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Dark-Matter Specifications and Gravitational Concepts That Explain Data and That Can Inform Cosmology Models

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Abstract: We suggest a specification for dark matter. We suggest concepts that associate with gravitational repulsion between objects. Together, the dark-matter aspects and gravitational aspects seem to explain data that may otherwise be unexplained. Some of the data pertains to ratios of dark-matter effects to ordinary-matter effects regarding galaxy evolution, depletion of cosmic microwave background radiation, and the compositions of galaxy clusters. Some of the data pertains to eras in the evolution of the universe. We assume that nature includes six isomers of a set of most elementary particles. One left-handed isomer underlies ordinary-matter stuff. One similar right-handed isomer underlies some not-cold dark-matter stuff. The other four isomers underlie cold-dark-matter stuff. A novel use of multipole notions and special relativity points to aspects of gravity that repel objects from each other. We suggest that the dark-matter and gravitational aspects can provide bases for tuning cosmological models of the universe.

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1. Introduction

Popular modeling, including the standard cosmological model, approximately fits some cosmic data and leaves unresolved some key aspects [1]. Popular modeling associates some unresolved aspects with the two-word term dark matter. Popular modeling associates some unresolved aspects with the two-word term dark energy.

Observations suggest data that popular modeling seems not to explain.

Some of the data features ratios of unexplained effects to ordinary-matter effects. The ratio 5+:1 pertains to the presence of stuff throughout the universe, stuff in some galaxy clusters, and stuff in some galaxies. Each one of ∼4:1, 1:0+, and 0+:1 pertains to the presence of stuff in some galaxies. 1:1 pertains to some contributions to the depletion of cosmic microwave background radiation.

Some of the seemingly insufficiently explained data relates to the rate of expansion of the universe.

Regarding dark energy and the seemingly unexplained data regarding the rate of expansion of the universe, we suggest herein that concepts related to two-body gravitational interactions provide useful insight. The concepts feature a novel use, regarding gravitational potentials, of multipole notions. Our multipole notions feature multiple properties of a single object, whereas popular modeling multipole expansions tend to feature spatial distributions of a single property. The concepts associate with some uses of special relativity. We suggest that monopole, quadrupole, and so forth aspects of gravity associate with the attraction of two bodies toward each other. We suggest that dipole, octupole, and so forth aspects of gravity associate with the repulsion of two bodies away from each other. The concepts can associate with Newtonian-like dynamics models and with other dynamics models. We suggest that two-body gravitational interactions between galaxy clusters shape the rate of expansion of the universe.

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Regarding the unexplained ratios, we suggest herein that nature includes six approximate copies of the set of known elementary particles, except the photon. We use the word isomer to denote each set. We associate five of the isomers with dark-matter stuff. We suggest that the dark-matter specification and gravitational-interaction concepts combine to explain ratios of dark-matter effects to ordinary matter effects.

We suggest that the dark-matter and gravitational-interaction aspects can provide bases for tuning cosmological models of the universe.

2. Methods

This unit develops and applies novel methods to fit and explain specific data.

2.1. Cosmic Data That Motivate Our Work

This unit discusses cosmological data that motivate our work. Some data associate with observed ratios of not-ordinary-matter effects to ordinary-matter effects. Some data associate with eras in the rate of expansion of the universe. We know of no other line of research that tries to fit all the relevant data.

The following observed ratios of not-ordinary-matter effects to ordinary-matter effects provide a basis for our work.

- 1:1 – Amount of some depletion of cosmic microwave background radiation [2–4].
- 1:0+ – Some galaxies [5–13].
- 0+:1 – Some galaxies.
  - Redshifts of more than approximately seven [14,15].
  - Redshifts of approximately six [16].
  - Redshifts of less than six through redshifts of nearly zero [17–22].
- $\sim$ 4:1 – Some galaxies [23,24].
- 5+:1 – Many galaxies [5].
- 5+:1 – Many galaxy clusters [25–28].
- 5+:1 – Densities of the universe [29].

We know of no data that would seem to point to other seemingly significant ratios of not-ordinary-matter effects to ordinary-matter effects.

A notion of eras in the rate of expansion of the universe provides a basis for our work.

Popular modeling suggests two observed multibillion-year eras [30–33]. Chronologically, the first multibillion-year era associates with a positive rate of expansion that decreases as time increases. The second multibillion-year era associates with a positive rate of expansion that increases as time increases.

2.2. Suggestions That Underlie Our Work

This unit discusses suggestions that we make and that underlie our work.

We suggest that the not-ordinary-matter effects associate with dark matter. We suggest that the appearances, in the relevant ratios, of approximate integers have significance.

The second 1 in the 1:1 ratio associates with effects of ordinary-matter hydrogen atoms. These atoms deplete, via hyperfine transitions, cosmic microwave background radiation. We suggest that the first 1 in the 1:1 ratio associates with dark-matter hydrogen-like atoms. Popular modeling associates ordinary matter with a set of elementary particles. We suggest that these dark-matter hydrogen-like atoms associate with a set of elementary particles that has similarities to, but does not equal, the ordinary-matter set of elementary particles.

We use the word isomer to denote such a set of elementary particles. We anticipate that the set includes all known elementary particles except the photon.

Based on the prevalence of 5+:1 ratios, we suggest that nature includes six isomers. We number the isomers. Isomer-0 associates with ordinary matter. Each one of isomer-1 through isomer-5 associates

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with dark matter. Based on the pluses in the 5+:1 ratios, we suggest that four of the dark-matter isomers are less like isomer-0 than is the one dark-matter isomer that associates with the first 1 in the ratio 1:1.

We suggest that decreases in the rate of expansion associate with gravitational forces that attract galaxy clusters to each other. We suggest that increases in the rate of expansion associate with gravitational forces that repel galaxy clusters from each other. We anticipate associating the forces with two-body physics.

2.3. Multipole Aspects of Electromagnetic Interactions Between Two Small Objects

This unit discusses the concept that a combination of multipole notions and special relativity points to, for example, for two small objects that have positive charges, multipole aspects that associate with electromagnetic repulsion between the objects and multipole aspects that associate with electromagnetic attraction between the objects. Our multipole notions feature multiple properties of a single object, whereas popular modeling multipole expansions tend to feature spatial distributions of a single property. We anticipate extrapolating from this notion to the notion that special relativity points to notions of both gravitational attraction and gravitational repulsion between two objects that model as having nonzero mass.

We consider a two-body interaction in which an object-A affects an object-P. The A in object-A associates with the popular modeling notion of active properties. The P in object-P associates with the popular modeling notion of passive properties.

We assume that each object models as having a nonzero charge that has a spherically symmetric distribution. We assume that the objects model as having charge distributions that are spatially sufficiently small that there is no overlap between the two distributions.

Discussion below does not depend on whether the charges of the two objects are both positive, both negative, or mixed with one charge being positive and one charge being negative.

For a first case, we assume that the two objects model, with respect to one frame of reference, as being stationary and non-rotating. Popular modeling suggests that the electromagnetic force that affects object-P has a representation that associates with three factors. The three factors are the rest charge of object-A, the distance between (the center of charge of) object-A and (the center of charge of) object-P, and the rest charge of object-P. Popular modeling suggests that, from the perspective of object-P, a nonzero electric field associates with object-A and that zero magnetic field associates with object-A. Popular modeling associates the two-word term monopole interaction with this case. In anticipation of later discussion, we suggest that this case associates with a three-vector that associates with the spatial location of object-A at the time at which object-A, in effect, propagated the relevant aspects of the electromagnetic field and with a three-vector that associates with the spatial location of object-P at the time that object-P interacts with the relevant aspects of the electromagnetic field that associates with object-A.

For the next case, we change one assumption. Object-P moves with respect to the frame of reference. The electromagnetic field that associates with object-A does not change. Popular modeling suggests that, from the perspective of object-P, a nonzero electric field pertains; also, a nonzero magnetic field pertains. Special relativity suggests that object-P senses that the magnitude of the electric field is larger than the magnitude of the electric field for the previous case. Special relativity suggests that object-P senses that the magnitude of the charge of object-A is larger than the magnitude of the rest charge of object-A. Popular modeling suggests that the notion of monopole interaction continues (from the previous case) to pertain regarding the electric-field aspect of the electromagnetic field that object-P senses. Popular modeling suggests that a notion of dipole interaction pertains to the magnetic-field aspect of the electromagnetic field that object-P senses. We suggest that an additional (compared to the previous case) three-vector pertains and associates with the velocity that associates with object-P. We suggest that the dipole aspect of the effects that object-A has on object-P associates with, in effect, an attempt to correct for the enhancement (compared to the previous case) of the magnitude of the electric field and for the enhancement (compared to the previous case) of the magnitude of the object-A charge

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that object-P senses. We suggest a notion that, regarding effects on object-P, dipole effects detract from monopole effects.

For the next case, we repeat the previous case and change the frame of reference from one in which object-A is at rest to one in which object-P is at rest. We suggest that a difference (between this case and the immediately previous case) is that the notion of a velocity-related three-vector associates with the motion of object-A and not with object-P. As with the immediately previous case, dipole effects detract from monopole effects. We associate the two-word term charge current with a property (of object-A) that object-P associates with a vector-related property of object-A.

For the next case, we repeat the immediately previous case, but we assume that the charge distribution within object-A rotates, and we assume that (with respect to object-P) object-A associates with zero linear velocity. We suggest that differences (between this case and the immediately previous case) are that the notion of an angular-velocity-related three-vector associates with object-A and the notion of a nonzero charge-current three-vector does not associate with object-A. Here, the angular motion (within object-A) of elements of charge associates with object-P sensing an object-A charge for which the magnitude is greater than the magnitude of the rest-charge of object-A. Popular modeling and we associate the two-word term magnetic moment with a property, as perceived by object-P, that associates with the rotating charge distribution that associates with object-A. Popular modeling associates magnetic moment with dipole effects. As with the immediately previous case, from the perspective of object-P, dipole effects detract from monopole effects.

For the next case, we repeat the previous case but assume that object-A moves with respect to object-P. Two motion-related three-vectors pertain. One motion-related three-vector associates with the charge current of object-A. The other motion-related three-vector associates with the magnetic moment of (or angular motion of the charge within) object-A. We suggest that the relevance of two motion-related three-vectors associates with popular modeling notions of quadrupole. We suggest that a dimensionless measure of the quadrupole property associates with a quotient. The numerator for the quotient is the magnitude of the cross product of the charge current and the magnetic moment. The denominator for the quotient is the product of the magnitude of the charge current and the magnitude of the magnetic moment. We suggest that quadrupole aspects, in effect, try to correct for possible otherwise miscounting regarding the motions of charges within the charge distribution of object-A. (If the cross product is nonzero, some of the rotational motion that associates with the charge distribution of object-A is not orthogonal to the linear motion that associates with the charge distribution of object-A. Miscounting would pertain regarding the non-orthogonal aspects.) From the perspective of object-P, the quadrupole aspects detract from dipole effects. We suggest that, thus, the quadrupole aspects associate with perceptions by object-P of an enhanced magnitude of the monopole effects. We suggest associating the three-word term magnetic moment current with the property that associates with the quadrupole aspects.

We note a pattern. Some properties of object-A are intrinsic to object-A. Examples include charge and magnetic moment. For each intrinsic property of object-A, there is a property for which a term of the form intrinsic-property current pertains. Each term of the form intrinsic-property current associates with a perception, by object-P, of a nonzero linear velocity for object-A.

For a set of next cases, we consider that the distances between the spatial location at which an object-A created relevant contributions to the electromagnetic field and the spatial locations at which various similar-to-each-other objects-P sense those contributions can vary. In the sense of Euclidean spatial coordinates, we consider cases in which the various objects-P lie along a straight line that starts at the position of object-A. For now, we de-emphasize effects that associate with nonzero propagation times for information that associates with values of properties of object-A. For cases in which the distances are adequately large, monopole aspects dominate regarding the relevant electromagnetic effects that an object-P experiences. At lesser distances, dipole aspects can dominate. At lesser distances, quadrupole aspects can dominate. Possibly, and so forth. To the extent that information propagation times have significance, one might consider rates at which the values of intrinsic properties of object-A change with time and rates at which object-A changes location with time. For sufficiently small rates of changes (and with some possible softening of the notion of straight line), the series that starts with monopole dominance at large distances and dipole dominance at lesser distances can pertain.

Throughout the discussion above, in the sense of electromagnetic attraction and electromagnetic repulsion, dipole effects detract from monopole effects; also, quadrupole effects add to monopole effects.

We note differences between the discussion above and much popular modeling discussion based on multipole expansions. Popular modeling based on multipole expansions tends to feature spatial distributions of a single monopole property, such as charge. In effect, the would-be object-A spreads out spatially. Accuracy increases to the extent that the series of terms (monopole, dipole, and so forth) increases in number. The accuracy of the expansion decreases with decreasing distance between the spread-out object-A and the perhaps point-like object-P. For our discussion above, the following three notions pertain. Object-A does not necessarily model as significantly spatially spread out. The number of multipole aspects can remain contained. Appropriateness can pertain at rather small separations between object-A and object-P.

Popular modeling suggests a type of quadrupole interaction in which a nonzero magnetic moment of object-A would interact with a nonzero magnetic moment of object-P. Our count of non-locational three-vectors could be two, as in one for each nonzero magnetic moment. Such a count could be compatible with our above-discussed notions of quadrupole. In popular modeling, an object, such as a bar magnet, can have both zero net charge and nonzero magnetic moment. To the extent that popular modeling would associate both magnetic moments with notions of rotating charge distributions, one might need to consider that circumstances are too complicated to try to overly rely on notions we discuss above.

The case of an object-A being a bar magnet illustrates the notion that an object-A can associate with a nonzero intrinsic magnetic moment and with zero intrinsic charge. In general, nonzero intrinsic dipole aspects can pertain and nonzero intrinsic monopole aspects do not necessarily need to pertain.

2.4. Attracting and Repelling Aspects of Two-Body Gravitation

This unit suggests that monopole, quadrupole, and 16-pole (or hexadecapole) aspects of gravity associate with forces that attract two objects toward each other and that dipole and octupole aspects of gravity associate with forces that repel two objects away from each other.

We suggest that aspects of two-body gravitation have parallels to aspects of two-body electromagnetism. For example, for gravitation, the following substitutions of properties pertain. Mass replaces charge. Mass current replaces charge current. Angular momentum replaces magnetic moment. Angular momentum current replaces magnetic moment current.

For each of an object-A and an object-P, popular modeling suggests that the mass is nonnegative. For our discussion, we assume that masses are always positive. Monopole aspects of gravitational interactions associate with the attraction of object-P toward object-A.

Popular modeling associates electromagnetism with a spin-one field. Popular modeling associates gravity with a spin-two field. We suggest that this difference regarding spins is not relevant for our discussion of two-body interactions.

Regarding object-A, we suggest the notion of relaxing the constraints that associate with spherical symmetry. Regarding object-A, we suggest that the popular modeling notion of a three-component-by-three-component moment of inertia tensor associates with a quadrupole intrinsic property. The tensor is symmetric and hence associates with six independent quantities. We suggest that such is compatible with above-discussed notions that associate quadrupole with two non-spatial three-vectors. The three-word term moments of inertia associates with this quadrupole intrinsic property. The associated octupole current is the moments of inertia current. A related octupole intrinsic property can associate with a three-vector that associates with rotation. For the intrinsic property, we suggest the four-word term rotating moments of inertia. The associated 16-pole current is the rotating moments of inertia current.

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We suggest that, for cases that we consider in this paper, one can retain adequate accuracy if one de-emphasizes the object-P gravitational properties other than mass.

We suggest that, from the perspective of object-P, monopole, quadrupole, and 16-pole gravitational properties of object-A associate with attraction of object-P toward object-A. We suggest that, from the perspective of object-P, dipole and octupole gravitational properties of object-A associate with repulsion of object-P away from object-A.

2.5. Cosmic Clumping of Stuff

This unit suggests that, from the perspective of dominant multipole aspects of gravitational forces, the formation and evolution of smaller cosmic objects occur more quickly than do the formation and evolution of larger cosmic objects.

We assume, for discussion purposes, that, at some time in the evolution of the universe, stuff - matter and dark matter - had a uniform spatial distribution.

We consider Newtonian notions. We consider two spatially non-overlapping, similarly-sized spherical regions of stuff. The amount of stuff in each region scales as the cube of the radius of the region. The monopole contribution to the gravitational force that one region exerts on the other region scales inversely as the square of the distance between the centers of the two regions. If one scales the two radii and the one distance similarly, the monopole aspect of gravitational force scales as $r^3r^3r^{-2} = r^4$. Dipole aspects scale as $r^3r^3r^{-3} = r^3$. Quadrupole aspects scale as $r^3r^3r^{-4} = r^2$. Octupole aspects scale as $r^3r^3r^{-5} = r^1$. 16-pole aspects scale as $r^3r^3r^{-6} = r^0$.

We suggest that the following notions pertain for Newtonian models and for other relevant popular modeling models.

We suggest notions that might associate with observed and possible clumping, at various scale sizes, in the history of the universe. 16-pole attraction might be scale invariant and might not necessarily be adequately relevant for this discussion of clumping. Across a range of sizes, octupole repulsion was dominant at some time. Smaller clumps transited a sequence, of octupole repulsion to quadrupole attraction and onward, faster than did larger clumps. Typically, pairs of neighboring solar-system-sized clumps transited to dominance by monopole attraction before pairs of neighboring galaxy-sized clumps transited to dominance by monopole attraction. Typically, pairs of neighboring galaxy-sized clumps transited to dominance by monopole attraction before pairs of neighboring galaxy-cluster-sized clumps might transit to dominance by monopole attraction.

2.6. Eras in the Rate of Expansion of the Universe

This unit suggests that eras in the rate of expansion of the universe associate with multipole aspects of gravitational interactions between galaxy clusters.

We suggest the following notions regarding the rate of expansion of the universe. If there was an inflationary epoch [34–37], octupole gravitational repulsion between neighboring proto galaxy clusters played an important role early in the inflationary epoch. Quadrupole gravitational attraction between neighboring proto galaxy clusters played a dominant role around the start of the first multibillion-year era. Dipole gravitational repulsion between neighboring galaxy clusters played a dominant role around the start of the second multibillion-year era.

2.7. Instances of Properties of Objects, Plus Reaches of Contributions to Fields

This unit discusses notions regarding electromagnetic interactions, gravitational interactions, and stuff that has bases in one isomer or in more than one isomer.

Popular modeling suggests that ordinary matter does not, at least much, sense electromagnetic phenomena that might associate with dark matter. We suggest that each isomer associates with its own instance of the electromagnetic monopole property, which is charge. We say that a monopole contribution to the electromagnetic field has a reach of one isomer. An object that associates just with one isomer might sense monopole electromagnetic contributions that associate with other same-isomer

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objects. An object that associates just with one isomer would not sense monopole electromagnetic contributions that associate just with objects that do not associate with the same isomer.

Popular modeling suggests that ordinary matter and dark matter sense each other gravitationally. We suggest that all six isomers associate with a common instance of the gravitational monopole property, which is mass. We say that a monopole contribution to the gravitational field has a reach of six isomers. An object that associates just with one isomer senses monopole gravitational contributions that associate with objects that associate just with any one isomer or that associate with more than one isomer.

We use the symbol n_{in} to denote the number of instances of a property. We use the symbol $R_{/in}$ to denote the reach of an instance of the property. The reach is a number of isomers. Each one of n_{in} and $R_{/in}$ is a positive integer.

We suggest that, for each electromagnetic property and for each gravitational property, Eq. (1) pertains.

$$n_{in} \cdot R_{/in} = 6 \tag{1}$$

Some aspects of our attempts to fit data associate with suggesting numbers of instances and reaches per instance for aspects, of gravitational fields, that associate with gravitational properties of objects. Some aspects of our attempts to fit data associate with suggesting numbers of instances and reaches per instance for aspects, of electromagnetic fields, that associate with electromagnetic properties of objects.

2.8. Galaxy Formation and Galaxy Evolution

This unit suggests galaxy formation scenarios that seem to explain seemingly preferred known ratios, for galaxies, of dark-matter presence to ordinary-matter presence.

The solar system that includes the earth associates with the notion of a solar-system-size clump of stuff that associates with just one isomer. Our solar system is not spatially spherical.

We suggest that many other such one-isomer, not-spatially-spherical, somewhat-solar-system-sized clumps exist and generally date to early in the history of the universe. Each such clump associates with nonzero moments of inertia. Discussion above suggests that moments of inertia is a quadrupole gravitationally attractive property.

We suggest that, during some period early in the history of the universe, quadrupole gravitational attraction dominated regarding interactions between neighboring same-isomer, solar-system-sized clumps. We assume that the relevance of same-isomer associates with there being six instances of the property of moments of inertia and with each instance associating with a reach of one isomer. We suggest that solar-system-sized clumps clumped to form the halos of galaxies.

We suggest that the discussion above explains 1:0+ ratios that pertain to some early galaxies and 0+:1 ratios that pertain to some early galaxies.

We suggest that some later 1:0+ galaxies and some later 0+:1 galaxies retain their ratios from early in the evolution of the universe.

Many later galaxies are 5+:1 galaxies. We suggest that many 5+:1 galaxies resulted from mergers of smaller, previous galaxies. We suggest that such mergers associate with monopole gravitational attraction, which discussion above associates with one instance and a reach of six isomers. We suggest that the earliest mergers that led to a 5+:1 galaxy can have been mergers that involved 1:0+ galaxies and 0+:1 galaxies.

The discussion above seems to explain all the galaxy-related ratios that we discuss above, except for the $\sim$ 4:1 ratio.

For each of some $\sim$ 4:1 galaxies, we suggest the following scenario. The galaxy started as a 0+:1 galaxy. Reach-2 repelling dipole contributions to gravity drove away some ordinary-matter stuff and the stuff that associated with one dark-matter isomer. Reach-6, attracting monopole contributions to gravity attracted remaining nearby stuff. The galaxy evolved to a ratio of $\sim$ 4:1.

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Table 1. Matches between masses and flavours, for isomers of charged elementary fermions. The symbol l_{isomer} denotes the isomer number. The symbol $l_{isomer-pair}$ denotes the isomer-pair number. Handedness associates with whether the relevant handed elementary particles are left-handed or right-handed. For each row, the quarks column assigns the three flavour numbers in the order of increasing geometric-mean mass, with the geometric mean associating with the masses for the two quarks that are relevant to the flavour. For each row, the charged leptons column assigns the three flavor numbers in the order of increasing mass for the one relevant charged lepton. The stuff column identifies stuff made from the isomer as OM, as in ordinary matter, or DM, as in dark matter. The evolution column suggests that isomer-3 stuff evolves similarly to isomer-0 (or ordinary matter) stuff. CDM abbreviates the popular modeling term cold dark matter.

l_{isomer}	$l_{isomer-pair}$	Handedness	Flavours - quarks	Flavours - charged leptons	Stuff	Evolution
0	0	Left	1, 2, 3	1, 2, 3	OM	Familiar
1	1	Right	1, 2, 3	3, 1, 2	DM	CDM
2	2	Left	1, 2, 3	2, 3, 1	DM	CDM
3	0	Right	1, 2, 3	1, 2, 3	DM	Like OM
4	1	Left	1, 2, 3	3, 1, 2	DM	CDM
5	2	Right	1, 2, 3	2, 3, 1	DM	CDM

For each of some $\sim$ 4:1 galaxies, we suggest the following scenario. The galaxy started as a 1:0+ galaxy. Reach-2 repelling dipole contributions to gravity drove away some dark-matter stuff but essentially no ordinary-matter stuff. Reach-6 attracting monopole contributions to gravity attracted remaining nearby stuff. The galaxy evolved to a ratio of $\sim$ 4:1.

2.9. Similarities and Differences Between Isomers of Elementary Particles

This unit suggests similarities and differences between the would-be six isomers of elementary particles.

Table 1 suggests a numbering scheme for the six isomers, specifications for the one ordinary-matter isomer and the five dark-matter isomers, and aspects of the evolution of the stuff that associates with each isomer.

We suggest that the fermion flavour-and-mass pairings for isomer-1, isomer-2, isomer-4, and isomer-5 led to those isomers forming stable counterparts to isomer-0 neutrons and to isomer-1, isomer-2, isomer-4, and isomer-5 not forming significant numbers of counterparts to isomer-0 atoms. We use the one-element term alt-isomer to designate an isomer other than isomer-0 and isomer-3. For each one of the six isomers, a charged baryon that includes exactly three flavour-3 quarks is more massive than the counterpart, within the same isomer, zero-charge baryon that includes exactly three flavour-3 quarks. For example, the hadron that includes just two tops and one bottom has a larger total mass than does the hadron that includes just one top and two bottoms. Per Table 1, alt-isomer flavour-3 charged leptons are less massive than isomer-0 flavour-3 charged leptons. When flavour-3 quark states are much populated, the stuff that associates with an alt-isomer converts more charged baryons to zero-charge baryons than does the stuff that associates with isomer-0. Eventually, regarding the stuff that associates with the alt-isomer, interactions that entangle multiple W bosons result in the stuff that associates with the alt-isomer having more counterparts to isomer-0 neutrons and fewer counterparts to isomer-0 protons than does the stuff that associates with isomer-0. The sum of the mass of a counterpart-to-isomer-0 proton and the mass of an alt-isomer flavour-1 charged lepton exceeds the mass of a counterpart-to-isomer-0 neutron. Compared to isomer-0 neutrons, alt-isomer neutrons scarcely decay.

2.10. The Pluses in 5+:1 Ratios of Dark-Matter Effects to Ordinary-Matter Effects

This unit suggests explanations for the pluses in the 5+:1 ratios of dark-matter effects to ordinary-matter effects.

We suggest that nature might include electromagnetic properties, of objects, that we would characterize as associating with notions of higher-pole than monopole or dipole and that we would

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associate with reach-6. Based on the reach-6 properties, early in the evolution of the universe, more electromagnetic energy would flow from isomer-pair-0 stuff to isomer-pair-1 stuff than would flow from isomer-pair-1 stuff to isomer-pair-0 stuff. Similarly, based on the reach-6 properties, early in the evolution of the universe, more electromagnetic energy would flow from isomer-pair-0 stuff to isomer-pair-2 stuff than would flow from isomer-pair-2 stuff to isomer-pair-0 stuff.

We suggest that the electromagnetic energy flow imbalances would result in the existence of more isomer-pair-1 stuff than isomer-pair-0 stuff and in the existence of more isomer-pair-2 stuff than isomer-pair-0 stuff. We suggest that the flows would not disturb a one-to-one ratio of presence of isomer-3 stuff to presence of isomer-0 stuff.

We suggest that these energy flow imbalances might have produced (or, at least, contributed to) the pluses in the 5+:1 ratios of dark-matter presence to ordinary-matter presence.

Our work does not necessarily rule out the possibility that some portions or the entireties of the pluses in the 5+:1 ratios of dark-matter presence to ordinary-matter presence associate with axions or with other popular modeling suggestions regarding the nature of dark matter.

2.11. Hyperfine Depletion of Cosmic Microwave Background Radiation

This unit discusses aspects related to the depletion of cosmic microwave background radiation by hyperfine transitions in hydrogen atoms or in hydrogen-like atoms.

We suggest that above-discussed notions of two-body electromagnetism might not suffice to ascribe a number of instances and a reach per instance that would associate with atomic-state transitions. For example, a hydrogen-atom object-A might not model as a one-body system but might model as a two-body system, with one-body being the atomic nucleus and one-body being the electron cloud.

We suggest that the reach for hyperfine-transition phenomena might be either two or six. A reach of two can suffice to explain the notion that isomer-3 hydrogen-like atoms can absorb, via hyperfine transitions, energy that associates with contributions, by ordinary-matter stuff, to electromagnetic fields. A reach of six might be appropriate, given that four dark-matter isomers might not underlie an adequately significant number of hydrogen-like atoms.

2.12. Collisions of Galaxy Clusters

This unit suggests that our specification for dark matter might not necessarily be incompatible with data about collisions of galaxy clusters.

Our specification for dark matter might not necessarily be incompatible with data about collisions, such as the Bullet Cluster collision, of two galaxy clusters [38,39]. Popular modeling suggests two types of trajectories for stuff. Most dark matter, from either one of the clusters, exits the collision with trajectories that are consistent with having interacted just gravitationally with the other cluster. Ordinary matter stars, from either cluster, exit the collision with trajectories that are consistent with having interacted just gravitationally with the other cluster. However, ordinary matter intergalactic medium, from either cluster, lags the cluster's ordinary matter stars and dark matter. Popular modeling suggests that the ordinary matter intergalactic medium interacted electromagnetically with the other cluster's ordinary matter intergalactic medium, as well as gravitationally with the other cluster. We suggest that the four alt-isomers do not form electromagnetically active intergalactic medium. We suggest that further analysis of data might help determine the validity of our notion that isomer-3 would form electromagnetically interactive intergalactic medium.

3. Results

This unit summarizes notions that our methods fit otherwise seemingly unexplained cosmic data, including data about the rate of expansion of the universe, dark-matter effects, and galaxy evolution.

We suggest a novel use of multipole notions. Multipole aspects associate with gravitational properties of a single object or with electromagnetic properties of a single object.

We suggest a novel relationship between dark-matter stuff and ordinary-matter stuff. Dark matter and ordinary matter share a notion of six isomers of a set of most known elementary particles. One

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isomer underlies ordinary-matter stuff. Each one of the five other isomers underlies some dark-matter stuff.

To fit cosmic data, we need to determine the so-called reaches (which are positive-integer numbers of isomers) of multipole aspects that associate with instances of properties of a single object. We suggest that each reach comports with Eq. (1). We suggest values for some reaches.

The suggested reaches might suffice to explain the otherwise seemingly unexplained cosmic data.

Our work might suffice to explain eras in the rate of expansion of the universe. Our work might suffice to fit or explain each one of various ratios of dark-matter effects to ordinary-matter effects, including ratios that pertain regarding galaxy evolution.

4. Discussion

This unit discusses notions of how our work fits with and might help enhance popular modeling that pertains to cosmology.

4.1. Our Work and the Standard Cosmological Model

Our work tries to fit about ten data clusters or data points. Some of the data clusters or data points are approximate ratios of dark-matter effects to ordinary-matter effects. Some of the data clusters or data points associate with inflection points regarding the rate of expansion of the universe. Each one of some of the data clusters associates with numerous observations. The inflection point regarding the start of the current multibillion-year era in the rate of expansion of the universe provides an example. One of the data points associates with some depletion of cosmic microwave background radiation and with one observation.

Our work seems to offer viable candidate explanations for the about ten data clusters or data points.

Our work does not try to suggest an alternative to the standard cosmological model.

Our work might offer notions that can inform understanding, refining, or replacing aspects of the standard cosmological model. For example, our notions regarding a candidate specification for dark matter might lead to refining aspects of the standard cosmological model.

4.2. Inflation Cosmology

Our work suggests that the beginning of the inflationary epoch [40] might associate with dominance by octupole gravitational repulsion.

4.3. Bounce Cosmology

Popular modeling suggests the notion of bounce cosmology [41,42].

Our work suggests that, before the inflationary epoch, dominance by either quadrupole gravitational attraction or 16-pole gravitational attraction might have led to a compressing, of stuff or energy, that might associate with popular modeling notions of a big crunch. For the case of dominance by 16-pole gravitational attraction, one might need to posit a mechanism that associates with a transition from big crunch to big bang [43]. Without such a mechanism, our modeling might suggest that a next (after a big crunch) era would associate with 32-pole (or dotriacontapole or triacontadipole) gravitational repulsion. A candidate mechanism might be Pauli exclusion effects that would associate with fermion objects. The fermion objects might be fermion elementary particles.

Our work suggests that, eventually, monopole gravitational attraction might lead to the slowing down of the rate of expansion that we suggest associates with forces between galaxy clusters.

We choose not to speculate regarding whether such a slowdown might eventually associate with a positive rate of contraction (as in a negative rate of expansion).

Possibly, popular modeling will identify structures larger than galaxy clusters for which people will discuss notions of rates of expansion or rates of contraction. To the extent that such larger structures follow our notions of multipole gravity, perhaps (at some size) quadrupole attraction dominates.

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4.4. General Relativity

Our work and applications of general relativity have some seeming similarities or compatibilities and some seemingly possible differences or seemingly possible incompatibilities.

Some of our gravitational properties might seem to associate with some components of the general-relativity stress-energy tensor. Mass might associate with energy density. The three components of mass current might associate with the three components of momentum density. The three components of angular momentum might associate with the three components of pressure. The three components of angular momentum current might associate with the three components of shear stress.

Such a set of associations might suggest credibility for our notion that angular momentum associates with (dipole) gravitational repulsion.

Such a set of associations might help people explore notions that our notions of intrinsic gravitational quadrupole attraction and intrinsic octupole gravitational repulsion might, in some sense, echo our notions of intrinsic monopole gravitational attraction and intrinsic dipole gravitational repulsion.

One might note differences (between our work and general relativity) that have bases in differences between properties of individual objects and properties (such as densities) that associate with regions.

One might note differences between the situations for which our notions might add insight and situations for which general relativity seems to add insight. For example, our notions might seem not to have direct use for detailed calculations regarding collisions or mergers involving two complicated objects, such as black holes or neutron stars. Also, our notions might seem not to have adequately novel direct use for detailed calculations regarding situations for which general relativity seems to have satisfied so-called precision tests [44].

One might want to explore notions that our work regarding instances and reaches points to situations for which modeling based on general relativity might not be adequately accurate. For example, to what extent might general relativity not suffice in situations for which the isomeric composition of stuff varies between regions? (To date, precision tests might seem to associate with just one isomer, the ordinary matter isomer. To date, many cosmological applications might seem to associate with just one isomer-mixture ratio, namely 5+:1.) Also, to what extent might general relativity not suffice in situations for which significant effective reaches might vary with time? (For example, regarding modeling the rate of expansion of the universe, an equation of state that works well regarding early in the first multibillion-year era might not extrapolate to work adequately well regarding the recent multibillion-year era.)

Another example of the possibility that applications of general relativity might not be adequately accurate features possible over-estimates of the so-called large-scale clumping of stuff [45–49]. We suggest that popular modeling might be assuming, in effect, that dipole gravitational repulsion that associates with angular momentum associates with a reach of one and that dipole gravitational repulsion that associates with mass current associates with a reach of one. We suggest that at least one of the following associations might be more appropriate. Dipole gravitational repulsion that associates with angular momentum associates with a reach of two. Dipole gravitational repulsion that associates with mass current associates with a reach of six.

4.5. ΛCDM-Cosmology

People discuss successes of and possible problems with ΛCDM-cosmology popular modeling [1].

Our work suggests that popular modeling notions of CDM (as in cold dark matter) can pertain regarding somewhat more than 80 percent of dark matter and seems not to pertain regarding somewhat less than 20 percent of dark matter.

Our work does not necessarily directly address the extent to which popular modeling notions of Λ (as in a cosmological constant) pertain. However, Λ associates with the use of general relativity and some of our previous remarks might shed light on possible limitations regarding the adequate applicability of general relativity.

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4.6. Notions That Might Link Gravitational and Electromagnetic Properties of an Object

Our work might inform a new look at popular modeling notions of the energy that associates with an object-A.

We suggest that squares of values of intrinsic gravitational properties might, when multiplied by appropriate factors, contribute to the square of an overall notion of energy.

This notion of squaring associates with multiplicative products for scalar properties such as mass and (for electromagnetism) charge, with dot products for three-vector properties such as angular momentum and (for electromagnetism) magnetic moment, and so forth.

Gravitationally relevant properties might include mass, angular momentum, moments of inertia, and rotating moments of inertia. For example, it takes energy to change an object from having zero angular momentum to having nonzero angular momentum. Also, it might take energy to change an object from having zero moments of inertia to having nonzero moments of inertia.

Regarding gravitational properties that associate with a nonzero velocity of object-A, perhaps one can use sums of squares of properties that associate with the word current to represent a relevant overall square of the magnitude of momentum.

Electromagnetically relevant intrinsic properties might include charge and magnetic moment. To the extent that these properties also associate with energy, the above notions might help inform popular modeling that tries to span, for an object-A, gravitational properties and electromagnetic properties.

4.7. Instances and Reaches

This unit summarizes aspects regarding instances and reaches per instance.

For charge, the notion of six instances associates with the notion that ordinary matter does not see much light that dark matter produces.

For magnetic moment, the work above does not necessarily imply a number of instances. Perhaps, a notion of six instances ties to the notion that ordinary matter does not feel much electromagnetism that dark matter produces.

For mass, the notion of one instance associates with the notion that gravitation, to a first approximation, attracts all stuff to all stuff.

For angular momentum, a notion of three instances (or, equivalently, reaches of two isomers) might help explain ratios of ∼4:1 for some galaxies. The related reach of two isomers might associate with dipole repulsion that drives away stuff that associates with the isomer that, via the notion of isomer-pairs, pairs with the galaxy's originally dominant one isomer. A notion of three instances, compared to six instances for moments of inertia, might help explain some notions that popular modeling overestimates some large-scale clumping of stuff. A notion of three instances, compared to six instances for moments of inertia, might help explain some notions that popular modeling might not adequately well extrapolate from equations of state for in early in the first multibillion-year era to equations of state for the second multibillion-year era.

For moments of inertia, the notion of six instances associates with the notion that each one of many galaxies likely originally formed based on stuff that associates mainly with just one isomer.

Each one of the properties mentioned above in this unit is an intrinsic property. For each associated current property, one might suggest that the number of instances of the current equals the number of instances of the intrinsic property. The notions of such equalities might be compatible with or seem to extrapolate from notions related to special relativity. However, we suggest that our work might not necessarily lead to such equalities.

For hyperfine-transition phenomena, discussion above suggests a notion of either three instances or one instance. We suggest that we do not know of enough data to enable choosing between three and one. We do not suggest a way to extrapolate from other numbers of instances to a hyperfine-phenomena number of instances.

In general, we suggest that people might want to consider using present and future data to suggest numbers of instances for each of various intrinsic properties and for each of various current properties.

5. Conclusions

We try to explain approximately ten cosmological data clusters or data points that the standard cosmology model seems not to explain adequately well. Some of the data clusters or data points associate with ratios of dark-matter effects to ordinary-matter effects. Some of the data clusters or data points associate with large-scale notions, such as the rate of expansion of the universe and large-scale clumping of stuff.

Our methods feature two novel concepts.

One concept is that dark matter and ordinary matter have a common basis in six isomers of a set of known elementary particles. One isomer associates with ordinary matter. Five isomers associate with dark matter. One dark-matter isomer underlies stuff that is a right-handed complement to the left-handed ordinary-matter stuff. The other four dark-matter isomers underlie stuff that comports with popular modeling notions of cold dark matter.

The other concept is that a new use of multipole notions points, for interactions between two-objects, to aspects of gravitational interactions. Our multipole notions feature multiple properties of a single object, whereas popular modeling multipole expansions tend to feature spatial distributions of a single property. Paralleling electromagnetism, one aspect associates with notions of a monopole interaction. Two aspects associate with notions of dipole interactions. Other aspects associate with higher-order poles, including perhaps at least 16-pole interactions. Monopole, quadrupole, and 16-pole aspects associate with gravitational attraction. Dipole and octupole aspects associate with gravitational repulsion.

We combine the two concepts and thereby suggest new insight regarding and explanations for the cosmological data clusters and data points.

We suggest notions about how our methods and results might help people understand and improve popular modeling notions regarding various aspects of the standard cosmological model.

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