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Models for Physics of the Very Small and Very Large

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To Helen Buckholtz.
In memory of Joel and Sylvia J. Buckholtz.
With appreciation for each of many people
who contributed to my being able
to attempt this work.

Preface

Welcome to *Models for Physics of the Very Small and Very Large.*

This is a monograph about math-based modeling.

However, let me start by describing a book I hope this monograph helps enable.

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Ideally, a book would do the following. List all known elementary particles. List all elementary particles people have not found. Show properties for each particle. Describe interactions in which each particle partakes. Use that information to close gaps between known data and traditional theory. Close gaps regarding particle physics, astrophysics, and cosmology. Predict data people have yet to measure. Point to practical applications. Do all that, based on one model or theory.

That program faces difficulties. For example, suppose someone produced that book. Not enough data exists to verify some aspects of the book.

That program features the following question. To what extent can models correlate with elementary particles?

That is a useful question to explore.

Consider theory. 95 % of the inferred stuff in the observable universe is unknown. To what extent is that stuff made of elementary particles? What properties do those particles have?

Consider practice. Experimentalists look for new elementary particles. What candidate particles might people look for? How might people look for them?

Consider society. Knowing of more particles might lead to useful applications.

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This monograph may not be that book.

Perhaps, this monograph demonstrates modeling and/or physics that that book might feature. Perhaps, this monograph provides steps toward that book.

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Models for Physics of the Very Small and Very Large discusses modeling.

This monograph tries to add to the extent models can correlate with elementary particles.

This monograph provides a meta-model. And, uses the meta-model to produce models. And, shows that such models correlate with the list of all known elementary particles. And, shows that the models correlate with some known properties of the particles. And, shows that the models correlate with some known interactions in which the particles partake.

Perhaps, people can use such a meta-model and such models to predict elementary particles. And, predict properties for predicted particles. And, predict interactions in which predicted particles partake. And, use concepts about predicted particles to explain data for which traditional physics theory does not seem to have adequate explanations. Some of this data might pertain to cosmology. Some of this data might pertain to astrophysics.

~ ~ ~

I hope people find value regarding the science and art of modeling.

People might decide to work on meta-modeling. People might hone the meta-model this monograph discusses. People might develop other meta-models.

People might use meta-models—perhaps including the one this monograph discusses—to develop models.

People might use models—perhaps including some this monograph discusses—to gain new understanding regarding known data. People might use such models to make predictions. People might use such models to guide experimental or observational efforts. People might use such models to augment traditional theories.

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Perhaps, people will find value regarding aspects of nature.

This monograph discusses a meta-model.

The meta-model outputs a list of known and candidate elementary particles. The meta-model outputs some properties for the particles.

This monograph shows examples of producing and using models. Some models output additional properties for particles. Some models output possible interactions in which particles partake.

Each of the next three paragraphs discusses a use of models. The three uses use the list of elementary particles that the meta-model outputs. The uses interpret one symmetry differently.

One use features the following. Interpret the symmetry as not correlating with reuse of particle sets. Add particles, beyond today's Standard Model particles. Perhaps, point to dark matter particles and to dark energy particles. Perhaps, explain the rate of expansion of the universe.

A second use features the following. Add some elementary particles, beyond today's Standard Model particles. Interpret the symmetry as correlating with reuse of particle sets. Reuse the particle set and Standard Model physics five times. Perhaps, explain much about dark matter. Add particles, beyond today's Standard Model particles. Perhaps, point to dark energy particles. Perhaps, explain the rate of expansion of the universe.

A third use features the following. Add some elementary particles, beyond today's Standard Model particles. Interpret the symmetry as correlating with reuse of particle sets. Reuse the particle set and Standard Model physics five times. Perhaps, explain much about dark matter. Add gravitons and some other particles to the particle set. Reuse the cumulative particle set. Perhaps, explain much about dark energy stuff. Add a particle related to photons and gravitons. Perhaps, explain the rate of expansion of the universe.

Perhaps, the first of the three uses dovetails best with some aspects of how people interpret data today.

Perhaps, the meta-model and various models will dovetail with new aspects of how people discuss nature in the future.

~ ~ ~

I hope people will use this work. I hope people will benefit from this work. I hope people will tell me of extensions to this work, shortcomings in the work, and developments to which the work contributes.

~ ~ ~

Finally, I especially acknowledge Keith Jones' efforts in coordinating the reviewing and editing processes for this monograph.

Portola Valley, CA, USA
March 2016

Thomas J. Buckholtz

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Chapter 1 Overview

Section 1.1 Some perspective

Section 1.1 discusses context for this monograph. We identify needs for models to predict aspects of nature. We review a past scenario in which modeling improved physics. We draw parallels between that scenario and today's situation. We discuss an opportunity to improve physics. We suggest an agenda for capturing that opportunity.

A need

We think physics needs ways to predict elementary particles.

People can use predictions to guide efforts to infer or find elementary particles.

People can use knowledge of elementary particles to explain presently unexplained facets of cosmology and of other aspects of nature.

An analogy

What is to elementary particles as the periodic table is to atoms?

A parallel

We think today's situation regarding elementary particles has parallels to past work regarding atoms.

By the nineteenth century, the notion of an element existed. Each chemical consists of one or more elements. An element correlates with a chemical that consists of just one type of basic unit.

By the nineteenth century, the notion of an atom was centuries old. Each element consists of one type of basic unit. That unit is an atom.

People knew that chemicals interact with each other. People measured atomic weights. People listed elements. People did not know how many elements nature includes or allows.

During the nineteenth century, people tried to catalog elements. Two principles proved useful. Consider chemical interactions. Consider atomic weights.

The following method proved useful. Create a two-dimensional table. In each column, try to list elements that interact similarly chemically. Within a column, list elements with higher atomic weights below elements with lower atomic weights.

The periodic table started as a model pertaining to what. What do people know about elements? What might people do depict such knowledge? What might people predict? People found gaps in tables. People predicted that gaps might correlate with elements.

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People did not know much about what an atom is. People did not know much about how atoms interact chemically.

Later, people developed models pertaining to atoms and to how. How do atoms interact chemically? Those models feature electrons and electronic structures of atoms and molecules. How does atomic weight arise? Those models feature atomic nuclei and nuclear physics.

Some parallels

We think today's situation regarding elementary particles has parallels to past work regarding elements and atoms.

By the end of the twentieth century, people listed elementary particles. People knew of interactions involving elementary particles. People knew properties of elementary particles. People suggested specific possibilities for a few new elementary particles.

In the early twenty-first century people found the Higgs boson. A list of somewhat well-defined anticipated particles shrank to a list of one item. Perhaps, gravitons exist.

People posit that yet other particles exist. For example, how else might one explain dark matter?

We can summarize today's situation. People have a list of elementary particles. People do not have a catalog that includes blank spaces.

And, perhaps, people do not have an optimal definition of a basic unit. For example, to what extent is each of the three generations (electron, muon, and tauon) of charged leptons an independent basic unit? Or, to what extent is a combination of one quark and one color charge a basic unit? Or, people have tried to posit concepts for mechanisms underlying elementary particles.

An opportunity

We think people can develop ways to catalog elementary particles. We think people can make predictions about what. What particles might exist? What properties do the particles have? In what interactions do the particles partake?

Develop ways to catalog and predict particles. We think that is a useful pursuit.

We think the pursuit faces difficulties. People may not have enough data about particles to well judge candidate catalogs. A catalog should match particles, properties, and interactions of which people know. But, how might people use predictions (and not just extant data about particles) to home in on useful models?

We think a way forward exists.

An agenda

We propose the following agenda.

Pinpoint simple elementary-particle data that extant physics models use as inputs but do not produce as outputs. Examples of such data include spin and, for fermions, numbers of generations.

Develop math-based meta-models that produce models that can output some of the simple data and can output lists of elementary particles.

Develop models, based on parameters for which a meta-model allows choices.

Use the meta-model and models to produce a catalog of elementary particles. See how well the catalog correlates with known aspects of elementary particles. See how well results the meta-model and models produce correlate with simple elementary-particle data. See with what the catalog correlates regarding possible new particles, properties, and interactions. Then, turn from what to how. Explore extents to which the new particles might explain the how of various aspects of cosmology and other fields of physics.

Interrelate and iterate, regarding meta-models, models, catalogs, predictions, data, and explanations.

Then, perhaps, gain insight regarding the how of elementary particles, properties, and interactions.

Section 1.2 This monograph

Section 1.2 discusses relationships between this monograph and the agenda the previous section suggests. People might say that work in this monograph provides impetus to tackle the agenda. We think this monograph provides examples of trying to take steps the agenda features. We note that models we show produce candidates for physics predictions. We note that some of candidates may prove useful and that some may prove to be wrong. We suggest next steps people might want to take. We summarize, from a modeling perspective, chapters in this monograph. We summarize, from a physics perspective, types of insight and examples of predictions that following the agenda might produce.

Some perspective

We think this monograph shows some promise for the agenda.

We show aspects of the agenda. We show a meta-model. We show models, catalogs of particles, and possible predictions. We possibly provide insight regarding some cosmology and some other phenomena. We possibly show some insight regarding the how of elementary-particle physics.

We think this monograph shows a prototype for approaches to the agenda. The meta-model has parameters. People might feel they need more data about nature to judge the value of this one meta-model, the models we show, the catalogs we develop, the possible insight and predictions we extract from models, and so forth.

We hope people use work in this monograph. We hope people advance various facets of physics to be as well understood as atoms and elements. We hope those facets include aspects of elementary particles, astrophysics, and cosmology.

The concept

This monograph features math-based modeling.

We try to follow the agenda.

We try to show details regarding developing and using the meta-model and models.

We use known physics data to limit the scope the meta-model. Given, a lack of some physics data, we try to keep the meta-model broad. We use known physics data to help select parameters within the meta-model.

We think that the meta-model correlates with a prototype for a catalog of elementary particles.

We think that parameters allow for differing interpretations regarding the physics-relevance of items in the catalog.

We try to go far regarding possible predictions. We think doing so can help people judge the promise of the agenda, the meta-model, some models, and so forth. People may find some of the possible predictions to be useful. People may find some of the possible predictions to be wrong.

We try to go far regarding possibly explaining facets of cosmology and of other physics. We think doing so can help people judge the promise of the agenda, the meta-model, some models, and so forth. People may find some of the explanations to be useful. People may find some of the explanations to be wrong.

We try to suggest ways to improve or extend work in this monograph.

We try to suggest ways to integrate work in this monograph and results from traditional physics.

We try to suggest opportunities for future research.

Three examples

This monograph shows examples of using models.

Each of the next three paragraphs discusses a use of models. The three uses use the list of elementary particles that the meta-model outputs. The uses interpret one symmetry differently.

One use features the following. Interpret the symmetry as not correlating with reuse of particle sets. Add particles, beyond today's Standard Model particles. Perhaps, point to dark-matter particles and to dark-energy particles. Perhaps, explain the rate of expansion of the universe.

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Perhaps, the first of the three uses dovetails best with some aspects of how people interpret data today.

Perhaps, at least one of these three uses will dovetail with new aspects of how people discuss nature in the future.

A convention

We start some sentences with the phrase people might say that. We do so to point to concepts people might want to ponder, strengthen, or rebut and ultimately might adopt or reject. We hope this convention adds usefulness to this monograph. We hope use of this convention hastens progress regarding the agenda.

The chapters

Generally, Chapter 2, Chapter 3, and Chapter 4 travel a series of steps. The steps provide a path from unexplained data to models for unexplained data. The first step starts from elementary-particle data that traditional models do not fully output. The first step develops a meta-model and, from the meta-model, models. The second step shows how to apply some such models. The second step provides a list of candidate elementary particles and some of their properties and interactions. The step applies the list to some elementary-particle data with which traditional models do not correlate well. The third step applies the list beyond the realm of elementary particles. The third step suggests models that could correlate with data with which traditional models do not correlate well. Some of the data is cosmology data. Some of the data is astrophysics data.

Generally, Chapter 5, Chapter 6, and Chapter 7 broaden perspectives from the perspectives previous chapters offer. Chapter 5 discusses correlations between work in this monograph and established models. This chapter provides concepts regarding harmonizing and integrating work in this monograph with traditional work. Chapter 6 discusses correlations between work in this monograph and established theories. This chapter provides concepts regarding harmonizing and integrating work in this monograph with traditional work. Chapter 7 discusses the extent to which models in this monograph might provide components for broader understanding of nature. This chapter suggests, especially to the extent people find merit in such models, opportunities people might want to pursue.

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Specifically, the next paragraphs summarize the chapters.

Chapter 1 (Overview) discusses context for this monograph and discusses work this monograph presents. We discuss an agenda to which this work might contribute. We discuss scope of the work. We discuss possible uses for the work. We summarize chapters in the monograph. We summarize some of the mathematical physics that models this monograph shows may help advance.

Chapter 2 (From data to the MM1 meta-model and MM1MS1 models) discusses modeling. We discuss differences between inputs to models and outputs from models. We discuss the desirability of extending modeling practices to include models that produce as outputs information that traditional models use as inputs but do not produce as outputs. We point to some physics data that generally accepted physics models treat as inputs and generally do not produce as outputs. We develop a meta-model. We use the MM1 meta-model to produce MM1MS1 models. We correlate aspects of the models with aspects of traditional mathematical physics. We correlate aspects of the models with possible future mathematical physics.

Chapter 3 (From the MM1 meta-model to particles and properties) starts from solutions we identify in the previous chapter, shows possibilities for listing known and possible elementary particles, and shows possibilities for modeling properties of particles and for modeling interactions in which particles partake.

Chapter 4 (From particles to cosmology and astrophysics) starts with the known and candidate elementary and composite particles that the previous chapter discusses and shows possibilities for correlating with or anticipating data about cosmology or astrophysics. We show models that possibly correlate with various cosmological phenomena and with various astrophysical phenomena. People might say that some models point to how to close some gaps between physics data and results from traditional theory.

Chapter 5 (From MM1MS1 models to traditional models) starts with models this monograph features, discusses extents to which people might correlate or integrate our models with traditional physics models, and discusses extents people might use our models to extend or improve on traditional physics models.

Chapter 6 (From MM1MS1 models to traditional theories) starts with models this monograph features, discusses extents to which people might correlate or integrate our models with traditional physics theories, and discusses extents people might use our models to extend or improve on traditional physics theories.

Chapter 7 (From the MM1 meta-model to perspective) discusses the extent to which models in this monograph might provide components for broader understanding of nature. We show results from applying the models. We suggest possible opportunities for research regarding and applications of models. We suggest possible applications regarding results from models.

Chapter 8 (Appendices) shows some data and math this monograph uses as inputs.

Chapter 9 (Compendia) provides a list of acronyms this monograph uses and provides lists for use in finding items in this monograph.