}{k}\right) \ll 1$, $\forall\, n \geq 2$. Hence we can calculate the coefficients b_n, with the approximate formula :

$$b_n = -\frac{\gamma}{(1+\gamma)^{2n-1}}\left(\frac{k}{M_0}\right)^{n-2}\left(\frac{1}{n-1}+\frac{k}{n\,M_0}\right),\ n \geq 2 \tag{56'}$$

To get an idea in this case we insert some numerical values for the SV parameters :

$\frac{k_e}{k} = 10^{-5}$	$\gamma = 10^{-5}$ $k/M_0 = 10^{-3}$	$\gamma = -10^{-5}$ $k/M_0 = 10^{-3}$	$\gamma = 10^{-5}$ $k/M_0 = -1$	$\gamma = -10^{-5}$ $k/M_0 = -1$
b_1	0.99999	1.00001	0.99999	1.00001
b_2	-1.000×10^{-5}	1.000×10^{-5}	-5.000×10^{-6}	5.000×10^{-6}
b_3	-5.003×10^{-9}	5.004×10^{-9}	1.667×10^{-6}	-1.667×10^{-6}
b_4	-3.336×10^{-12}	3.336×10^{-12}	-8.333×10^{-7}	8.334×10^{-7}
b_5	-2.502×10^{-15}	2.502×10^{-15}	5.000×10^{-7}	-5.000×10^{-7}

More coefficients are available online at, http : // apminstitute.org/category/physics /.

Inserting eq. (52) into eq. (28) we get the SV electric charge unit with respect to mean redshift :

$$\frac{q_0(z_M)}{q_0} \simeq \frac{1}{V_R}\left(1+\frac{W_0}{k_e}\left(1-\left(1-\frac{k}{M_0}z_M\right)^{k_e/k}\right)\right)^{-1} \tag{57}$$

$\left(\text{where always, } 1-\frac{k}{M_0}z_M>0\right)$. This is the analog to eq. (53), only that in this case the SV parameters do not cancel out. Both equations are very useful to investigate physical phenomena in the SVU model, which depend on the rest mass and electric charge.

Eq. (57) is derived under the same approximation as eq. (53). We can also get the exact equation giving the dependence of redshift from electric charge, by inverting eq. (28) and inserting into eq. (38) :

$$1+z = V_R^4\left(1+\frac{M_0}{k}\left(1-\left(1+\frac{k_e}{W_0}\left(1-\frac{q_0}{V_R\, q_0(r)}\right)\right)^{k_e/k}\right)\right)\left(\frac{q_0}{V_R\, q_0(r)}\right)^4 \tag{58}$$

Setting the relative SV potential, $V_R \simeq 1$, we get an equation analogous with eq. (54), which can be inverted in *a* similar way.

5. Evolution of the SV rest mass unit

5.1. Evolution of the SV rest mass unit

From eqs. (5), (17), we have :

$$m_0(t) = \frac{b\,k\,\hbar}{c^2}\,\frac{1+\frac{k}{M_0}}{1+\frac{k}{M_0}-e^{k\,t}} \tag{59}$$

The beginning and eventual evolution of the SV rest mass unit depends crucially on the sign of k. In the table below we give the limit of, $m_0(t)$, for the various cases :

$m_0(t)\to$	$t\to-\infty$	$t\to+\infty$
$k>0$	$\mathfrak{m}$	0
$k<0$	0	$\mathfrak{m}$

(60)

where :

$$\mathfrak{m} = \frac{b\,k\,\hbar}{c^2} \tag{61}$$

is an extremely small positive or negative universal mass constant depending on the SV constants b, and k. It is interesting that, considering Cd8, eq.(59) alone does not guarantee *a* positive SV rest mass unit. From conditions (C8) we have :

$$0 < |\mathfrak{m}| < 5.42\times10^{-69}$$
$$\left(\begin{array}{l} -2.1 < \frac{k}{M_0} < -1 \\ 0 < \frac{k}{M_0} < 0.21 \end{array}\right) \Rightarrow \mathfrak{m} > 0 \qquad \text{(C10)}$$
$$-1 < \frac{k}{M_0} < 0 \Rightarrow \mathfrak{m} < 0$$

From eqs.(19), (59), (61), we have :

$$m_0(t) = \mathfrak{m}\,\frac{k + M_0}{k + M_0 - M} \qquad (62)$$

$$m_0 = \mathfrak{m}\left(1 + \frac{M_0}{k}\right) \qquad (63)$$

Another interesting feature of eq. (59) is that there are cases where, $1 + \frac{k}{M_0} - e^{k\,T_R} = 0$, for some finite time T_R. At time, $t = T_R$, the SV rest mass unit becomes infinite, $m_0(T_R) = \pm\infty$. We can calculate T_R, by :

$$T_R = \frac{1}{k}\,log\left(1 + \frac{k}{M_0}\right) \qquad (64)$$

where from condition C2a we have, $\frac{k}{M_0} \neq -1$. At time T_R, we have *a* sign reversal for the SV rest mass unit, where it changes from positive to negative or vice versa. The reversal time T_R, is real only for, $\frac{k}{M_0} > -1$. In the other case where, $-2.1 < \frac{k}{M_0} < -1$, there is no sign reversal and the evolution of the SV rest mass unit follows *a* smooth pattern. But what does the sign reversal mean? Assuming that the current SV rest mass unit is positive, the universe will enter *a* reverse phase after time T_R, where the SV rest mass unit will be negative. Under the rest mass selfvariation law stated at the beginning, all rest masses in the universe must follow that pattern. The universe will have entered *a* reverse phase predicted by the SVU model.

The next figure shows the reversal time T_R, with respect to the value of, $\frac{k}{M_0}$.

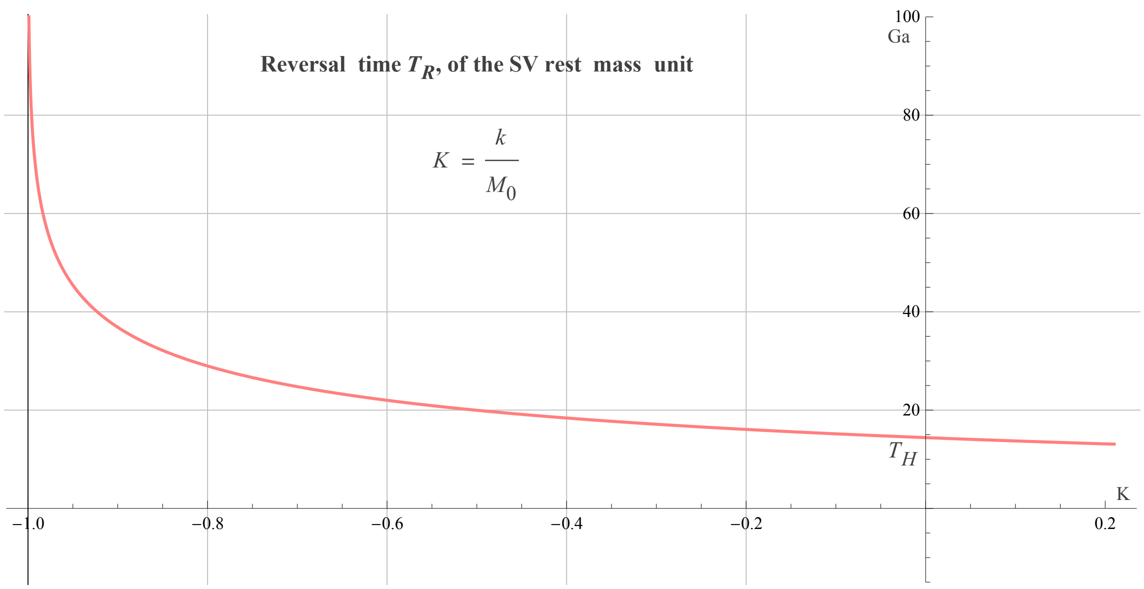

Fig. 4 : Sign reversal time T_R, of the SV rest mass unit in Ga (where positive is the future).

From Fig .4 we see that the reversal time is positive for all allowed values of, $\frac{k}{M_0} > -1$, thus *a* sign reversal of the SV rest mas unit has not happened in the past history of the universe. The sign reversal will happen in the future. However it will not happen for at least 13 Bill years from now. It is interesting and certainly no coincidence that for, $\frac{k}{M_0} \simeq 0$, the reversal time is, $T_R \simeq T_H = \frac{1}{H_0} = 14.4$ Ga, thus comparable with the Hubble time, though T_R, lies in the future. We will come back to this case in section 5.2.

In the following diagrams we show the time evolution of the SV rest mass unit relative to the SV mass constant. Current time epoch is set at, $t = 0$.

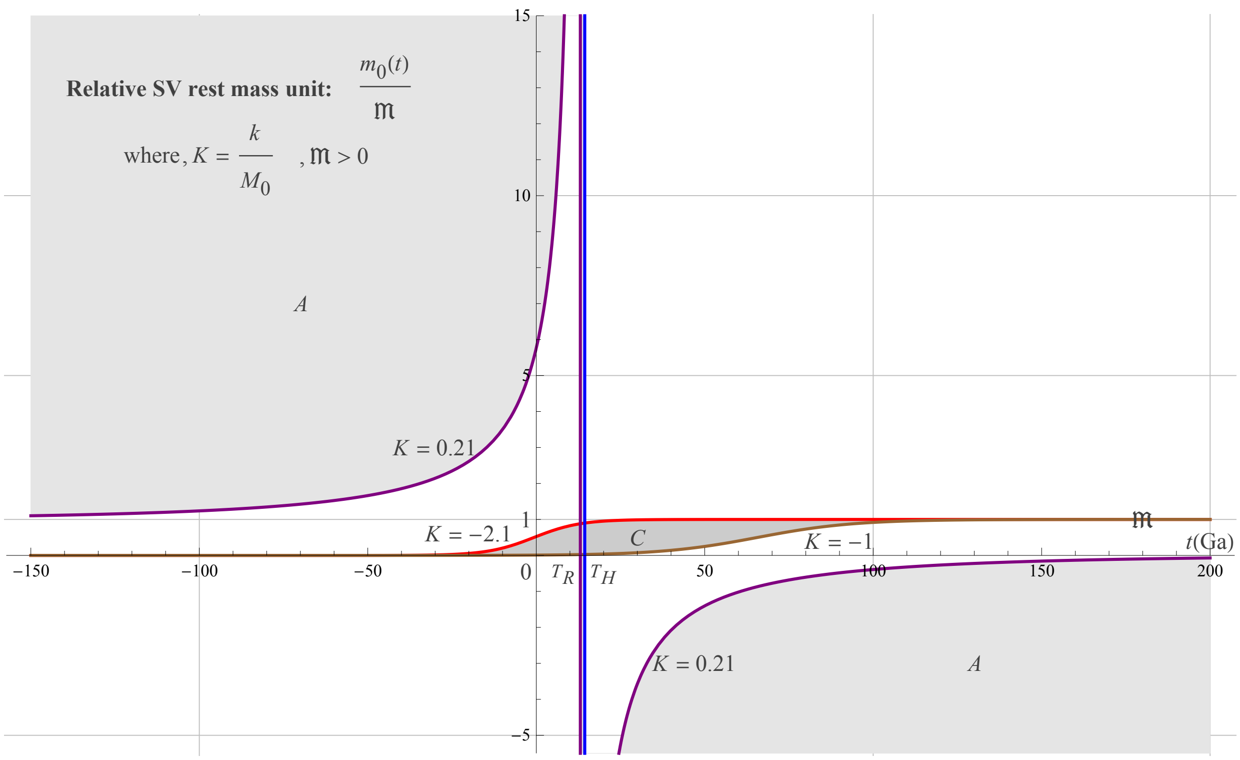

Fig. 5 *a* : Evolution of SV rest mass unit (eq. 59) with time (Ga), given in $\mathfrak{m}$, units. The shaded areas *A* and *C* are shown. T_R, is the reversal time and T_H, is the Hubble time.

Area *A*, corresponds to, $0 < \frac{k}{M_0} < 0.21$, and area *C*, to, $-2.1 < \frac{k}{M_0} < -1$. In both cases the rest mass constant $\mathfrak{m}$, is positive.

In the case *A*, the current SV rest mass unit is positive, however *a* finite reversal time is expected, after which the universe will enter *a* reverse phase, with negative rest mass unit. In case *C*, no such reversal will take place and the SV rest mass unit was and will remain forever positive. We do not know yet in which universe we live, according to the SVU options. To find which is the case, we have to determine, $\frac{k}{M_0}$, more precisely.

The next diagram shows case *B*, where, $-1 < \frac{k}{M_0} < 0$, and currently both the rest mass constant $\mathfrak{m}$, and the SV rest mass unit are negative. In this case also there is *a* finite reversal time, after which the SV rest mass unit will enter *a* positive phase (notice that the diagram shows their ratio). Since by convention we assign positive values to rest mass, we probably have to exclude this case.

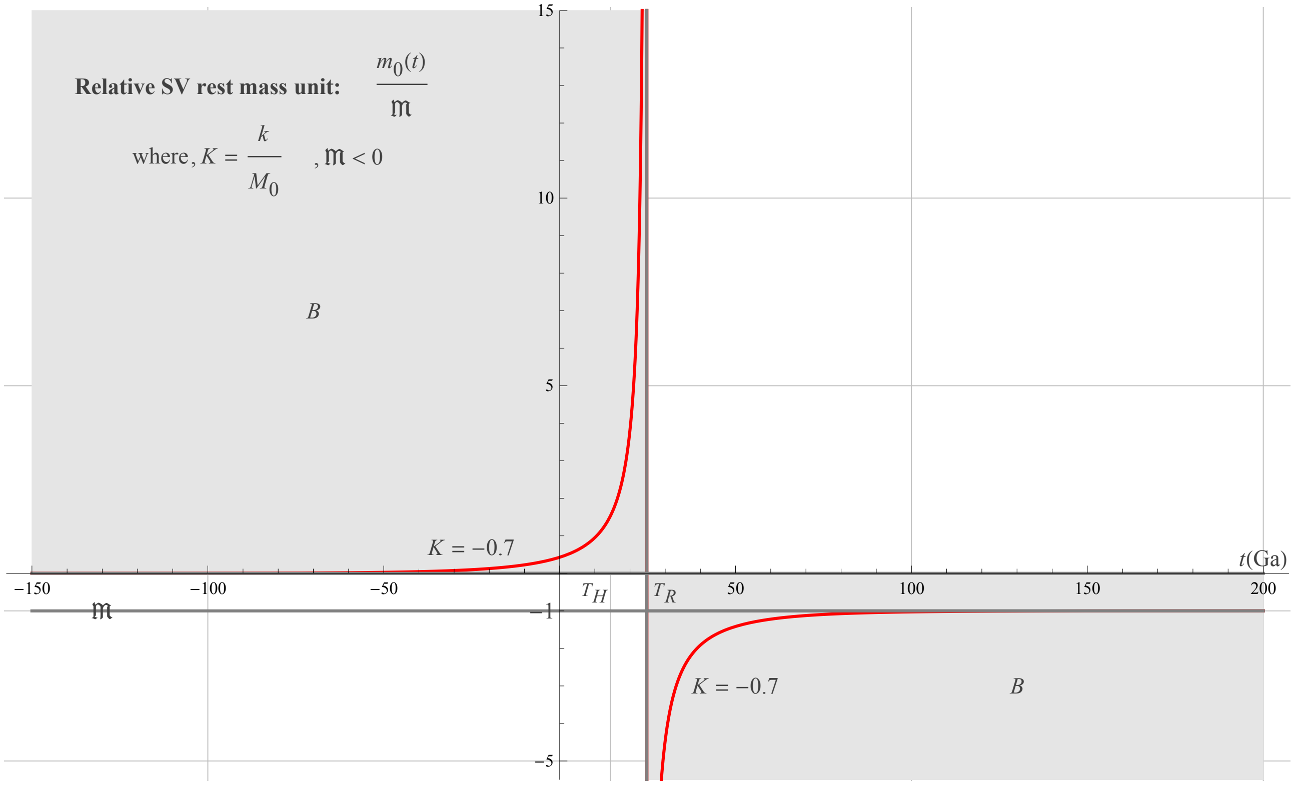

Fig. 5 *b* : Evolution of SV rest mass unit (eq. 59) with time (Ga), given in $\mathfrak{m}$, units. The shaded area *B* is shown. T_R, is the reversal time and T_H, is the Hubble time.

In this diagram the curve with, $K = -0.7$, is an example curve, as the whole shaded areas are possible.

5.2. The case of the reversed rest mass selfvariation law

For all cases of the SV parameters which predict *a* reversal time, the calculated reversal time lies in the future. However extending the parameter conditions to complex values might bring about negative reversal times lying in the past. Another interesting case is the reversal of the selfvariation law itself. In this case, without changing eq.(1), we may postulate that the SV rest mass unit decreases with time. This is not so grave as it seems, because eq.(1) , stems from two symmetric equations involving rest mass and rest energy (see (Manousos 2013 *b*, §5 .2)). The reversal of the law just means to reverse rest mass with rest energy.

What is interesting in this case, is that current SV rest mass unit is positive and the reversal time is roughly the Hubble time, but lying in our past. Hence in this model, the 'beginning' of the universe is actually the beginning of the current phase, starting with *a* phase reversal, which has happened roughly 14 Bill years ago. Prior to this, there existed *a* reversed phase with negative SV rest mass unit.

This is *a* surprising prediction of the SVU model, since it actually opens the possibility of *a* phase reversal in the universe. If this actually happens or not, is *a* case for further study.

5.3. Evolution of the SV electric charge unit

The evolution of the SV electric charge unit follows *a* similar pattern, since it is based on *a* similar selfvariation law. However matters are complicated by the SV electric potential. Also the parameter conditions gathered in this paper, are less strict than for the SV rest mass unit, leaving more options open.Certainly in some cases there is also *a* reversal time for the electric charge.

6. Derivatives

6.1. SV rest mass unit

From eq.(15), (62) we have :

$$\frac{\partial_t m_0(t)}{m_0(t)} = \frac{k M}{k + M_0 - M} \Rightarrow \qquad (65)$$

From eq.(7) we have :

$$\frac{\partial_r m_0(r)}{m_0(r)} = -\frac{M_0 m_0(r)}{c\, m_0} e^{-\frac{k r}{c}} \Rightarrow \tag{66}$$

$$\frac{\partial_r m_0(r)}{m_0} = -\frac{M_0}{c}\left(\frac{m_0(r)}{m_0}\right)^2 e^{-\frac{k r}{c}} < 0 \Rightarrow \tag{67}$$

$$\frac{\partial_r m_0}{m_0} = -\frac{M_0}{c} \tag{68}$$

and considering eq.(17) :

$$\partial_r m_0 + \frac{1}{c}\partial_t m_0 = 0 \tag{69}$$

In the same way as we calculated eqs.(27) and (62) we have :

$$\frac{m_0(r, t)}{m_0} = \frac{k}{k + M_0 - M e^{-\frac{k r}{c}}} \Rightarrow \tag{70}$$

$$\frac{m_0(t)}{m_0} = \frac{k}{k + M_0 - M} \tag{71}$$

6.2. Redshift

From eq.(43) we have :

$$\partial_r z_M \simeq \frac{M_0}{c} e^{-\frac{k r}{c}} > 0 \Rightarrow \tag{72}$$

From eq.(70) we calculate redshift at any time, $z_M(t)$, in the same way as eq.(43) :

$$z_M(r, t) \simeq \frac{1}{k}\left(M_0 - M e^{-\frac{k r}{c}}\right) \Rightarrow \tag{73}$$

$$\partial_t z_M(r, t) \simeq -M e^{-\frac{k r}{c}} < 0 \Rightarrow \tag{74}$$

$$\partial_t z_M \simeq -M_0 e^{-\frac{k r}{c}} < 0 \tag{75}$$

where z_M, is the current redshift at any distance. Hence combining with eq.(72) :

$$\partial_t z_M + c\,\partial_r z_M \simeq 0 \tag{76}$$

From eq.(16) the sign of, $\partial_t M$, depends on the sign of k. From this and condition C7 it follows that the sign of, $\partial_t H$, may be positive or negative.

7. Discussion

We have started from very broad assumptions about the SV parameters :

$$b, b_e = \pm 1, \text{ and, } \begin{pmatrix} k, k_e \in \mathbb{R} \setminus 0 \\ \mu, \mu_e \in \mathbb{R} \end{pmatrix}$$

We have also introduced the new parameters, $M, W \in \mathbb{R} \setminus 0$, as a combination of the above. Despite the fact that we have started with these broad assumptions, we have considerably narrowed their possible values. However the possibilities left open are more than that presented by Manousos in (Manousos 2013 b, §7 .3, 2013 c, §5, 2013 d, §2, 4, 2014 a, §1, 3), where the assumptions were :

$$b = b_e = 1, \text{ and, } \begin{pmatrix} k, k_1 > 0 \\ \mu = \mu_e \\ k + \mu < 0 \end{pmatrix} \Rightarrow 0 < A, B < 1$$

Notice however that the parameters B_e, W, k_e, used in this paper are not exactly coincident with, B, W, k_1, used by Manousos since the latter incorporate the SV electric potential. We have deliberately done so, in order to separate the effects of the SV electric potential with that of the electric charge selfvariation.

In section 3 we have took into account that Webb (2011) describes the variation of the fine structure constant α, as having *a* large dipole form, with only *a* small isotropic component. Finally for the first time we present the different possible cases for the evolution of the SV universe. The choice of cases depends on the values of the SV parameters. We have also found that the time derivatives, $\partial_t z$, $\partial_t M$, and, $\partial_t H$, may take positive or negative values.
We have confirmed that the equation which gives the relative SV rest mass unit,

$$\frac{m_0(z_M)}{m_0} \simeq \frac{1}{1+z_M} \qquad (42)$$

is almost independent of the SV parameters, which is the same result as in Manousos (2013 *c*, §4). We have however calculated the small higher order terms, which are not independent of the SV parameters.
Finally it is also conceivable that the investigation of the consequences of the SVU model can proceed by starting with complex values of the parameters, as long as it produces real valued observables.

8. Conclusion

The SVU model of the theory of selfvariations (TSV) predicts *a* flat static non–expanding universe, in which the rest mass of material particles and the absolute electric charge of particles of matter, slightly increase with time. The SVU model conforms with all current cosmological observations (Manousos 2013 *c*, 2014 *c*). It particular it explains the variation, over large distances, of the fine structure constant observed by Webb (2011), since at large distance we see the smaller value of the electric charge in the past. No mainstream cosmology can explain this variation. The rest mass of all material particles follows the evolution of the SV rest mass unit, which we have studied in this paper.
At large cosmological distance we observe *a* smaller value of the rest mass in the past. This, in combination with the variation of the electric charge, explains cosmological redshift without the need of the expansion of the universe and all other assumptions that follow from the expansion and are incorporated in the SCM. The SVU model predicts an exponential redshift/distance relation, which is very closely matched by the redshift/ comoving distance relation of the Λ–CDM model. This is expected, as the comoving distance of the Robertson–Walker metric corresponds to the distance in the static SVU model.
We have found that, depending on the exact values of the SV parameters, the SV rest mass unit (and thus the rest mass of all particles), will either evolve towards *a* limit mass constant $\mathfrak{m}$, in the infinite future, or it will acquire an infinite value at *a* finite time in the future, called the reversal time T_R. After the reversal time the universe will enter into *a* reversed phase, where the rest mass unit has *a* negative sign. We have found that, due to the restrictions of the parameters studied in this paper, the reversal time can be no less than 13 Bill years from now. It may however be hundreds of Bill years in the future. Precise measurements of the distance of astronomical objects, independently of any cosmological model, will show the precise values of the SV parameters and thus select between the different evolutions in the context of the SVU model.
In the case where, k, $k_e > 0$, redshift tends to *a* limit $z_{\max}$, at infinite distance. In all other cases redshift tends to infinity. We have found also that the SVU model predicts *a* fluctuation of cosmological redshift producing an anisotropy over the sky, for astronomical objects lying at the same distance from us and ideally having the same peculiar velocities. This fluctuation is in part covered by the peculiar velocities. The fluctuation however is proportional to redshift, and increases with distance, while peculiar velocities probably have an upper bound throughout the observed universe.

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