Qeios

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

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Abstract

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 span and entwine endeavors. One role enables leading-edge physics research. Tags unite properties of objects and aspects of fields. Tags span and help specify elementary particles, dark matter, and gravity.

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

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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.

Human communications feature characterizations. People characterize things and activities. Characterizations feature nouns, adjectives, verbs, and adverbs. Integers are nouns.

Integers are unambiguous. Other aspects of human discussion are more subject to 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.

We suggest that integers can play a useful role. Amass a relevant catalog of things or activities. Suggest a tagging scheme that uses integers. Tag items in the catalog. Characterize items via associations between the tags and human-centric concepts. Anticipate that the concepts will drift. Anticipate that the characterizations will drift. Hope that the tags help enable useful thinking and innovation.

2. Using tags to study and shape endeavors

We discuss using 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?

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

Figure 1 provides a hierarchy for cataloging activities that comprise an endeavor. (References [1, 2, 3] discuss and deploy similar hierarchies, but do not discuss tags.)

Figure 1: Activities within an endeavor

Activities within an endeavor

Hierarchy of activities

Theme			Tag		
Endeavor			E		
	Do great			E.3	
		Enable reuses			E.3.3
		Recognize results			E.3.2
		Perform actions			E.3.1
	Think well			E.2	
		Declare intentions			E.2.3
		Evaluate scenarios			E.2.2
		Make assumptions			E.2.1
	Be able			E.1	
		Deploy teams			E.1.3
		Foster teamwork			E.1.2
		Have resources			E.1.1
	?			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
- Further characterizations and themes:
  - 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.

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 1 features two levels of uses of the doing, thinking, and being trio. The notes portion of Figure 1 shows examples of four levels.

Figure 1 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 1 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 1 provide an example of non-uniform depth.

For networks of prerequisite activities, .3 aspects of a prerequisite activity might link to .1 aspects of one or more (at least somewhat) subsequent 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 perspective 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, the telecommunications industry has roots in (from the perspectives of customers) .1 services and horizontal integration. The computer-based services industry has roots in (from the perspectives of customers) .2 and .3 services and vertical reach.

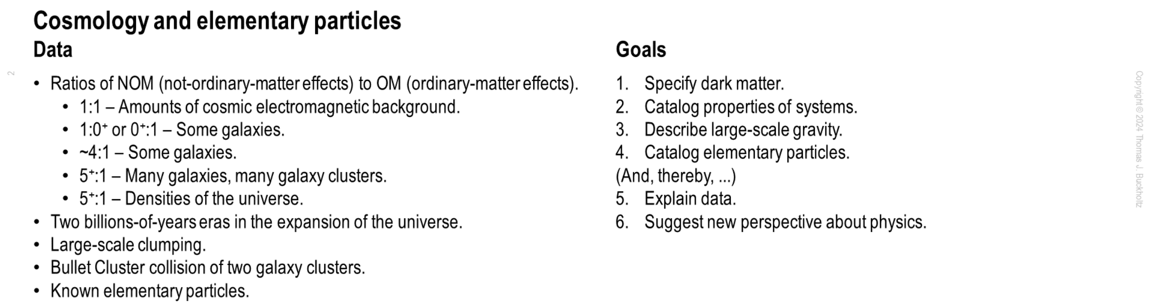
Regarding science and society, three-tier use of the hierarchy might help people gain insight about attention to the following questions. How does or could society enhance its results based on resources that science produces? How does or could science enhance its results based on resources that society 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 1 discusses.

2.4. Tagging that helps to 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. (Reference [4] discusses that work.) 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 principles – atomic number (or number of protons) and

Figure 2: Cosmology and elementary particles



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. For one element (or, equivalently, one atomic number), nuclear physics and other sciences provide insight regarding atomic weight, which can vary from sample to sample.

How might today's 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 discuss - as a case study - research that suggests new integer tagging techniques and new catalog items. The research spans elementary particles, properties of systems, and conservation laws. Some magic behind the research stems from using 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 aspects of some physics research that uses tags to suggest new physics regarding cosmology and elementary particles.

3.1. Goals of the research

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 – for example, about the so-called rate of expansion of the universe.

References [5, 6, 7, 8, 9] discuss research that suggests possible progress regarding each of the three goals and regarding other aspects of physics. References [8, 9] include citations regarding data that the research uses.

Figure 2 and Figure 3 outline key aspects of the research.

3.2. Nature, human discussion, physics models, and physics catalogs

Physics features human discussion about perceptions and inferences regarding nature.

Vocabulary underlying the discussion has bases in human languages, terms (such as words or symbols), mathematics, and inputs to and outputs from physics models. 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.

Figure 3: Physics notions

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 4: Relationships between some catalogs and physics modeling

Relationships between some catalogs and physics modeling

Relationships

Catalogs	MOD … items.	CAT+ 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+ - Cataloguing that associates with characterizations
  - PAT - Pattern matching, including pattern matching that develops CAT+
  - DAT - Data

A science goal features consistency among terminology, data, modeling, and applications. Applications can pertain specifically within individual sciences - for example, physics, chemistry, 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 (or blackbody) temperature, atomic state, energy, momentum, angular momentum, moments of inertia, boson (behavior), fermion (behavior), and so forth.

Figure 4 reprises - from the research - a suggested framework for previewing and understanding the research. The research suggests the following notions. MOD (as in 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. The research explores the notion that items that MOD tends to assume or that MOD might need to assume can become suggestions from catalogs that do not necessarily have direct bases in MOD techniques.

The research explores possibilities for augmenting CAT (as in cataloging) with CAT+ (as in cataloging that associates with characterizations). 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. The research uses PAT (as in pattern matching) and DAT (as in data) to extend CAT to CAT+. CAT+ uses integer-based tagging. The research suggests themes that associate with tags. The combination of a theme and a tag associates with notions of characterization.

The research involves the following notions. Observer systems O can make inferences about inferred 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 perceptions of inadequate consistency between inferences, data, and models.

3.3. Key research results, plus consistency with data and models

One observation suggests that people infer twice as much depletion of cosmic microwave background radiation as people expect based on modeling that assumes that the depletion associates just with hyperfine transitions in hydrogen atoms. Some people expect that unfound elementary particles underlie dark matter. MOD associates all known elementary particles, except the photon and the Higgs boson, with a notion of left handedness. The research suggests that dark matter includes entities that are like hydrogen atoms, can undergo hyperfine transitions, and can contribute to the depletion of cosmic microwave background radiation. Consistency might suggest that an elementary particle set underlying those hydrogen-like entities is like an elementary particle set that underlies ordinary matter. The research uses the word isomer to denote a set of all elementary particles that MOD considers (or, if found in the future, would consider) to exhibit handedness. The research suggests that the dark-matter hydrogen-like atoms associate with an isomer that associates with right handedness, whereas ordinary matter hydrogen atoms associate with an isomer that associates with left handedness. (Aside: The research suggests that this pairing of a left-handed isomer and a right-handed isomer might provide a basis for understanding so-called baryon asymmetry.) MOD associates notions of two modes with photons and does not associate a notion of handedness with photons. The research assumes that electromagnetic phenomena provide internal binding for the ordinary-matter hydrogen atoms and for the dark-matter hydrogen-like atoms.

Reference [10], which appeared while we were writing our paper, suggests that ordinary matter senses hyperfine electromagnetic radiation that associates with a starless dark-matter galactic halo. This observation might support the following two notions that the research suggests. Nature includes dark-matter hydrogen-like atoms. Ordinary matter can detect radiation produced by dark-matter hydrogen-like atoms. Reference [11] discusses another starless dark-matter galaxy that associates with hydrogen-generated electromagnetic radiation and apparently no visible light.

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, the research assumes 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 - discussing how the research suggests resolving the quandary.)

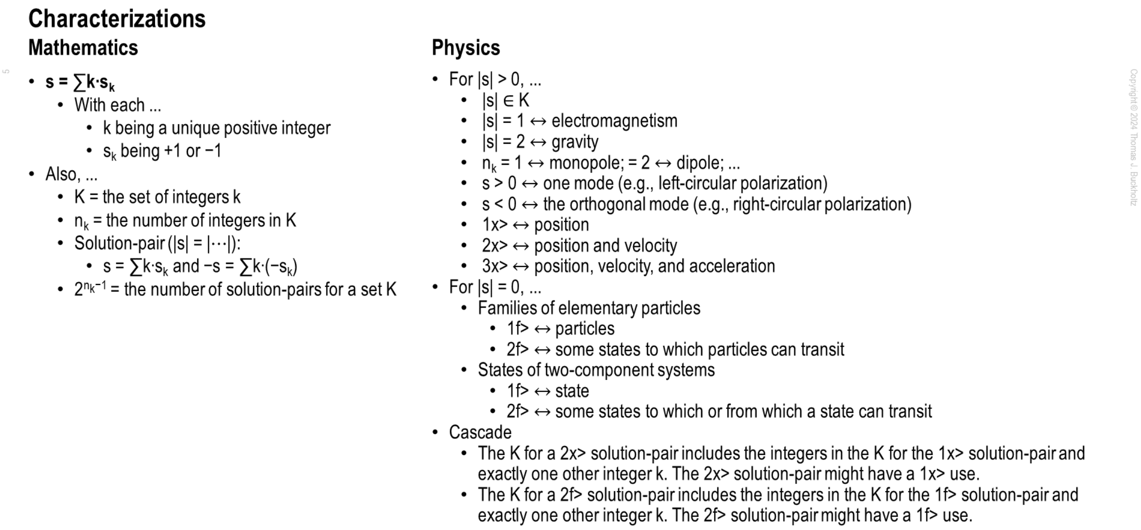
How many somewhat similar isomers might nature include? Inferences regarding many galaxies, regarding many galaxy clusters, and regarding densities of the universe suggest that there is five plus times as much dark matter as ordinary matter. The number of isomers might be either six or seven, with one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

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

Inferences suggest that some galaxies consist essentially only of ordinary-matter stuff and that some galaxies associate essentially only with dark-matter stuff. The research suggests that some galaxies started with and maintained those composition ratios (that is, respectively, one to zero-plus dark matter to ordinary matter and zero-plus to one dark matter to ordinary matter). The research suggests 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. The research suggests that at least some galaxies formed based on one-isomer halos and then accrued stuff associating with other isomers.

The research suggests that electromagnetic effects are sensitive to the properties about which electromagnetism conveys information. The research suggests that ordinary matter (or, indeed, 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. The research suggests that information about surface brightness (or blackbody

Figure 5: Characterizations



temperature) is specific to single isomers. Ordinary matter senses electromagnetically conveyed information about atomic states or atomic transitions that associate with each one of two isomers. The research suggests that there are six instances of charge, with one instance pertaining to each isomer. The research suggests that stuff made from one isomer does not directly sense the charge of stuff made from any other one isomer.

In general, the research suggests that, for any such property, the number of instances of the property is one of one or three or six. The research deploys the word reach. The research says that the respective reach of one instance of the property is six isomers or two isomers or one isomer.

The research uses a form of CAT+ to organize catalogs of properties of systems. This form of CAT+ associates with integer-based tags.

Figure 5 reprises notions that suggest a basis for characterizing properties that associate with at least electromagnetism and gravity.

The following aspects indicate possible consistency between the research and MOD.

- 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, the research currently assumes (but does not necessarily need to assume) 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.

- The number of terms, n_k, to the right of the equal sign generalizes from MOD 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 the research, the number of solution-pairs tracks and generalizes from MOD 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.

- The research suggests associating the number two, of solutions in a solution-pair, with the notion that the relevant field models as having two (orthogonal) modes. The research suggests 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.

- The research introduces notation that associates with the number of degrees of spatial freedom, of velocity freedom, and so forth that pertain. For an $|s|$ greater than zero, monopole associates with

Figure 6: Electromagnetic and gravitational properties

Electromagnetic and gravitational properties

Properties, solution-pairs, and instances

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

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

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.

knowing a position for the property. Dipole associates with knowing either a position and a linear velocity or a position and an angular velocity. The research uses 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>. The research suggests that the series 1x>, 2x>, and so forth is consistent with MOD Newtonian dynamics and with MOD 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 and with assumptions that system O de-emphasizes inferring the motion. 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.)

- In modeling, the notion of acceleration (which in the research associates with 3x> but not with 1x> and not with 2x>) 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 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 6 suggests associations between some electromagnetic properties or gravitational properties and 1x> or 2x> uses of specific solution pairs.

Discussion above does not necessarily cover some details including some numbers of instances and some solution-pairs. Discussion below suggests some such details.

Regarding gravitational properties, the first two rows in the gravitational part of Figure 6 parallel, with respect to solution pairs, the first two rows in the electromagnetism part of Figure 6. 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 second two rows in the gravitational part of Figure 6 do not have parallels with respect to electromagnetism.

Modeling includes multipole expansions for which each term in an expansion is a zero-tensor (or scalar) and is not a higher-order tensor. 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. Noting that invariance, the research suggests 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. The greater the inferred velocity of

Figure 7: Explanations for cosmic data

Explanations for cosmic data

Timelines and data

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 notions regarding the Bullet Cluster collision of two galaxy clusters.
- 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.

system I, the greater the magnitude of the electric field and the greater the magnitude of the magnetic field.

Based on possible notions of consistency between gravity and electromagnetism, the research suggests, regarding gravitational effects, that effects of inferred momentum and effects of inferred angular momentum detract from effects of inferred energy. The research generalizes 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.

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 momentum (that associates with a component of system O) equals the negative of a change in momentum that associates with the field. Modeling for each change associates with a D-vector. (For modeling regarding astrophysical systems, modeling associates with three dimensions and $D = 3$.) Modeling considers that the change in momentum that associates with the field associates with the word force. The force associates with the D-dimensional gradient of a potential, which associates (in the sense of modeling) with a scalar field.

The research suggests that such a scalar field carries information about each instance of each property (that associates with that type – that is, electromagnetic or gravitational – of field) 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 (here, considered as inferred dark-matter systems I) can model as interacting (with respect to an ordinary-matter system O) with ordinary-matter.

Figure 7 recaps the research's uses of inferences about solar systems, galaxies, and so forth to suggest some instances and reaches that Figure 6 labels as TBD (as in to be determined). Figure 7 also recaps the research's suggested explanation 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 7 suggests notions that might explain the notion that modeling underestimates the rate of expansion for the most recent billions of years era. Reference [12] discusses data that might suggest that the rate of expansion is entering or will enter a new era that might associate with dominance by attractive monopole aspects of gravity.

Beyond the pair of isomers that underlie ordinary matter and a right-handed analog to ordinary matter, the research suggests that there are four other isomers. Modeling suggests incompatibility between inferences about the aftermath of the Bullet Cluster collision of two galaxy clusters and the notion that the other four isomers underlie stuff that might interact electromagnetically significantly with itself. Reference [13] suggests, based on observations about one merging galaxy cluster, that (at least some) dark matter is electromagnetically self-interacting.

Figure 8 summarizes aspects that the research suggests about the six isomers and about stuff that associates with each of the six isomers.

Figure 8: Dark matter and ordinary matter

Dark matter and ordinary matter

Isomers and evolution of stuff

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 9: Reach per instance

Reach per instance

Math

For 1x> use of a solution-pair, …

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

The research suggests a formula for determining the number of instances and the reach per instance that associates with a 1x> use of a solution pair. Figure 9 discusses the formula.

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 10 discusses the notion (that the research suggests) that CAT+ and solution-pairs for which $|s|$ is zero might tag all known and some possible elementary particles. Except for solution-pairs in the $n_k = 3$ column, each shown solution-pair cascades in one step from a solution-pair that associates with a set of known elementary particles. (Figure 5 discusses notions that associate with the word cascade.) 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 10 shows. The notes section of Figure 10 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 an LRI (as in long-range interaction) field. Each one of electromagnetism and gravity is an LRI field. The research suggests that the overall reach of such a field can be six. The research suggests that individual LRI bosons do not necessarily associate with a reach of one.

Figure 10: Some elementary particles

Some elementary particles

Families and non-MCS-modeling solution-pairs

<table>
<tr><td></td><td>n_k = 3
S = 1</td><td>n_k = 4
S = 0.5</td><td>n_k = 4
S = 0</td><td>n_k = 5
S = 0.5</td><td>n_k = 5
S = 1</td></tr>
<tr><td>Q = 1, M > 0</td><td>W boson
|−1−2+3|</td><td>Charged leptons
|−1−2−3+6|</td><td></td><td>“Quarks”
|−1+2−3−6+8|</td><td></td></tr>
<tr><td>Q = 0, M > 0</td><td></td><td></td><td></td><td>|−1+2−3−4+6|</td><td></td></tr>
<tr><td>Q = 0, M > 0</td><td>Z boson
|−1−3+4|</td><td>Neutrinos
|+1−3−4+6|</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Higgs boson
|+1−2−3+4|</td><td></td><td></td></tr>
<tr><td>Q = 0, M = 0</td><td></td><td></td><td>I boson ■
|−1−3−4+8|</td><td></td><td>“Gluons”
|+1−2−3−4+8|</td></tr>
<tr><td>Q = 0, M = 0, LRI</td><td></td><td></td><td></td><td></td><td>Photon
|−1−3−4−8+16|</td></tr>
</table>

Notes

- MCS: multi-component systems.
- Q: Magnitude of “charge divided by the charge of an electron.”
- M: Rest mass.
- ■: Not yet found.
- LRI: Long-range interaction boson.
  - Possible values of S: 1, 2■, 3■, and 4■.
  - Solution-pair of S = 2: |−1−3−4−8−16+32|
- Each numeric item associates with 1f> use of a solution-pair for which |s| = 0.
- Each solution-pair other than |−1−2+3| and |−1−3+4| is a 1f> use of a 2f> solution-pair that associates with known elementary particles.
- For bosons, $S = |n_k−4|$.
- For fermions, $S = |n_k−4.5|$.
- Lack of a 4 implies Q = 1.
- Presence of a 4 implies Q = 0.
- Presence of a 6 implies fermions.
- For bosons, presence of 8 implies M = 0.
- Presence of a 16 implies LRI.
- For the “quarks” solution-pairs and the “gluons” solution-pair, the two 2f> solution-pairs are |∓1−2∓3±4−6+8|. (±(−1−3+4) = 0)
  - For quarks, the duality of solution-pairs might associate with fractional charges (as in (2/3)1+(1/3)0 and (1/3)1+(2/3)0).
  - For bosons, the duality of solution-pairs might associate with 3×3=9 elementary particles, of which 8 are gluons.
  - 2f> |∓1−2∓3±4−6+8| might associate with usefulness of modeling for MCS.

Figure 11: Elementary particles

Elementary particles

Families and solution-pairs

<table>
<tr><td>n_k = 4
S = 0.5</td><td>n_k = 5
S = 0.5</td></tr>
<tr><td>Charged leptons
|−1−2−3+6|</td><td>Quarks
|+1+2−5−6+8|</td></tr>
<tr><td>Neutrinos
|+1−3−4+6|</td><td>Quarks
|+2+3−6−7+8|</td></tr>
</table>

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

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 10 associates with possible inconsistencies with MOD. While 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 MOD notions of longitudinal polarization and with MOD notions that the I boson would associate with nonzero mass.

The research suggests the following notions. Quarks and gluons associate with notions of components of multi-component systems. 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. Per Figure 10, solution-pairs that associate with the eight known gluons might associate also with one more elementary particle.

Figure 11 lists and tags known and possible families of elementary particles.

Regarding quarks, the relevant multi-component system is a hadron. The research suggests (as a parallel to electromagnetism binding together, in an atom, two components - the atomic nucleus and the electron cloud) that gluons bind together two types of quarks. For two-quark systems, one component

Figure 12: The might-be I boson and might-be J boson

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+ 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+ 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+ 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+ 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 13: Notions regarding properties and conserved quantities

Notions regarding properties and conserved quantities

Properties and conserved quantities

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

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+ 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)

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 12 notes aspects that the research suggests regarding the might-be I boson and the might-be J boson.

Figure 13 suggests - based on the research - an extent to which the research that has bases in CAT+ might comport with aspirations that people might associate with Figure 4. Figure 13 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.

3.4. Other aspects of the research, plus consistency with data and models

Figure 14 notes solutions - that MOD uses - to equations that associate with harmonic oscillator mathematics, suggests solutions that MOD seems not to use, and suggests possibly new notions that MOD might consider regarding possible raising and lowering operators regarding fermion states.

Figure 15 suggests that CAT+ might provide an alternative (to MOD-related techniques) way to point to MOD notions of gauge symmetries and to MOD aspects related to the Higgs field.

Figure 14: Notions regarding isotropic harmonic oscillators

Notions regarding isotropic harmonic oscillators

Solution sets

14 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 ≥ 2, $n_* \geq 0$, $E \propto (1/2)(D+2n_*) \geq D/2$
   - Radial coordinates, one-term solutions
3. Integer D ≥ 1, $n_* > -D/2$, $E \propto (1/2)(D+2n_*) > 0$
   - Radial coordinates, one-term solutions
4. Even integer D ≥ 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) $\propto (1/2)(D+2n_*)$
- Ω (as in $\Omega/(r^2)$) $\propto n_*(n_*+D-2)$

1. Popular MOD
2. Popular MOD
3. ϕ normalizes but can be infinite at r=0.
4. ϕ 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 $n_* = -1/2$, Ω = 3/4.)
   - Possible fermion raising and lowering operators (for n ∈ {0,1} and e being, for example, one of 1/2 and 1):
     - a+ |n> = $(1-n)^e$ |n+1>
     - a− |n> = $(n)^e$ |n−1>
   - These might parallel boson raising and lowering operations, which are for integer n ≥ 0, ...
     - a+ |n> = $(1+n)^{1/2}$ |n+1>
     - a− |n> = $(n)^{1/2}$ |n−1>

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

Figure 15: Gauge symmetries and the Higgs field

Gauge symmetries and the Higgs field

Possibly relevant notions

15 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 ≥ 2 isotropic harmonic oscillator. ($D^2-1 = (D+1)\cdot(D-1)$)

Figure 16: Properties of fermion elementary particles

Properties of fermion elementary particles

Data

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 17: Properties of boson elementary particles

Properties of boson elementary particles

Possibly relevant notions

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 … $(\text{Mass(W)})^2 : (\text{Mass(Z)})^2 : (\text{Mass(Higgs)})^2 :: 7 : 9 : 17$.
   - $(\text{Mass(W)})^2 : (\text{Mass(Z)})^2$ 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 $n_\cdot = -1$ and with $E \propto (1/2)(D+2n_\cdot) = 0$.

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

The first item in Figure 16 suggests the following notions. It might be possible to predict a more accurate tau mass than DAT suggests (and that MOD 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 MOD does not seem to suggest.

Figure 17 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. The research notes a lack of certainty regarding 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 18 discusses aspects regarding time, space-time coordinates, and notions of space-time.

Figure 19 discusses aspects regarding limits on the applicability of general relativity, regarding modeling and quantum gravity, and regarding the possibility that MOD modeling might want to include the possibility that so-called vacuum energy (associating with electromagnetism and possibly associating

Figure 18: Time, space-time coordinates, and space-time

Time, space-time coordinates, and space-time

Notions about CAT+ and MOD

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

Notes

1. …
   - CAT+ 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+ 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 19: General relativity, quantum gravity, and ground state of the vacuum

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

CAT+ suggestions

1. CAT+ seems compatible with the notion that some uses of general relativity might not comport adequately with data.
2. CAT+ 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+ 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+ suggests that energy and momentum associate with LRI and with a reach of six isomers.
   - CAT+ suggests that angular momentum associates with LRI and with three instances of a reach of two isomers.
   - CAT+ suggests that other gravitational properties associate with six instances of a reach of one isomer.
   - CAT+ 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+ differences between gravitational properties and electromagnetic properties might limited to the difference between $|s| = 2$ for gravity and $|s| = 1$ for electromagnetism.
3. CAT+ 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 $E \propto (1/2)(D+2n_-) = 0$.

with gravity) can model as zero.

Reference [14] discusses the notion that people might want to use general relativity for force-related applications and might want to de-emphasize using general relativity regarding notions of geodesic motion and space-time. The research does 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. References [15, 16] suggest notions that might point to modeling that could transcend general relativity, enable the incorporation of properties (such as temperature and other electromagnetic properties) other than gravitational properties, and enable quantization of gravity.

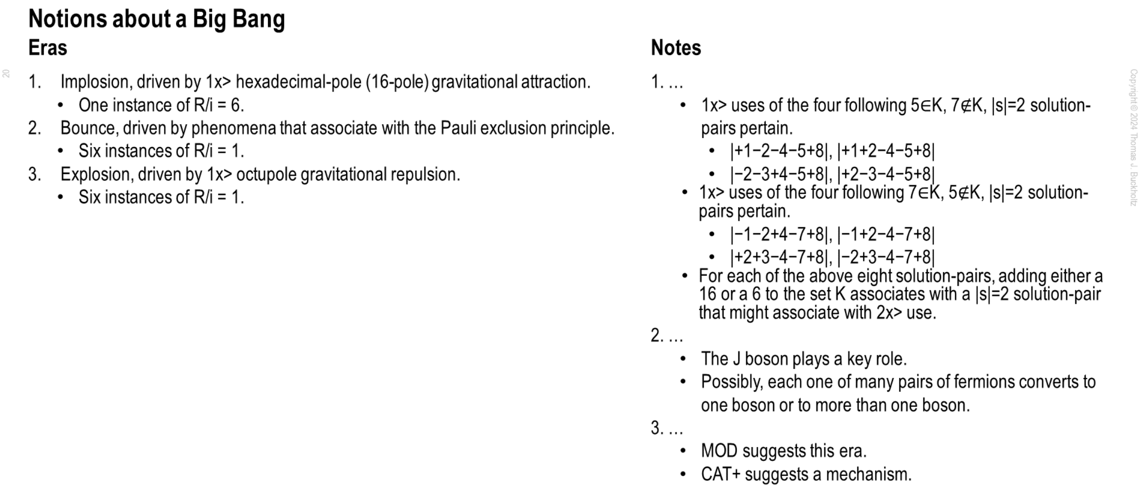
Figure 20 suggests that CAT+ might be consistent with some MOD notions about a possible so-called Big Bang.

The research suggests that CAT+ 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, $n_k = 4$.) $0 = |-2-4+5-6+7|$ might characterize a spin-one-half state. $0 = |-2-4+5-7+8|$ might characterize a spin-one state. And so forth.

3.5. Usefulness and consistency, possibly without untoward interdependence

Research discussed above suggests possibly noteworthy progress regarding each one of the first four goals that Figure 2 states.

Figure 20: Notions about a Big Bang



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

The research might be adequately consistent - for now - with DAT and MOD.

To the extent that people find inadequate consistency with DAT or with useful MOD, people might want to consider changing aspects (of the research discussed above) 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 the research do not necessarily imply that some aspects of the research depend on some other aspects of the research. We suggest that the 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 1 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 1 hierarchy also provides the first aspect for a two-aspect checklist regarding some checklists.

Discussion related to Figure 1 focuses on networks of prerequisite activities. The theme of doing pertains. People might tag the Figure 1 checklist as a .3 checklist. Reference [17] suggests a checklist for cataloging motivations or purposes. People might associate motivations and purposes with thinking. People might tag the motivations and purposes checklist as a .2 checklist. Reference [17] suggests a checklist for cataloging so-called styles for doing work. Examples of styles include haphazard and procedural. People might associate styles with abilities to do work. People might tag the styles checklist as a .1 checklist.

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 (1.2) than to measure planning activities (2.2) or to measure outcomes (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. The descriptions of individual cataloged items might change. Notions - beyond the descriptions - that people associate with individual items might change. Integer-based tags can link items and associated notions. Integer-based tags enable useful thinking based on stability associated with integers and based on the separating of discussions of associated notions from descriptions of items. Integer-based tags can enable appropriate rewordings - of associated notions or of descriptions - that occur based on general insight, situation-specific factors, translation from one language to another language, evolution of a language, and so forth

Within such a framework, notions and items can co-evolve.

Figure 10 and Figure 11 illustrate one such co-evolution. Figure 10 associates with not considering that some elementary particles seem to exist only within systems that involve more than one type of elementary particle. Figure 11 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 11 seems to associate with a step forward from Figure 10. Figure 11 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 MOD 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 about research 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 the research by associating aspects of the research 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 research regarding cosmology and elementary particles associates with such themes. The research 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 four-word term principle of stationary action with much of MOD. Direct overlaps between the principle of stationary action and Figure 13 might seem minimal. Similar minimal overlaps with the principle of stationary action might pertain regarding other figures, including Figure 16 and Figure 17. CAT+ 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

Figure 5 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 11 and Figure 13 might tend to confirm possibilities for usefulness for such unity.

Present vocabulary might limit perceptions of the possible depth of such unity. For $|s| > 0$, people might associate the two solutions in a solution-pair with two orthogonal polarization modes of an LRI field. For $|s| = 0$, people might associate the two solutions in a solution-pair with the two isomers that associate with an isomer-pair. (Regarding such, one might note discussion - that Figure 13 includes - about $k' = 0$ and potentials. A potential with a spatial dependence of r^0 would not lead to acceleration of systems. Also, one might consider - in the place of sets K for which members are positive integers - sets K' for which members would be nonnegative integers.)

Some aspects of MOD suggest notions that systems (including elementary particles) model as excitations of fields (though, aside from the photon, not of the electromagnetic field; and, aside from the might-be graviton, not of the gravitational field).

Some non-MCS (as in not multi-component systems) aspects of Figure 10 and Figure 11 suggest a 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 (as would the electromagnetic field and the gravitational field) 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 (with each family of elementary particles associating with an I-boson-field-related property).

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

4.6. Possible structure of or components for elementary particles

Reference [4] seems to be not 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 - for example, an electron cloud and a nucleus.

Are there hints that MOD 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 research

Extending the physics research 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 a number - presumably, one, three, or six - of instances to associate with the Higgs boson.

Determine a number - presumably, one, three, or six - of instances to associate with the I boson.

Fill in details regarding MCS (as in 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 CAT+ that would associate with MOD for which indices of refraction are not necessarily one. (Figure 17 might suggest a start toward such exploration.)

Figure 21: Possible bases for other physics uses of CAT+

Possible bases for other physics uses of CAT+

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.

Look for and explore new (compared to the current state of the research) patterns regarding data and regarding relationships between tags.

Explore ways that MOD can embrace the notion that isomer is a property. Reference [18] establishes bases, including the equation $F = ma$ (in which F denotes force, m denotes mass, and a denotes acceleration), for MOD. MOD embraces the notion that a force can depend on properties of the system for which m pertains (as well as on 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.

Try to extend applications of CAT+ techniques to other (generally more complex) areas of physics. Figure 21 describes some possible opportunities. Reference [19] discusses properties of low-dimensional heterostructures and might provide an example of a possible opportunity for uses of CAT+.

Explore possible synergies between notions we discuss in this paper and other activities that seek to develop and make available useful catalogs. Reference [20] discusses some such cheminformatics activities.

4.8. Reuses

Item E.3.3 in Figure 1 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.

5. Conclusion

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.

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