Dark matter and dark energy: Specifications that associate with data

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Abstract

This paper suggests a specification for dark matter and an explanation for dark energy. This paper features two key hypotheses. First, this paper assumes that nature includes six isomers of most elementary particles. Five of the six isomers associate with dark matter. Second, this paper assumes that multipole expansions can prove useful regarding gravity. Some terms in the expansions associate with gravitational attraction. Some terms associate with dilution of attraction. Dilution can associate with mutual repulsion between objects and with dark energy. This paper suggests that those two assumptions lead to explanations for data that pertain to the rate of expansion of the universe, the formation of galaxies, and other aspects of cosmology and astrophysics.

Keywords: dark matter, dark energy, rate of expansion of the universe, galaxy formation

Contents

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1. Introduction

Describing dark matter has been an open opportunity for more than 80 years. Understanding dark energy has been an open opportunity for more than 80 years.

This paper suggests specifications for dark matter and dark energy.

This paper suggests similarities between the specifications and familiar physics. For example, the following notions pertain.

- Dark matter might be like ordinary matter.
- Multipole expansions regarding gravity might explain dark energy.

This paper suggests differences from familiar physics. For example, this paper suggests bounds on the applicability of general relativity.

The modeling that this paper suggests might meet the following criteria.

- Explain data that physics otherwise seems not to explain.
- Have no incompatibilities with data.
- Suggest possible future data.

This paper uses the following acronyms. PEM (as in popularly employed modeling) denotes familiar physics modeling. SAM (as in suggested additional modeling) denotes physics modeling that this paper suggests as augmentations to PEM.

2. Methods

This unit suggests a specification for dark matter. This unit suggests modeling that associates with dark energy.

2.1. Ordinary matter and dark matter

This unit suggests a specification for dark matter and discusses some consequences that associate with the specification.

SAM suggests that nature includes six isomers of a so-called isomeric set of elementary particles. Each known elementary particle - except the photon - associates with a member of the isomeric set. The might-be graviton does not associate with a member of the isomeric set. Any other elementary particle in the series that consists of photon, graviton, and so forth does not associate with a member the isomeric set. Any other elementary particle associates with a member of the isomeric set. The isomeric set includes no members other than those to which the above discussion alludes.

SAM suggests that ordinary matter associates with one isomer. SAM suggests that dark matter associates with the other five isomers.

SAM calls the isomers isomer-0, isomer-1, ..., and isomer-5. SAM calls the ordinary matter isomer isomer-0.

SAM suggests the following similarities and differences between the isomers.

- Similarities include the masses, spins, and charges of counterpart elementary particles.
- One difference associates with handedness. Each one of the ordinary matter isomer (or, isomer-0), isomer-2, and isomer-4 associates with left-handedness. Each one of isomer-1, isomer-3, and isomer-5 associates with right-handedness.
- One difference associates with matches between the flavours of charged leptons and the flavours of quarks.
  - Across the six isomers, SAM associates the one-element term flavour-1 with the flavour of the counterpart to the up quark and the counterpart to the down quark. SAM associates the one-element term flavour-2 with the flavour of the counterpart to the charm quark and the counterpart to the strange quark. SAM associates the one-element term flavour-3 with the flavour of the counterpart to the top quark and the counterpart to the bottom quark.
  - For each one of isomer-0 and isomer-3, the following sentences pertain. The counterpart to the electron associates with flavour-1. The counterpart to the muon associates with flavour-2. The counterpart to the tau associates with flavour-3.

– For each one of isomer-1 and isomer-4, the following sentences pertain. The counterpart to the electron associates with flavour-3. The counterpart to the muon associates with flavour-1. The counterpart to the tau associates with flavour-2.
– For each one of isomer-2 and isomer-5, the following sentences pertain. The counterpart to the electron associates with flavour-2. The counterpart to the muon associates with flavour-3. The counterpart to the tau associates with flavour-1.

SAM suggests differences in the evolution of the stuff associating with the various isomers.

This paper designates isomer-1, isomer-2, isomer-4, and isomer-5 as alt-isomers. Alt-isomer stuff evolves differently from isomer-0 stuff and isomer-3 stuff. For each alt-isomer, the flavour-3 charged lepton is less massive than the isomer-0 tau. When the universe is adequately hot, for each alt-isomer, interactions that feature W bosons convert more (than for isomer-0 stuff) counterpart top quarks to counterpart bottom quarks. Later, the stuff that associates with each alt isomer has more neutron counterparts and fewer proton counterparts than does isomer-0 stuff. For each alt-isomer, the rest energy of the flavour-1 charged lepton exceeds the mass-difference between a counterpart neutron and a counterpart proton. The stuff that associates with an alt-isomer scarcely (compared to the stuff that associates with isomer-0 or compared to the stuff that associates with isomer-3) generates electromagnetic radiation. The stuff that associates with an alt-isomer associates with little (compared to the stuff that associates with the ordinary matter isomer) electromagnetically active IGM (or, intergalactic medium).

2.2. Perspective regarding modeling regarding electromagnetism and gravity

This unit alludes to PEM notions - regarding modeling regarding electromagnetism and gravity - that have some similarities to SAM modeling.

PEM discusses modeling that has some similarities to SAM modeling regarding electromagnetic properties and fields and regarding gravitational properties and fields. References [1], [2], and [3] discuss gravitoelectromagnetism, which suggests similarities between gravity and electromagnetism. Reference [4] discusses notions of repulsive components of gravity.

2.3. Electromagnetism

This unit suggests relationships between electromagnetic properties of objects and aspects of electromagnetic fields.

PEM suggests that an object can have more than one electromagnetic property. Examples of electromagnetic properties include charge and magnetic moment.

Equation (1) reprises a PEM aspect of electromagnetism. $q_{intrinsic}$ denotes the charge - of an observed object - as measured in the rest frame of the observed object. $\overrightarrow{E}$ denotes the contribution - to the electric field - that an observer object associates with the notion that the observed object creates a contribution to the electromagnetic field. $\overrightarrow{B}$ denotes the contribution - to the magnetic field - that an observer object associates with the notion that the observed object creates a contribution to the electromagnetic field. c denotes the speed of light.

$$\overrightarrow{E} \cdot \overrightarrow{E} - c^2 \overrightarrow{B} \cdot \overrightarrow{B} \propto q_{intrinsic} \cdot q_{intrinsic} \geq 0 \quad (1)$$

Equation (1) associates with SR (or, special relativity) and with the PEM notion of Lorentz invariance.

SAM uses the symbol $\overrightarrow{v}$ to denote the 3-vector that associates with the velocity - relative to an observer object - that the observer object associates with an observed object. v denotes the magnitude of $\overrightarrow{v}$.

For an observed object and a set of various observer objects, $\overrightarrow{v}$ and v can vary based on the observer object. Each one of observed $\overrightarrow{E} \cdot \overrightarrow{E}$ and observed $\overrightarrow{B} \cdot \overrightarrow{B}$ increases with increasing v. Per SR, the value - in equation (1) of $q_{intrinsic}$ is invariant with respect to the choice of an observer. Each observer object can use the standard set of Maxwell's equations. Based on observed $\overrightarrow{E} \cdot \overrightarrow{E}$, greater v associates with greater perceived $|q_{Maxwell}|$ (regarding the observed object). To the observer, $v > 0$ associates with the positive $\overrightarrow{B} \cdot \overrightarrow{B}$ and with a perceived reduction with respect to the effects of $\overrightarrow{E} \cdot \overrightarrow{E}$. The perceived reduction with respect to the effects of $\overrightarrow{E} \cdot \overrightarrow{E}$ associates with a perceived reduction of effects regarding the inferred charge $q_{Maxwell}$.

If an observed charged object rotates - with uniform angular velocity $\overrightarrow{\omega}$ - around an axis that associates with rotation of the observed object, an observer object considers that (essentially) each component (possibly except point-like components that reside on the axis of rotation) of the charge moves with a nonzero $\overrightarrow{v_r}$. $\overrightarrow{v_r}$ can vary among the various components of the observed object. The observer object

Table 1: Low-tier components of electromagnetic fields that associate with observed objects. Intrinsic properties associate with observations (of an observed object) that associate with the rest frame of the object. Extrinsic properties associate with observations that associate nonzero v with the observed motion of the object. For some intrinsic properties and for some extrinsic properties, the table shows commonly used PEM symbols. The symbol † denotes the three-word phrase to be determined. The aspects column lists vectors that have relevance regarding the strength - near an observer object - of the component of the electromagnetic field. q denotes - in the context of discussion related to equation (1) - $q_{Maxwell}$. Tier denotes the number of aspects that are not $\overrightarrow{r}$ or $\overrightarrow{v}$. Tier associates with the rank of the tensor that associates with an intrinsic property. For example, q associates with the notion of scalar (or, a rank-0 tensor). Magnetic dipole moment associates with the notion of 3-vector (or, a rank-1 tensor). $\overrightarrow{\omega_p}$ associates with precession of the axis of magnetic moment around another axis. For the planet Earth, the period of precession is one day. (Larmor precession associates with notions of external magnetic fields. $\overrightarrow{\omega_p}$ does not necessarily associate with Larmor precession.) The two tier-2 items can associate with notions of stress-energy within the observed object. The symbol ‡ associates with the notion that the item lies beyond the scope of this paper.

Intrinsic property	Extrinsic property	Aspects	Observed effective $\lvert q \rvert$	$\widehat{t}$
Charge (q)	-	$\overrightarrow{r}$	Nonzero	0
Charge (q)	Electric current ($\overrightarrow{I}$)	$\overrightarrow{r}, \overrightarrow{v}$	Less than for $\overrightarrow{v} = 0$	0
Magnetic dipole moment ($\overrightarrow{\mu}$)	-	$\overrightarrow{r}, \overrightarrow{\omega}$	Less than for $\overrightarrow{\omega} = 0$	1
Magnetic dipole moment ($\overrightarrow{\mu}$)	† (†)	$\overrightarrow{r}, \overrightarrow{\omega}, \overrightarrow{v}$	‡	1
Precessing magnetic moment (†)	-	$\overrightarrow{r}, \overrightarrow{\omega}, \overrightarrow{\omega_p}$	‡	2
Precessing magnetic moment (†)	† (†)	$\overrightarrow{r}, \overrightarrow{\omega}, \overrightarrow{\omega_p}, \overrightarrow{v}$	‡	2
...	...	...	...	...

perceives that the overall effect contributes - as a nonzero magnetic dipole moment $\overrightarrow{\mu}$ for the observed object - to the magnetic field $\overrightarrow{B}$. The observer perceives (compared to a similar non-rotating observed object) more $\overrightarrow{B} \cdot \overrightarrow{B}$, less $\overrightarrow{E} \cdot \overrightarrow{E}$, and, hence, less $|q_{Maxwell}|$.

For a pair of one observed object and one observer object, SAM uses the symbol $\overrightarrow{r}$ to denote a vector from the position of the observed object to the position of the observer object. r denotes the magnitude of $\overrightarrow{r}$.

Table 1 discusses so-called low-tier components of electromagnetic fields that associate with observed objects. Table 1 extends notions that this paper discusses above.

2.4. *Gravity and dark energy*

This unit suggests relationships between gravitational properties of objects and aspects of gravitational fields.

Table 2 discusses low-tier components of gravitational fields that associate with observed objects.

2.5. *Components of electromagnetism and gravitation*

This unit suggests aspects that associate with components of electromagnetic fields and aspects that associate with components of gravitational fields.

Regarding table 1 and table 2, SAM uses the two-word term intrinsic property to refer to a property (of objects) for which $\overrightarrow{v}$ is not an aspect. SAM uses the two-word term extrinsic property to refer to a property (of objects) for which $\overrightarrow{v}$ is an aspect.

Regarding ND (or, PEM notions that associate with the two-word term Newtonian dynamics), equation (2) associates with a potential that associates with an intrinsic property that associates with tier-n (and, based on the notion of intrinsic property, not with $\overrightarrow{v}$) and equation (3) associates with a potential that associates with an extrinsic property that associates with tier-n (and, based on the notion of extrinsic property, with $\overrightarrow{v}$).

$$r^{-(1+n)} \tag{2}$$

$$r^{-(2+n)} \tag{3}$$

For example, the potential that associates with the intrinsic property of charge q (and not with $\overrightarrow{v}$) has a spatial dependence factor of r^{-1}. ND deploys the word monopole. The potential that associates with the extrinsic property of electric current $\overrightarrow{I}$ (and with q and with $\overrightarrow{v}$) has a spatial dependence factor of r^{-2}. ND deploys the word dipole. (The following references pertain regarding ND multipole modeling. Reference [5] discusses multipole expansions regarding electrostatics and the property of charge. Reference [6] discusses a multipole expansion regarding gravitation and the property of mass.)

Table 2: Low-tier components of gravitational fields that associate with observed objects. Intrinsic properties associate with observations (of an observed object) that associate with the rest frame of the object. Extrinsic properties associate with observations that associate nonzero v with the observed motion of the object. For some intrinsic properties and for some extrinsic properties, the table shows commonly used PEM symbols. The symbol † denotes the three-word phrase to be determined. The aspects column lists vectors that have relevance regarding the strength - near an observer object - of the component of the gravitational field. The word pull associates with attraction - of the observer object - toward the observed object. The word push associates with repulsion - of the observer object - away from the observed object. The symbol $\widehat{t}$ associates with the word tier. Tier denotes the number of aspects that are not $\overrightarrow{r}$ or $\overrightarrow{v}$. Tier associates with the rank of the tensor that associates with an intrinsic property. The rightmost two columns deploy symbols and words that associate with a stress-energy tensor, $T^{\mu\nu}$. Regarding each two-character item in the column with label $T^{\mu\nu}$, the first character associates with μ and the second character associates with ν. The ranges $1 \leq a \leq 3$ and $1 \leq b \leq 3$ pertain. The notion that $a \neq b$ pertains.

Intrinsic property	Extrinsic property	Aspects	Force	$\widehat{t}$	$T^{\mu\nu}$	Interpretations
Mass (m) or Energy (E)	-	$\overrightarrow{r}$	Pull	0	00	Energy density
Mass (m) or Energy (E)	Momentum ($\overrightarrow{P}$)	$\overrightarrow{r}, \overrightarrow{v}$	Push	0	$0a$, $a0$	Momentum density, Energy flux
Angular momentum ($\overrightarrow{s}\hbar$)	-	$\overrightarrow{r}, \overrightarrow{\omega}$	Push	1	aa	Pressure
Angular momentum ($\overrightarrow{s}\hbar$)	† (†)	$\overrightarrow{r}, \overrightarrow{\omega}, \overrightarrow{v}$	Pull	1	ab, ba	Momentum flux, Sheer stress
Moments of inertia (I_{xy})	-	$\overrightarrow{r}$	Pull	2	00	Energy density
Moments of inertia (I_{xy})	† (†)	$\overrightarrow{r}, \overrightarrow{v}$	Push	2	$0a$, $a0$	Momentum density, Energy flux
† (†)	-	$\overrightarrow{r}, \overrightarrow{\omega}$	Push	3	aa	Pressure
† (†)	† (†)	$\overrightarrow{r}, \overrightarrow{\omega}, \overrightarrow{v}$	Pull	3	ab, ba	Momentum flux, Sheer stress
...	...	...	...	...	...	...

Regarding SR and GR (or, general relativity), SAM suggests that the notions of tier and $\cdots$pole can pertain. Regarding SR and GR, equation (2) and equation (3) do not necessarily pertain.

Generally, regarding each one of table 1 and table 2 and regarding a pair of objects, at adequately low density (or, adequately low number of objects per unit volume) lower tier aspects dominate - compared to higher tier aspects - regarding interactions between the two objects. Regarding ever higher densities, higher tier aspects can become significant, can become dominant, and can become dominated by yet higher tier aspects.

PEM suggests that - during the evolution of the universe - objects generally move away from each other.

SAM suggests - for each one of electromagnetism and gravity - that, for pairs of similar objects, the dominant tier-number can decrease over time. SAM suggests that - generally - pairs of smaller objects associate with earlier changes in dominant tier-numbers than do pairs of larger objects. SAM suggests that, for relatively (on astrophysical scales of sizes) small objects, tier-0 effects now dominate.

To a first approximation, ordinary matter stuff does not see electromagnetism emitted by stuff that associates with other isomers. SAM suggest that each isomer associates with its own instance of charge and with its own instance of tier-0 electromagnetism.

To a first approximation, gravity links all six isomers. SAM suggests that - across all six isomers - there is one instance of mass (or of energy) and one instance of tier-0 gravitation.

SAM suggests that equation (4) pertains for each tier of electromagnetism and for each tier of gravitation. n_I denotes the number of instances of an intrinsic property and the number of instances of the associated extrinsic property. R_I denotes the so-called reach of any one of the instances. The reach is the number of isomers that interact with each other via one instance of the tier of the appropriate one of electromagnetism and gravitation.

$$n_I R_I = 6 \tag{4}$$

Discussion above suggests that the pair $n_I = 6$ and $R_I = 1$ pertains for tier-0 electromagnetism.

SAM anticipates that the pair $n_I = 6$ and $R_I = 1$ also pertains for other circumstances.

Discussion above suggests that the pair $n_I = 1$ and $R_I = 6$ pertains for tier-0 gravitation.

SAM anticipates that the pair $n_I = 1$ and $R_I = 6$ also pertains for other circumstances.

SAM anticipates that the pair $n_I = 3$ and $R_I = 2$ pertains for some circumstances.

SAM anticipates that the pair $n_I = 2$ and $R_I = 3$ does not necessarily pertain within the scope of this paper.

Unlike SAM, PEM tends to associate with $n_I = 1$, $R_I = 1$, and $n_I R_I = 1$.

3. Results

This unit suggests reaches for electromagnetic phenomena that associate with various tiers and for gravitational phenomena that associate with various tiers. The suggested reaches have bases in data.

3.1. Basics: Tier-0 electromagnetism and gravitation

To a first approximation, gravity links all six isomers. For tier-0 gravity, SAM suggests that $R_I = 6$.

To a first approximation, each isomer does not see electromagnetism emitted by stuff that associates with other isomers. For tier-0 electromagnetism, SAM suggests that $R_I = 1$. For thermal radiation (including stellar radiation) electromagnetism, SAM suggests that $R_I = 1$.

3.2. Atoms and electromagnetism

Data suggest that people sometimes detect twice as much - compared to modeling-based expectations - presence of light or depletion of light as people expect. (References [7], [8] and [9] provide data and discussion regarding the amount of cosmic optical background. References [10], [11], and [12] provide data and discussion regarding depletion of cosmic microwave background.)

PEM associates the creation of electromagnetic radiation - that today measures as cosmic optical background or as cosmic microwave background - with atomic phenomena that occurred about 400,000 years after a time that PEM associates with the two-word term Big Bang.

SAM suggests that the presences and depletions associate with atomic phenomena that associate with isomer-0 (the expected amounts) and isomer-3 (the unexpected amounts). SAM associates electromagnetic atomic properties with tier-undetermined electromagnetism. (For an atom, such properties associate with interactions between the charge and magnetic moment of the atomic nucleus and various aspects of the atomic electron cloud.) For atomic electromagnetism, SAM suggests that $R_I = 2$.

3.3. Large-scale presences of ordinary matter and dark matter

Data suggest that large-scale ratios of dark matter presence to ordinary matter presence exceed five-to-one. (Reference [13] provides data and discussion regarding densities of the universe. References [14], [15], [16], and [17] provide data and discussion regarding galaxy clusters.)

SAM suggests that - at sufficiently high densities of stuff - electromagnetic interactions can transfer energy between isomers. An interaction for which the incoming stuff associates with one isomer can produce electromagnetic radiation that transforms into matter-and-antimatter pairs of elementary fermions that associate with another isomer. Each one of isomer-0 and isomer-3 associates with more charged hadron-like particles than does each one of the other four isomers. SAM suggests that the net flow - into each alt-isomer isomer - of energy exceeds the net flow of energy into each one of isomer-0 and isomer-3. SAM suggests that, for at least one tier of electromagnetism, $R_I = 6$.

3.4. Galaxy formation and evolution

SAM suggests that some galaxies formed via tier-2 gravitation. SAM suggests that some of those galaxies evolved primarily via tier-1 gravitation or tier-0 gravitation. SAM suggests that each one of many galaxies associates with mergers - of previous galaxies - that associate with tier-0 gravitation.

3.4.1. Galaxies that associate with tier-2 gravitation

Data suggest that some galaxies include little - compared to the presence of dark matter - ordinary matter. (References [18] and [19] provide data and discussion regarding early galaxies. Regarding observations of later galaxies, references [20], [21], [22], [23], [24], [25], and [26] provide data and discussion. Reference [27] discusses a galaxy that might have started as containing mostly ordinary matter. Reference [28] discusses a trail of galaxies for which at least two galaxies have little dark matter.)

SAM suggests that tier-2 gravitational pull assembled such galaxies. For tier-2 gravity, SAM suggests that $R_I = 1$.

Data suggest that some galaxies include little - compared to the presence of ordinary matter - dark matter. PEM associates the three-word term dark matter galaxies with such galaxies. (References [29], [30], [31], and [32] provide data and discussion regarding dark matter galaxies. References [33] and [34] suggest, regarding galaxy clusters, the existence of clumps of dark matter that might be individual galaxies. Extrapolating from results that references [29] and [35] discuss regarding ultrafaint dwarf galaxies that orbit the Milky Way galaxy might suggest that the universe contains many dark matter galaxies.)

SAM suggests that tier-2 gravitational pull assembled such galaxies. For tier-2 gravity, SAM suggests that $R_I = 1$.

3.4.2. Galaxies that associate with tier-1 gravitation and tier-0 gravitation

Data suggest that some galaxies include approximately four times as much dark matter as ordinary matter. (References [36] and [37] provide data and discussion.)

SAM suggests that - during and after the formation of a one-isomer galaxy halo - tier-1 gravitational repulsion drives away most of the stuff that associates with one other isomer. Then, the galaxy attracts, via tier-0 gravity - stuff from up to five isomers. For tier-1 gravity, SAM suggests that $R_I = 2$.

3.4.3. Galaxies that associate with tier-0 gravitation

Data suggest that many galaxies include somewhat more than five times as much dark matter as ordinary matter. (Reference [29] provides data and discussion. References [38] and [39] provide data about collisions of galaxies.)

SAM suggests that tier-0 gravitational pull assembled - from smaller galaxies - such galaxies. For tier-0 gravity, SAM suggests that $R_I = 6$.

3.5. The rate of expansion of the universe

References [40] and [41] provide overviews of cosmology. References [42], [43], [44], and [45] review aspects of cosmology. Reference [46] discusses observational tests for cosmological models. A prevalent theme associates with notions of a rate of expansion of the universe.

PEM points to three possible eras regarding the rate of expansion. A possible inflationary epoch would feature the moving away - from each other - of clumps of stuff. A subsequent observed multi-billion-years era features continued moving away, with the moving away slowing down. The next (and current) observed era features continued moving away, with the moving away speeding up.

SAM suggests that eras in the rate of expansion of the universe associate with transitions in dominance among gravitational tiers.

If the universe experienced an inflationary epoch, SAM suggests that tier-3 gravitation led to the inflationary epoch. Tier-3 gravitation associates with push. PEM associates the inflationary epoch with the moving away - from each other - of clumps of stuff.

SAM suggests that tier-2 gravitation led to the first multi-billion-years era. Tier-2 gravitation associates with pull. PEM associates the first multi-billion-years era with the slowing down of the moving away - from each other - of clumps of stuff.

SAM suggests that tier-1 gravitation led to the current multi-billion-years era. Tier-1 gravitation associates with push. PEM associates the current multi-billion-years era with the speeding up of the moving away - from each other - of clumps of stuff.

3.6. Large-scale tensions between data and modeling

Data suggest the following three types of so-called tensions between observations and PEM modeling regarding large-scale phenomena.

1. Models underestimate - for a recent multi-billion-years era - increases in the rate of expansion of the universe. (References [47], [48], [49], [50], [51], [52], [53], and [54] provide further information. Reference [55] suggests that the notion that dark matter is like ordinary matter might help resolve the relevant tension. Reference [56] discusses various possible resolutions.)
2. Models overestimate large-scale clumping of matter - ordinary matter and dark matter. (References [57], [58], [59], and [50] provide data and discussion.)
3. Models might not account for some observations about effects - within individual galaxies - of the gravity associated with nearby galaxies. (Reference [60] provides further information.)

SAM suggests that $R_I = 2$ for tier-1 gravitational push associates with extra inter-object repulsion, compared to projections that models would make based on extrapolating from successful modeling that pertains for tier-2 gravitational pull. (For example, PEM modeling regarding the rate of expansion of the universe tends to feature the notion of an equation of state. The equation of state links notions - such as notions to which table 2 alludes - of pressure to notions - such as notions to which table 2 alludes - of energy density. A PEM model that includes an equation of state and that comports with data about the first multi-billion-years era might try to apply the same equation of state to phenomena that

Table 3: Reaches that associate with components of electromagnetism and with components of gravitation. Regarding tiers, (or, $\widehat{t}$), the symbol ‡ associates with the notion that the topic of a value or a range of values for $\widehat{t}$ is not within the scope of this paper. R_I denotes the reach, in number of isomers. Regarding R_I, the symbol †† associates with the notion that there might not be enough information to determine - just based on data - a value for R_I. A note pertains regarding each component of gravitation. The word pull associates with attraction - of an observer object - toward an observed object. The word push associates with repulsion - of an observer object - away from an observed object. Regarding the expansion of the universe, the gravitational phenomena affect the era to which the row alludes. The word affect associates with the notion that the phenomena led to the era and drove early aspects of the era. The table shows earlier eras below later eras.

Phenomena	$\widehat{t}$	R_I	Note	Expansion of the universe
Electromagnetism	0	1	-	-
Electromagnetism	1	††	-	-
Electromagnetism - dense plasma	‡	6	-	-
Electromagnetism - atomic	‡	2	-	-
Electromagnetism - thermal	‡	1	-	-
Gravitation	0	6	Pull	-
Gravitation	1	2	Push	A recent multi-billion-years era
Gravitation	2	1	Pull	An earlier multi-billion-years era
Gravitation	3	††	Push	A possible yet-earlier inflationary epoch

associate with the second multi-billion-years era. SAM suggests that such a model might underestimate the pressure relevant to the transition to the second multi-billion-years era and the pressure relevant to an original portion of the second multi-billion-years era.) The only R_I for which $R_I < 2$ is $R_I = 1$. For tier-2 gravitational pull, SAM suggests that $R_I = 1$.

3.7. Collisions that involve galaxy clusters

Data suggest that - during some collisions of two galaxy clusters - some IGM in each galaxy cluster interacts electromagnetically with some IGM in the other galaxy cluster. (Reference [61] discusses the Bullet Cluster collision of two galaxy clusters.)

SAM suggests the possibility that data are not necessarily incompatible with the SAM suggestions that isomer-3 stuff includes IGM and that the stuff that associates with the four alt-isomers includes little IGM.

3.8. Recap: Reaches that associate with components of electromagnetism and gravitation

Table 3 summarizes reaches that associate with components of electromagnetism and with components of gravitation.

4. Discussion

This unit discusses another (compared to discussion above) aspect that might affect large-scale ratios of dark matter presence to ordinary matter presence. This unit discusses possible limits regarding the accuracy of modeling that has bases in GR.

4.1. Possible isomer-0 dark matter elementary particles

This unit suggests that SAM might not necessarily be incompatible with PEM notions of dark matter elementary particles.

PEM suggests possibilities for elementary particles - including possible dark matter elementary particles - that people have yet to find.

SAM is not necessarily incompatible with PEM notions that SAM would interpret as suggesting that isomer-0 stuff includes elementary particles or other objects that measure as dark matter. Via the isomeric set, each one of the six isomers could include elementary particles or other objects that measure as dark matter. The six counterparts would contribute to the plus in large-scale dark-matter to ordinary-matter ratios of five-plus to one.

4.2. Newtonian dynamics, special relativity, and general relativity

This unit suggests that the combination of ND, PEM, and SAM and the combination of SR, PEM, and SAM can be more broadly applicable than the combination of GR and PEM.

PEM associates with at least three modeling techniques - ND, SR, and GR - that pertain regarding motion.

References [62], [63], [64], and [65] discuss so-called precision tests of theories of gravity.

The following notions pertain regarding precision tests of GR. SAM suggests that the gravitational effects associate with objects that associate with just one isomer (or, just isomer-0). SAM suggests that the electromagnetic effects associate with sources (of light) that associate with isomer-0 and (possibly) isomer-3. SAM suggests that relevant equipment associates with just one isomer (or, just isomer-0). SAM does not necessarily suggest that modeling - that pertains to completed precision tests - based on GR is incompatible with nature.

More broadly, SAM suggests that modeling based on GR does not comport with some significant phenomena. The following notions provide one example. For a rotating isomer-0 star (such as the Sun), the reach of tier-2 gravitation is two isomers. The rotation of the Sun would affect the trajectory of an isomer-0 planet. The rotation of the Sun would affect the trajectory of an isomer-3 planet. The rotation of the Sun would not affect the trajectory of an alt-isomer planet.

SAM suggests that modeling based on GR can be adequately accurate for circumstances in which - across all relevant objects - only stuff that associates with one isomer plays significant roles. SAM suggests that modeling based on GR might not be adequately accurate for circumstances in which - across all relevant objects - stuff that associates with more than one isomer plays significant roles.

SAM suggests that modeling based on ND or SR can be adequately accurate for circumstances in which - across all relevant objects - only stuff that associates with one isomer plays significant roles. SAM suggests that modeling based on ND or SR can be adequately accurate for circumstances in which - across all relevant objects - stuff that associates with more than one isomer plays significant roles.

5. Conclusions

This paper suggests a specification for dark matter and an explanation for dark energy.

This paper suggests that the specification and the explanation may suffice to explain some data - that physics modeling might not otherwise explain - regarding dark matter and regarding phenomena associated with dark energy. Some of the data pertains to the rate of expansion of the universe or to galaxy formation.

Methods that this paper suggests might not be incompatible with known data. Results that this paper suggests might not be incompatible with known data.

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