A Wess-Zumino Scenario for Dark Matter and Asymmetric Visible Matter

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Abstract

We extend a previous Wess-Zumino Lagrangian inspired preon model of visible matter to enclose the dark sector with both bosonic and fermionic fields. The bosonic dark sector includes the axion and axion-like particles. They are candidates for both dark matter and dark energy depending on the axion masses. Dark matter consists predominantly of bosonic particles and e.g. primordial black holes and the rest is fermionic dark particles, which may form celestial bodies. We propose a novel mechanism for the creation of the matter-antimatter asymmetric universe. Dark matter avoids reheating and is thus differently distributed in the universe than visible matter. Due to early time field fluctuations, dark matter provides regions of varying gravitational potential for visible matter to accumulate.

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1 Introduction

There is no present experimental need for another pointlike structural level of matter below the standard model (SM) particles. We have taken, however, the liberty of making a Gedanken experiment to see if we can by logical analysis find something applicable for a pivot point to vault beyond the SM. The motivation is that there are old, but still unsolved problems within the SM including the dark matter (DM) and matter-antimatter asymmetry issue. Our main clue is supersymmetry which we suppose to be unbroken. The experimental situation in the search of the SM superpartners indicates, in our opinion, that the standard model is not supersymmetric. To propose an alternative scenario for SM matter supersymmetric preons were introduced [1, 2]. They only have global quantum numbers that are not eaten by black holes. Following Finkelstein [3, 4, 5] we extended our scenario to include the symmetry group *SLq(2)* [2], which has preons and the SM fermions in its $j = \frac{1}{2}$ and $\frac{3}{2}$ representations, respectively. Harari [6] and Shupe [7] have also proposed preon models of this type. All four models are physically equivalent with each other and the standard model but their preon symmetries are different from ours.

The purpose of this note is to (i) introduce candidates for dark matter and dark energy that follow from the Wess-Zumino model (WZ) [8], and (ii) propose a matter-antimatter asymmetric genesis in the preon scenario. The asymmetry is made possible by a torsion induced C violation and subsequent C symmetric preon level processes. A WZ based no-scale mini supergravity model for inflation, presented in the literature, is discussed as a first step towards including interactions in the scenario.

The article is organized as follows. In section 2 we summarize briefly the setup of our preon scenario, which has turned out to be quite similar to the global supersymmetry model of Wess and Zumino. In the WZ Lagrangian, we construe the pseudoscalar and its superpartners to be the dark sector, which is considered in section 3. Dark particles participate inflation as spectator fields yielding candidates for cold dark matter and dark energy. Standard model matter is produced in reheating by coupling to the inflaton in a no-scale WZ supergravity model, with hints from string theory, as described in section 4. In section 5 the scenario for the creation of matter-antimatter asymmetric universe by charge symmetric preons is proposed. The idea behind the asymmetry is that the *same* twelve C symmetric preons may form matter at one time and antimatter at another time, see (5.1). A prefatory mechanism is described why matter was chosen for our universe. Conclusions are given in section 6. – The original contributions of this author are the supersymmetric preon (superon) scenario for the visible and dark sector particles, and the mechanism for producing the asymmetric universe, with dark and visible matter distributed differently because only the latter undergoes reheating. The inflationary model potential and the axions are adopted from the literature. At the same time, our purpose is to present in a brief mini review a coherent physical picture of the Wess-Zumino based model building for fundamental particles and the cosmological inflation.

2 Superon scenario

We briefly recap the superon scenario of [1, 2], which turned out to have close resemblance to the simplest N=1 globally supersymmetric 4D model, namely the free, massless Wess-Zumino model [8, 9] with the kinetic Lagrangian including three neutral fields m, s, and p with $J^P = \frac{1}{2}^+, 0^+$, and 0^-, respectively

$$\mathcal{L}_{\rm WZ} = -\frac{1}{2}\bar{m}\partial\!\!\!/ m - \frac{1}{2}(\partial s)^2 - \frac{1}{2}(\partial p)^2 \tag{2.1}$$

where m is a Majorana spinor, s and p are real fields (metric is mostly plus). The scalars can be written in complex form $s + ip = S\exp^{i\theta}$.

We assume that the pseudoscalar p is the axion [10], and denote it below as a. It has a fermionic superparther, the axino n, and a bosonic superpartner, the saxion s^0.

In order to have visible matter we assume the following charged chiral field Lagrangian

$$\mathcal{L}_{-} = -\frac{1}{2}m^{-}\partial\!\!\!/ m^{-} - \frac{1}{2}(\partial s_i^{-})^2, \quad i = 1, 2 \tag{2.2}$$

The first generation standard model particles are formed combinatorially (mod 3) of three superons, the charged $m^{\pm}$, with charge $\pm\frac{1}{3}$, and the neutral m^0, as composite states below an energy scale Λ_{cr} [2], see lower part of Table 1.

Confinement of superons within quarks and leptons can be caused by a gauge boson interaction, a Yukawa interaction, an attractive gravity-like intense interaction (yet to be defined), or by rotation charge sharing [4]. The indexes (i, j, k) of the m and n in table 1 look, and are, SU(3) color indexes, but no

$J \propto M^2$ QCD-like excitations are known.[1] The deconfnement temperature Λ_{cr} is in principle calculable but at present it has to be accepted as a free parameter. Numerically $\Lambda_{cr} \sim 10^{10-16}$ GeV, somewhat above the reheating temperature (at reheating there must be SM particles, i.e. visible matter). The R-parity in the scenario is simply $P_R = (-1)^{2\times spin}$.

Introducing local supersymmetry for superons is an open question in our scenario at the moment. It is a task for the future. In section 4 we discuss a boson sector interaction potential for inflation within a mini supergravity model.

3 Dark Matter

For a general introduction to particle dark matter, see e.g. [15, 16]. Literature on dark matter, dark energy, and axions is extensive, see e.g. [17, 18, 19, 20]. In this section we patch our shortage to consider the pseudoscalar of (2.1) in [2]. So we start from the Lagrangian (2.1).

As stated in the previous section 2, the superpartners of the axion a are the fermionic axino n, and the scalar saxion s^0, also indicated in Table 1.[2] Particle dark matter consists of all these three particles. The axino n may appear physically as single particle dust or three n composite o gas, or a large astronomical object. The fermionic DM behaves naturally very differently from bosonic DM, which may form in addition Bose-Einstein condensates.

Other candidate forms of DM include primordial black holes (PBH). They can be produced by gravitational instabilities induced from scalar fields such as axion-like particles or multi-field inflation. It is shown in [22] that PBH DM can be produced only in two limited ranges of 10^{-15} or 10^{-12} Solar masses (2×10^{30} kg). Dark photons open a rich phenomenology described [23]. We also mention another supergravity (the graviton-gravitino supermultiplet) based model [24], which may help to relieve the observed Hubble tension [25].

The axion was originally introduced by Peccei and Quinn to solve the strong CP problem in quantum chromodynamics (QCD) [10]. The PQ axion has a mass in the range 10^{-5} eV to 10^{-3} eV. Axions, or axion-like particles (ALP), occur also in string theory in large numbers (in the hundreds), they form the axiverse.

The axion-like particle masses extend over many orders of magnitude making them distinct candidate components of dark matter. Ultra-light axions (ULA), with masses 10^{-33} eV $< M_a < 10^{-20}$ eV, roll slowly during inflation and behave like dark energy before beginning to oscillate (as we see below). The lightest ULAs with $M_a \lessapprox 10^{-32}$ eV are indistinguishable from dark energy. Higher mass ALPs, $M_a \gtrapprox 10^{-25}$ eV behave like cold dark matter [17]. Quantum mechanically, an axion of mass of, say 10^{-22} eV, has a Compton wavelength of 10^{16} m.

[1] The superons may be in a Higgs phase of a gauge Higgs theory. The Higgs field would be in the fundamental representation of the gauge group SU(3). In this case it is claimed there are no fermion excitations [11, 12].

[2] In this note we mostly talk about all spin zero particles freely as scalars.

Table 1: Superon content of Dark Matter and the Standard Model particles.

Dark Matter	Superon state
boson(system)	axion, s^0
o	$\epsilon_{ijk}n_i n_j n_k$
SM Matter	Superon state
e^-	$\epsilon_{ijk}m_i^- m_j^- m_k^-$
u_k	$\epsilon_{ijk}m_i^+ m_j^+ m^0$
d_k	$\epsilon_{ijk}m^- m_i^0 m_j^0$
ν	$\epsilon_{ijk}m_i^0 m_j^0 m_k^0$

Ultra-light bosons with masses $\ll$ eV can form macroscopic systems like Bose-Einstein condensates, such as axion stars [13, 14]. Due to the small mass the occupation numbers of these objects are large, and consequently, they can be described classically.

The fermionic axino n is supposed to appear, like the m superons, as free particle if $T > \Lambda_{cr}$ and when $T \lesssim \Lambda_{cr}$ in composite states. If the mass of the axino composite state o is closer to the electron mass rather than the neutrino mass it may form 'lifeless' dark stars in a wide mass range. These are not distributed like ordinary stars in the universe since they are spectators in the early universe, as discussed in section 4.

Let us go to the early universe. Axions are treated as spectator fields during inflation [18, 19, 20].[3] In fact, all superons are spectators until reheating, which in turn heats the visible matter only. The axion is massless as long as non-perturbative effects are absent. When these effects are turned on the PQ symmetry is broken and the axion acquires a mass. A minimally coupled scalar field in General Relativity has an action

$$S = \int d^4x\sqrt{-g}\Big[-\frac{1}{2}(\partial\phi)^2 - V(\phi)\Big] \tag{3.1}$$

In the Friedmann-Lemaitre-Robertson-Walker metric with potential $V = \frac{1}{2}M_a^2\phi^2$ [4] the axion equation of motion is

$$\ddot{\phi}_0 + 2\mathcal{H}\dot{\phi}_0 + M_a^2 a^2\phi_0 = 0 \tag{3.2}$$

where ϕ_0 is the homogeneous value of the scalar field as a function of the conformal time τ, a is here the cosmological scale factor, and dots denote derivatives with respect to conformal time.

At an early time $t_i \gtrsim 10^{-36}$s, $M_a \ll H$ and the axion rolls slowly. If the initial velocity is zero it has equation of state $w_a \equiv P_a/\rho_a \simeq -1$. Consequently,

[3] On the other hand, the axion can be modeled as causing the inflation [21].

[4] This is an adequate approximation over most of the parameter space observationally allowed provided $f_a < M_{\rm Pl}$. The potential is anyway unknown away from the minimum without a model for nonperturbative effects.

the axion is a component of dark energy. With $t > t_i$ the temperature and H decrease and the axion field begins to oscillate coherently at the bottom of the potential. This happens when

$$M_a = 3H(a_{osc}) \tag{3.3}$$

which defines the scale factor a_{osc}. Now the number of axions is roughly constant and the axion energy density redshifts like matter with $\rho_a \propto a^{-3}$. The relic density parameter Ω_a is

$$\Omega_a = \left[\frac{1}{2a^2}\dot{\phi}_0^2 + \frac{M^2 a}{2}\phi_0^2 \right]_{M_a^2=3H} a_{osc}^3/\rho_{crit} \tag{3.4}$$

where ρ_{crit} is the cosmological critical density today. Explicit estimates for the relic density are given in [17]. This applies to all axion-like particles, if there are many like in string theory.

When radiation and matter match in ΛCDM model the Hubble rate is $H(a_{eq}) \sim 10^{-28}$ eV. Axions with mass larger than 10^{-28} eV begin to oscillate in the radiation era and may provide for even all of dark matter. The upper limit of the ultralight axion mass fraction Ω_a/Ω_{DM}, where Ω_a is the axion relic density and Ω_{DM} is the total DM energy density parameter, varies from 0.6 in the low mas end 10^{-33} eV to 1.0 in the high mass limit 10^{-24} eV. In the middle region Ω_a/Ω_{DM} is constrained to be below about 0.05 [17].

The dark fermions may be at this stage be approximated as fermion-antifermion pairs. Their behavior follows that of scalar particles until reheating at which time the composite states o may form (without heating up).

4 Inflation and Supergravity

This section is a brief review of work done by other authors. It is included because CMB measurements offer data of inflation in the relevant energy region for testing supergravity.

At the beginning of inflation, $t = t_i \sim 10^{-36}$ s, the universe is modeled by gravity and a scalar inflaton with some potential $V(\phi)$. The Einstein-Hilbert action is

$$S = \int d^4x\sqrt{-g}\Big(\frac{1}{2}R - \frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - V(\phi)\Big) \tag{4.1}$$

Inflation ends at $t_R \approx 10^{-32}$ s when the inflaton, which is actually coherently oscillating homogeneous field, a Bose condensate, reaches the minimum of its potential. There it oscillates and decays by coupling to SM particles produced from m superons at the end of inflation. This causes the reheating phase, or the Bang.

The CMB measurements of inflation can be well described by a few simple slow-roll single scalar potentials in (4.1). One of the best fits to Planck data

[26] is obtained by one of the very oldest models, the Starobinsky model [27]. The action is

$$S = \frac{1}{2}\int d^4x\sqrt{-g}\Big(R + \frac{R^2}{6M^2}\Big) \tag{4.2}$$

where $M \ll M_{\rm Pl}$ is a mass scale. Current CMB measurements indicate scale invariant spectrum with a small tilt in scalar density $n_s = 0.965 \pm 0.004$ and an upper limit for tensor-to-scalar ratio $r < 0.06$. These values are fully consistent with the Starobinsky model (4.2) which predicts $r \simeq 0.003$.

The model (4.2) has the virtue of being based on gravity only physics. Furthermore, the Starobinsky model has been shown to correspond to no-scale supergravity coupled to two chiral supermultiplets. Some obstacles have to be sorted out before reaching supergravity. In this section we follow the review by Ellis, García, Nagata, Nanopoulos, Olive and Verner [28].

The first problem with generic supergravity models with matter fields is that their effective potentials do not provide slow-roll inflation as needed. Secondly, they may have anti-deSitter vacua instead of deSitter ones. Thirdly, looking into the future, any new model of particles and inflation should preferably be consistent with some string model properties. These problems can be overcome by no-scale supergravity models. No-scale property comes from their effective potentials having flat directions without specific dynamical scale at the tree level. This has been derived from string models, whose low energy effective theory supergravity is.

Other authors have studied other implications of superstring theory to inflationary model building focusing on scalar fields in curved spacetime [21] and the swampland criteria [29, 30, 31]. These studies point out the inadequacy of slow roll single field inflation. We find it important to first establish a connection between the Starobinsky model and (two field) supergravity.

The bosonic supergravity Lagrangian includes a Hermitian function of complex chiral scalar fields ϕ_i which is called the Kähler potential $K(\phi^i, \phi^*_j)$. It describes the geometry of the model. In minimal supergravity (mSUGRA) $K = \phi^i\phi^*_i$. Secondly the Lagrangian includes a holomorphic function called the superpotential $W(\phi^i)$. This gives the interactions among the fields ϕ^i and their fermionic partners. K and W can be combined into a function $G \equiv K + \ln|W|^2$. The bosonic Lagrangian is of the form

$$\mathcal{L} = -\frac{1}{2}R + K^j_i\partial_\mu\phi^i\partial^\mu\phi^*_j - V - \frac{1}{4}\mathrm{Re}(\mathrm{f}_{\alpha\beta})\mathrm{F}^\alpha_{\mu\nu}\mathrm{F}^{\beta\mu\nu} - \frac{1}{4}\mathrm{Im}(\mathrm{f}_{\alpha\beta})\mathrm{F}^\alpha_{\mu\nu}\tilde{\mathrm{F}}^{\beta\mu\nu} \tag{4.3}$$

where $K^j_i \equiv \partial^2 K/\partial\phi^i\partial\phi^*_j$ and $\mathrm{Im}(\mathrm{f}_{\alpha\beta})$ is the gauge kinetic function of the chiral fields ϕ^i. In mSUGRA the effective potential is

$$V(\phi^i, \phi^*_j) = e^K\left[|W_i + \phi^*_i W|^2 - 3|W|^2\right] \tag{4.4}$$

where $W_i \equiv \partial W/\partial\phi^i$. It is seen in (4.4) that the last term with negative sign may generate AdS holes with depth $-\mathcal{O}(m^2_{3/2}M^2_{\rm Pl})$ and cosmological instability.

Solution to this and the slow-roll problem is provided by no-scale supergravity models. The simplest such model is the single field case with

$$K = -3\ln(T + T^*) \tag{4.5}$$

where T is a volume modulus in a string compactification. Now the the Lagrangian (4.3) becomes as

$$\mathcal{L} = \frac{3}{(T + T^*)^2}\partial^\mu T \partial_\mu T^* = \frac{1}{12}(\partial_\mu K)^2 + \frac{3}{4}e^{2K/3}|\partial_\mu(T - T^*)|^2 \tag{4.6}$$

The single field (4.5) model can be generalized to include matter fields ϕ^i with the followng Kähler potential

$$K = -3\ln(T + T^* - \frac{1}{3}|\phi_i|^2) \tag{4.7}$$

The corresponding Lagrangian is

$$\mathcal{L} = \frac{1}{12}(\partial_\mu K)^2 + e^{K/3}|\partial_\mu \phi^i|^2 + \frac{3}{4}e^{2K/3}|\partial_\mu(T - T^*) + \frac{1}{3}(\phi_i^*\partial_\mu\phi^i - \phi^i\partial_\mu\phi_i^*)|^2 - V \tag{4.8}$$

where

$$V = e^{2K/3}V' = \frac{V'}{\left((T + T^*) - |\phi^i|^2/3\right)^2} \tag{4.9}$$

and

$$V' \equiv |W_i|^2 + \frac{1}{3}(T + T^*)|W_T|^2 + \frac{1}{3}\left(W_T(\phi_i^* W^{*i} - 3W^*) + h.c.\right) \tag{4.10}$$

The no-scale Starobinsky model is now obtained with some extra work from the scalar potential (4.9) and (4.10) with two fields taking ϕ as the inflaton and assuming $\langle T \rangle = \frac{1}{2}$. For the superpotential the Wess-Zumino form is introduced [32]

$$W = \frac{1}{2}M\phi^2 - \frac{1}{3}\lambda\phi^3 \tag{4.11}$$

which is a function of ϕ only. Then $W_T = 0$ and from (4.10) $V' = |W_\phi|^2$ and the potential becomes as

$$V(\phi) = M^2\frac{|\phi|^2|1 - \lambda\phi/M|^2}{(1 - |\phi|^2/3)^2} \tag{4.12}$$

The kinetic terms in (4.8) can be written now

$$\mathcal{L} = (\partial_\mu\phi^*, \partial_\mu T^*)\Big(\frac{3}{(T + T^* - |\phi|^2/3)^2}\Big)\begin{pmatrix} (T + T^*)/3 & -\phi/3 \\ -\phi^*/3 & 1 \end{pmatrix}\begin{pmatrix} \partial^\mu\phi \\ \partial^\mu T \end{pmatrix} \tag{4.13}$$

Fixing T to some alue one can define the canonically normalized field χ

$$\chi \equiv \sqrt{3}\tanh^{-1}\left(\frac{\phi}{\sqrt{3}}\right) \tag{4.14}$$

By analyzing the real and imaginary parts of χ one finds that the potential (4.12) reaches its minimum for $\text{Im}\chi = 0$. $\text{Re}\chi$ is of the same form as the Starobinsky potential in conformally transformed Einstein-Hilbert action [33] with a potential of the form $V = \frac{3}{4}M^2(1 - e^{-\sqrt{2/3}\phi})^2$. when

$$\lambda = \frac{M}{\sqrt{3}} \tag{4.15}$$

Most interestingly, λ/M has to be very accurately $1/\sqrt{3}$, better than one part in 10^{-4}, for the potential to agree with measurements.

This is briefly the basic mechanism behind inflation in the Wess-Zumino mSUGRA model, which foreruns reheating for visible matter. Up to now, model dependence in our scenario has been rather mild. Essential during inflation is that none of the fields have interactions, apart from gravity. All particles in (2.1) and (2.2) fulfill this condition. At $T \sim \Lambda_{cr}$ the m and n superons form composite states. But only the particles containing m superons, i.e. the visible matter gets reheated. The dark sector is going through reheating unaffected. The quantum fluctuations of the dark fields are enhanced by gravitation and provide an underlay for visible matter to form objects of various sizes, from stars to large scale structures.

In the next section 5 we study the relative abundances of matter and antimatter in the new born universe, and propose a mechanism for producing matter-only universe(s) - together with two other kinds of universes.

5 Matter-Antimatter Asymmetry

An interesting fact is that the same twelve superons, namely four m^+, four m^- and four m^0, may form either hydrogen or anti-hydrogen atoms

$$\begin{aligned} p + e^- &:= u^{2/3} + u^{2/3} + d^{-1/3} + e^- \\ &:= \sum_{l=1}^{4} \left[m_l^+ + m_l^- + m_l^0 \right] =: \bar{p} + e^+ \end{aligned} \tag{5.1}$$

where the superscript is the charge of the particle and $\pm$ indicates charge $\pm\frac{1}{3}$ (note the =: on the second line must be read from right to left). When a large number of superon-antisuperon pairs are created from vacuum the question is which way they will organize themselves: will they be all hydrogen, or anti-hydrogen, or both of them in a certain ratio? The common answer is the third alternative. This is not, however, what an astronomy textbook tells. We try next to develop a precursory mechanism for the observed alternative.

In this scenario fermionic superons m and n are created as spectator quantum fields when inflation starts and the metric still has significant quantum fluctuations. Let us start from the case most relevant to us. There is small but non-zero quantum probability for three m^- superons to spontaneously form an electron at time $t \gtrapprox t_i$. This formation has interesting consequences if there is some asymmetry in spacetime like one caused by torsion which leads to a difference in fermion masses. The torsional correction to a fermion mass is $M_t = M + a/M_{\rm Pl}^2$ where $a \propto 1$ [34]. For an antifermion the correction term is negative. In the environment at $t \sim t_i$ this mass difference needs not be small. The heavier superon m^- is expected to create subtle order and cause movement of the lighter superons in spacetime towards it. It generates a small correlation length λ_{cor}, and a corresponding 3D volume, within which different superon charge states are differentiated. Therefore when three m^- superons are about to form an electron the correlated region, or bubble, contains antifermions m^+ and m^0 which in turn form u and d quarks, which form much later hydrogen atoms.

Inflation is advanced by the potential (4.11). After the first electron-quark pair correlation has formed the correlation length scale λ_{cor} and the corresponding bubble volume expand exponentially due to inflation.[5] Inside the first such bubble, every newly formed smaller bubble, which contains again twelve, or in fact a myriad more, superons at high density in the formation point, the torsion induced correlation occurs again between the three heavier m^- and the lighter two m^+ and an m^0 (or an m^+ and two m^0). Consequently, only matter production occurs during inflation.

The inflaton decay takes place after the inflaton has reached the minimum of its potential and it couples to the quarks and leptons while vibrating in its ground state causing reheating. The SM particles have now no antiparticles to annihilate with. Without further interactions we have $r_B \approx 0$. The expansion, reheating and all the later processes ultimately produce what we see as the observed universe.

All dark matter is smoothly distributed in the universe after inflation because they were unaffected by the reheating. Visible matter fields in turn loose their original quantum fluctuations and are remodulated by reheating. Quantum fluctuations in the dark fields during inflation lead to (i) dark matter density variations and (ii) the formation of primordial black holes in the universe. These density variations grow stronger after inflation by gravity and provide attractive gravitational potential regions for visible matter to accumulate in the various formations we observe [16].

We expect roughly twice as much visible matter from the m^+ and m^0 than fermionic dark matter from the n. The fraction of n of all matter today is about 2.5%. Therefore there should be about ten times more bosonic dark matter and e.g. primordial black holes than fermionic dark matter.

When inflation started the first formed three superon state could be any composite state in table 1. Our universe was built up originally around three m^-, or an electron. A universe inflating around a two m^- and an m^0 will form a universe with antimatter only.

Thirdly, there are radiation dominated visible matter universes from anni-

[5] This idea of λ_{cor} growing exponentially during inflation was suggested to us by R. Brandenberger.

hilating lepton-antilepton and quark-antiquark pairs. As a result of superons being created in huge numbers there is a multitude of each type of these three universes. This can be called a *tripleverse* scenario of the universe.

6 Conclusions

The present scenario is a bottom up approach to particle structure beyond the standard model. By redefining the fundamental fields as superons in (2.1) and (2.2) it has been possible to define a scenario for visible matter as well as for dark matter. The latter shows up as both fermionic and bosonic fields. The bosonic sector of (2.1) includes axion-like particles. They are obvious candidates for dark matter if $M_a \gtrapprox 10^{-25}$ eV and dark energy if $M_a \lessapprox 10^{-32}$.

The matter-antimatter asymmetric is, according to our proposal, created from C symmetric superons. Dark matter is insensitive to reheating and therefore occurs in the universe as a background gravitational potential for visible mater to form the astronomical objects we observe.

A natural WZ supergravity potential for inflation is adopted from literature. This model gives an excellent fit to CMB data. The model uses some of hints from string theory.

In a nutshell, starting from the Wess-Zumino Lagrangian (2.1) and the second piece (2.2) we propose a unified picture of quarks, leptons, dark sector and the inflationary period of the creation of the asymmetric universe. This scenario may cover, in principle, a huge energy range: up to over fifty orders of magnitude. To prove or disprove the scenario presented above, extensive simulations must be done, more detailed Lagrangians be written and much phenomenological work is to be carried out with current data while waiting for future precision experiments to be carried out in the years to come. A crucial next step is to find the mathematics of gluing the fermionic superons back into standard model particles.

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