Qeios

# Using integer-based tags to study and shape science and society

Thomas J. Buckholtz

*Ronin Institute for Independent Scholarship, Marlton, New Jersey, USA*

**Abstract**

After ninety years of effort, physics has yet to list all elementary particles, describe dark matter, or adequately understand large-scale gravity. We suggest that a novel approach, nuance-bearing integer-based tagging, explains otherwise unexplained data that associate with those efforts. More generally, we explore two roles for tags that have bases in integers. One role promotes teamwork between science and society. Tags unite work within single endeavors. Tags entwine multiple endeavors. One role enables physics research. Tags unite properties of objects and aspects of fields. Tags help specify elementary particles, dark matter, and gravity. Physics results include the following. We catalog electromagnetic and gravitational properties of objects. We suggest a well-specified description of dark matter. We describe long-range aspects of gravity. We catalog all known and predict new elementary particles. We suggest insight regarding galaxy evolution. We suggest that those physics results help explain data that seemingly no other work explains.

*Keywords:* philosophy of science, systems thinking, service science, elementary particles, dark matter, galaxy evolution, cosmology

**Contents**



*Email address:* `tjb@alumni.caltech.edu` (Thomas J. Buckholtz)

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## 1. Introduction

Easy as one, two, three. A theme for songs? Yes. A dream? Sometimes. A pivotal goal? We explore this notion.

People develop catalogs of items. For an item, people might assign a name or other brief description. For an item, people might develop further characterizations or nuances.

A description or a nuance likely exhibits ambiguity. A word can have multiple meanings. Meanings drift over time. Language translations blur meanings. And so forth. Moreover, a speaker or writer does not fully anticipate the perspective or attentiveness of a listener, reader, or viewer.

Integers are unambiguous.

We suggest that integers can play useful roles regarding cataloging. Amass a catalog of things or activities. Suggest a tagging scheme that uses integers. Tag items in the catalog. Characterize items via associations between nuances and tags. Anticipate that names will drift. Anticipate that nuances will drift. Hope that the tags help enable useful thinking and innovation.

Figure 1 suggests a framework for using integer-based tagging. A catalog of items features, for each item, a description of the item; at least one integer-based tag that associates with the item; and nuances that associate with the tags. The figure suggests using tags to organize items in catalogs.

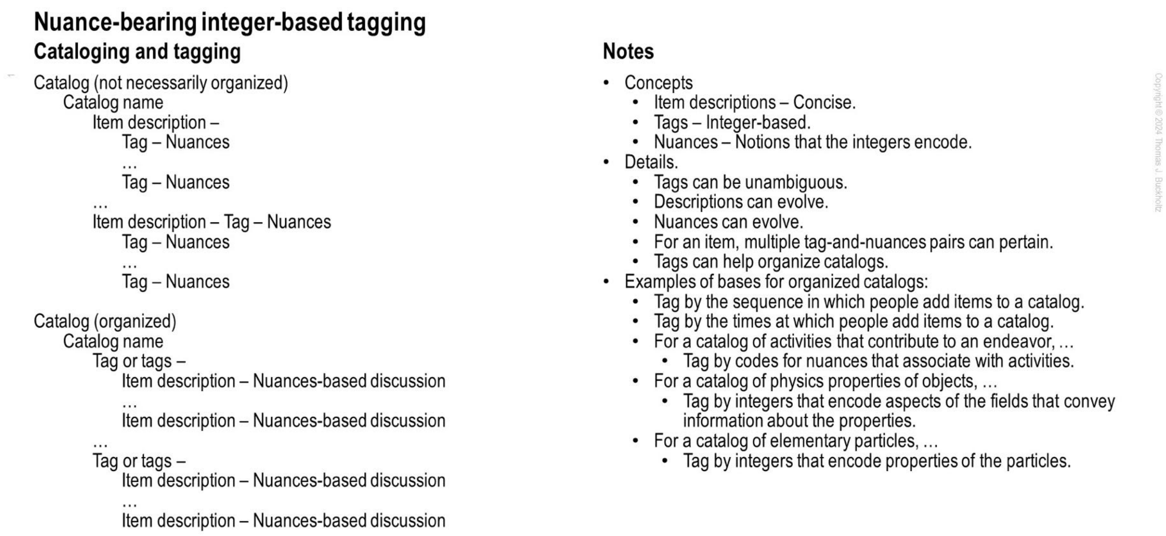


Figure 1: Nuance-bearing integer-based tagging

## 2. Using tags to study and shape endeavors

We discuss using integer-based tags to study and shape relationships between activities within endeavors and relationships between scientific endeavors and societal endeavors.

### *2.1. Themes for human endeavors and frameworks for shaping endeavors*

Detectives consider means, motive, and opportunity.

Journalists consider who, what, why, when, where, and how.

Program leaders and project managers consider networks of prerequisite activities.

Product planners and marketeers consider how - from the standpoint of clients and customers - services and products add value.

Are there frameworks that embrace many such means to consider aspects of human endeavors? How might use of a framework add value for a specific endeavor?

**Activities within an endeavor**

**Hierarchy of activities**

| Tag | Nuance | Activities |
|---|---|---|
| E | Endeavor | |
| E.3 | Do great | |
| E.3.3 | Enable reuses | … |
| E.3.2 | Recognize results | … |
| E.3.1 | Perform actions | … |
| E.2 | Think well | |
| E.2.3 | Declare intentions | … |
| E.2.2 | Evaluate scenarios | … |
| E.2.1 | Make assumptions | … |
| E.1 | Be able | |
| E.1.3 | Deploy teams | … |
| E.1.2 | Foster teamwork | … |
| E.1.1 | Have resources | … |
| E.0 | ? | … |

**Notes**

- At any level, results tend to grow …
  - … from .1 toward .2 and .3
  - … from .1 and .2 toward .3
- At any level, planning from .3 toward .2 and .1 and from .3 and .2 toward .1 can be helpful
- Some other tags and nuances:
  - E.2.1.3 Determine sufficiency (for example, for formulating scenarios) of a set of assumptions
  - E.2.1.2 Evaluate assumptions …
    - E.2.1.2.3 … for usefulness (for example, in the context set by E.2.1.3)
    - E.2.1.2.1 … for quality (for example, independently of the context set by E.2)
  - E.2.1.1 Identify assumptions
- E.0 associates with notions of TBD, as in (a more appropriate category has yet) to be determined



Figure 2: Activities within an endeavor

*2.2. Tags that help define, shape, and interrelate activities*

Figure 2 provides a hierarchy for cataloging activities that comprise an endeavor. People have deployed similar hierarchies [1, 2, 3] but not with integer-based tags.

An endeavor can amass resources, adopt plans, and achieve results. Resources can include people, people's skills, data, information systems, equipment, energy, funds, and so forth. Resources can adopt plans and achieve results. A theme for resources is being able. Plans can have bases in notions for how to improve resources and achieve results. A theme for adopting plans is thinking well. Results can include improved resources, new thinking, and the results of actions achieved based on resources and thinking. A theme for achieving results is doing great.

The sequence of being, thinking, and doing mimics evolution of endeavors. Endeavors tend to build from resources toward results. The sequence of doing, thinking, and being calls attention to opportunities to foresee results and to plan accordingly.

The trio of doing, thinking, and being provides a basis for cataloging activities within an endeavor. People can gain further insight into endeavors by using catalogs that nest uses of the trio. For example, people can apply the trio to each of doing, thinking, and being. The main portion of Figure 2 features two levels of uses of the doing, thinking, and being trio. The notes portion of Figure 2 shows examples of four levels.

Figure 2 suggests that the trio of doing, thinking, and being provides a basis for tagging activities within an endeavor. The tags feature integers.

The tags enable restating the themes for purposes such as the following. Use terminology that is specific to an endeavor. Minimize untoward effects of using specific wordings or languages. Support processing of information by project-management systems or other automated systems.

In short, the tags can support consistency and enable useful flexibility.

*2.3. Consistency and flexibility regarding uses of activity tagging*

We discuss uses for the tagging hierarchy that Figure 2 shows.

For endeavor participants, for endeavor planners, or for historians, the hierarchy might underlie methodical efforts to record completed work and to point to work to do. A participant, planner, or historian can expand or contract the depth of the hierarchy to be appropriate to that person's work. Within an application of the hierarchy, the depth does not need to be uniform. Taken together, the two sections of Figure 2 provide an example of non-uniform depth.

Regarding networks of prerequisite activities, .3 aspects of a prerequisite activity might link to .1 aspects of one or more subsequent activities.

For project participants, the hierarchy might help match resources and activities.

For product planners, .3 services might associate with more value for clients and higher margins for providers than would associate with .2 services. Also, .2 services might associate with more value for clients and higher margins for providers than would associate with .1 services.

For marketeers, tuning marketing messages might benefit from considering, from the perspectives of recipients of a marketing message, matches with perceived needs and with perceived proclivities of message recipients.

For detective work, means might link to .1, motive might link to .2, and opportunity might link to .3.

In journalism, who might link to .1; why might link to .2; and what, when, where, and how might link to .3.

For people studying possible synergies between enterprises or business segments, use of the hierarchy might call attention to strengths, weaknesses, opportunities, or threats. For example, from customer perspectives, the telecommunications industry has roots in .1 services and horizontal integration. From customer perspectives, the computer-based services industry has roots in .2 and .3 services and vertical reach.

Regarding science and society, three-tier use of the hierarchy might help people gain insight about attention to the following three questions. How does or could society enhance its results based on resources that science produces? How does or could science enhance its results based on resources that society produces? How does or could society produce results that science uses as resources? More nuanced use of the hierarchy might associate some resources with notions that associate with plans or with notions that associate with results.

Regarding scientific endeavors that strive to produce results via modeling, we discuss below the notion that attention to activities for which the activity tag E.2.1 pertains can be important. We suggest that tagging items in physics catalogs might prove useful, including regarding important activities that associate with each one of the activity tags E.2.1.1, E.2.1.2, and E.2.1.3. Tagging for items in physics catalogs can use integers and, as exemplified below, does not necessarily need to parallel the tagging scheme that Figure 2 discusses.

### *2.4. Tagging that helps shape science*

The evolution of science related to the periodic table of chemical elements illustrates roles for tagging. Mendeleev cataloged elements based on atomic weights and based on similarities regarding chemical reactions [4]. Each one of the atomic weight and the types of reactions served as a cataloging theme. Atomic weights were quantitative. At the time, a catalog of types of chemical reactions might not have had much of an organizing principle. Science and catalogs co-evolved. Today, tables of isotopes feature two organizing numbers. One number is the atomic number or the number of protons. One number is the number of neutrons. Both numbers are integers. Both numbers can serve as integer tags. Types of chemical reactions associate most closely with atomic number. Atomic physics and molecular physics provide insight regarding chemical reactions. Each element associates with one atomic number. For an element, nuclear physics and other sciences provide insight regarding atomic weight, which can vary from sample to sample.

Integer-based tagging pertains to energy levels that atoms exhibit [5] and to energy levels for electromagnetic fields in cavities.

How might physics benefit from new integer tagging?

The following provide examples of catalogs that might be ripe for new integer-based tagging.

- Electromagnetic properties of systems, gravitational properties of systems, and inertial properties of systems. Items in catalogs include charge, magnetic moment, energy, momentum, mass, and so forth.
- Elementary particles. Items in catalogs include the electron, the Higgs boson, six quarks, eight gluons, and so forth.
- Conservation laws. Items in catalogs include conservation of energy, conservation of momentum, conservation of angular momentum, conservation of charge, and so forth.

Below, we suggest new integer tagging techniques and new catalog items. The techniques and catalogs span elementary particles, properties of systems, and conservation laws. We use data and patterns that bridge multiple physics fields and that bridge multiple catalogs.

## 3. Using tags to suggest cosmology and elementary-particle advances

We discuss physics research that uses integer-based tags to suggest new physics regarding cosmology and elementary particles.

**Some physics opportunities**

**Opportunity**

A. Catalog measurable properties of objects.
B. Catalog elementary objects.
C. Specify dark matter (or otherwise explain effects that people attribute to dark matter).
D. Determine and explain the large-scale evolution of the universe.
E. Explain the evolution of galaxies.

**Notes**

A. ...
   1. The opportunity dates back thousands of years.
   2. Modern-physics properties include charge, mass, momentum, and so forth.
B. ...
   1. Notions of elementary objects date back thousands of years.
   2. Elementary objects seem today to include the electron, six quarks, and so forth
   3. The notion that the electron is an elementary particle arose around the 1890s.
C. ...
   1. People proposed the notion of dark matter around 1933.
   2. Many conjectures regarding specifications for dark matter exist.
D. ...
   1. Some modern discussion dates to 1922.
   2. Data suggest a previous multibillion-years era of slowing rate expansion of the universe and a current multibillion-years era of increasing rate of expansion of the universe.
   3. Recent concerns include mismatches between data and models.
E. ...
   1. Discussion dates to the 1920s.
   2. Many aspects, including possibly prevalent ranges of ratios of dark matter to ordinary matter, remain unresolved.



Figure 3: Some physics opportunities

*3.1. Opportunities related to properties of objects, elementary particles, and cosmology*

Figure 3 notes some physics opportunities.

The notion of dark matter dates to 1933 [6]. Proposed means for gathering data about dark matter are diverse and people suggest diverse possible specifications for dark matter [7, 8]. Modern discussion of the evolution of the universe pivoted based on the 1922 announcement of a solution to the Einstein field equations [9]. Discussions regarding galaxies date to no later than 1925 [10].

Physics modeling suggests three eras regarding the so-called rate of expansion of the universe. The notion of a rate of expansion of the universe associates with notions of typical speeds of moving away from each other regarding neighboring large objects, such as galaxy clusters. The first era, about which there may be no data, would feature a typical speed of moving away that rapidly increases. The second era, about which there is data, features a typical speed of moving away that, while remaining positive, decreases while the era progresses. The third era, about which there is data, features a typical speed of moving away that increases while the era progresses.

Figure 4 notes some patterns that associate with the physics opportunities.

We anticipate that notions regarding the discreteness that associates with items in catalogs and notions regarding ratios of near-integers point to opportunities to develop useful integer-based tags.

The following paragraphs exemplify notions that Figure 4 notes. Many gaps between data and modeling seem to exist.

Data suggest twice as much absorption of cosmic microwave background radiation as modeling suggests [11, 12, 13].

Data suggest twice as much presence of cosmic optical background radiation as modeling suggests [14, 15, 16, 17].

Data suggest the existence of galaxies that have dark matter and essentially no ordinary matter [18, 19, 20, 21, 22, 23].

Data suggest the existence of early galaxies that have ordinary matter and essentially no dark matter [24, 25]. Here, we associate the word early with redshifts of more than approximately seven. Current techniques might not be capable of observing early galaxies that have little ordinary matter.

Data suggest that a galaxy might have had mostly ordinary matter at a time that associates with a redshift of approximately six [26].

Data suggest the existence of later galaxies that have ordinary matter and essentially no dark matter [27, 28, 29, 30, 31, 32, 33, 34].

Data suggest that some galaxies have about four times as much dark matter as ordinary matter [35, 36].

Data suggest that many galaxies have five-plus times as much dark matter as ordinary matter [18].

Data suggest diversity regarding processes that associate with mergers of galaxies [37].

Data suggest that many galaxy clusters have five-plus times as much dark matter as ordinary matter [38, 39, 40, 41].

**Some patterns regarding catalogs, data, and amounts that models suggest**

**Pattern**

a. Individual catalogs feature lists of discrete items.
b. Some ratios of data to amounts that models suggest tend to associate approximately with ratios of small integers.
c. Some ratios of amounts that data suggest of dark matter to amounts that data suggest of ordinary matter can tend to associate approximately with ratios of small integers.
d. Successive eras in the rate of expansion of the universe may alternate between increasing rate and decreasing rate.
e. Data suggest less clumping of stuff than amounts that models suggest.

**Notes**

a. …
   1. A catalog of properties of objects is one such catalog.
   2. A catalog of elementary particles is one such catalog.
b. …
   1. Some ratios are two to one.
c. …
   1. Modeling based on first principles does not necessarily suggest amounts for either one of the two numbers that associate with a ratio.
   2. Some ratios are five-plus to one.
   3. Some ratios are approximately-four to one.
   4. Some ratios are zero-plus to one.
   5. Some ratios are one to zero-plus.
d. …
   1. Modeling suggests an era of increasing, followed by an era of decreasing, followed by an era of increasing. Data suggest the last two eras of the three eras that modeling suggests.
e. …
   1. Data suggest that, for a recent some billions of years, the rate of expansion of the universe exceeds amounts that models suggest.
   2. Data suggest that modeling overestimates large-scale clumping of matter.



Figure 4: Some patterns regarding catalogs, data, and amounts that models suggest

**Cosmology and elementary particles**

**Data**

- Ratios of NOM (not-ordinary-matter effects) to OM (ordinary-matter effects).
  - 1:1 – Amounts of cosmic electromagnetic background.
  - $1{:}0^+$ or $0^+{:}1$ – Some galaxies.
  - ~4:1 – Some galaxies.
  - $5^+{:}1$ – Many galaxies, many galaxy clusters.
  - $5^+{:}1$ – Densities of the universe.
- Two billions-of-years eras in the expansion of the universe.
- Aspects regarding large-scale clumping.
- Aspects regarding collisions of galaxy clusters.
- Known elementary particles.

**Goals**

1. Specify dark matter.
2. Catalog properties of systems.
3. Describe large-scale gravity.
4. Catalog elementary particles.

(And, thereby, ...)

5. Explain data.
6. Suggest new perspective about physics.



Figure 5: Cosmology and elementary particles

Data suggest a ratio of five-plus to one for the ratio of dark-matter density of the universe to ordinary-matter density of the universe [42].

Data suggest that modeling underestimates, regarding the recent multi-billion-year era, the rate of expansion of the universe [43, 44, 45, 46, 47]. People discuss various possible resolutions [48, 49]. People discuss data about the Hubble constant [50]. Some discussions suggest that some gravitational effects might weaken over time [51]. People use the three-word term emergent dark energy to describe such weakening.

Data suggest that modeling overestimates large-scale clumping of matter [52, 53].

Data might suggest that modeling does not adequately discuss gravitational interactions between neighboring galaxies [54].

Modeling seems not to explain the current catalog of elementary particles.

### *3.2. Goals*

Each one of the following three goals is unmet and, in some sense, is at least 90 years old. Catalog all elementary particles. Specify dark matter. Understand gravity well enough to comport with data about the rate of expansion of the universe.

Figure 5 and Figure 6 outline key aspects of our physics work.

Some progress toward the goals is ongoing and has bases in the assumptions that Figure 6 states [55, 56].

### *3.3. Nature, human discussion, physics models, and physics catalogs*

Physics features human discussion about perceptions and inferences regarding nature.

## Physics notions

### Assumptions

- Nature includes six isomers of elementary particles (not including the photon and the would-be graviton).
  - One isomer underlies ordinary-matter stuff.
  - Five isomers underlie dark-matter stuff.
- Mathematics related to multipole-expansions can be useful.

### Possible bases and explanations

- Atoms made from right-handed elementary particles.
  - NOM:OM 1:1 (electromagnetic-related).
- Multipole gravity, plus six isomers.
  - NOM:OM other than 1:1 (gravity-related).
  - Rate of expansion of the universe (gravity-related).
- Other multipole-related mathematics.
  - Elementary particles.



Figure 6: Physics notions

## Relationships between some catalogs and physics modeling

### Relationships

| Catalogs | MOD … items. | CAT+NUBIT might … items. |
|---|---|---|
| † Properties of systems | Assumes | Suggest |
| † Fields | Assumes | Suggest |
| ‡ Interactions between systems and fields | Assumes | Suggest |
| † Families of elementary particles | Assumes | Suggest |
| ‡ or † Systems | Assumes or suggests | Suggest |
| Values of properties of systems or of fields | Assumes or suggests | Suggest |
| Conservation laws | Assumes or suggests | Suggest |
| MOD coordinate systems | Assumes | Suggest notions regarding |
| MOD models | Uses | Suggests bases for |
| Motions of systems | Suggests | - |
| Rates of change of properties of systems | Suggests | - |

### Notes

- Catalogs
  - † - List of
  - ‡ - List of types of
- Items - Items in catalogs
- Systems include elementary particles, objects that model as not having components, and multi-component systems of objects
- Fields mediate interactions between systems
- Abbreviations
  - MOD - Modeling that associates with space-time coordinates
  - CAT - Cataloging that associates with – or might eventually associate with – patterns or characterizations
  - CAT+NUBIT - Cataloguing that associates with characterizations that associate with nuance-bearing integer-based tags
  - PAT - Pattern matching, including pattern matching that develops CAT+NUBIT
  - DAT - Data



Figure 7: Relationships between some catalogs and physics modeling

Vocabulary underlying the discussion has bases in human languages, terms, mathematics, and inputs to and outputs from physics models. Terms can include words and symbols. Each one of language, terms, mathematics, and modeling is a human creation. There might be no guarantee that nature behaves in ways that people might associate with models and modeling.

A science goal features consistency among terminology, data, modeling, and applications. Applications can pertain specifically within an individual science, such as physics or biology, or generally regarding creating societal opportunities or solving practical problems.

Each one of physics terminology, data, and modeling is diverse. Terminology includes notions of the word system. Modeling suggests that systems model as ranging in size from being zero or negligibly small to being at least the size of clusters of galaxies. Modeling includes models that treat systems as simple objects and models that treat systems as having multiple components. Terminology includes notions of the word property. Physics properties that people consider include charge, magnetic moment, surface temperature, atomic state, energy, momentum, angular momentum, moments of inertia, boson behavior, fermion behavior, and so forth. Another term for surface temperature is blackbody temperature.

Figure 7 suggests a framework for previewing and understanding our physics work. We suggest the following notions. Modeling that associates with space-time coordinates tends to assume and sometimes to suggest items that appear or might appear in various physics catalogs of terms. We explore the notion that items that modeling tends to assume or that modeling might need to assume can become suggestions from catalogs that do not necessarily have direct bases in modeling techniques.

We explore possibilities for augmenting cataloging with characterizations that associate with nuance-bearing integer-based tags. In mathematics, a characterization of an entity is a set of conditions that, while different from the definition of the entity, is logically equivalent to it [57]. We use pattern matching and data to extend cataloging to cataloging that associates with nuance-bearing integer-based tags. We suggest themes that associate with tags. The combination of a theme and a tag associates with the term nuance-bearing and with notions of characterization.

Our work involves the following notions. Observer systems O can make inferences about inferred

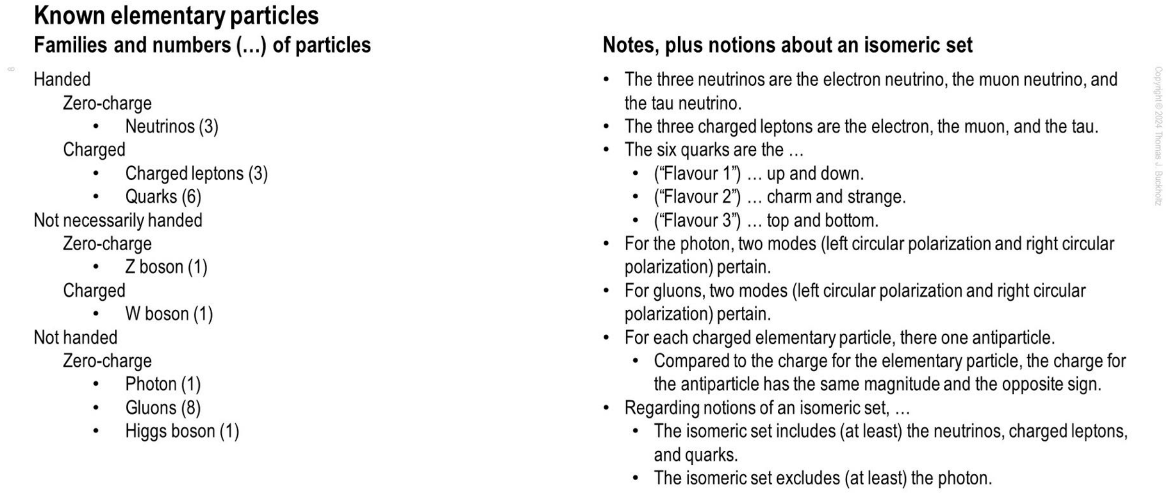


Figure 8: Known elementary particles

systems I and about fields that mediate interactions between systems. Exploring consistency regarding inferences, data, and models can prove beneficial. Transiting from one seemingly somewhat stable, somewhat useful set of inferences and models to another seemingly somewhat stable, possibly more useful set of inferences and models might take several steps. Taking some but not all the steps might result in unhelpful perceptions of inadequate consistency between inferences, data, and models.

### *3.4. Tag-based physics results*

Figure 8 discusses information about known elementary particles and introduces the notion of an isomeric set.

Modeling suggests that a notion of left handedness associates with the neutrinos, charged leptons, and quarks. Modeling suggests that right handedness associates with antiparticles of the charged leptons and with antiparticles of the quarks. Data suggest that known antiparticles do not include right handed neutrinos. Modeling associates notions of two modes with photons and does not associate a notion of handedness with photons.

Per Figure 8, we suggest a notion of an isomeric set. We use the word isomer to denote a set of all elementary particles that modeling considers to exhibit handedness or, if found in the future, that modeling would consider to exhibit handedness.

Per discussion above, data suggest twice as much absorption of cosmic microwave background radiation as modeling suggests based on hyperfine transitions in hydrogen atoms.

We suggest that ordinary matter has a basis in a left-handed isomer. We suggest that some dark matter has a basis in a right-handed isomer, that, aside from handedness, is like the left-handed isomer that associates with ordinary matter. We suggest that stuff that has bases in the right-handed isomer evolves similarly to stuff that associates with the left-handed isomer. We suggest that stuff that associates with the right-handed isomer includes hydrogen-like atoms. We suggest that the hydrogen-like atoms can undergo hyperfine-like transitions.

We suggest that the hydrogen-like atoms and hyperfine-like transitions associate with the otherwise-unexplained half of the absorption of cosmic microwave background radiation.

We suggest that this pairing of a left-handed isomer and a right-handed isomer might provide a basis for understanding baryon asymmetry, which people also call matter asymmetry [58].

Data suggest that ordinary matter senses hyperfine electromagnetic radiation that associates with a starless dark-matter galactic halo [59]. Data suggest that ordinary matter detects radiation, which hydrogen might have generated, from a starless dark-matter galaxy [60].

Per discussion above, more than one observation suggests that people observe twice as much cosmic optical background as people expect based on modeling. Based on notions of consistency, we suggest that ordinary matter produced one half of the cosmic optical background radiation and that stuff that associates with the above-suggested right-handed isomer produced the other half.

The notion that dark matter contributed to the cosmic optical background leaves a possible quandary. There might seem to be no reason to assume that the right-handed elementary particle set could not underlie dark-matter stars. Why do people not detect light that dark-matter stars might emit? We postpone, until discussion below, resolving the quandary.

How many somewhat similar isomers might nature include? Inferences regarding many galaxies, regarding many galaxy clusters, and regarding densities of the universe suggest that there is five plus times as much dark matter as ordinary matter. The number of isomers might be at least six, with one isomer underlying ordinary matter and the other isomers underlying dark matter. Given the notion of one matched pair of isomers, we suggest a notion of six, as in three times two, isomers.

We associate the word stuff with objects and with systems of objects. We associate the word system with a collection of one or more than one object. Examples of systems include galaxies, stars, and electrons. We use a phrase such as single-isomer stuff to describe stuff that has bases in one and no more than one isomer. We suggest that our work is consistent with the notion that stuff also has bases in electromagnetism and in gravity.

Data suggest that some galaxies consist essentially only of ordinary-matter stuff. We suggest that some galaxies started with and maintained ordinary matter to dark matter ratios of one to zero-plus.

Data suggest that some galaxies consist essentially only of dark-matter stuff. We suggest that some galaxies started with and maintained ordinary matter to dark matter ratios of zero-plus to one.

We suggest that some galaxies form based on single-isomer halos.

Some inferences suggest that, among some early galaxies that people can infer through electromagnetic data, some galaxies that start with having mostly ordinary matter accrue over time dark matter. We suggest that some galaxies formed based on one-isomer halos and then accrued stuff associating with other isomers.

We discuss the above-mentioned quandary that relates to dark-matter stars.

We suggest that electromagnetic effects are sensitive to the properties about which electromagnetism conveys information.

We suggest that stuff that associates with any one isomer can sense, depending on the property, one of effects that associate with one isomer, effects that associate with two isomers, or effects that associate with six isomers.

- People do not see dark-matter stars. We suggest that information about surface brightness is specific to single isomers.
- We suggest that stuff made from one isomer does not directly sense the charge of stuff made from any other one isomer. We suggest that there are six instances of charge, with one instance pertaining to each isomer.
- Ordinary matter senses electromagnetically conveyed information about atomic states or atomic transitions that associate with each one of two isomers. We suggest that there are three instances of the relevant properties. Each instance pertains to a pair of isomers.
- At least to a first approximation, ordinary matter senses gravitationally conveyed information that associates with each one of the six isomers. We suggest that there is one instance of the usually most relevant gravitational property, energy. That one instance pertains to all six isomers.

In general, we suggest that, for any such property, the number of instances of the property is one of one or three or six. We deploy the word reach. We suggest that the respective reach of one instance of the property is six isomers or two isomers or one isomer. For example, the reach of each one of the six instances of charge is one isomer. The reach of the one instance of energy is six isomers.

We use a form of nuance-bearing integer-based tags to organize catalogs of properties of systems.

Figure 9 discusses notions that suggest a nuance-bearing integer-based tagging basis for characterizing some aspects of physics. Immediately below, we discuss using $s \neq 0$ characterizations for properties that associate with at least electromagnetism and gravity. Later, we discuss using $s = 0$ characterizations for elementary particles.

For integers $s$ that are not zero, the following aspects suggest possible consistency between modeling and our work.

- For integers $s$ that are not zero, the magnitude of $s$ equals the spin, in units of $\hbar$, that modeling associates with the respective field. One associates with electromagnetism. Two associates with gravity. Regarding the cataloging of properties, our work currently includes the constraint that the absolute value of $s$ is a member of the set $K$, which pertains to the right-hand side of the equation through which one calculates $s$. For now, that constraint might comport with data. In the future, removing that constraint might prove useful.

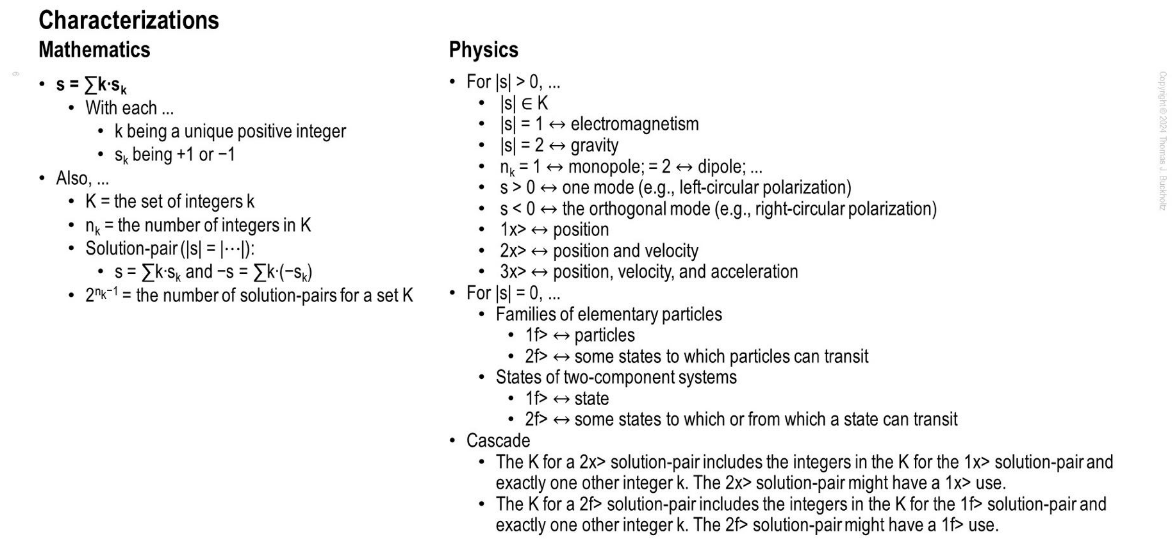


Figure 9: Characterizations

- The number of terms, $n_k$, to the right of the equal sign generalizes from modeling notions that associate with the terms monopole, dipole, quadrupole, and so forth. Regarding electromagnetism, modeling considers that a point charge associates with a monopole electric field. Modeling considers that a spatially moving point charge or a spatially non-moving rotating charge associates with a dipole magnetic field. In our work, the number of solution-pairs tracks and generalizes from modeling notions of monopole, dipole, and so forth. For $n_k = 1$, one solution-pair pertains. For $n_k = 2$, two solution-pairs pertain. For $n_k = 3$, four solution-pairs pertain. When a set $K$ has more than one member, the number of values of the absolute value of $s$ exceeds one.

- We suggest associating the number two, of solutions in a solution-pair, with the notion that the relevant field models as having two orthogonal modes. We suggest that this notion is consistent with modeling for which the modes feature circular polarization and with modeling for which the modes feature linear polarization.

- Modeling suggests that charge current and magnetic moment can contribute to a magnetic field. Modeling also suggests that charge current and magnetic moment are not necessarily the same property.

- We introduce notation that associates with the number of degrees of spatial freedom, of velocity freedom, and so forth that pertain. For $|s|$ greater than zero, monopole associates with knowing a position for the property. Dipole associates with knowing either a position and a linear velocity or a position and an angular velocity. We use the notation 1x>, 2x>, 3x>, and so forth to denote the series position, position and linear velocity, position and linear velocity and linear acceleration, and so forth. Charge associates with 1x>. Charge current associates with 2x>. Magnetic moment associates with 1x>. We suggest that the series 1x>, 2x>, and so forth is consistent with Newtonian dynamics and with special relativity. The notion that values that a system O infers about properties of an inferred system I vary based on notions of the motion of system I relative to system O associates with special relativity. The notion that values that a system O infers about properties of an inferred system I vary based on notions of the motion of system I relative to system O does not necessarily associate with Newtonian dynamics.

- Acceleration associates with 3x> but not with 1x> and not with 2x>. In modeling, acceleration associates with an inferred system I that, from the perspective of a system O that infers system I, is part of a larger than system I system and is subject to accelerations that associate with interactions with other components of the larger system. The smallest value of $n_k$ that can associate with 3x> is three. Generally regarding properties, quadrupole solution-pairs and higher-order solution-pairs tend to associate with some aspects of complexity. For the solution-pair for which the 3x> usage associates with linear acceleration of charge, 1x> usage might associate with non-Larmor precession

## Electromagnetic and gravitational properties

### Properties, solution-pairs, and instances

| Electromagnetic: | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1x> Property ‡1 | \|s\| | - | i ‡3 | $R_{/i}$ ‡3 | 2x> Property ‡1 | \|s\| | - |
| Charge | 1=\|+1\| | - | 6 | 1 | Charge current | 1=\|−1+2\| | - |
| Magnetic moment | 1=\|−1+2\| | - | 6 | 1 | ... | 1=\|−1−2+4\| | - |
| ‡4 | 1=\|−1−2+4\| | - | TBD | TBD | ... | ... | - |
| Atomic state | TBD | - | 3 | 2 | ... | TBD | - |
| Surface temperature | TBD | - | 6 | 1 | ... | TBD | - |

| Gravitational: | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1x> Property ‡1 | \|s\| | Force ‡2 | i ‡3 | $R_{/i}$ ‡3 | 2x> Property ‡1 | \|s\| | Force ‡2 |
| Energy | 2=\|+2\| | Attracts | 1 | 6 | Momentum | 2=\|−2+4\| | Repels |
| Angular momentum | 2=\|−2+4\| | Repels | TBD | TBD | ... | 2=\|−2−4+8\| | Attracts |
| Moments of inertia | 2=\|+1−2+3\| | Attracts | TBD | TBD | ... | 2=\|−1±2−3+4\| | Repels |
| Rotations ‡5 | 2=\|−1±2−3+4\| | Repels | TBD | TBD | ... | 2=\|−1±2−3−4+8\| | Attracts |

### Notes

- TBD: To be determined.
- ‡1 – Charge and charge current associate with a 4-vector. Energy and momentum associate with a 4-vector. For a 4-vector, 1x> links to the word scalar and 2x> links to a 3-vector.
- ‡2 – For |s|=2: $n_k$=1 (monopole), $n_k$=3 (quadrupole), ... associate with attracting between systems. For |s|=2: $n_k$=2 (dipole), $n_k$=4 (octupole), ... associate with repelling between systems.
- ‡3 – The integer i is the number of instances of the properties. The integer $R_{/i}$ is the so-called reach (in number of isomers) per instance of the forces associated with the properties. Always, $i \cdot R_{/i}$=6. The number of instances, i, can be 6, 3, or 1. The respective reaches, $R_{/i}$, are 1, 2, and 6. Each $R_{/i}$=2 associates with one isomer-pair.
- ‡4 – Precessing magnetic moment (intrinsic, not Larmor precession).
- ‡5 – Rotations with respect to the two axes of moments of inertia.



Figure 10: Electromagnetic and gravitational properties

of the axis of the magnetic moment. In this case, the complexity associated with the 1x> usage associates with aspects internal to the inferred system I.

Figure 10 suggests associations between some electromagnetic properties or gravitational properties and 1x> or 2x> uses of specific solution pairs.

Regarding gravitational properties, the first two rows in the gravitational part of Figure 10 parallel, with respect to solution pairs, the first two rows in the electromagnetism part of Figure 10. Each one of the magnitude of $s$ and each relevant member of the set $K$ has twice the value of the corresponding integer that pertains to electromagnetism. The solution-pairs in the third and fourth rows in the gravitational part of Figure 10 do not have electromagnetic parallels.

Modeling includes multipole expansions for which each term in an expansion is a zero-tensor and is not a higher-order tensor. The word scalar pertains. Modeling based on special relativity suggests that $(E_{EM})^2 - c^2(B_{EM})^2$ is an observer-independent scalar. Here, $(E_{EM})^2$ is the square of the magnitude of the electric field that an observer system associates with an inferred system, $c$ is the speed of light in a vacuum, and $(B_{EM})^2$ is the square of the magnitude of the magnetic field that the observer system associates with the inferred system. The greater the inferred velocity of system I, the greater the magnitude of the electric field and the greater the magnitude of the magnetic field. Noting the invariance and the notion that $(E_{EM})^2 - c^2(B_{EM})^2$ is a scalar, we suggest that, from the point of view of an observer system O, effects of an inferred charge current, with which the magnetic field associates, of system I detract from effects of charge, with which the electric field associates, of system I.

Based on notions of possible consistency between gravity and electromagnetism, we suggest, regarding gravitational effects, that effects of inferred momentum detract from effects of inferred energy. We generalize to suggest that gravitational monopole, quadrupole, and so forth properties that a system O infers about a system I associate with attraction of system O toward system I and that gravitational dipole, octupole, and so forth properties associate with repulsion of system O away from system I.

In circumstances in which like objects generally move apart from each other, the dominant gravitational force can transit a portion of the sequence that starts with octupole repulsion and ends with monopole attraction. We suggest that pairs of neighboring smaller objects transit part of the sequence faster than would pairs of neighboring larger objects. Regarding Figure 4, we suggest that, today, monopole attraction dominates regarding interactions between galaxies. We suggest that, today, dipole repulsion dominates regarding galaxy clusters.

How might one think about how an observer system O interacts with the electromagnetic or gravitational field that associates with an inferred system I? Modeling suggests the notion that a change in the momentum that associates with a component of system O equals the negative of a change in momentum that associates with the field. We suggest that modeling for each change associates with a $D$-vector. For modeling regarding astrophysical systems, we suggest that modeling can associate with three dimensions and $D = 3$. Modeling considers that the change in momentum that associates with the field associates with the word force. We suggest that modeling regarding the force can associate with the $D$-dimensional

## Reach per instance

### Math

For 1x> use of a solution-pair, …

- $\{1,2,3,4\} \cap K \neq \emptyset$
- $k_{n_0} \equiv \max\{k \mid 1 \le k \le 4 \text{ and } k \in K\}$
- $n_0 \equiv$ the number of k for which $1 \le k \le 4$ and $k \notin K$
- gen(X) ≡ the number of generators of the group X
- For $n_0 = 0$, …
  - $R_{/i} = 1$
- For $1 \le n_0 \le 3$, $R_{/i} = \text{gen}((SU(7)) / \text{gen}(SU(2n_0+1))$
- For $n_0 = 1$, …
  - $R_{/i} = 6$
- For $n_0 = 2$, …
  - $R_{/i} = 2$
- For $n_0 = 3$, …
  - $R_{/i} = 1$

For 2x> use of a solution-pair that cascades in one step from (a 1x> use of) a solution-pair, …

- $R_{/i}$ for the 2x> use of the former solution-pair equals $R_{/i}$ for the 1x> use of the latter solution-pair.

### Physics notions and modeling notions

- The reaches seem to comport with data.
- $2n_0$ might comport with a notion of a count of (perhaps non-physical) harmonic oscillators that would not excite. Each harmonic oscillator might associate with an unused value of an $s_k$.
- The reach of a 2x> use of a solution-pair should equal the reach of 1x> solution-pair from which the former solution-pair cascades (in one step), to comport with special relativity.



Figure 11: Reach per instance

gradient of a potential, which for multipole modeling associates with a scalar field.

We suggest that, in such multipole modeling, such a scalar field carries information about each instance of each electromagnetic or gravitational property of an inferred system I. A component of system O can interact only with instances for which the reach overlaps with the component of system O. For example, light emitted by the above-discussed right-handed hydrogen-like atoms can model as interacting with ordinary-matter.

Figure 11 suggests means for determining the number of instances and the reach per instance that associates with a 1x> use of a solution-pair or with a 2x> use of a solution-pair. The means output only reaches of one, two, or six. We are not aware of data that would seem to contradict the reaches.

Figure 12 suggests that our work provides bases and explanations that Figure 6 anticipates. Immediately below, we discuss details regarding Figure 12.

Figure 12 suggests, regarding ratios of dark matter to ordinary matter, notions that comport with data that we discuss above. Clumps the size of solar systems tend to form based on gravitational quadrupole reach-one attraction and subsequently tend not to attract stuff that associates with other isomers. Clumps the size of galaxies tend to form based on gravitational quadrupole reach-one attraction. Some one-isomer galaxies continue as one-isomer galaxies. Some one-isomer galaxies repel stuff that associates with one isomer, then attract via gravitational monopole reach-six attraction stuff that associates with four non-original isomers, and then remain as five-isomer galaxies. Many galaxies grow based on mergers and contain stuff that associates with each one of the six isomers.

Figure 12 suggests explanations for the two eras, each of which lasts for billions of years, in the rate of expansion of the universe. The notes portion of Figure 12 suggests notions that might explain the notion that modeling underestimates the rate of expansion for the most recent billions of years era. Modeling uses the Friedmann-Lemaitre-Robertson-Walker metric [9]. Use requires assuming an equation of state. The equation of state enables computing a pressure, which associates with repulsive components of gravity, based on a density, which associates with an attractive component of gravity. We suggest that such modeling would need to, but does not, consider aspects that associate with our notions of isomers and reaches. For early in the previous multi-billion-year era, we suggest that reach-one attraction pertains. For early in the recent multi-billion-year era, we suggest that the reaches for instances of repulsion are at least two. We suggest that the transition, from one to more than one, regarding dominant reaches associates with the notion that modeling underestimates, compared to data, recent increases in the rate of expansion.

Data about a merging galaxy cluster suggest that some dark matter is electromagnetically self-interacting [61]. Modeling suggests incompatibility between inferences about the aftermath of the Bullet Cluster collision of two galaxy clusters and the notion that much of the relevant dark matter significantly interacts with itself electromagnetically [62].

Beyond the pair of isomers that underlie ordinary matter and a right-handed analog to ordinary matter, we suggest that there are four other isomers. We suggest that the other four isomers underlie

**Explanations for cosmic data**

**Timelines and data**

12

| Timelines → | Earlier ... | ... | ... | ... Later |
|---|---|---|---|---|
| Notable force | Repelling | Attracting | Repelling | Attracting |
| · \|s\|=2 solution-pairs | \|−1±2−3+4\| | \|+1−2+3\| | \|−2+4\| | \|+2\| |
| · 1x> $R_{/i}$ , 2x> $R_{/i}$ | 1 , 1 | 1 , N/A | 2 , 6 | 6 , N/A |
| Solar system | | 1-isomer ($0^+$:1 or 1:$0^+$) | | |
| Galaxy | | 1-isomer halo ($0^+$:1 or 1:$0^+$ galaxy) | Repelling of one isomer | ~4:1 or $5^+$:1 (merged galaxy) |
| Galaxy cluster | | | | $5^+$:1 |
| Observable universe NOM:OM | {Possibly, Inflation} $5^+$:1 | Previous billions of years - $5^+$:1 | Recent billions of years - $5^+$:1 | |
| COB \| CMB effects | | 1:1 ‡ | | |

**Notes**

- Smaller entities (such as solar systems) transit "earlier to later" timelines sooner and quicker than do larger entities (such as galaxies).
- Notable force – A component of interactions between nearby similar systems.
- $R_{/i}$ – Reach (in number of isomers) of one instance of a component of the notable force. N/A – not applicable.
- Differences in the evolutions of the isomers and $R_{/i}$ = 6 electromagnetism can lead to the plus in $5^+$:1 NOM:OM ratios and can lead to explanations for aspects regarding galaxy-cluster collisions.
- Part-explanation for rate-of-expansion tension between data and popular modeling – $R_{/i}$ > 1 for 1x> |−2+4| and for 2x> |−2+4| vs. $R_{/i}$ = 1 for 1x> |+1−2+3| leads (via extrapolating from early attracting-era equations of state) to underestimating repelling-era acceleration.
- Part-explanation for large-scale-clumping tension between data and popular modeling – $R_{/i}$ > 1 for 1x> |−2+4| and for 2x> |−2+4| vs. $R_{/i}$ = 1 for 1x> |+1−2+3| leads to underestimating repulsion between systems.
- COB refers to the amount of cosmic optical background radiation.
- CMB refers to specific depletion of cosmic microwave background radiation.
- ‡ - The ratio pertains regarding these two eras in the timeline for the observable universe. The notion of "notable force" does not necessarily pertain.



Figure 12: Explanations for cosmic data

**Dark matter and ordinary matter**

**Isomers and evolution of stuff**

13

| Isomer number | Isomer-pair | Handedness | Quark flavours (ordered by ascending geometric-mean masses) | Charged-lepton flavours (ordered by ascending masses) | OM (ordinary matter) or DM (dark matter) | Evolution (of stuff that associates with the isomer) |
|---|---|---|---|---|---|---|
| 0 | 0 | Left | 1, 2 ,3 | 1, 2 ,3 | OM | Familiar |
| 1 | 1 | Right | 1, 2 ,3 | 3, 1, 2 | DM | Cold dark matter ‡ |
| 2 | 2 | Left | 1, 2 ,3 | 2 ,3, 1 | DM | Cold dark matter ‡ |
| 3 | 0 | Right | 1, 2 ,3 | 1, 2 ,3 | DM | Like OM |
| 4 | 1 | Left | 1, 2 ,3 | 3, 1, 2 | DM | Cold dark matter ‡ |
| 5 | 2 | Right | 1, 2 ,3 | 2 ,3, 1 | DM | Cold dark matter ‡ |

**Notes**

- Across isomers, counterpart elementary-particle masses are the same.
- OM quark ascending geometric-mean masses – up and down, charm and strange, top and bottom
- OM charged lepton ascending masses – electron, muon, tau
- ‡ – Neutron-like hadrons predominate and decay at most slowly. (For each of flavour-3 quarks and flavour-2 quarks, the masses of zero-charge 3-quark hadrons are less than the masses of charged 3-quark hadrons. 3-quark hadrons evolve into neutron-like hadrons. The flavour-1 charged leptons have too much mass to enable decays of neutron-like hadrons into proton-like hadrons.)



Figure 13: Dark matter and ordinary matter

stuff that, with respect to collisions of galaxy clusters, does not interact electromagnetically significantly with itself.

Figure 13 summarizes aspects that we suggest about the six isomers and about stuff that associates with each of the six isomers. We suggest that the second data item in Figure 20 and the related notes item in Figure 20 associate with mismatches between quark flavours and charged lepton flavours. We suggest that, when an interaction creates a neutrino and a charged lepton, the flavour of the neutrino equals the flavour of the charged lepton.

Modeling suggests many possible notions and terms regarding dark matter. Figure 13 suggests that some dark matter associates with modeling notions for which the term cold dark matter pertains. Figure 13 suggests that some dark matter associates with modeling notions for which the term strongly interacting dark matter pertains.

Our work suggests mechanisms that might have led to the plus in the dark-matter to ordinary-matter ratios of five-plus to one that data provide and that Figure 12 notes. Any one of the mechanisms might suffice. The mechanisms are not mutually exclusive. More than one mechanism might pertain. We discuss two of the mechanisms. One mechanism would associate with the notion that ordinary matter forms primordial black holes and measures as dark matter some effects of those primordial black holes. One mechanism would associate with electromagnetic reach-six inter-isomer transfers of energy. Each one

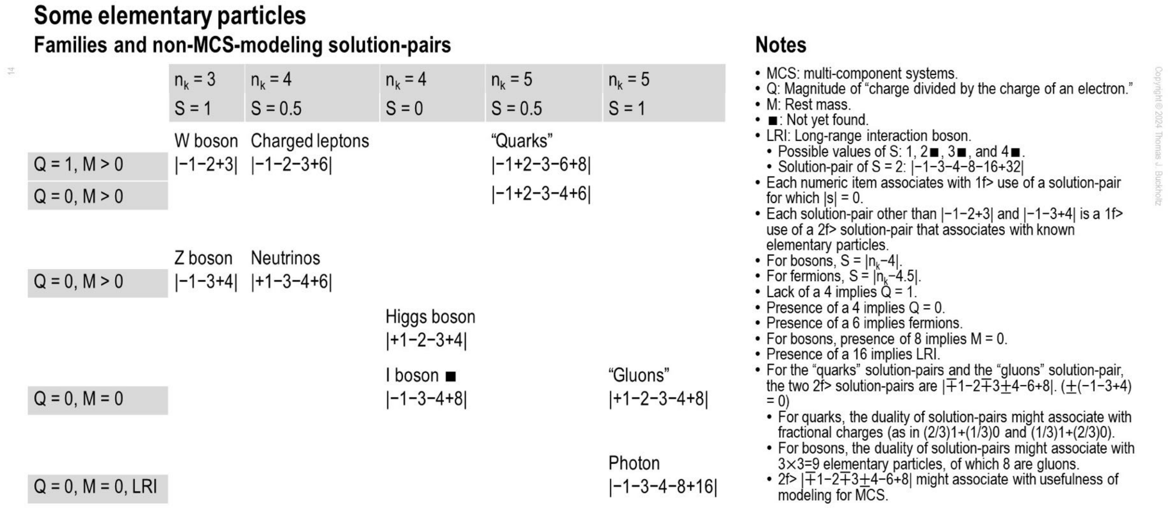


Figure 14: Some elementary particles

of the four isomers that do not associate with isomer-pair zero might not transfer out as much energy as would each one of the two isomers that associate with isomer-pair zero. Ordinary matter would, in effect, infer, relative to density of ordinary matter, growth in the densities of the universe that associate with each one of the four isomers that do not associate with isomer-pair zero. We suggest that most effects of this mechanism would occur early in the history of the universe. We suggest that sensing by ordinary matter of effects of this mechanism might lag actual transfers of energy.

We discuss $s = 0$ solution-pairs and elementary particles.

For monopole sets $K$ and for dipole sets $K$, it is arithmetically not possible to have solution pairs for which $s$ is zero. For quadrupole, octupole, and so forth sets $K$, solution pairs for which $s = 0$ can possibly exist if the number of odd integers in a set $K$ is an even number.

Figure 14 discusses the notion that nuance-bearing integer-based tags and solution-pairs for which $|s|$ is zero might tag all known and some possible elementary particles. Figure 9 discusses notions that associate with the word cascade. Except for solution-pairs in the $n_k = 3$ column, each solution-pair that Figure 14 shows cascades in one step from a solution-pair that associates with a set of known elementary particles. For example, the solution-pair for gluons cascades from the solution-pair for the Higgs boson. Each one of the integers one and three appears in each one of the solution-pairs that Figure 14 shows. The notes section of Figure 14 suggests that some integers, such as four, six, and eight serve as characterizations regarding properties. For example, the presence of a four associates with zero charge. The presence of a six associates with fermion. For bosons, the presence of an eight associates with zero mass. The presence of a sixteen associates with a boson that associates with a long-range interaction field. Each one of the electromagnetic field and the gravitational field is a long-range interaction field. We suggest that the overall reach of such a field can be six. We suggest that individual long-range interaction bosons do not necessarily associate with a reach of one.

Figure 14 associates with possible inconsistencies with modeling. Hadrons associate with charges that are integer multiples of the magnitude of the charge of the electron. Quarks, which model as components of hadrons, do not associate with magnitudes of charge that are integer multiples of the magnitude of the charge of the electron. While the I boson might associate with cosmology-suggested notions of an inflaton elementary particle, excitation of an I boson might associate with modeling notions of longitudinal polarization and with modeling notions that the I boson would associate with nonzero mass.

We suggest the following notions.

- The combination of $5 \in K$ and $7 \in K$ characterizes a multi-component system. The combination of $5 \in K$ and $7 \notin K$ can associate with one component of a two-component system. The combination of $5 \notin K$ and $7 \in K$ can associate with the other component of the two-component system.
- For an atom, the atomic nucleus can associate with one component and the electron cloud can associate with the other component. Electromagnetism binds the two components to each other.
- Quarks and gluons associate with notions of components of multi-component systems.

### Elementary particles

**Families and solution-pairs**

| $n_k = 4$ | $n_k = 5$ |
|---|---|
| S = 0.5 | S = 0.5 |
| Charged leptons<br>\|−1−2−3+6\| | Quarks<br>\|+1+2−5−6+8\| |
| Neutrinos<br>\|+1−3−4+6\| | Quarks<br>\|+2+3−6−7+8\| |

| $n_k = 3$ | $n_k = 4$ | $n_k = 5$ | $n_k = 6$ | $n_k = 6$ | $n_k = 7$ |
|---|---|---|---|---|---|
| S = 1 | S = 0 | S = 1 | S = 2 | S = 3 | S = 4 |
| W boson<br>\|−1−2+3\| | Higgs boson<br>\|+1−2−3+4\| | Gluons<br>‡ | | | |
| Z boson<br>\|−1−3+4\| | I boson ■<br>† | J boson ■<br>‡ | | | |
| | | Photon<br>\|−1−3−4−8+16\| | Graviton ■<br>⋆ | TBD ■<br>⋆ | TBD ■<br>⋆ |

**Notes**

- 1f> uses of 0 = |···| solution-pairs
- $n_k$ = the number of integers in the set K (or, per solution-pair)
- S = spin, in units of $\hbar$: S = $|n_k-4|$ for bosons; S = $|n_k-4.5|$ for fermions
- ■ = proposed
- TBD: To be determined
- Compared to the W boson solution-pair, …
  - 4∈K ↔ zero charge; 5∈K, 7∉K or 7∈K, 5∉K ↔ one component of a multi-component system; 6∈K ↔ fermions; 8∈K, 6∉K ↔ zero-mass bosons; 16∈K ↔ spans more than one isomer
- Q = |charge|/|charge of the electron|
  - Q = 1 for the W boson and the charged leptons
  - Q = 2/3 for three quarks (or, one quark solution-pair)
  - Q = 1/3 for three quarks (or, the other quark solution-pair)
- 16∈K ↔ long-range-interaction bosons
  - Possible values of S: 1, 2■, 3■, and 4■
- ⋆ S ≥ 2 solution-pairs:
  - S = 2: |−1−3−4−8−16+32|
  - S = 3: |−1−3−4−8−16−32+64|
  - S = 4: |−1−3−4−8−16−32−64+128|
- For the I boson, quarks, gluons, and the J boson …
  - 5∈K, 7∉K ↔ one component of a two-component system
  - 7∈K, 5∉K ↔ the other component of a two-component system
- † I-boson solution-pairs: |+1−4−5+8| and |+3−4−7+8|
- ‡ Gluon and J-boson solution-pairs:
  - 5∈K, 7∉K: |−1+2−4−5+8| and |−2+3−4−5+8|
  - 7∈K, 5∉K: |+1+2−4−7+8| and |−2−3+4−7+8|.
- Charged leptons ↔ electron, muon, tau
- J boson ↔ Pauli exclusion



Figure 15: Elementary particles

### The might-be I boson and might-be J boson

**Notions**

1. I boson.
   - Cosmology MOD suggests an inflationary epoch (regarding the rate of expansion of the universe) and that a scalar field that would associate with zero-mass boson elementary particles (or, inflatons) plays a role.
   - The CAT+NUBIT suggested I boson might be consistent with MOD notions of an inflaton.
2. J boson.
   - MOD suggests a possible discrepancy between modeling and data regarding the energy that associates with the $2^3S_1 \rightarrow 2^3P_0$ transition regarding positronium.
   - People report detection of so-called Pauli crystals.
   - The CAT+NUBIT suggested J boson might mediate interactions between two adequately similar fermions, with the interactions attempting, in effect, to repel the fermions from each other and/or to charge the values of properties (such as spin-orientation, flavour, or state within a multi-component system) to reduce similarity.

**Notes**

1. …
   - There might be no data that pertain directly to the would-be inflationary era.
   - MOD might suggest an inconsistency between zero-mass and so-called longitudinal polarization.
   - CAT+NUBIT suggests that the Higgs boson and the I boson would share 2f> use of 0=|+1−2−3 −4+8| and that at a range perhaps less than that of the weak interaction, a multi-component (Higgs and I) system can excite with I in effect interacting with itself or other with stuff.
2. …
   - MOD modeling based on wave functions uses notions of antisymmetric with respect to the exchange of two identical fermions. CAT+NUBIT suggests the possibility for MOD modeling that would feature a potential (related to the J boson) that might be useful, independently of whether two fermions are multi-component systems or the two fermions are elementary particles.



Figure 16: The might-be I boson and might-be J boson

- Per Figure 14, solution-pairs that associate with the eight known gluons might associate also with one more elementary particle.

Figure 15 lists and tags known and possible families of elementary particles.

Regarding quarks, the relevant multi-component system is a hadron. We suggest that gluons bind together two types of quarks. For two-quark systems, one component might associate with matter quarks and the other component might associate with antimatter quarks. For three-quark systems, one component might be quarks for which the magnitude of charge, in units of the magnitude of the charge of the electron, $Q$ is one-third. The other component might associate with $Q = 2/3$.

Figure 16 notes aspects that we suggest regarding the might-be I boson and the might-be J boson.

Figure 17 suggests an extent to which our work that has bases in nuance-bearing integer-based tags might comport with aspirations that people might associate with Figure 7. Figure 17 suggests some uses, of solution-pairs, that might associate with some properties, suggests instances and reaches for some properties, and points to aspects regarding conserved properties and conservation laws.

Studying patterns that might associate with Figure 17 might lead to useful advances regarding physics. For example, to what extent does Figure 17 point to new insight regarding notions of conserved properties and notions of conservation laws?

## Notions regarding properties and conserved quantities

### Properties and conserved quantities

<table>
<tr><th>Property</th><th>CAT+NUBIT expression</th><th>n<sub>i</sub></th><th>R/i</th><th>Conser.</th><th>MMNZ</th></tr>
<tr><td>Charge</td><td>1x> 1=|+1|</td><td>6</td><td>1</td><td>CT</td><td>B,EF</td></tr>
<tr><td>Energy</td><td>1x> 2=|+2|</td><td>1</td><td>6</td><td>CTPVO</td><td>-</td></tr>
<tr><td>Momentum</td><td>2x> 2=|−2+4|</td><td>1</td><td>6</td><td>CTPVO</td><td>-</td></tr>
<tr><td>Angular momentum</td><td>1x> 2=|−2+4|</td><td>3</td><td>2</td><td>CTPO</td><td>B,F</td></tr>
<tr><td>EF handedness</td><td>1x> 3=|+3|</td><td>3</td><td>2</td><td>CT?</td><td>EF</td></tr>
<tr><td>EP baryon number</td><td>1x> 4=|+4|</td><td>6</td><td>1</td><td>CT?</td><td>EF</td></tr>
<tr><td>EP lepton number</td><td>1x> 4=|+4|</td><td>6</td><td>1</td><td>CT?</td><td>EF</td></tr>
<tr><td>Isomer-pair</td><td>k'=0</td><td>3</td><td>2</td><td>-</td><td>-</td></tr>
<tr><td>Color charge</td><td>k'=−1</td><td>6</td><td>1</td><td>CTP</td><td>(B),EF</td></tr>
<tr><td>Modeling dimensions</td><td>k'=−2</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Precessing magnetic moment ⋆</td><td>1x> 1=|−1−2+4|</td><td>1</td><td>6</td><td>-</td><td>-</td></tr>
<tr><td>Surface temperature</td><td>1x> 1=|±(−1−2+3)−4+5| †</td><td>6</td><td>1</td><td>-</td><td>-</td></tr>
<tr><td>MCS (e.g., atomic state) ‡</td><td>1x> 1=|+1−4−5+7|</td><td>3</td><td>2</td><td>-</td><td>-</td></tr>
<tr><td>MCS (e.g., atomic state) ‡</td><td>1x> 1=|±1+2−4−5+7|</td><td>1</td><td>6</td><td>-</td><td>-</td></tr>
</table>

### Notes

- B: boson; F: fermion; EP: elementary particle; EB: boson EP; EF: fermion EP
- ⋆: Intrinsic property (not Larmor precession)
- MCS: (For atoms, ...) Modeling based on an electron cloud and a nucleus.
- ‡: Either one of the two rows might comport with data regarding observed depletion of cosmic microwave background radiation.
- Notions related to k' and Newtonian dynamics:
  - A radial $r^{-1}$ potential pertains for 1x> 1=|+1| and 1x> 2=|+2|.
  - MOD suggests that, for a non-negative k' with k'≤2, notions of an $r^{k'}$ potential might pertain. PAT suggests related properties.
  - Modeling dimensions: 3 spatial, 1 temporal
- †: Other (such as 1=|±(−1+2)−3−4+7|) solution-pairs might pertain.
- Notions related to Conser. (as in conservation laws):
  - C: MOD or CAT+NUBIT suggests that a conservation law pertains.
  - T: The related field transmits (? - or would transmit) energy, momentum, and angular momentum.
  - P: The related field transmits the property.
  - V: MOD suggests a notion of complementary variable(s).
  - O: One instance of a conservation law pertains. (Otherwise, if C pertains, $n_i$ instances of the property pertain.)
- Notions related to MMNZ (as in nonzero minimal magnitude of nonzero inferred values):
  - B charge: $|q/|q_e||=1$
  - EF charge: $|q/|q_e||=1/3$
  - B angular momentum: B $|J/\hbar|=1$
  - F angular momentum: $|J/\hbar|=1/2$
  - EF handedness: 1
  - EP baryon number: 1
  - EP lepton number: 1
  - (B) color charge: Varies, depending on the specific gluon
  - EF color charge: 1 (for each of the 3 color charges)



Figure 17: Notions regarding properties and conserved quantities

*3.5. Some mathematics for isotropic harmonic oscillators*

We discuss mathematics related to the three-word term isotropic harmonic oscillators.

Modeling for a $j$-dimensional isotropic harmonic oscillator can feature $j$ linear coordinates $x_{l_x}$, each with a domain $-\infty < x_{l_x} < \infty$, and an operator that is the sum, over the $l_x$, of $j$ operators of the form that Eq. (1) shows. The number $C$ is positive and is common to all $j$ uses of Eq. (1). The word isotropic associates with the commonality, across all $j$ uses of Eq. (1), of the number $C$.

$$-\frac{\partial^2}{\partial(x_{l_x})^2} + C \cdot (x_{l_x})^2 \tag{1}$$

For $j \geq 2$, one can split the overall operator into pieces. Eq. (2) associates with a split into two pieces. Here, each of $j_1$ and $j_2$ is a positive integer.

$$j = j_1 + j_2 \tag{2}$$

In discussion below, the symbol $D$ might be any one of $j$, $j_1$, and $j_2$.

For $D \geq 2$, mathematics related to isotropic harmonic oscillators can feature partial differential equations, a radial coordinate, and $D - 1$ angular coordinates. Eq. (3) defines a radial coordinate.

$$x = (\sum_{l_x} (x_{l_x})^2)^{1/2} \tag{3}$$

We replace $x$ via the expression that Eq. (4) shows. Here, $r_*$ denotes the radial coordinate and has dimensions of length. The parameter $\eta$ has dimensions of length. The parameter $\eta$ is a nonzero real number. The magnitude $|\eta|$ associates with a scale length.

$$x = r_*/\eta \tag{4}$$

In physics modeling applications, the following notions can pertain. Solutions, that can associate with wave functions, to the pair of Eq. (5) and Eq. (6) can have the form $\Psi = \phi_R(r_*)Y$, in which $Y$ is a function of $D - 1$ angular coordinates and is not a function of $r_*$. $\Omega$ associates with operators that associate with angular coordinates. For example, for $D = 3$, a representation for $\Omega$ in terms of an operator that is a function of spherical coordinates can pertain [63]. $D$ is a nonnegative integer. The domain for $r_*$ is $0 \leq r_* < \infty$. Each one of $\xi$ and $\xi'$ is an as-yet unspecified constant. For $D = 1$, Eq. (5) and Eq. (6) might not be appropriate.

$$\xi\Psi = (\xi'/2)(-\eta^2\nabla^2 + (\eta)^{-2}(r_*)^2)\Psi \tag{5}$$

$$\nabla^2 = (r_*)^{-(D-1)}(\partial/\partial r_*)(r_*)^{D-1}(\partial/\partial r_*) - \Omega(r_*)^{-2} \tag{6}$$

We consider solutions that comport with Eq. (7), Eq. (8), Eq. (9), Eq. (10), Eq. (11), Eq. (12), and Eq. (13). With respect to the domain $0 \leq r_* < \infty$, $\phi_R$ associates with the mathematics notion of having a definition almost everywhere. In physics modeling, solutions that associate with Eq. (1) and with $D = 1$ have the form $H(x_1)\exp(-(x_1)^2)$, in which $H(x_1)$ is a Hermite polynomial. In our work, for each relevant $D$, each solution that is relevant associates with, in effect, a one-term polynomial. In our work, $D = 1$ is a relevant $D$. Eq. (11) and Eq. (12) echo Eq. (5) and Eq. (6). That the function $\phi_R(r_*)$ normalizes will be significant. Per the equal-sign symbol in Eq. (13), normalization to a value of one is not necessarily relevant for our discussion.

$$D \text{ is a real number} \tag{7}$$

$$\Omega \text{ is a constant} \tag{8}$$

$$\phi_R(r_*) \text{ is a function of just } r_*,\ \eta, \text{ and a number } n_* \tag{9}$$

$$0 < r_* < \infty \tag{10}$$

$$\xi\phi_R(r_*) = (\xi'/2)(-\eta^2\nabla^2 + (\eta)^{-2}(r_*)^2)\phi_R(r_*) \tag{11}$$

$$\nabla^2 = (r_*)^{-(D-1)}(\partial/\partial r_*)(r_*)^{D-1}(\partial/\partial r_*) - \Omega(r_*)^{-2} \tag{12}$$

$$\phi_R(r_*) \ = \ (r_*/\eta)^{n_*}\exp(-(r_*)^2/(2\eta^2)), \text{ with } \eta^2 > 0 \tag{13}$$

Eq. (14) and Eq. (15) characterize solutions of the form that Eq. (13) shows. The parameter $\eta$ does not appear in Eq. (14) and Eq. (15).

$$\xi = (D + 2n_*)(\xi'/2) \tag{14}$$

$$\Omega = n_*(n_* + D - 2) \tag{15}$$

$\phi_R(r_*)$ normalizes if and only if Eq. (16) pertains. The symbol $(\phi_R(r_*))^*$ denotes the complex conjugate of $\phi_R(r_*)$.

$$\int_0^\infty (\phi_R(r_*))^*\phi_R(r_*)\cdot(r_*)^{D-1}dr_* < \infty \tag{16}$$

Eq. (17) associates with the domains of $D$ and $n_*$ for which normalization pertains for $\phi_R(r_*)$. For $D + 2n_* = 0$, normalization pertains in the limit $\eta^2 \to 0^+$. Regarding mathematics relevant to normalization for $D + 2n_* = 0$, the delta function that Eq. (18) shows pertains [64]. Here, $(x')^2$ associates with $(r_*)^2$ and $4\epsilon$ associates with $\eta^2$. The difference in domains, between $-\infty < x' < \infty$ and Eq. (10), is not material here.

$$D + 2n_* \geq 0 \tag{17}$$

$$\delta(x') = \lim{}_{\epsilon\to 0^+}(1/(2\sqrt{\pi\epsilon}))e^{-(x')^2/(4\epsilon)} \tag{18}$$

Physics modeling uses Eq. (19) to describe the energy $E$ of the $n_*$-times excited state of a $D$-dimensional isotropic harmonic oscillator. Eq. (17) compares with Eq. (14). In physics modeling, $n_*$ is a nonnegative integer. In physics modeling, $n_* = 0$ links to the two-word term ground state. $\omega$ is a frequency. Physics modeling links a wavelength $\lambda$ to the frequency via the equation $\lambda = c/\omega$. The symbol $c$ denotes the speed of light.

$$E = 0.5(D + 2n_*)\hbar\omega \geq 0 \tag{19}$$

### Notions regarding isotropic harmonic oscillators

**Solution sets**

D – positive integer, $n_*$ – integer:

1. Integer D = 1, $n_* \geq 0$, $E \propto (1/2)(D+2n_*) \geq 1/2$
   - Linear coordinate, Hermite polynomial solutions
2. Integer $D \geq 2$, $n_* \geq 0$, $E \propto (1/2)(D+2n_*) \geq D/2$
   - Radial coordinates, one-term solutions
3. Integer $D \geq 1$, $n_* > -D/2$, $E \propto (1/2)(D+2n_*) > 0$
   - Radial coordinates, one-term solutions
4. Even integer $D \geq 2$, $n_* = -D/2$, $E \propto (1/2)(D+2n_*) = 0$
   - Radial coordinate, one-term solutions

Other:

A. Integer D, half-integer $n_* \geq -D/2$, $E \propto (1/2)(D+2n_*) \geq 0$
   - Radial coordinate, one-term solutions

B. Non-integer D, $n_* \geq -D/2$, $E \propto (1/2)(D+2n_*) \geq 0$
   - Possibly, extensions via algebra but not necessarily via partial differential equations.

**Notes**

- D = number of (spatial) dimensions
- Radial factor in a solution $\phi = r^{n_*} \cdot \exp(r^2/2)$
- E (as in energy) $\propto (1/2)(D+2n_*)$
- $\Omega$ (as in $\Omega/(r^2)$) $\propto n_* (n_*+D-2)$

1. Popular MOD
2. Popular MOD
3. $\phi$ normalizes but can be infinite at r=0.
4. $\phi$ normalizes in the limit that a length-related scale-factor goes to zero.

Other

A. Half-integer $n_*$ might associate with fermions. (For example, for D = 1 and $n_* = -1/2$, $\Omega = 3/4$.)
   - Possible fermion raising and lowering operators (for $n \in \{0,1\}$ and e being, for example, one of 1/2 and 1):
     - $a+ |n\rangle = (1-n)^e |n+1\rangle$
     - $a- |n\rangle = (n)^e |n-1\rangle$
   - These might parallel boson raising and lowering operations, which are for integer $n \geq 0$, ...
     - $a+ |n\rangle = (1+n)^{1/2} |n+1\rangle$
     - $a- |n\rangle = (n)^{1/2} |n-1\rangle$

B. Possibly, associates with notions of non-boson and non-fermion.



Figure 18: Notions regarding isotropic harmonic oscillators

### Gauge symmetries and the Higgs field

**Possibly relevant notions**

1. Gauge symmetries
   - Photon:
     - 2 = 2 (as in excitation modes) × 1 (as in 1f> solution-pairs).
     - Excitation leaves a D = 1 (as in 2 − 1) HO symmetry.
     - U(1) symmetry.
   - Each weak interaction boson:
     - 3 = 3 (as in excitation modes) × 1 (as in 1f> solution-pairs).
     - Excitation leaves a D = 2 (as in 3 − 1) HO symmetry.
     - SU(2) symmetry.
   - Gluons:
     - 4 = 2 (as in excitation modes) × 2 (as in 1f> solution-pairs for either 5∈K or 7∈K ).
     - Excitation leaves a D = 3 (as in 4 − 1) HO symmetry.
     - SU(3) symmetry.
2. Higgs field and Higgs boson
   - The Higgs field ground state links to D = 3, $n_* = 0$, and an energy $E \propto (1/2)(D+2n_*) = 3/2$.
   - The Higgs boson ground state links (with respect to the Higgs field) to D = 3, $n_* = -1$, and an energy $E \propto (1/2)(D+2n_*) = 1/2$.
   - Higgs boson excitations link to one mode, D = 1, $n_* \geq 0$, and energies $E \propto (1/2)(D+2n_*) = (1/2)(1+2n_*) \geq 1/2$.

**Notes**

1. Gauge symmetries.
   MOD notions.
   - U(1) – Electromagnetic interaction.
   - SU(2) × U(1) – Electroweak interaction.
   - SU(3) – Strong interaction.

   Possible PAT notions.
   - No symmetry – Higgs-related interaction.
   - U(1) – Gravitational interaction.
2. Higgs field and Higgs boson.
   MOD notion.
   - The ground state energy of the Higgs boson is less than the ground state energy of the Higgs field.

A. Mathematics.
   - HO: harmonic-oscillator mathematics.
   - U(1): 1 generator; excitation symmetry for a D = 1 harmonic oscillator.
   - SU(D): $D^2-1$ generators; ground-state symmetry for a $D \geq 2$ isotropic harmonic oscillator. ($D^2-1 = (D+1)\cdot(D-1)$)



Figure 19: Gauge symmetries and the Higgs field

## *3.6. Other physics results*

Figure 18 notes solutions, that modeling uses, to equations that associate with harmonic oscillator mathematics, suggests solutions that modeling seems not to use, and suggests possibly new notions that might pertain regarding possible raising and lowering operators regarding fermion states. Solutions that modeling seems not to use associate with discussion related to Eq. (17).

Figure 19 suggests that nuance-bearing integer-based tags might provide an alternative, to modeling-related techniques, way to point to modeling notions of gauge symmetries and to modeling aspects related to the Higgs field.

Figure 20 notes possibly useful notions about relationships among properties of fermion elementary particles.

The first item in Figure 20 suggests the following notions. It might be possible to predict a more accurate tau mass than data suggest and that modeling seems not to have a means to predict. The strength of electromagnetic forces and the strength of gravitational forces might interrelate in a way that modeling does not seem to suggest.

Figure 21 notes possibly useful notions about relationships among properties of boson elementary particles.

The formula regarding masses for nonzero-mass elementary bosons has bases in three data points. We

## Properties of fermion elementary particles

### Data

20

1. A possible relationship between the strength of electromagnetism and the strength of gravity.
   - $(4/3)\cdot((m_{tau}/m_{electron})^2)^6 = ((q_{electron})^2/(4\pi\varepsilon_0))/(G_N(m_{electron})^2)$
2. Approximate $\log_{10}$ (mass / electron mass), for …
   - Charged lepton masses (flavours 1, {N/A}, 2, 3)
     - 0.00, {1.23}, 2.32, 3.54
   - Geometric-mean quark masses (flavours 1, 2, 3)
     - 0.80, 2.83, 4.72
3. Suggested rest energies for at least two neutrinos.
   - $0.034^{+}$ eV.

### Notes

1. This formula predicts a tau mass for which several standard deviations fit within one experimental standard deviation.
   - A factor of 4 associates with electromagnetism. A factor of 3 associates with gravity. Extrapolation suggests that a factor of 0 associates with spin-5 and thus a series of spins ends before or at spin-4.
2. The six flavour-related numbers come from data. The one N/A number comes from a formula that approximately fits the masses of all nine known charged elementary fermions.
   - The notion that the flavour of the lowest-mass isomer-one charged lepton might be three might associate with (A) the notion that exponent six (in the (4/3)·… formula might associate with the notion of six isomers and (B) the notion that - for $0 \leq i \leq 5$ - the flavour of the isomer-(i+1) lowest-mass charged lepton might associate with the flavour of the isomer-i highest-mass charged lepton.
3. Suggested rest energies for neutrinos come from extrapolating based on the formula that fits the masses of the nine known charged leptons. The notion of two or three neutrinos having the stated rest energy seems to comport with data from astrophysics. If the stated rest energy pertains only to two of the neutrinos, the formula suggests that the remaining rest energy no larger than about 0.00042 eV.



Figure 20: Properties of fermion elementary particles

## Properties of boson elementary particles

### Possibly relevant notions

21

1. Nonzero-mass boson elementary particles.
   - $(N')^2 = (M')^2 + (S')^2 + (Q')^2 + (\mu')^2 - 1$
     - N' = 4 for the Higgs boson.
     - N' = 3 for the W and Z bosons.
     - M' = Mass / ((1/3) × (the mass of the Z boson)).
     - S' = S
     - Q' = |Charge / (the charge of the electron)|.
     - μ' = |(Magnetic moment) / (the magnetic moment of the W boson)|
2. Zero-mass boson elementary particles.
   - $(N')^2 = (S')^2$

### Notes

1. Nonzero-mass boson elementary particles.
   - $3 \leq N' \leq 4$.
   - The $(N')^2 = \ldots$ equation might comport with data.
   - The $(N')^2 = \ldots$ equation suggests … $(\mathrm{Mass}(W))^2 : (\mathrm{Mass}(Z))^2 : (\mathrm{Mass}(\mathrm{Higgs}))^2$ :: 7 : 9 : 17.
   - $(\mathrm{Mass}(W))^2 : (\mathrm{Mass}(Z))^2$ is the weak mixing angle.
2. Zero-mass boson elementary particles.
   - $0 \leq N'$.
   - Possibly, $N' \leq 4$.

A. Possible ground-state energies for LRI boson elementary particles.
   - $(S')^2$ might associate with $(S')(S' + D - 2))$ and D = 2.
   - Given D = 2, the ground state might associate with $n_* = -1$ and with $E \propto (1/2)(D+2n_*) = 0$.

B. Possible links to MOD special relativity or MOD index of refraction.
   - $(N'-S')\cdot(N'+S') = ((c^2-v^2)/c^2)\cdot((M')^2 + (Q')^2 + (\mu')^2 - 1)$
   - c = speed of light.
   - v = inferred velocity.
   - $c^2-v^2 = (c-v)\cdot(c+v)$.

C. Limits.
   - N'=4, S'=0; N'=3, S'=1; … stops before N'=2, S'=2 (for which (N'−S') would be 0).
   - N'=4, S'=0; N'=5, S'=1; … stops before or at N'=8, S'=4 (per force-strength-related factors of 4, 3, 2, and 1 for S' = respectively 1, 2, 3, and 4.)



Figure 21: Properties of boson elementary particles

### Time, space-time coordinates, and space-time

**Notions about CAT+NUBIT and MOD**

22

1. CAT+NUBIT does not necessarily link directly to notions of time or to notions of temporal coordinates.
2. CAT+NUBIT seems compatible with the notion that an observer system O can make choices regarding notions regarding time.
3. CAT+NUBIT seems compatible with the notion that an observer system O can make choices regarding notions about temporal and spatial coordinates and choices regarding MOD models.
4. CAT+NUBIT seems compatible with the notion that notions of space-time being an entity might not be necessary.

**Notes**

1. ...
   - CAT+NUBIT seems scarcely to associate with notions of time or with notions of temporal coordinates.
   - One touchpoint might be in notions regarding 1x>, 2x>, and so forth.
   - Such lack of association might be appropriate, given that CAT+NUBIT might not fail to comport with successful MOD that associates with Newtonian dynamics and might not fail to comport with successful MOD that associates with special relativity.
2. A system O might make choices based on inferences regarding seemingly periodic phenomena.
3. To the extent that models involve space-time coordinates, the coordinates might need need only to span a system O, inferred aspects I, and a 3-dimensional (for Newtonian dynamics) or a 4-dimensional (for special relativity) coordinate patch that adequately connects O and the I:s.



Figure 22: Time, space-time coordinates, and space-time

### General relativity, quantum gravity, and the ground state of the vacuum

**CAT+NUBIT suggestions**

23

1. CAT+NUBIT seems compatible with the notion that some uses of general relativity might not comport adequately with data.
2. CAT+NUBIT seems compatible with the notion that some aspects of quantum gravity might be as straightforward and as difficult as aspects of quantum electromagnetism.
3. CAT+NUBIT offers the possibility that MOD modeling can consider to be zero the so-called vacuum energy that might associate with electromagnetism and the perhaps vacuum energy that might associate with gravity.

**Notes**

1. ...
   - To date, general relativity may have passed all so-called precision tests.
   - The precision tests may have been limited to phenomena involving electromagnetism, gravity, and stuff that associates with the isomer that associates with ordinary matter.
   - CAT+NUBIT suggests that that energy and momentum associate with LRI and with a reach of six isomers.
   - CAT+NUBIT suggests that angular momentum associates with LRI and with three instances of a reach of two isomers.
   - CAT+NUBIT suggests that other gravitational properties associate with six instances of a reach of one isomer.
   - CAT+NUBIT suggests that – regarding forces and regarding notions of space-time – uses of general relativity are not necessarily adequately accurate, especially to the extent that modeling needs to consider stuff that associates with more than one isomer.
2. For quantum effects that associate with transitions within multi-component systems, significant CAT+NUBIT differences between gravitational properties and electromagnetic properties might limited to the difference between $|s| = 2$ for gravity and $|s| = 1$ for electromagnetism.
3. CAT+NUBIT suggests that MOD might consider that the ground state of a photon or of a graviton might associate with $D \geq 2$, $n_* = -D/2$, and an energy $E \propto (1/2)(D+2n_*) = 0$.



Figure 23: General relativity, quantum gravity, and the ground state of the vacuum

are uncertain as to the extent to which the equation might associate with notions, regarding gravitational properties, that inferred nonzero spin might detract from inferred mass, that inferred nonzero charge might detract from inferred mass, or that inferred nonzero magnetic moment might detract from inferred mass.

Figure 22 discusses aspects regarding time, space-time coordinates, and notions of space-time.

Figure 23 discusses aspects regarding limits on the applicability of general relativity, regarding modeling and quantum gravity, and regarding the possibility that modeling might want to include the possibility that vacuum energy, associating with electromagnetism and possibly associating with gravity, can model as zero.

The creator of general relativity discussed the notion that people might want to use general relativity for force-related applications and the notion that people might want to de-emphasize using general relativity regarding notions of geodesic motion and space-time [65]. People suggest modeling that might transcend general relativity; enable the incorporation of properties, such as temperature and other electromagnetic properties, other than gravitational properties; and enable quantization of gravity [66]. We do not explore the extent to which people might be able, even for just force-related applications, to adjust general relativity to include notions related to more than one isomer.

Figure 24 suggests that nuance-bearing integer-based tags might be consistent with some modeling notions about a possible Big Bang.

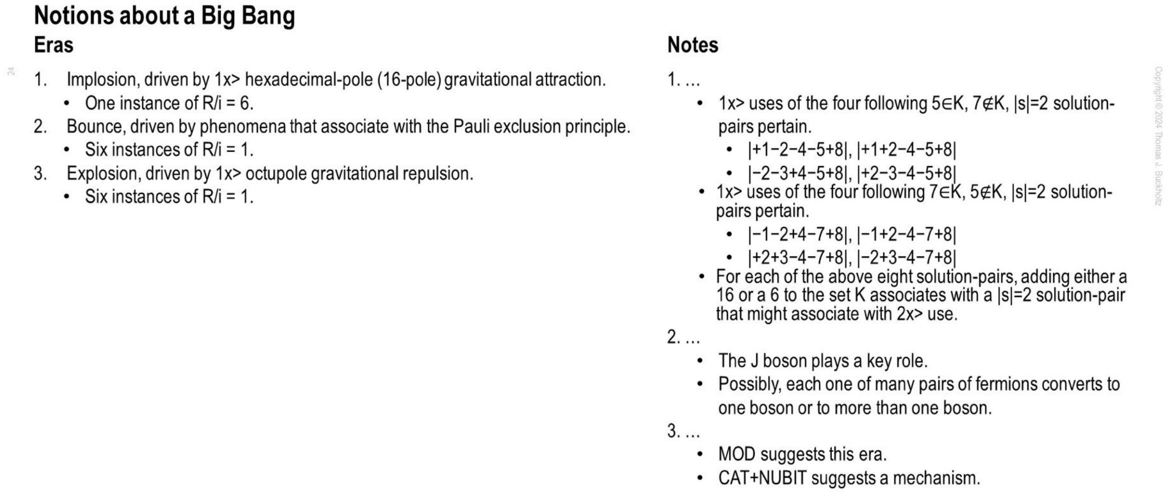


Figure 24: Notions about a Big Bang

We suggest that nuance-bearing integer-based tags might provide a basis for characterizing spin states of multi-component systems. For example, the solution-pair $0 = |+2-4-5+7|$ might characterize a spin-zero state of a zero-charge multi-component system. Here, like for spin-zero elementary particles, $n_k = 4$. The solution-pair $0 = |-2-4+5-6+7|$ might characterize a spin-one-half state. The solution-pair $0 = |-2-4+5-7+8|$ might characterize a spin-one state. And so forth.

*3.7. Usefulness and consistency*

Work that we discuss above suggests possibly noteworthy progress regarding each one of the first four goals that Figure 5 states.

Regarding each one of the four goals, people might want to consider the extent to which our work suggests results that might be at least as useful as other notions that people might consider to be state of the art.

Our work might be adequately consistent, for now, with data and modeling.

To the extent that people find inadequate consistency with data or with useful modeling, people might want to consider changing aspects of our work regarding one or a few of the four goals independently of possibly changing aspects regarding other ones of the four goals. The methods that underlie our work do not necessarily imply that some aspects of the work depend on some other aspects of the work. We suggest that the nuanced-bearing integer-based tagging that the methods deploy might prove useful regarding developing and evaluating notions for changed aspects.

## 4. Discussion

*4.1. Cataloging and using checklists for scientific and societal endeavors*

The Figure 2 activity hierarchy provides one aspect of a two-aspect checklist. Regarding the first aspect, the themes catalog types of activities that an endeavor has performed, is performing, or might perform. People can develop the second aspect by listing activities.

The Figure 2 hierarchy also provides the first aspect for a two-aspect checklist regarding some checklists. Discussion related to Figure 2 focuses on networks of prerequisite activities. The theme of doing pertains. People might tag the Figure 2 checklist as a .3 checklist. Some checklists enable cataloging motivations or purposes [67]. People might associate motivations or purposes with thinking. People might tag motivations checklists or purposes checklists as .2 checklists. Some checklists enable cataloging styles for doing work [67]. Examples of styles include haphazardly and procedurally. People might associate styles with abilities to do work. People might tag styles checklists as .1 checklists.

People might perceive integer-based tagging to be useful though not necessarily rigorous. Rating a product or service based on a scale of one star through 5 stars provides an example. People use some such rating scales for which there might seem to be no explicit guidance regarding meanings to attach to or infer from steps on such a scale.

The numeric tagging, regarding activities within endeavors, that we discuss above seems somewhat qualitatively rigorous. Some seeming degree of rigor might increase as one increases the number of hierarchical uses of the trio of do, think, and be.

One use of the trio calls attention to opportunities, within any activity, to consider using analytic (or, type .2) skills.

The appearance of .2 calls attention to opportunities to try to measure relevant aspects. An interesting notion might be that people might be more inclined to measure resources, as in .1.2, than to measure planning activities, as in .2.2, or to measure outcomes, as in .3.2. Another interesting notion might be that people might find more value in and take more interest in outcomes than in planning or resources.

The numeric tagging, regarding physical systems, that this paper discusses above seems to exhibit some quantitative rigor within the realm of physics. For example, one tagging number associates with whether a system associates with non-zero charge. Or, one tagging number associates with whether a system associates with boson statistics or with fermion statistics.

### *4.2. Working with integer-tagged catalogs*

For a catalog, the set of cataloged items might change over time. Descriptions of items might change. Tags might change. Nuances might change.

Figure 14 and Figure 15 illustrate co-evolution regarding items, descriptions, tags, and nuances. Figure 14 associates with not considering that some elementary particles seem to exist only within systems that involve more than one type of elementary particle. Figure 15 associates with trying to use notions that quarks and gluons seem to exist only in multi-component systems that include both quarks and gluons. Figure 15 seems to associate with a step forward from Figure 14. Figure 15 points toward notions regarding which more work might be appropriate. For example, specifically from the standpoint of solution-pairs that associate with gluons, to what extent does the notion of multi-component system associate with notions of more than two components? In general, to what extent can the use of $5 \in K$ or $7 \in K$ associate with modeling that associates with more than two components in multi-component systems? Might characterizations based on, for example, $9 \in K$ or $11 \in K$ provide insight about systems that model as having more than two components?

### *4.3. Consistency and physics*

The notion of consistency calls attention to opportunities to explore similarities and differences. Similarities and differences can pertain within physics at a specific time. Similarities and differences can pertain between physics at some time and physics at a different time.

Discussion above regarding cosmology and elementary particles features possible similarities between physics now and possible forthcoming physics. That discussion uses consistency as a theme to help people grasp our work by associating aspects of our work with familiar physics.

The following discussion pertains to consistency at a specific time. To what extent should people consider modeling regarding electromagnetism and modeling regarding gravitation to be similar?

- For example, to what extent are some differences between electromagnetism and gravity adequately characterized by the notion that electromagnetism associates with a spin-one field and gravity associates with a spin-two field? To what extent might reliance on possible differences associating with trying to associate spin-one with the word vector and trying to associate spin-two with the word tensor be not appropriate?

- For example, if modeling regarding electromagnetism does not seem to necessitate the notion of an ether, to what extent does modeling regarding gravitation necessitate a notion of a physical space-time? Further, to the extent that modeling features interactions between pairs of systems and that three-body modeling is more difficult than two-body modeling, to what extent does the use of notions of space-time associate with unnecessary introduction of three-body complexity regarding the modeling of interactions between two systems?

Possibly, striving for consistency limits some advances in physics. Physics has made progress by, for example, extrapolating based on mathematics-based models or other notions that seemed to have relevance. But applications of mathematics are flexible, and people might find it easy to focus on mathematics-based extrapolations. Sometimes, new data hints at needs for new physics. With the complexity that associates with consistency, people might de-emphasize opportunities that might seem to associate with changing perhaps too many seemingly consistent notions. Discussion above about cosmology and elementary particles associates with such themes. Our work has roots in seemingly unexplained data. The discussion tries to make palatable some notions of multiple changes with respect to popular physics notions.

### 4.4. *Fundamental physics principles*

People associate the five-word term the principle of stationary action with much of modeling. Direct overlaps between the principle of stationary action and Figure 17 might seem minimal. Similar minimal overlaps with the principle of stationary action might pertain regarding other figures, including Figure 20 and Figure 21. Nuance-bearing integer-based tags might point toward possibilities for developing new fundamental principles of physics. Such new fundamental principles might complement the principle of stationary action.

### 4.5. *Uniting notions regarding some properties, some fields, and elementary particles*

Some aspects of modeling suggest notions that systems, including elementary particles, model as excitations of fields.

Figure 9 might provide a basis for uniting, via one equation and a set of solution-pairs, notions of some properties of objects, some fields, and elementary particles. Figure 15 and Figure 17 might tend to confirm possibilities for usefulness for such unity.

Some aspects of Figure 14 and Figure 15 suggest the notion of a solution-pair cascade that links, in order, the might-be I boson, the photon, and the might-be graviton. This linkage suggests possibilities for considering that at least some elementary particles associate with properties about which a spin-zero field, which would associate with the I boson, does or would convey information. Presumably, because the I boson would have zero mass, the field related to the I boson would, in a vacuum, transmit information at the speed of light.

Considerations related to that solution-pair cascade might suggest a basis for uniting notions regarding some properties, some fields, and some elementary particles. Future vocabulary might better, than does present vocabulary, unite notions of electromagnetic properties of systems, gravitational properties of systems, and I-boson-field-related properties of systems. Each family of elementary particles might associate with an I-boson-field-related property.

Beyond the above notions, people might want to explore possible modeling notions that each system associates with a property about which the I boson field carries information.

### 4.6. *Possible structure of or components of elementary particles*

Around the time of the first publication of the periodic table [4], people might not have been much concerned with notions that atoms might have structure or components. Today, physics associates non-trivial structure with atoms and considers that an atom includes components.

Are there hints that modeling should consider that at least some elementary particles have structure or components? Perhaps the notion that charged leptons exhibit nonzero anomalous magnetic moments suggests that at least one of a distribution of charge or a distribution of mass might model as being, not spherical or point-like but, oval or oblate.

### 4.7. *Possibilities for extending the above-featured physics work*

Extending the above-featured physics work might lead to new consistencies with data and modeling, based on broadening the set of inputs or on explaining more data. Some notions for extensions follow.

Better nail down the tags that associate with known properties, such as surface temperature.

Determine numbers of instances to associate with not necessarily handed elementary particles and with zero-charge bosons other than long-range interaction bosons. However, because the ranges of the relevant bosons would be spatially limited, experimental verification of such numbers of instances might prove difficult.

Fill in details regarding multi-component systems aspects related to gluons, the I boson, and the J boson.

Explore uses for $|s| > 0$ tags that do not seem to associate with known properties.

Explore uses of $s = 0$ solution-pairs that might associate with spin states of multi-component systems.

Improve descriptions of items in catalogs and wording that associates with tags.

Explore possible extensions of nuance-bearing integer-based tags that would associate with modeling for which indices of refraction are not necessarily one. Figure 21 might suggest a start toward such exploration.

Look for and explore new, compared to the current state of our work, patterns regarding data and regarding relationships between tags.

Explore ways via which modeling can embrace the notion that isomer is a property. Modeling includes the equation $F = ma$ [68]. $F$ denotes force, $m$ denotes mass, and $a$ denotes acceleration. Modeling embraces the notion that a force can depend on the properties of the system for which $m$ pertains as

**Possible bases for other physics uses of nuance-bearing integer-based tags**

**Candidate bases**

Possible conflations between ...

- The number of relevant spatial dimensions.
- Numbers of degrees of freedom that associate with 1x>, 2x>, and so forth uses of various solution-pairs.
- Integers in sets K and property-centric interpretations that associate with the integers.
- Sequences of signs (that associate with the $s_k$) within solution-pairs.
- Interpretations based on cascade relationships (with respect to 1x>, 2x>, and so forth and with respect to 1f> and 2f>) of solution-pairs.
- The number of excitable modes (for at least some elementary particles).
- The numbers of elementary particles in some elementary-particle families.
- The number D in the spin-related physics expression S(S+D−2).
- The integers d' in the expressions $\int x^{d'}dx$ that might pertain regarding relationships between elementary-particle masses or other notions of energy levels. (d' = 1, and thus squares of numbers, might pertain for masses for elementary bosons. d' = −1, and thus logarithms of numbers, might pertain for masses for elementary bosons. d' = −3, and thus reciprocals of squares of numbers, might pertain for principal energy levels in hydrogen atoms.)
- The number D is the HO expression $n_*(n_*+D-2)$.
- The number D in the HO expression $\Omega \propto n_*(n_*+D-2)$
- The numbers of generators of some groups.
- Other discrete sets of integers (or of other numbers).

**Notes**

Applications might include ...

- Uses regarding fermion pairs and related bosons in, for example, semiconductors, superconductors, topological materials, surface (or two-dimensional) physics, or linear (or one-dimensional) physics.
- Understanding new aspects regarding and possibly making extrapolations based on series (or sets) such as…
  - Classical physics, Bose statistics, and Fermi-Dirac statistics.
  - Free-ranging (such as idealized photons), affected by backgrounds (such as photons plus indices of refraction), constrained by boundary conditions (such as photons in a reflecting cavity), and existing in multi-component systems (such as gluons in hadrons).
- Uses regarding "fractional" charges (such as quarks exhibit), magnetic effects, angular momenta (such as fermions exhibit), or other properties.
- MOD models for which forces might not associate with 3x>. (An example might involve viscosity effects that associates with 2x>.)
- MOD models that include notions of non-integer numbers of dimensions.



Figure 25: Possible bases for other physics uses of nuance-bearing integer-based tags

well as on the properties of systems that associate with producing the relevant field. For example, the electrostatic force that influences the motion of a system for which $m$ pertains depends on the charge of that system. Our work suggests that isomer is a property.

Try to extend applications of nuance-bearing integer-based tagging techniques to other, generally more complex, areas of physics. Figure 25 notes some possible technical bases for opportunities. We suggest that, for example, properties of low-dimensional heterostructures [69] might provide a possible subject-area opportunity.

Explore possible synergies between notions we discuss in this paper and other activities that seek to develop and make available useful catalogs. Cheminformatics [70] exemplifies such activities.

*4.8. Reuses*

Integer-based tags can help people do the following. Add items to a catalog. Clarify items in a catalog. Remove items from a catalog. Characterize items in a catalog. Discuss items in a catalog. Use a catalog. Perform scientific research. Steer other scientific endeavors. Steer societal endeavors. Foster synergies between endeavors.

Item E.3.3 in Figure 2 calls attention to opportunities to enable reuses of aspects of endeavors.

How can one describe, in human usable terms, what people can learn or did learn from an endeavor?

Today, the notion that machine learning can describe, in human useful terms, what a machine learned might be a dream. Moreover, perhaps people too often overlook opportunities to describe, in human useful terms, what people learn from an endeavor.

Perhaps, in the future, enabling reuses of learnings will become more a pivotal goal and more of a reality. Perhaps, uses of tagged catalogs will play roles in enabling reuses and in effecting reuses.

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## References

[1] Thomas J. Buckholtz. Metrics That Matter: Measuring and Improving the Value of Service. Chapter 13 in H. Demirkan et al. (eds.), Service Systems Implementation, Service Science: Research and Innovations in the Service Economy, Springer Science+Business Media, LLC, pp. 211-221., 2011. DOI: 10.1007/978-1-4419-7904-9.

[2] Thomas J. Buckholtz and William E. Donald. Direct Outcomes and Win-Win Relationships Between University Careers Advisors and Graduate Recruiters. *GiLE Journal of Skills Development*, 2(1):9–25, May 2022. ISSN: 2732-3781.

[3] Thomas J. Buckholtz. *Information Proficiency: Your Key to the Information Age.* Van Nostrand Reinhold, 1995. ISBN: 0-442-01954-8.

[4] D. Mendeleev. Ueber die Beziehungen der Eigenschaften zu den Atomgewichten der Elemente. *Zeitschrift fur Chemie*, 12:405–406, March 1869. URL: https://babel.hathitrust.org/cgi/pt?id=uc1.b3481652.

[5] Niels Bohr. The structure of the atom. The Nobel Foundation, December 1922. URL: http://nobelprize.org.

[6] J. G. de Swart, G. Bertone, and J. van Dongen. How dark matter came to matter. *Nature Astronomy*, 1(3), March 2017. DOI: 10.1038/s41550-017-0059.

[7] N. Fornengo. Dark matter overview. In *XXV ECRS 2016 Proceedings*, 2016. DOI: 10.48550/arXiv.1701.00119.

[8] Kathryn M. Zurek. From direct detection to astrophysical probes of dark matter substructure: A Hitchhiker's guide to dark matter. *Nuclear Physics B*, 1003:116438, June 2024. DOI: 10.1016/j.nuclphysb.2024.116438.

[9] A. Friedman. Uber die Krummung des Raumes. *Zeitschrift fur Physik*, 10(1):377–386, December 1922. DOI: 10.1007/bf01332580.

[10] E. P. Hubble. A spiral nebula as a stellar system, Messier 31. *The Astrophysical Journal*, 69:103, March 1929. DOI: 10.1086/143167.

[11] Judd D. Bowman, Alan E. E. Rogers, Raul A. Monsalve, Thomas J. Mozdzen, and Nivedita Mahesh. An absorption profile centred at 78 megahertz in the sky-averaged spectrum. *Nature*, 555(7694):67–70, March 2018. DOI 10.1038/nature25792.

[12] Rennan Barkana. Possible interaction between baryons and dark-matter particles revealed by the first stars. *Nature*, 555(7694):71–74, March 2018. DOI 10.1038/nature25791.

[13] Paolo Panci. 21-cm line Anomaly: A brief Status. In *33rd Rencontres de Physique de La Vallee d'Aoste*, July 2019. URL: https://cds.cern.ch/record/2688533.

[14] Tod R. Lauer, Marc Postman, Harold A. Weaver, John R. Spencer, S. Alan Stern, Marc W. Buie, Daniel D. Durda, Carey M. Lisse, A. R. Poppe, et al. New Horizons Observations of the Cosmic Optical Background. *The Astrophysical Journal*, 906(2):77, January 2021. DOI 10.3847/1538-4357/abc881.

[15] Jose Luis Bernal, Gabriela Sato-Polito, and Marc Kamionkowski. Cosmic Optical Background Excess, Dark Matter, and Line-Intensity Mapping. *Physical Review Letters*, 129(23):231301, November 2022. DOI: 10.1103/physrevlett.129.231301.

[16] Tod R. Lauer, Marc Postman, John R. Spencer, Harold A. Weaver, S. Alan Stern, G. Randall Gladstone, Richard P. Binzel, Daniel T. Britt, Marc W. Buie, et al. Anomalous Flux in the Cosmic Optical Background Detected with New Horizons Observations. *The Astrophysical Journal Letters*, 927(1):L8, March 2022. DOI: 10.3847/2041-8213/ac573d.

[17] Teresa Symons, Michael Zemcov, Asantha Cooray, Carey Lisse, and Andrew R. Poppe. A Measurement of the Cosmic Optical Background and Diffuse Galactic Light Scaling from the R $<$ 50 au New Horizons-LORRI Data. *The Astrophysical Journal*, 945(1):45, March 2023. DOI: 10.3847/1538-4357/acaa37.

[18] Joshua D. Simon and Marla Geha. Illuminating the darkest galaxies. *Physics Today*, 74(11):30–36, November 2021. DOI 10.1063/pt.3.4879.

[19] Charles Day. A primordial merger of galactic building blocks. *Physics Today*, 2021(1):0614a, June 2021. DOI 10.1063/PT.6.1.20210614a.

[20] Yuta Tarumi, Naoki Yoshida, and Anna Frebel. Formation of an Extended Stellar Halo around an Ultra-faint Dwarf Galaxy Following One of the Earliest Mergers from Galactic Building Blocks. *The Astrophysical Journal Letters*, 914(1):L10, June 2021. DOI 10.3847/2041-8213/ac024e.

[21] Elena Asencio, Indranil Banik, Steffen Mieske, Aku Venhola, Pavel Kroupa, and Hongsheng Zhao. The distribution and morphologies of Fornax Cluster dwarf galaxies suggest they lack dark matter. *Mon Not R Astron Soc*, June 2022. DOI 10.1093/mnras/stac1765.

[22] Massimo Meneghetti, Guido Davoli, Pietro Bergamini, Piero Rosati, Priyamvada Natarajan, Carlo Giocoli, Gabriel B. Caminha, R. Benton Metcalf, Elena Rasia, Stefano Borgani, et al. An excess of small-scale gravitational lenses observed in galaxy clusters. *Science*, 369(6509):1347–1351, September 2020. DOI 10.1126/science.aax5164.

[23] Joshua D. Simon and Marla Geha. The Kinematics of the Ultra-faint Milky Way Satellites: Solving the Missing Satellite Problem. *Astrophys. J.*, 670(1):313–331, November 2007. DOI 10.1086/521816.

[24] Peter Behroozi, Risa Wechsler, Andrew Hearin, and Charlie Conroy. UniverseMachine: The correlation between galaxy growth and dark matter halo assembly from z = 0-10. *Monthly Notices of The Royal Astronomical Society*, 488(3):3143–3194, May 2019. DOI 10.1093/mnras/stz1182.

[25] R. Genzel, N. M. Forster Schreiber, H. Ubler, P. Lang, T. Naab, R. Bender, L. J. Tacconi, E. Wisnioski, S. Wuyts, T. Alexander, et al. Strongly baryon-dominated disk galaxies at the peak of galaxy formation ten billion years ago. *Nature*, 543(7645):397–401, March 2017. DOI 10.1038/nature21685.

[26] R. Herrera-Camus, N. M. Forster Schreiber, S. H. Price, H. Ubler, A. D. Bolatto, R. L. Davies, D. Fisher, R. Genzel, D. Lutz, T. Naab, et al. Kiloparsec view of a typical star-forming galaxy when the Universe was ∼1 Gyr old. *Astronomy and Astrophysics*, 665:L8, September 2022. DOI: 10.1051/0004-6361/202142562.

[27] Pieter van Dokkum, Roberto Abraham, Jean Brodie, Charlie Conroy, Shany Danieli, Allison Merritt, Lamiya Mowla, Aaron Romanowsky, and Jielai Zhang. A High Stellar Velocity Dispersion and ˜100 Globular Clusters for the Ultra-diffuse Galaxy Dragonfly 44. *Astrophysical Journal*, 828(1):L6, August 2016. DOI 10.3847/2041-8205/828/1/l6.

[28] Pavel E. Mancera Pina, Filippo Fraternali, Elizabeth A. K. Adams, Antonino Marasco, Tom Oosterloo, Kyle A. Oman, Lukas Leisman, Enrico M. di Teodoro, Lorenzo Posti, Michael Battipaglia, et al. Off the Baryonic Tully-Fisher Relation: A Population of Baryon-dominated Ultra-diffuse Galaxies. *Astrophysical Journal*, 883(2):L33, September 2019. DOI 10.3847/2041-8213/ab40c7.

[29] Pavel E. Mancera Pina, Filippo Fraternali, Tom Oosterloo, Elizabeth A. K. Adams, Kyle A. Oman, and Lukas Leisman. No need for dark matter: resolved kinematics of the ultra-diffuse galaxy AGC 114905. *Mon. Not. R. Astron Soc.*, December 2021. DOI 10.1093/mnras/stab3491.

[30] Qi Guo, Huijie Hu, Zheng Zheng, Shihong Liao, Wei Du, Shude Mao, Linhua Jiang, Jing Wang, Yingjie Peng, Liang Gao, et al. Further evidence for a population of dark-matter-deficient dwarf galaxies. *Nature Astronomy*, 4(3):246–251, November 2019. DOI 10.1038/s41550-019-0930-9.

[31] Pieter van Dokkum, Shany Danieli, Roberto Abraham, Charlie Conroy, and Aaron J. Romanowsky. A Second Galaxy Missing Dark Matter in the NGC 1052 Group. *Astrophysical Journal*, 874(1):L5, March 2019. DOI 10.3847/2041-8213/ab0d92.

[32] Kristi A Webb, Alexa Villaume, Seppo Laine, Aaron J Romanowsky, Michael Balogh, Pieter van Dokkum, Duncan A Forbes, Jean Brodie, Christopher Martin, and Matt Matuszewski. Still at odds with conventional galaxy evolution: the star formation history of ultradiffuse galaxy Dragonfly 44. *Monthly Notices of the Royal Astronomical Society*, 516(3):3318–3341, August 2022. DOI 10.1093/mnras/stac2417.

[33] Sebastien Comeron, Ignacio Trujillo, Michele Cappellari, Fernando Buitrago, Luis E. Garduno, Javier Zaragoza-Cardiel, Igor A. Zinchenko, Maritza A. Lara-Lopez, Anna Ferre-Mateu, and Sami Dib. The massive relic galaxy NGC 1277 is dark matter deficient. From dynamical models of integral-field stellar kinematics out to five effective radii, March 2023. DOI: 10.48550/ARXIV.2303.11360.

[34] Pieter van Dokkum, Zili Shen, Michael A. Keim, Sebastian Trujillo-Gomez, Shany Danieli, Dhruba Dutta Chowdhury, Roberto Abraham, Charlie Conroy, J. M. Diederik Kruijssen, et al. A trail of dark-matter-free galaxies from a bullet-dwarf collision. *Nature*, 605(7910):435–439, May 2022. DOI 10.1038/s41586-022-04665-6.

[35] J. Jimenez-Vicente, E. Mediavilla, C. S. Kochanek, and J. A. Munoz. Dark Matter Mass Fraction in Lens Galaxies: New Estimates from Microlensing. *Astrophysical Journal*, 799(2):149, January 2015. DOI 10.1088/0004-637x/799/2/149.

[36] J. Jimenez-Vicente, E. Mediavilla, J. A. Munoz, and C. S. Kochanek. A Robust Determination of the Size of Quasar Accretion Disks Using Gravitational Microlensing. *Astrophysical Journal*, 751(2):106, May 2012. DOI 10.1088/0004-637x/751/2/106.

[37] O. LeFevre, M. Bethermin, A. Faisst, G. C. Jones, P. Capak, et al. The ALPINE-ALMA [CII] survey. *Astronomy and Astrophysics*, 643:A1, October 2020.

[38] Ewa L. Lokas and Gary A. Mamon. Dark matter distribution in the Coma cluster from galaxy kinematics: breaking the mass-anisotropy degeneracy. *Monthly Notices of The Royal Astronomical Society*, 343(2):401–412, August 2003. DOI 10.1046/j.1365-8711.2003.06684.x.

[39] Elena Rasia, Giuseppe Tormen, and Lauro Moscardini. A dynamical model for the distribution of dark matter and gas in galaxy clusters. *Monthly Notices of The Royal Astronomical Society*, 351(1):237–252, June 2004. DOI 10.1111/j.1365-2966.2004.07775.x.

[40] Lawrence Rudnick. The Stormy Life of Galaxy Clusters: astro version. Preprint, January 2019. DOI 10.48550/arXiv.1901.09448.

[41] Lawrence Rudnick. The stormy life of galaxy clusters. Physics Today, January 2019. DOI 10.1063/pt.3.4112.

[42] R. L. Workman and Others. Review of Particle Physics. *PTEP*, 2022:083C01, 2022. DOI: 10.1093/ptep/ptac097.

[43] L. Verde, T. Treu, and A. G. Riess. Tensions between the early and late Universe. *Nature Astronomy*, 3(10):891–895, September 2019. DOI 10.1038/s41550-019-0902-0.

[44] Johanna L. Miller. Gravitational-lensing measurements push Hubble-constant discrepancy past 5σ. *Physics Today*, 2020(1):0210a, February 2020. DOI 10.1063/pt.6.1.20200210a.

[45] Wendy L. Freedman, Barry F. Madore, Taylor Hoyt, In Sung Jang, Rachael Beaton, Myung Gyoon Lee, Andrew Monson, Jill Neeley, and Jeffrey Rich. Calibration of the Tip of the Red Giant Branch (TRGB). *Astrophysical Journal*, 891(1):57, March 2020. DOI 10.3847/1538-4357/ab7339.

[46] Vivian Poulin, Tristan L. Smith, Tanvi Karwal, and Marc Kamionkowski. Early Dark Energy can Resolve the Hubble Tension. *Physical Review Letters*, 122(22):221301, June 2019. DOI 10.1103/physrevlett.122.221301.

[47] Eleonora Di Valentino, Luis A. Anchordoqui, Ozgur Akarsu, Yacine Ali-Haimoud, Luca Amendola, Nikki Arendse, Marika Asgari, Mario Ballardini, Spyros Basilakos, Elia Battistelli, et al. Snowmass2021 - Letter of interest cosmology intertwined II: The hubble constant tension. *Astroparticle Physics*, 131:102605, 2021. DOI 10.1016/j.astropartphys.2021.102605.

[48] Helena Garcia Escudero, Jui-Lin Kuo, Ryan E. Keeley, and Kevork N. Abazajian. Early or phantom dark energy, self-interacting, extra, or massive neutrinos, primordial magnetic fields, or a curved universe: An exploration of possible solutions to the $H_0$ and $\sigma_8$ problems. *Phys. Rev. D*, 106:103517, November 2022. DOI: 10.1103/PhysRevD.106.103517.

[49] Francis-Yan Cyr-Racine, Fei Ge, and Lloyd Knox. Symmetry of Cosmological Observables, a Mirror World Dark Sector, and the Hubble Constant. *Phys. Rev. Lett.*, 128:201301, May 2022. DOI 10.1103/PhysRevLett.128.201301.

[50] Mauricio Cruz Reyes and Richard I. Anderson. A 0.9% calibration of the Galactic Cepheid luminosity scale based on Gaia DR3 data of open clusters and Cepheids. *Astronomy and Astrophysics*, 672:A85, April 2023. DOI: 10.1051/0004-6361/202244775.

[51] Gan Gu, Xiaoma Wang, Xiaoyong Mu, Shuo Yuan, and Gongbo Zhao. Dynamical dark energy in light of cosmic distance measurements I: a demonstration using simulated datasets. *Research in Astronomy and Astrophysics*, 2024. DOI: 10.1088/1674-4527/ad3f57.

[52] Khaled Said, Matthew Colless, Christina Magoulas, John R. Lucey, and Michael J. Hudson. Joint analysis of 6dFGS and SDSS peculiar velocities for the growth rate of cosmic structure and tests of gravity. *Monthly Notices of The Royal Astronomical Society*, 497(1):1275–1293, July 2020. DOI 10.1093/mnras/staa2032.

[53] Supranta S. Boruah, Michael J. Hudson, and Guilhem Lavaux. Cosmic flows in the nearby Universe: new peculiar velocities from SNe and cosmological constraints. *Monthly Notices of The Royal Astronomical Society*, August 2020. DOI 10.1093/mnras/staa2485.

[54] Kyu-Hyun Chae, Federico Lelli, Harry Desmond, Stacy S. McGaugh, Pengfei Li, and James M. Schombert. Testing the Strong Equivalence Principle: Detection of the External Field Effect in Rotationally Supported Galaxies. *The Astrophysical Journal*, 904(1):51, November 2020. DOI 10.3847/1538-4357/abbb96.

[55] Thomas J. Buckholtz. *Models for Physics of the Very Small and Very Large*, volume 14 of *Atlantis Studies in Mathematics for Engineering and Science*. Springer, 2016. Series editor: Charles K. Chui. DOI: 10.2991/978-94-6239-166-6.

[56] Thomas J. Buckholtz. Characterizations That Help Explain Particle and Cosmic Data. May 2024. DOI: 10.32388/5bnwlo.3 (Accepted for publciation by the Journal of High Energy Physics, Gravitation and Cosmology.).

[57] Anonymous. The Definitive Glossary of Higher Mathematical Jargon. Math Vault. URL: https://mathvault.ca/math-glossary.

[58] Laurent Canetti, Marco Drewes, and Mikhail Shaposhnikov. Matter and antimatter in the universe. *New Journal of Physics*, 14(9):095012, September 2012. DOI: 10.1088/1367-2630/14/9/095012.

[59] Alejandro Benitez-Llambay, Rajeshwari Dutta, Michele Fumagalli, and Julio F. Navarro. Not So Round: VLA Observations of the Starless Dark Matter Halo Candidate Cloud-9. 2024. DOI: 10.48550/ARXIV.2406.18643.

[60] Jonathan O'Callaghan. Empty Galaxy. *Scientific American*, 33(2s):46, June 2024. DOI: 10.1038/scientificamerican062024-7faqthc37i0smk8vqxhukz.

[61] R. Valdarnini. An N-body/hydrodynamical simulation study of the merging cluster El Gordo: A compelling case for self-interacting dark matter? *Astronomy and Astrophysics*, 684:A102, April 2024. DOI: 10.1051/0004-6361/202348000.

[62] D. Paraficz, J.-P. Kneib, J. Richard, A. Morandi, M. Limousin, E. Jullo, and J. Martinez. The Bullet cluster at its best: weighing stars, gas, and dark matter. *Astronomy and Astrophysics*, 594:A121, October 2016. DOI: 10.1051/0004-6361/201527959.

[63] Anonymous. Digital Library of Mathematical Functions. National Institute of Standards and Technology, 2022. URL: https://dlmf.nist.gov/.

[64] Eric Weisstein. Delta Function. Wolfram MathWorld web page. URL: http://mathworld.wolfram.com/DeltaFunction.html.

[65] Albert Einstein. *The Collected Papers of Albert Einstein, Volume 6: The Berlin Years*. Princeton University Press, 1997. ISBN: 9780691017341.

[66] Sjors Jacco Heefer. *Finsler Geometry, Spacetime & Gravity – From Metrizability of Berwald Spaces to Exact Vacuum Solutions in Finsler Gravity*. Phd thesis, Eindhoven University of Technology, May 2024. DOI: 10.48550/arXiv.2404.09858.

[67] Thomas J. Buckholtz. *Create Crucial Insight*. T. J. Buckholtz and Associates, 2011. LCCN: 2011917403. URL: https://www.amazon.com/Create-Crucial-Insight-Outcomes-checklists/dp/1466283505.

[68] Isaac Newton. *Philosophiae Naturalis Principia Mathematica*. Jussu Societatis Regiae ac Typis Josephi Streater ..., 1687. DOI: 10.3931/E-RARA-440.

[69] Yuri Saida, Thomas Gauthier, Hiroo Suzuki, Satoshi Ohmura, Ryo Shikata, et al. Photoinduced dynamics during electronic transfer from narrow to wide bandgap layers in one-dimensional heterostructured materials. *Nature Communications*, 15(1), May 2024. DOI: 10.1038/s41467-024-48880-3.

[70] Shadrack J. Barnabas, Timo Bohme, Stephen K. Boyer, Matthias Irmer, Christoph Ruttkies, et al. Extraction of chemical structures from literature and patent documents using open access chemistry toolkits: a case study with PFAS. *Digital Discovery*, 1(4):490–501, 2022. DOI: 10.1039/d2dd00019a.


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