Axiom

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Contents

Chapter 1

Preface

”If you start with the right axioms, the rest will follow.”— David Hilbert

This book ”Axiom” is a continuation of my previous project Lógos. Which was mostly a collection of essays on several topics; physics, philosophy, religion, civilization, psychology, personal plans, etc.

It was previously meant to work through my ideas, using the fact I was writing it out. It allowed me to keep track of the dozens of ideas and how they all interacted with each other. Developing on the complexity without forgetting and creating a full framework with defined axioms.

Creating this new project is for multiple reasons.

1. To create a more organized book
    - What I mean is have an order, like create a fully formalized epistemology and basic metaphysics and then using that to create a fully organized Ontology. Rather than a chaotic coll
2. To mark the end of my high school career and beginning

of University

3. Lógos had become too big and had too many errors
    - Too big to run on Overleaf, too many errors to run directly in the terminal.
        - This will start smaller, and once it is bigger will be made without errors so it can be run on the terminal once it gets bigger. Also more modular
4. Be able to rewrite with my new knowledge to update it.
5. Write it with a better understanding of the packages, LaTeX, and even create my own custom packages

In the end, it serves the same purpose; to help me better understand things through writing, develop thing iteratively over time using writing, and write out notes to remember things for the future.

As of writing this section, the text will be broken into three parts. Part one being ”The Foundation.” It would be a axiomatic approach to creating the foundations needed for future systems. Two, being ”Notes” on things that I have learned. Three, being writings on my ”Projects”; mostly physics research projects but also projects in further developing philosophy or other similar things. Finally, ”Life in Practice” being more practical things; plans for the future, self-analysis, ideals on society, etc.

Part I

The Foundation

Chapter 2

Introduction

As mentioned in the preface, this section is made to axiomatically develop the foundations needed.

To illustrate, in order to develop physical theories, mathematics must be developed, a philosophy of science must be made, metaphysics, epistemology, and formal logic. Thus, a complete theory of all of these things and more should be created. One that has fundamental, expressible axioms.

Also, most of these theories rely on one another, so a logical chronology must be defined. At the moment of writing this it is defined to be logic $\rightarrow$ metaphysics $\rightarrow$ Epistemology$\rightarrow$ philosophy of science $\rightarrow$ philosophy of physics $\rightarrow$ mathematics $\rightarrow$ physics $\rightarrow$ theology $\rightarrow$ ethics $\rightarrow$ social philosophy $\rightarrow$ personal philosophy.

One additional thing to add, you may notice the separation of metaphysics and the philosophy of physics. These are both meant to signify a difference where metaphysics represents extremely fundamental questions like does existence exist. Things that must be answered before epistemology can be fully introduced. The next section, philosophy of physics, are slightly less fundamental, like the ontology of entropy. Questions that require a theory of epistemology to be answered.

Chapter 3

Logic

"One must be able to say at all times—instead of points, lines, and planes—tables, chairs, and beer mugs." — David Hilbert

3.1 Introduction

Logic is an important tool for the creation of all formal systems. It is the foundation of mathematics, which is for the most part the foundation of everything else. It is also simply important to anything else by clarify concepts, giving them formal definitions, and insures consistency. Allowing for a bedrock behind all analytical thinking.

Though, before I can get into it too much, I should define what the study of logic is. It is the branch of philosophy that critically examines the fundamental nature, scope, and principles of logic itself.

It has a couple fo subfields as well.

- Philosophy of Logic
  - The study of logic at a high level, analyzing its nature

and scope.

- Formal Logic
  - A creation and usage of symbolic logic symbols to create systems; mainly mathematics.
- Metalogic
  - The technical, mathematical study of the properties of formal logical systems. The philosophy of logic often uses the results of metalogic (like Gödel's incompleteness theorems) to address its conceptual questions, such as the limits of a formal axiomatic system

3.2 Defining an Axiom

This entire text is named Axiom, for it is the foundation. To define systems axiomatically and then build them out into their true complexity is not only one of my favorite things to do, but as an extension of that it is what this book is trying to do.(Obviously, I wouldn't do something like this if I didn't enjoy it.)

So let's define it. As I mention extensively in my last book, Lógos, we must define things extremely rigorously. By testing against edge cases and keep it with consistent.

A good way to start is with the dictionary definition. ”a statement accepted as true as the basis for argument or inference.” For instance, our understanding of scientific realism is the understanding of the fact that our observations of reality are accurate.

A more defined definition can then be defined to say that an axiom is a statement that either cannot be proved or cannot be proved currently that is used within a greater statement that can be proved upon its edifice. These axioms, while don't require 'proof' generally desire some type of reasoning even if it is not objective or purely analytical in nature. For instance, the above arguments for the objective nature of reality aren't true objective proof, they still exist as semi-arguments. While we cannot prove the objectivity of reality with true and objective reasoning, some reasoning can be applied to get some kind of 'proof' of the statement so that further studies can be applied based upon that said axiom.

An astute observer can find that these mean the same thing, my is more of an explanation so, the dictionary definition does work:

Definition 3.1. *Axiom: a statement accepted as true as the basis for argument or inference.*

3.3 *****

I am currently a little stuck on how to write this chapter, so I will return at a later point.

3.3.0.1 Propositional logic

The most basic form of classical logic, but instead of telling you now, I will develop it.

3.3.0.2 Axiom System for the Propositional Calculus

For this simple system a number of axioms must be assumed:

- $A \Longrightarrow (B \Longrightarrow A)$
- $(A \Longrightarrow (B \Longrightarrow C)) \Longrightarrow ((A \Longrightarrow B) \Longrightarrow (A \Longrightarrow C))$

- $(\neg B \Longrightarrow \neg A) \Longrightarrow (A \Longrightarrow B)$

Then one rule of inference is needed. Modus Ponens(MP)

From A and $A \Longrightarrow B$ infer B

This defines all tautologies and thus the larger system as a whole.

3.3.0.3 Defining Tautologies

A tautology is simply a statement form that is always true, regardless of the truth values of the statement letters.

An example would be the law of the excluded middle. $(A \vee (\neg A)).Thisisastatementthatistruebydefinitionandthereisnocasewhereitcanbefa$

3.3.0.4 Truth Tables

Negation is the first an simplest form. The symbol is $\neg$, so $\neg A$ is the negation of A.

so the table can be constructed

A	$\neg A$
T	F
F	T

Where T, represents true, and F represents false.

A further complication is the conjunction operator $\wedge$ or "and."

It combines to functions into a greater set.(a union of function)

A	B	$A \wedge B$
T	T	T
T	F	F
F	T	F
F	F	F

$A \wedge B$ is only true when both ”A” and ”B” are true.

$\vee$ is the inverse, only one of the functions must be true. It is called a disjunction.

A	B	$A \vee B$
T	T	T
T	F	T
F	T	T
F	F	F

$A{\Longrightarrow}B$ means ”if A, then B” meaning that A needs to happen for B or that A causes B.

	A	B	$A{\Longrightarrow}B$
T	T		T
T	F		T
F	T		F
F	F		T

There are a couple of other operators used in prepositional logic, but for not I will move on and if needed bring those back up at a later point.

Chapter 4

Philosophy of Mathematics

Chapter 5

Fundamental Metaphysics

5.1 Scope

This chapter will cover fundamental metaphysics, what I mean by this is for my progression of metaphysics I need a theory of epistemology, philosophy of science, inductive and deductive research on physics, etc; however, for all of these things I need some concepts of metaphysics. Things like the existence, reality, consciousness, questions of God, and so much more. Thus, this will serve that purpose.

5.2 Reality

5.2.1 Existence Exists

To truly come to a thorough understanding of a system, one must create it from first principle slowly and carefully. To question every implicit assumption, this for the most part is the quest of philosophy; especially metaphysics.

Thus let us begin our creation of reality.

Existence Exists, this is by definition an irrefutable point. To negate an argument an antithesis must be supplanted, non-existing, but non-existence by definition implies a existence. This is because you cannot have a non-existence without an existence. $\neg E(x) \Longrightarrow E(x) \Longleftrightarrow ((\forall P(Prop(P) \Longrightarrow E(p))) \wedge (\exists Prop(E(\neg E(x)))))$. By the simple definition of existence to be everything. Another more concrete argument is that to deny the existence is a claim, a claim is an act, an act requires and actor, and thus an actor must exist, an actor exists within the subsect of existence, so if it exists so must existence.

Though, this doesn't say anything about the existence, in fact there is a special case in which existence is the absent of all things. Using the second argument, we create a conscious entity. Cognito, ergo sum. I think therefore I am. Now upon inspection of this entity it is quite simple, the only capacity it necessarily has is the ability to make a claim, such a claim needs no basis in reality, sense, logic, or anything of such. It could be the dream of a butterfly, random interactions of particles in the dead of space, or anything of the such.

One constraint does exist, that entity is me. While it could still(at least for now) be some random assortment of particles or what ever machinations you may dream of, there is some knowledge we do know. It has the ability to observe, reason, and has innate concepts like space, time, similarities, and differences. One thing to be clear, at this point their is no justification that any of these things have any connection to reality, but they are apart of the entities observations.

5.2.2 The Entity and Observable reality

Now, it is technically true that the entity has no way to truly and faithfully validate his observations and reasoning beyond self-referential, due the fact that these are the entities' only capacity to make claims.

Thus, taking these as true is a fair axiom, unprovable but logical in the necessity of the argument. I do not mean taking all observations as true(in fact always questioning them is of great importance as I will address later). I mean regarding that our observations are a consequence of reality. Taking the reality that existed around us as the "truth." While observations can be complete, wrong, they are not false by the nature of being observations by the entity.

Now this creates a dichotomy between the observed reality and "true reality"(whatever that might be). There is a spectrum of how much these two overlap.

Ranging from:

A: Scientific Materialism; that all of observed reality and true reality overlap because these observations are directly true, and nothing exists beyond what is within the capacity of theoretical observation.

B: Idealism; there is no overlap at all. Such as the Boltzmann brain.

Now, this observable reality, is still apart of existence, and is thus no metaphysically distinct if some greater "true reality" and is thus given the same importance and study. While other sub-existences beyond our observable are lesser for reasons, these are more ethical, aesthetic, and theological rather than truly metaphysical.

5.2.3 Beyond Observable

Given this spectrum, it is entirely possible for there to exist unobservable reality that is true. This reality has unknown capacity and can theoretically interact and cause observabes.

5.2.4 Independence of Reality

Given that this entity is me, I observe the continuation of reality beyond my direct observation. Once again this is not direct proof that it is, but makes it indistinguishable from if it was.

5.3 The Entity and Observations

5.3.1 Introduction

Now this entity observes a great many things; matter, other entities, change, relations, space, time, identity, theory, mathematics, difference, categories, individuation, emotions, structure, aesthetics, fundamentalism, layers, evidence, argumentation, possibility, necessity, abstracta, causation, and much more. Categorizing these and understanding them is the foundation of metaphysics.

5.3.2 Properties

All observables are made up of properties, and many of the observables themselves are properties.

5.3.3 Abstraction: Math, sets, and Relations

Given this nature, these properties can act as sets of 1 and can make up object which are thus observables. They thus follow the same mathematical rules of sets.

- Relations to other sets(and themselves)
- Shared Properties with other sets
- can be apart of larger sets(categories)

- and so much more

Now I won't examine all of this because it is mentioned in the earlier chapter so we will move on.

These sets can be whatever, such as the other properties or something new all together.

5.3.4 Matter

One of the most important sets is matter, within this set is a near infinite amount of subsets. These subsets can "theoretically" have about any property. The main one that define it is that it must have the capacity to affect the properties of other matter(and thus be effected too). It must also have the properties of existing within space and time. Direct space or time is not needed, but having the property is required. Finally, it must be independent of a thinker.

5.3.5 SpaceTime

Once again, given the simplicity of this model this examination will be quite simple. Essentially all that can be taken at this moment is that space and time are properties of many things. Extremely important ones,

5.3.6 Thinker

A thinker is an entity like object of matter. These entities are capable of creating, holding, using, being effected by, etc by non-material objects. These thinkers do not need to be human, or even alive for that matter.

5.3.7 Non-material

Already defined to be objects that exist(observable have effects) dependent of a thinker.

Chapter 6

*Epistemology

Chapter 7

Philosophy of Science

Chapter 8

Philosophy of Physics

Chapter 9

Foundations of Physics

Chapter 10

Foundations of Mathematics

Chapter 11

Foundation of Computations

Chapter 12

Foundations of Mathematics

Chapter 13

Theology

Chapter 14

Ethics

Chapter 15

Social Philosophy

Chapter 16

Personal Philosophy

Part II

Notes

Chapter 17

Introduction

This part is for the purpose of writing my notes on other people's work, rather than my own. Whether it be notes from a class, a textbook, a regular book, or anything of that nature. Pretty simple.

Chapter 18

Textbooks

18.1 Introduction

Here I will write my notes from books I have read or am reading.

18.2 Theoretical Physics by Georg Joos

The vector analysis portion is intresting due to the fact that it takes something as simple as vector analysis and brings rigorous ideas to it like that $\oint ds = 0$ for close surfaces.

I also never really thought about using vector analysis instead of tensors.

The rest of curl, gauss, and such is very simple. Though, now it is getting into tensors though vectors.

$$dv_x = ds\nabla v_x$$

$$dv_y = ds\nabla v_y$$

$$dv_z = ds\nabla v_z$$

So therefore $dv = ds\nabla v$

To calculate v, three vectors or nine scaler must be known.

Another interesting addition is the fact that in physics, symmetric tensors can be represented as a surface to the second degree.

One thing I have noticed is I need a more intuitive grasp into the relationships between curl, div, laplance, and grad. They use it a lot to simplify the calculations.

$$\nabla^2 f = \nabla \cdot (\nabla f)$$

The Laplace operator is equal to the divergence of the gradient.

$$\nabla \times (\nabla f) = 0$$

For smooth scaler fields. The curl of the gradient is zero.

$$\nabla \cdot (\nabla \times \mathbf{F}) = 0$$

The same is true for the divergence of the curl. $\nabla^2 \mathbf{F} = \nabla(\nabla \cdot \mathbf{F}) - \nabla \times (\nabla \times \mathbf{F})$ For vector fields, the Laplace operator has different relations.

Next, onto calculus of variations. I will derive Euler-Lagrange differential equation.

Let: $\tilde{y}$ be a neighboring function to y. Where $\in$ be a small quantity and $\eta(x)$ be a arbitrary function of x. so if $\tilde{y} = y + \epsilon\eta$ then $\tilde{y'} = y' + \epsilon\eta'$. Here we stipulate that the two functions $\tilde{y}$ and y converge at the beginning and end. Thus, η must vanish at the ends. So if we substitute an integral I,, we find that it becomes a function of ϵ. Then we require that $I(\epsilon)$ must have an extreme value of $\epsilon = 0$. Here it is in mathematical terms:

$$I(\epsilon) = \int_{x_0}^{x_1} F(x, y + \epsilon\eta, y' + \epsilon\eta')dx = extremum\ for\ \epsilon = 0$$

This gives us a simple way of determining the extreme value for a given integral. The condition is:

$$(\frac{dI}{D\epsilon})_{\epsilon=0} = 0$$

We can then expand the integrad function F in Taylor's series, according to the powers of ϵ.

The differentiate with respect to ϵ.

This expression then vanishes for $\epsilon = 0$. Thus then simply remains the condition for the extremum.

Integrate this to get the Euler-Lagrange differential equation:

$$\frac{d}{dx}\frac{\partial F(x,y,y')}{\partial y'} - \frac{\partial F(x,y,y')}{\partial y} = 0$$

For writing constraining forces, we find it to be

$$Z = \lambda \; grad \; G$$

Where $G(x,y,z)$ is the equation of the surface

18.3 On Sympathetic Reduction in Classical Mechanics

18.4 Magnetic Fields and Magnetic Diagnostics for Tokamak Plasmas by Alan Wooton

18.5 Advanced MHD with Applications to Laboratory and Astrophysical Plasmas by Cambridge

For wide variety of MHD instabilities operating in tokamaks, represented by normal modes of the form(assuming that cylindrical approximation and the toroidal representation may be ignored):

$$f(\psi,\vartheta,\varphi,t)=\sum\nolimits_m \tilde{f}(\psi)e^{i(m\vartheta+\eta\varphi-\omega t)}$$

Is only unstable for perpendicular wave vectors.

The reason is the enormous field line bending energy of the Alfven waves

18.6 Hamiltonian description of the ideal Fuid by P.J.Morrison

18.7 Classical Dynamics a Modern Perspective

18.7.1 Chapter 6

A lot more importation stuff I forgot to write down, well I will start in chapter 6: If multiple canonical transformations, directly transforming would be canonical. $w \to w' \to w''$ then $w \to w''$. This is the group Composition Law.

Next is the Associativity of Composition Law: if $w' = \phi(w)$, $w" = \Phi(w')$, and $w''' = \xi(w")$ so no matter what order of transformation they will be the same, whether $(T_3(T_2T_2)$ or $(T_3T_2)T_1$ or anything of the such.

Identity: The identity transformation w' = w obviously obeys the conditions for being canonical.

Inverses: If $\omega \to \omega'$ is canonical, then so is the transformation id $\omega' \to \omega$.

"Thus all the properties needed to define a group are trivially obeyed. (In Chapter 12 we discuss group structure in a little more detail). "

The canonical group is characterized by the dimension, 2k, of the phase space.

The subgroups of such a phasespace is very large, though three can be easily defined.

Another subgroup is the contact transformations.(when a poission bracket can be formed)

Note: changing coordinate systems can satisfy phasespace rules, but isn't generally considered to be a transformation

"Intuitively speaking, a finite canonical transformation that can be connected continuously to the identity should be built up as a succession of infinitesimal transformations."

To express the relation between Poission Brackets and canonical transformations through differential equations:

$$\frac{d\omega}{d\theta} = \{\omega^\mu, \phi(\omega)\}_\omega = \epsilon^{\mu v}\frac{\partial\phi(\omega)}{\partial\omega^v}$$

Let us first clarify the meaning of this equation. We look upon the w^μ as functions of θ; ϕ is a function with a fixed functional form, and w^μ are the unknowns in the differential equation. Thus on the right-hand side of this equation, the arguments of ϕ are just the quantities we are trying to solve for. From the theory of differential equations, we know that there is a unique solution for w^μ if we are given the values of w^μ at $\theta = 0$. Calling these boundary values of w^μ as w_0^μ, the solution of the equation can be written as:

$$\omega^\mu = \varphi^\mu(\omega_0;\theta), \varphi^\mu(\omega_0;0) = \omega_0^\mu$$

18.7.2 Chapter 7

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Chapter 19

Video classes

19.1 Differential Geometry - Robert Davie

19.1.1 1-forms

These are linear functionals that map tangent vectors at a point on a manifold to real numbers. In local coordinates on a manifold M, a 1-form can be written as $\omega = \omega_i dx^i$, where ω_i are smooth functions and dx^i are basis 1-forms (dual to coordinate basis vectors). For example, the differential of a function $df = \frac{\partial f}{\partial x^i} dx^i$ is a 1-form. They are used to measure vectors, like gradients or line integrals.

19.1.2 2-forms

These are antisymmetric bilinear maps that take two tangent vectors and produce a real number. In coordinates, a 2-form looks like $\omega = \omega_{ij} dx^i \wedge dx^j$, where $\wedge$ denotes the wedge product (ensuring antisymmetry: $dx^i \wedge dx^j = -dx^j \wedge dx^i$). 2-forms are used to measure oriented areas, such as in surface integrals or the electromagnetic field tensor in physics.

19.1.3 3-forms

These are antisymmetric trilinear maps, taking three tangent vectors to a real number. In coordinates, a 3-form is $\omega = \omega_{ijk} dx^i \wedge dx^j \wedge dx^k$, with antisymmetry in all indices. They measure oriented volumes and are used in integrals over 3-dimensional submanifolds, like in fluid dynamics or general relativity.

19.1.4 k-form

This can then be made general as

$$\omega = \Sigma_{i_1..i_k} \omega_{i_1...i_k} dx^{i_1} ... \wedge dx^{i_k}$$

19.1.5 Introduction to Exterior calculus

An exterior derivative maps k-forms into k+1-forms.

$$d : \wedge^k(M) \to \wedge^{k+1}(M)$$

and must follow these rules Linearity: $d(\alpha + \beta) = d\alpha + d\beta$ Leibniz(product rule): $\wedge(\alpha + \beta) = d\alpha \wedge \beta + (-1)^k \alpha \wedge d\beta$ Nilpotency: $d(d\alpha) = 0$

$$\therefore d\omega = \Sigma_{i<j} (\frac{\partial \omega_i}{\partial x_j} - \frac{\partial \omega_j}{\partial x_i}) dx^i \wedge dx^j$$

In 3D, the exterior derivative of the 2-form correspondence to the divergence in vector field.

Allows for integration of manifolds. Shows that the integral of the exterior derivative of a differential form over a manifold of the integral of the form itself over the boundary of the manifold:

$$\int_M d\omega = \int_{\partial M} \omega$$

This unifies vector calculus in areas like divergence or green's theorem.

It also show vector flow

Lie derivatives measure the change of forms

19.1.6 Exterior calculus-2

The exterior for a k-form is

$$d\omega = \sum(\sum_{n=1} \frac{\partial x_{i.....k}}{\partial x^{i_n}} dx^{i_n}) \wedge dx^{i_1} \wedge .... \wedge dx^{i_k}$$

4-form is the highest form

Back to to integration of manifolds with stokes theorem. While $\int_M d\omega = \int_{\partial M} \omega$ is true $\int dx \wedge dy$ and $\int dxdy$ represent slightly different mathematical concepts. In diff forms, it is the integral of an oriental area. In Multi-variable calculus it is the integral of over a region in the xy-plane

19.1.7 Wedge Product-2

Properties of the wedge product: Anti-symmetry: $\omega \wedge \eta = (-1)^{pq} \eta \wedge \omega$. Where p & q are the dimensionality of ω, η

Symmetric group: S_{p+q} is the group of all possible permutations.

Permutation and sign of permutations: σ is essentially a specific way of ordering a set of elements. The sign of permutation $sign(\sigma)$ tells us if the permutation can be achieved in an even or odd number of swaps. Where odd is negative and even is positive

Role of these two things: The sign tells us the sign of a wedge product given a permutation. $dx^1 \wedge dx^2 \rightarrow -dx^2 \wedge dx^1$.

The symmetric groups tells us all possible permutations.

$$\therefore (\omega \wedge \eta)(X_1 ..., X_{p+q}) = \frac{1}{p!q!} \sum_{\sigma \in S_{p+q}} sign(\sigma)\omega(X_{\sigma(1)} ..., X_{\sigma(p)}),$$
$$\eta(X_{\sigma(p+1)} ... X_{\sigma(p+q)})$$

This $\frac{1}{p!q!}$ ensures correct normalization.

19.1.8 Introduction to the Hodge Star Operation

This operator allows us to relate manifolds. Crucial in formulating coordinate free theories. It transforms k-forms into (n-k)-forms. Specifically it is an isomorphism between the spaces of k-forms and (n-k)-forms on an n-dimensional Riemannian(M,g). Where g is the metric tensor. It is denoted as:

$$\star : \wedge^k (T^* M) \rightarrow \wedge^{n-k} (T^* M)$$

The way it works is hard to write out, so just remember it. To construct a hodge star

$$\omega \wedge \star\eta = \langle \omega, \eta \rangle vol_M$$

Where $\langle ., . \rangle$ is the inner product and Vol is the volume form of M. Defined as $vol_M = \sqrt{|g|} dx^1 \wedge .. \wedge dx^n$ Where $|g|$ is the determinate of the Metric Tensor.

The equation is long, so just look it up, it is simple but long.

19.1.9 Hodge star 2

Hodge star establishes duality between geometric theories. Involution: Doing it twice returns it to the original Linear transformations: You know what this means Interacts like multiplication with exterior derivative: $\star(d\omega) = d(\star\omega)$ The co-differential is defined using the Hodge Star.

19.1.10 The push forward of vectors on manifolds

A pushforward is a way to map a vecotr on a tangent space onto another manifold's tangent space.

Properties:

Linearity: The pushforward $\phi_* : T_pM \to T_{\phi(p)}N$ is a linear map. For vectors $v, w \in T_pM$ and scalars a, b,

$$\phi_*(av + bw) = a\phi_*v + b\phi_*w$$

Chain rule: If you have another smooth map $\psi : N \to P$, the pushforward satisfies the composition rule:

$$(\psi \circ \phi)_* = \psi_* \circ \phi_*$$

This follows from the chain rule for derivatives.

Action on curves: If you think of a vector $v \in T_pM$ as the tangent to a curve $\gamma : (-\epsilon, \epsilon) \to M$ with $\gamma(0) = p$, then ϕ_*v is the tangent vector to the curve $\phi \circ \gamma$ at $\phi(p)$.

The pushforward $\phi_*v \in T_{\phi(p)}N$ is given by:

$$\phi_*v = v^i \frac{\partial \phi^j}{\partial x^i} \frac{\partial}{\partial y^j}$$

Here, v^i are the components of v, and $\frac{\partial \phi^j}{\partial x^i}$ are the Jacobian entries. The result is a vector in $T_{\phi(p)}N$, expressed in the basis $\left\{ \frac{\partial}{\partial y^1}, \dots, \frac{\partial}{\partial y^n} \right\}$.

19.1.11 Pull-Back in k-forms

Given a smooth map $\phi : M \to N$ between manifolds M (dimension m) and N (dimension n), and a k-form $\omega \in \Omega^k(N)$ on N, the pullback $\phi^*\omega \in \Omega^k(M)$ is a k-form on M. The pullback essentially "transfers" ω from N to M by composing it with the map ϕ. The pullback is defined pointwise. For a point $p \in M$, and k tangent vectors $v_1, \ldots, v_k \in T_pM$, the pullback $\phi^*\omega$ at p is:

$$(\phi^*\omega)_p(v_1, \ldots, v_k) = \omega_{\phi(p)}(\phi_* v_1, \ldots, \phi_* v_k)$$

Here:

$\phi_* : T_pM \to T_{\phi(p)}N$ is the pushforward (differential) of ϕ, which maps each tangent vector v_i to $\phi_* v_i$. $\omega_{\phi(p)} \in \wedge^k T^*_{\phi(p)}N$ is the k-form ω evaluated at $\phi(p)$, acting on the pushed-forward vectors.

This definition ensures that $\phi^*\omega$ is a k-form on M, as it takes k vectors in T_pM and produces a number.

Key Properties of the Pullback

Linearity: The pullback $\phi^* : \Omega^k(N) \to \Omega^k(M)$ is a linear map.

Preserves degree: The pullback of a k-form is a k-form.

Functoriality: For maps $\phi : M \to N$ and $\psi : N \to P$,

$$(\psi \circ \phi)^* = \phi^* \circ \psi^*$$

Commutes with exterior derivative: For any k-form ω,

$$d(\phi^*\omega) = \phi^*(d\omega)$$

This is a powerful property, making pullbacks compatible with the exterior calculus.

Wedge product: The pullback respects the wedge product:

$$\phi^*(\omega \wedge \eta) = (\phi^*\omega) \wedge (\phi^*\eta)$$

Computing the Pullback in Coordinates To compute $\phi^*\omega$ in practice, we typically use local coordinates. Here's the step-by-step process:

Choose coordinates:

On M, use coordinates $(x^1, \ldots, x^m)$ around p.

On N, use coordinates $(y^1, \ldots, y^n)$ around $\phi(p)$.

The map ϕ is expressed as $y^i = \phi^i(x^1, \ldots, x^m)$.

Express the k-form:

Let $\omega \in \Omega^k(N)$ be written in coordinates as:

$$\omega = \sum_I a_I(y)\, dy^{i_1} \wedge \cdots \wedge dy^{i_k}$$

where $I = (i_1, \ldots, i_k)$ is a multi-index with $1 \leq i_1 < \cdots < i_k \leq n$, and $a_I(y)$ are smooth functions on N.

Pull back the form:

The pullback is:

$$\phi^*\omega = \sum_I (a_I \circ \phi)\, \phi^*(dy^{i_1} \wedge \cdots \wedge dy^{i_k})$$

Compute $a_I \circ \phi$: Replace y with $\phi(x)$, so $a_I(y) = a_I(\phi(x))$.

Compute the pullback of the basis k-form:

$$\phi^*(dy^{i_1} \wedge \cdots \wedge dy^{i_k}) = \phi^*(dy^{i_1}) \wedge \cdots \wedge \phi^*(dy^{i_k})$$

For a 1-form dy^j, the pullback is:

$$\phi^*(dy^j) = d(y^j \circ \phi) = d(\phi^j(x)) = \frac{\partial \phi^j}{\partial x^\ell} dx^\ell$$

(using the chain rule, summing over ℓ). Thus:

$$\phi^*(dy^{i_1} \wedge \cdots \wedge dy^{i_k}) = \left(\frac{\partial \phi^{i_1}}{\partial x^{\ell_1}} dx^{\ell_1}\right) \wedge \cdots \wedge \left(\frac{\partial \phi^{i_k}}{\partial x^{\ell_k}} dx^{\ell_k}\right)$$

This is a k-form on M, expressed in the dx^ℓ basis.

Simplify:

Expand the wedge products and collect terms. The result is a sum of terms involving $dx^{\ell_1} \wedge \cdots \wedge dx^{\ell_k}$, with coefficients that depend on the Jacobian $\frac{\partial \phi^j}{\partial x^\ell}$ and $a_I(\phi(x))$.

19.1.12 Pull-Back of volume forms

The pullback of a volume form $\omega = f(y)\, dy^1 \wedge \cdots \wedge dy^n$ on N under a map $\phi : M \to N$ is an n-form on M, computed as:

$$\phi^*\omega = (f \circ \phi) \cdot \det\left(\frac{\partial \phi^i}{\partial x^{j_k}}\right) dx^{j_1} \wedge \cdots \wedge dx^{j_n}$$

If $\dim M = \dim N$, and ϕ is a local diffeomorphism, $\phi^*\omega$ is a volume form on M. If $\dim M < \dim N$, the pullback is zero. The Jacobian determinant captures the volume scaling, making this operation central to integration and geometric transformations.

19.1.13 Integration on Manifolds Using the Pull-back of Volume Forms

The pullback of volume forms allows for integration of manifolds. Which is useful in the integration of curved coordinate systems.

volumes generalize ”dx” or ”dxdy.”

The steps in integration of manifolds using volume forms is:

Step 1: M: The domain of integration (often $\mathbb{R}^n$ or a simpler manifold). N: The target manifold with a volume form ω. $\phi : M \to N$: A smooth map, typically a parametrization or diffeomorphism. $f : N \to \mathbb{R}$: The function to integrate (if $f = 1$, we're computing the volume).

Express the volume form:

Write $\omega = f_\omega(y)\, dy^1 \wedge \cdots \wedge dy^n$ in coordinates on N.

Compute the pullback:

Compute $\phi^*\omega$, which involves:

Substituting $y = \phi(x)$ into $f_\omega(y)$. Computing the Jacobian determinant of ϕ. Forming $\phi^*\omega = (f_\omega \circ \phi) \cdot \det\left(\frac{\partial \phi^i}{\partial x^j}\right)\, dx^1 \wedge \cdots \wedge dx^n$ (if $m = n$).

Set up the integral:

The integral becomes:

$$\int_{\phi(M)} f\,\omega = \int_M (f \circ \phi) \cdot \phi^*\omega$$

In coordinates, if $\phi^*\omega = g(x)\, dx^1 \wedge \cdots \wedge dx^n$, and M corresponds to a region $U \subset \mathbb{R}^n$:

$$\int_U (f \circ \phi)(x) \cdot g(x)\, dx^1 \dots dx^n$$

Evaluate the integral:

Perform the integral over U using standard multivariable calculus techniques, accounting for the Jacobian determinant and any orientation changes.

19.1.14 Line Integrals on Manifolds

Parameterize the curve: Define the curve $\gamma(t) = (x(t), y(t), \dots)$ for $t \in [a, b]$.

Define the one-form: Let the one-form be $\omega = f(x, y, \dots)dx + g(x, y, \dots)dy + \dots$.

Calculate the pullback: Substitute the coordinate functions $x(t), y(t), \dots$ and their differentials into the one-form. This gives the pullback one-form $\gamma^*\omega$ on the interval $[a, b]$. For example, if $\omega = f(x, y)dx + g(x, y)dy$ and $\gamma(t) = (x(t), y(t))$, the pullback is $\gamma^*\omega = (f(x(t), y(t))\frac{dx}{dt} + g(x(t), y(t))\frac{dy}{dt})dt$.

Integrate the pullback: Integrate the resulting expression with respect to t from a to b.

This gives the value of the line integral:

$$\int_\gamma \omega = \int_a^b (f(x(t), y(t))\frac{dx}{dt} + g(x(t), y(t))\frac{dy}{dt})dt$$

.

19.1.15 Classical Stokes Thereom in Manifolds

19.2 Symplectic geometry classical mechanics

19.2.1 Lecture 1

Symplectic doesn't work well in dissipative structures.

It also goes over the definition of local eucledian space, which is pretty basic.

They also go over how you can make an object unique by maxionable defining coordinate systems.

This is given by an atlas of coordinate charts

To get a differntiable structure, an atlas is described through coordinate charts (U_α, ϕ_α) such that:

Each $\psi_\alpha : U_\alpha \to R^n$ is a homeimorphism Also, on overlaps between $U_\alpha \cap U_\beta$ it is continously differentiable.

19.2.2 Lecture 2

They go over catogories in a brief overview, and that this lecture will be going over a map of differential geometry.

So, let us start with a manifold: $f(p) \in N$

Now there isn't much we can say about this basic manifold, though let's add a bit more context. Say that manifolds seem like flat-space(euclidian) locally.

So we can take the charts in the manifold to project euclidian space upon it to differentiate.

When k is $\inf$ f is smooth.

Chapter 20

Coding

20.1 *Linux Terminal

20.2 *Github

20.3 *FORTRAN

20.4 *Python

20.5 *Emacs

20.6 *LaTeX

Part III

Research

Chapter 21

Introduction

Chapter 22

Previous Research

These are brief/lazy copies/explanations of things I have written previously made projects. Copied from my last book Logos

22.1 3D Modeling of Non-Equilibrium Dynamics in Compressed Plasma Using Lattice Boltzmann Method

The construction of a theoretical model, magnetohydrodynamic lattice boltzmann method(MHD-LBM) model for 3D compressed plasma, using a finite volume scheme is constructed. The hyperbolic Maxwell equations, which satisfy the elliptic constraints of Maxwell's equations and the constraint of charge conservation, are used to simulate the electromagnetic field. The flow field and electromagnetic field are coupled to simulate a compressible plasma through the electromagnetic force and magnetic induction equations. This model can further be applied to create a quantitative simulation to model complex nonequilibrium effects of compressed plasma to provide mesoscopic physical insights into the flow mechanism of a shock wave in a supersonic plasma.

Theoretical model, Finite volume scheme, hyperbolic maxwell equations, and nonequilibrium effects

22.1.1 3D Modeling of Non-Equilibrium Dynamics in Compressed Plasma Using Lattice Boltzmann Method Introduction

The study of nonequilibrium dynamics in compressible plasma is a critical area of research in plasma physics, with significant implications for both theoretical understanding and practical applications. Compressible plasmas are found in a variety of contexts, such as astrophysical phenomena(1), industrial processes(2,3), and fusion. Understanding the complex interactions and behaviors of plasma under nonequilibrium conditions is essential for advancing these fields.

Previous research has primarily focused on two-dimensional models(4) While these models have provided valuable insights, they often fall short in capturing the full complexity of three-dimensional plasma dynamics. The limitations of these models highlight the need for more advanced simulation techniques that can accurately represent the intricate behaviors of compressible plasma in three dimensions.

The Lattice Boltzmann Method (LBM) offers a powerful tool for modeling fluid dynamics at the microscopic level.(4,5) Unlike traditional computational fluid dynamics methods, such as the Navier-Stokes equation, the LBM is particularly well-suited for simulating nonequilibrium effects and complex boundary conditions. Its ability to handle multiphase flows and incorporate microscopic interactions makes it an ideal choice for studying compressible plasma dynamics.(5)

This paper aims to develop a comprehensive 3D model using the LBM to simulate nonequilibrium effects in compressible plasma. By leveraging the strengths of the LBM, we seek to overcome the limitations of previous models and provide a more accurate and detailed representation of plasma behavior. Our research focuses on the coupling of flow and electromagnetic fields, exploring the interactions and dynamics that arise under nonequilibrium conditions.

22.1.2 Physical Model

Kinetic Equation

Li and Zhong(10) introduced the potential energy distribution function as well as a compressed DDF Lattice Boltzmann equation. A potential energy distribution function can be added so the Boltzmann BGK can obtain an adjustable specific heat ratio or Prandtl number(4)

This new Boltzmann Kinetic equation can be written as followed:

$$\frac{\partial f_k}{\partial t} + (\mathbf{e}_k \cdot \nabla) f_k + \mathbf{a} \cdot \nabla_e f_k = -\frac{1}{\tau_f}(f_k - f_k^{eq})$$

$$\frac{\partial h_k}{\partial t} + (\mathbf{e}_k \cdot \nabla) h_k + \mathbf{a} \cdot \nabla_e h_k = -\frac{1}{\tau_h}(h_k - h_k^{eq}) + \frac{z_k}{\tau_{hf}}(f_k - f_k^{eq})$$

Where k is the direction of discrete velocity. f_k is the density distribution function. h_k is the potential energy distribution function, while f_k^{eq} is the equilibrium distribution function. e_k is the discrete velocity component, and τ_f is the relaxation time of the density distribution function. τ_h is the relaxation time of the potential energy distribution function.

This can also be defined as:

$$\tau_{fh} = \frac{\tau_f}{\tau_h}$$

The force term can be approximated as:

$$\mathbf{a} \cdot \nabla_e f \approx \mathbf{a} \cdot \nabla_e f^{eq} = -\frac{a \cdot (\mathbf{e}_k - \mathbf{u})^2}{RT} f^{eq}$$

22.1.3 Density Distribution Function

$$f_k^{n+1}(x_i, y_j, z_l) = f_k^n(x_i, y_j, z_l) - \Delta t \left(\frac{F_{k,i+1/2,j,l} - F_{k,i-1/2,j,l}}{\Delta x} + \frac{F_{k,i,j+1/2,l} - F_{k,i,j-1/2}}{\Delta y} \right.$$

$$-\Delta t \cdot \frac{1}{\tau}(f_k - f_k^{eq})$$

22.1.4 Potential Energy Distribution

$$h_k^{n+1}(x_i, y_j, z_l) = h_k^n(x_i, y_j, z_l) - \Delta t \left(\frac{G_{k,i+1/2,j,l} - G_{k,i-1/2,j,l}}{\Delta x} + \frac{G_{k,i,j+1/2,l} - G_{k,i,j-1/}}{\Delta y} \right.$$

$$-\Delta t \cdot \frac{1}{\tau_h}(h_k - h_k^{eq}) + \frac{z_k}{\tau_{hf}}(f_k - f_k^{eq})$$

22.1.5 Hyperbolic Maxwell Equations

The previously used Maxwell equations have been enhanced with Lagrange multipliers, Ψ and Φ, to combine with the evolution equation. These are the new Maxwell equations in derivative form:

$$\frac{\partial \mathbf{B}}{\partial t} + \nabla \times \mathbf{E} + \gamma \nabla \psi = 0$$

$$\frac{\partial \mathbf{E}}{\partial t} - c^2 \nabla \times \mathbf{B} + \chi c^2 \nabla \phi = -\frac{\mathbf{J}}{\epsilon_0}$$

$$\frac{\partial \Psi}{\partial t} + \gamma c^2 \nabla \cdot \mathbf{B} = 0$$
$$\frac{\partial \Phi}{\partial t} + \chi \nabla \cdot \mathbf{E} = 0$$

Where E is the electric field, B is the magnetic field, Ψ and Φ are introduced divergence variables, γ and χ are divergence error propagation speeds, c is the speed of light, and ϵ_0 is the vacuum permittivity.

22.1.6 Kinetic Non-Equilibrium Method

The nonequilibrium effects on compressed plasma are observed through differences in molecular speed. Each non-equilibrium kinetic moment can be represented as the difference between the corresponding kinetic moment and the local equilibrium kinetic moment. The equations of kinetic moments may be used to find the nonequilibrium quantities.

$$M_{f,m}^{neq} = M_{f,m} - M_{f,m}^{eq}$$
$$M_{h,m}^{neq} = M_{h,m} - M_{h,m}^{eq}$$

22.1.7 Discussion

In this paper, a 3D MHD-LBM analytical model was constructed for compressed kinetic plasma. Future research must be done in developing a computer model and validating said computer model. A third-order finite volume MUSCL could be applied to this analytical model combined with a D3Qx density equilibrium distribution function to create an easily solvable numerical solution. While electromagnetic fluxes were evaluated through Steger-Warming flux vector splitting. MHD-LBM models have shown to have greater accuracy when it comes to plasma shockwaves, therefore MHD-LBM models have good reason for continual development.

22.2 A Hamiltonian Framework on ICF Implosions Rocket Equation Based on Rayleigh–Taylor Instabilities

22.2.1 Background

Inertial Confinement Fusion (ICF) Implosions: One of the primary methods of heating fusion environments is through lasers. In this approach, high-energy lasers heat spherical fuel capsules, causing them to implode. This implosion leads to an increase in pressure and heat on the fuel, creating the necessary environments for fusion.

Hamiltonian: A Hamiltonian is a function in classical mechanics that describes the total amount of energy in the system. From here, equations of motion are derived.

Rayleigh–Taylor Instabilities: Rayleigh–Taylor instabilities are specific types of instabilities caused by forceful interactions between higher and lower density fluids. In the context of ICF Implosions, when the higher density outer shell interacts with the lower-density inside, it creates perturbations through finger-like structures and bubbles that interfere with the efficiency of the implosion.

Mass Ablation (Rocket Effect): During the process of ICF Implosion, the interaction between the outer shell and the inner fuel causes mass to be sprayed off, giving a rocket-like effect.

22.2.2 Problem Statement

Achieving commercial fusion energy through inertial-confinement-fusion (ICF) remains one of the most significant scientific and engineering challenges of our day. One of the key obstacles is optimizing the interactions between high-energy lasers and fuel capsules, which are prone to Rayleigh-Taylor instabilities during implosions. These instabilities can lead to inefficient energy confinement and hinder the overall success of the fusion process. Traditional numerical simulations are computationally expensive and often lack the accuracy needed to address this issue. Therefore, there is a need for a robust analytical framework to model these instabilities and provide new insights for optimizing the interactions. This research aims to develop a Hamiltonian framework for ICF implosions, specifically focusing on Rayleigh–Taylor instability and mass ablation. By leveraging this theoretical approach, we seek to provide deeper insights and practical solutions for optimizing laser-capsule interactions in fusion experiments.

22.2.3 Assumptions

Thin-Shell Approximation: The thickness of the shell is assumed to be insignificant compared to the size of the imploding object. This approximation simplifies the creation of the model and the subsequent numerical analysis. It is valid given that the perturbations caused by the instabilities are much larger than the actual thickness of the shell.

Deceleration: This model is specifically for an imploding spherical shell that decelerates as it converges onto the compressed fluid within its interior.

Acceleration: This model does not consider the acceleration phase of an ICF capsule implosion at the beginning of the capsule-laser interaction.

22.2.4 Framework

In order to analyze the dynamics of the imploding shell, it must first be parameterized through two Lagrangian coordinates ϑ and ϕ. Here, ϑ corresponds to the polar angle θ, and ϕ corresponds to the azimuthal angle. The position vector is $\mathbf{X} = \mathbf{X}(t, \phi, \vartheta)$. Thus, the parameterization can be expressed as:

$$\mathbf{X} = \mathbf{X}(t, \phi, \vartheta)$$

The derivative of the surface is given by:

$$\frac{d\mathbf{X}}{dt}$$

Reference: D. E. Ruiz; Degradation of performance in ICF implosions due to Rayleigh–Taylor instabilities: A Hamiltonian perspective. Phys. Plasmas 1 December 2024; 31 (12): 122701.

22.2.5 Shell Kinematics

The force differential can be described by:

$$dF = p(t) \cdot \mathbf{dA} \times \mathbf{n}$$

where $p(t)$ is the function of pressure with respect to time, and the cross product involves the vectors following the surface of the shell. This leads to the derivation of several important quantities, such as the velocity vector field, position vector, and centrifugal forces, which are relevant to the shape and dynamics of the shell.

An example of the centrifugal force is:

$$F_{\text{centrifugal}} = m \cdot \omega^2 \cdot r$$

22.2.6 Shell Areal Density

The change in density of the shell is critical to its dynamics. Given that total mass is not conserved in this equation, deriving it becomes more complex.

$$\rho_{\text{areal}} = \frac{M(t)}{A}$$

where $M(t)$ is the mass at time t, and A is the area of the shell's surface.

22.2.7 Compressed-Fuel Pressure

The pressure that decelerates the shell can be described in several ways depending on the known information and boundary conditions. One example is:

$$P = P_0 \left(\frac{V_0}{V}\right)^{\gamma}$$

where P_0 is the initial pressure, V_0 is the initial volume, γ is the adiabatic index, and V is the current volume.

22.2.8 Variational Principles

To mathematically solve the Hamiltonian framework, given that the equation is asymptotic, variation principles are applied.

22.2.8.1 Phase-Space Lagrangian

This formulation describes the dynamics of a system by combining its configuration space (position variables) and momentum space into a single framework, called phase space.

Euler–Lagrange Equations

Through the principle of least action, a set of differential equations are derived to provide an analytical solution to complex nonlinear functions. For example, for radial velocity:

$$\frac{d}{dt}\left(\frac{\partial L}{\partial \dot{r}}\right) - \frac{\partial L}{\partial r} = 0$$

where L is the Lagrangian of the system.

22.2.8.2 Conservation Laws

Generally, conservation laws are employed to show that certain parts of the Euler-Lagrange or phase-space Lagrangian are conserved. However, due to mass ablation, parts of the fuel and capsule are lost, which complicates these conservation laws.

22.2.9 Conclusion

Summary: A Hamiltonian framework was developed to include both Rayleigh–Taylor Instabilities and mass ablation in an inertial confinement fusion implosion, leading to a set of variational principles for future work on optimizing ICF implosions in practical applications.

Significance: Analytical analysis can provide future insights into optimizing ICF implosions in fusion reactors. Additionally, nonlinear numerical models can be developed based on these principles, leading to less computationally expensive models.

Limitations:

1. This model does not account for more complex laser-plasma interaction phenomena (e.g., bremsstrahlung x-ray losses, alpha heating).

2. This model does not consider the initial acceleration phase of the interaction.
3. This model uses the thin-shell approximation, which may not be accurate when perturbations caused by instabilities are smaller than the shell thickness.

Future Works:

1. Quasilinear Models To study additional insights from this model, a quasilinear model must be developed for analytical study.
2. Acceleration Phase Incorporating the initial acceleration phase into the model will increase its accuracy.
3. Nonlinear Growth Calculations Developing nonlinear numerical simulations will be useful in generating further insights and advancing current models.

22.3 Basic MHD

22.3.1 MHD Module

The first section of it is initializing the values of things like magnetic field, pressure, and velocity. Future work will be done to have it so such values can be edited in a config file.

Next is computing the current density. The analytical equation can be written as

$$J = \frac{1}{\mu}\nabla \times B$$

Which in finite difference is:

$$J_z(i,j) = \frac{1}{\mu_0}[\frac{B_y(i+1,j) - B_y(i-1,j)}{2\Delta x} - \frac{B_x(i+1,j) - B_x(i-1,j)}{2\Delta y}$$

Next we have

Update: I have advanced the MHD simulations time steps, magnetic field calculations, current, pressure calculations, and density calculations. Beyond that I have created animations based on magnetic field and made graphical outputs for heat, velocity, temperature, and magnetic field.

I also created another one specifically made for Tokamak geometry.

22.3.2 Hamiltonain MHD

My next project was creating a Hamiltonian based MHD simulation also in FORTRAN.

I explicitly created simulation of plasma thrusters with it.

22.4 A Metriplectic Formulation of Reduced Magnetohydrodynamics with Resistivity

22.4.1 Introduction

Here I will use the Strauss formulation of RMHD. Then I will incorporate resistivity. This resistivity typically breaks Hamiltonian structure, but I will use metriplectic to preserve the geometric identities through adding a separate antisymmetric bracket.

22.4.2 Defining the Hamiltonian

For Strauss MHD, a reduced MHD model that works for strongly magnetized Plasmas, we will formulate the Hamiltonian system.

$$\mathcal{H}[\omega, \psi] = \frac{1}{2} \int (\phi\omega + \psi j) dxdy$$

Here the $\phi\omega$ represents the kinetic energy with ψj represents the magnetic energy.

Now onto the Noncannonical Poisson Structure for this ideal Hamiltonian.

$$\{F, G\} = \int \omega[\frac{\delta F}{\delta \omega}, \frac{\delta G}{\delta \omega}]dxdy + \int \psi([\frac{\delta F}{\delta \omega}, \frac{\delta G}{\delta \psi}] - [\frac{\delta G}{\delta \omega}, \frac{\delta F}{\delta \omega}])dxdy$$

22.4.3 Entropy and Dissipation

Now to add dissipation. While generally adding this will break Hamiltonian structure, we will use a couple of tools.

Though first we must define our function we are using, or more accurately funcional. This is our functional for entropy:

$$S[\psi] = \frac{1}{2} \int \psi^2 dxdy$$

22.4.4 Metric Bracket and Metriplectic Structure

To incorporate we define our symmetric bracket. We make sure to construct it so that it only affects the magnetic flux variable ψ, since resistivity only affects the magnetic field lines and not vorticity directly.

$$(F, G) = \int \frac{\delta F}{\delta \psi} \eta \nabla^2 \frac{\delta G}{\delta \psi} dxdy$$

This has

- Symmetry $((F, G)) = ((G, F))$
- Positive semi-definiteness: $((S, S)) \leq 0$
- Energy Conservation: $((\mathcal{H}, F)) = 0$ for any F

22.4.5 Combined Dynamics

22.5 Death Star

Not to long ago(from when I wrote this section) I tried to simulate the death star using FLASH-X(which is really a testament to who I am as a person, getting my hands on government codes and the fist thing I do is play around with pop-culture based planetary destruction) anyways. It failed. The laser dynamics were based upon old code that was outdated and I couldn't figure it out. Though I did learn a lot about Flash-X as a system, which is good.

So for it... what am I doing, this doesn't make sense if I am trying to teach myself through practical action of writing but I already did the most practical action of all, doing it. This is kinda useless.

I later went back and ended up actually making the simulation.

22.6 Interstellar travel

22.6.1 Speeds and forces

Before we can get to all of the more complex stuff about design and the effects of extreme environments of specific interstellar space travel we must first look at how forces effect speeds at at relativistic speeds. Here is the math stuff in simplified form: We all know that force is the derivative of the momentum over time:

$$F = \frac{dp}{dt}$$

Where momentum can be expand for relativistic momentum:

$$p = \gamma m v$$

You can then expand force to be(this is a constant mass, we will look at that in a second)

$$F = m\frac{d(\gamma v)}{dt}$$

One thing to keep in mind for future maths is that in simplifying $\dot{\gamma}$ is equal to $\frac{\gamma v}{c^2}\frac{dv}{dt}$ With the force you can calculate acceleration with

$$a = \frac{F}{m\gamma}\frac{1}{1+\frac{\gamma^2 v^2}{c^2}}$$

Due to the fact most rockets use propulsion which lowers the mass, we must include mass variations:

$$F = \frac{\gamma m v}{dt}$$

Where you must use the product rule to expand

$$F = \dot{\gamma} m v + \gamma \dot{m} v + \gamma m \dot{v}$$

Which can be further expanded to

$$F = mv\frac{\gamma v}{c^2}\frac{dv}{dt} + \gamma v\frac{dm}{dt} + \gamma m\frac{dv}{dt}$$

With $\dot{m}$ being the infinitesimal change in mass over time.
To calculate acceleration you must find $\frac{dv}{dt}$. First subtract the middle equation without acceleration within it.

$$F - \gamma v\frac{dm}{dt} = mv\frac{\gamma v}{c^2}\frac{dv}{dt} + \gamma m\frac{dv}{dt}$$

Then factor for acceleration

$$F - \gamma v\frac{dm}{dt} = \frac{dv}{dt}(mv\frac{\gamma v}{c^2} + \gamma m)$$

Then divide the parentheses:

$$(F - \gamma v\frac{dm}{dt})\frac{1}{mv\frac{\gamma v}{c^2} + \gamma m} = a$$

Now, this is all well and good, now let us find the position. To take position from acceleration you must take a double integral, but this integral can only be solved numerically(maybe it could be approximated)

Another possible way to solve this is through Hamiltonians/Lagrangians (I will choose Hamiltonians)
Let us first start with the Hamiltonian expressed for relativistic speeds in covariant form
First the Lagrangian must be calculated: The four-momentum is

$$P^{\mu} = m\gamma(c, v)$$

Energy:

$$E = \gamma mc^2$$

Therefore the Lagrandian is:

$$L = -mc^2\sqrt{1 - \frac{v^2}{c^2}}$$

Now to find generalized momentum:

$$p = \frac{\partial L}{\partial \boldsymbol{v}}$$

$$p = \gamma m v$$

Now the Hamiltonian

$$H = p \cdot v - L$$

Therefore a relativistic Hamiltonain can be represented as

$$H = \sqrt{(pc)^2 + (mc^2)^2}$$

Now to include acceleration

$$H(r, p) = \sqrt{(pc)^2 + (mc^2)^2} + V(r)$$

Now to make mass variable for the rockets:

$$H(r, p, t) = \sqrt{(p(t)c)^2 + (m(t)c^2)^2} + H_{thrust}$$

Now to incorporate with equations of motion:

$$\frac{dr}{dt} = \frac{pc^2}{\sqrt{(p(t)c)^2 + (m(t)c^2)^2}}$$

Now, this works for the time for most people, now let us look at proper time

$$H(r, p, \tau) = \sqrt{(p(\tau)c)^2 + (m(\tau)c^2)^2} + H_{thrust}$$

For specific cases, these equations will be evolved to include them, but this is the general theoretical framework.

One thing I will add, is the force will likely be variable, a couple of days of 2-3 g, most of the time in g then reversing after the half-way point.

22.6.2 Magnetic Fusion Plasma Drive

22.6.2.1 Theoretical Basis

Magnetic Fusion Plasma Drive is a type of propulsion system specifically for interstellar travel.

The basis of this concept is that there is a fusion reactor undergoing Thermal Nuclear fusion:

$$D + T \rightarrow^4 He + n + 17.6MeV$$

The spent fuel then being shot out the nozzle as propulsion.

22.6.3 *Optimization

22.6.4 *Special Circumstances

22.6.4.1 *Strong Magnetic Fields

22.6.4.2 *Gravitational Fields

22.7 Kerr Black hole stuff

22.7.1 Energy (finish)

Kerr Black holes, or spinning black holes are a great source of energy. They have extreme amounts of radial kinetic energy that we are actually capable of 'bleeding' off through several methods.

First, we must ask why we are able to do this. Well, because a rotating object with a strong gravitational field 'drags' spacetime, that spacetime can affect the direction, speed, and even waves in a way that can amplify them.

First, Penrose(really like that dude) found that if you break apart an object rotating a Kerr black hole, the object that escapes gains energy. This process is challenging given that the object that escapes must have a velocity of $v > \frac{c}{2}$. There is a whole lot of math involved in proving this, but I will skip ahead.

The next that is found is that electromagnetic waves can be amplified. That if they are reflected around the black hole, they will gain energy and be amplified(this process is different from the Doppler shift and does not change the frequency.

After a lot, and I mean a lot of very complected mathematics you can find the amplification factor as

$$Z = 8r_+^2 T_{H(^{2l+1}))}(r_+ - r_-)^{2l}[\frac{\Gamma(1+l-s)\Gamma(1+l+s)}{2l+1)!!\Gamma(l+1)\Gamma(2l+1)}]^2 \times,$$

$$\sinh\left(\frac{m\Omega_H}{r_+T_H}\right)\Gamma(l-\frac{im\Omega_H}{\pi r_+T_H}+1)\Gamma(l+\frac{im\Omega_H}{\pi r_+T_H}+1)$$

For more information visit here

Now the point of this is to take strange theoretical and apply it, so I will apply it for actual application. For this I will assume the average mass of 10 $M_\odot$ or ten solar masses. A spin of 0.98(if 1 refers to an extremal Kerr black hole)

First we must find out what a spin 0.98 really means for a $10M_\odot$ black hole. We can find this with a simple equation with a being the spin parameter, r being the radius, and M being the mass

$$\Omega = \frac{ac^3}{2GMr_h}$$

Though, for a kerr black hole the is slightly different to the swarzchild radius.

$$r_H = \frac{GM}{c^2}(1+\sqrt{1-\frac{ac}{GM}}$$

You know, I wanted to optimize the black hole engine, but I don't want to do that anymore, so I choice to move on.

22.7.2 *Multiversal Travel

22.7.3 *Other effects

22.8 *Extreme Theoretical Work

22.9 Astroid Game

22.9.1 Introduction

I have recently created a Python game based on the Atari game Asteroid.

22.9.2 Classical

Just like the regular game, nothing special.

22.9.3 Newtonian Gravity

This adds that the asteroids and UFO's mass, so they attract each other and add more challenges.

22.9.4 Dark Matter

Add the challenge of invisible mass attractors, though when you are close by they light up.

22.9.5 Relativistic

This adds time dilatation(time skips or slow downs), length contractions(changing shapes of objects), black holes, and even doopler effect.

Chapter 23

Omega-X

23.1 Pre-planing(part 1)

23.1.1 Ideas & Overarching Plan

Start with replicating 1D thermal fluid model, then start with more complex models, then experiment with other ways to do it, then dive deeper into the mathematics and hopefully come up with something(maybe metriplectic integrator), then create a code base, compare these systems to other traditional models, and create tokomak simulation(maybe, not sure if possible yet) that is it so far. Hopefully these ideas will evolve.

Basically, the whole idea is to create a Flash-X like project with Metriplectic formulism underlying the the dynamics rather than lagrangian or Newtonian. Obviously much simpler though.

23.1.2 Metriplectic 4-bracket algorithm for constructing thermodynamically consistent dynamical systems

23.1.2.1 Math

1: Identify dynamical variables 2: Propose energy and entropy functionals 3: Find Poisson bracket F, G for which entropy S is a Casimir invariant, $F, S = 0 \forall F$ 4: Construct metriplectic 4-bracket (F, K; G, N) via Kulkarni-Nomizu product by a new method that separates local thermodynamics from phenomenological quantities, giving the EoMs as Poisson bracket + 4-bracket

To find the Σ and M a new method is derived.

$$\partial_t \xi^\alpha = \{\xi^\alpha, H\} + \nabla \cdot J^\alpha$$

$\alpha = 1, 2 ... N - 1$

$$\partial_t \xi^N = \{\xi^N, H\} + \nabla \cdot J^N + Z_\alpha \cdot \tilde{L}^{\alpha\beta} \cdot Z_\beta$$

where $\xi_N = \sigma$, the entropy density. Above splits Hamiltonian and conservative. Which leads to:

$$M(dF, dG) = F_{\xi N} G_{\xi N}$$

$$\Sigma(dF, dG) = \nabla F_{\xi\alpha} \frac{L^{\alpha\beta}}{H_{\xi N}} \nabla(G_{\xi\beta})$$

23.1.3 A thermodynamically consistent discretizations of 1D thermal-fluid models using their metriplectic 4-bracket structure

23.1.3.1 Math

Edit: so I don't keep forgetting, ρ is mass density, m is momentum density, and σ is entropy density. Then for the thermodynamic quantities: η is specific entropy, u is velocity, and T is temperature Let $V_h = v_h \subset H^1(\Omega)$ be the degree-p continuous Galerkin finite element space defined over a uniform grid, τ_h, on Ω: i.e.

$$V_h = v_h \in H^1(\Omega) : v_h|K \in P_p(K), \forall K \in T_h$$

The discretizations is accomplished using the method of lines by positing that all dynamical fields have spatial dependence modeled in this Galerkin subspace. However, rather than discretizing the equations of motion themselves, we discretize the weak forms implied by the metriplectic formulation.
Let $(\rho_h.m_h.\sigma_h) \in V_h \times V_h \times V_h$ So that the discretized Hamiltonian and entropy can be given as:

$$H^h[\rho_h.m_h.\sigma_h] = \int_\Omega [\frac{1m_h^2}{2\rho_h} + \rho_h U(\rho_h, \frac{\sigma_h}{\rho_h}]dx$$

$$S^h[\sigma_h] = \int_\Omega \sigma_h dx$$

Then the Metriplectic 4 Bracket can be expressed through:

$$(F^h, K^h, G^h, N^h)_h = -\frac{1}{\text{Re}} \int_\Omega \frac{1}{T_h} \left[\left(K^h \partial_x F^h_{m_h} - F^h \partial_x K^h_{m_h} \right) \right],$$

$$\left(N^h \partial_x G^h_{m_h} - G^h \partial_x N^h_{m_h} \right) +,$$

$$\frac{1}{\text{Pr}\gamma - 1}\frac{1}{T_h}\left(K^h\partial_x F^h - F^h\partial_x K^h\right)\left[\left(N^h\partial_x G^h - G^h\partial_x N^h\right)\right]\, dx$$

Then the poission bracket is thus:

$$\{F^h, H^h\}_h(u_h) = -(m_h\partial_x u_h, \phi_m)_{L^2} + (m_h u_h, \partial_x, \phi_m)_{L^2} - (\rho_h\partial_x\eta_h, \phi_m)_{L^2} + (\rho_h u_h, \partial_x, \phi_\rho)_{L^2} - (\sigma_h\partial_x T_h, \phi_m)_{L^2} + (\sigma_h u_h, \partial_x, \phi_\sigma)_{L^2}$$

Now, one thing I will say is that this is not technically a Poisson bracket, because it is fails to satisfy the Jacobi identity. This is because it is impossible(or at least nobody has figured out a way to discretize fluid poission brackets.

To then find equations of motion, adding them together $F^h = \{F^h, H^h\}_h + (F^h, H^h; S^h, H^h)_h$ where F^h is the observable.

In the case of momentum we must let $\phi_\rho = \phi_\sigma = 0$ so that only ϕ_ρ the momentum test function in the finite element(FE) test space V_h.

$$(\phi_m, \partial_t m_h) + (m_h\partial_x u_h, \phi_m)_{L^2} - (m_h u_h, \partial_x, \phi_m)_{L^2} + (\rho_h\partial_x\eta_h, \phi_m)_{L^2} + (\sigma_h\partial_x T_h\phi_m)_{L^2}$$

Next, I will have $\phi_m = \phi_\sigma = 0$ to get continuity equations:

$$(\phi_\rho, \partial_g\rho_h)_{L^2} - (\rho_h u_h, \partial_x\phi_\rho)_{L^2}$$

Finally the entropy equation is derived in a similar fashion:

$$(\phi_\sigma, \partial_g\sigma_h)_{L^2} - (\sigma_h u_h, \partial_x\phi_\sigma)_{L^2} + \frac{1}{Re}[(\frac{(\partial_x u_h)^2}{T_h}, \phi_\sigma)_{L^2} - \frac{1}{Pr}\frac{\gamma}{\gamma - 1}[(\frac{\partial_x T_h}{T_h}, \partial_x\phi_\sigma)_{L^2} - ($$

To prove energy conservation

$$(\frac{u_h^{n+1}-u_h^n}{\Delta t},\delta h_h)=\frac{H(u_h^{n+1})-H(U_h^n)}{\Delta t}=0$$

Positive entropy production can be found through:

$$\frac{s_h^{n+1}-s_h^n}{\Delta t}=\frac{1}{Re}[(\frac{(\partial_x u_h^n)^2}{T_h^n},1)_{L^2}+\frac{1}{Pr}\frac{\gamma}{\gamma-1}\frac{(\partial_x T_h^n)^2}{T_h^n},1)_{L^2}]\geq 0$$

Let's figure out all we need to find for each equation, starting with momentum. Start with $M_{ii}=\phi_m$, this should be equal to dx, but I will confirm. Also need the time derivative of the momentum variational, u_h variational, ρ_h variational, T_h, η_h, and $\frac{1}{Re}$, reynolds number, decide later

$$M_{ii}=dx$$

$$u_h=(\rho_h,m_h,\sigma_h)$$

ρ_h, T_h, and η_h are the respective fields, initialized simply and evolved through the equation. Obviously $\rho_h,m_h,$ and σ_h evolve through their metriplectic equations of "motion." T_h, η_h, are evolved through these equations:

$$(\eta_h+\frac{m_h^2}{2\rho_h^2}-U(\rho_h,\frac{\sigma_h}{\rho_h})-\rho_h\partial_1 U(rho_h,\frac{\sigma_h}{\rho_h})+\frac{\rho_h}{\sigma_h}\partial_2 U(\rho_h,\frac{\sigma_h}{\rho_h},\phi_\eta)_{L^2}=0$$

$$(u_h-\frac{m_h}{\rho_h},\phi_u)=0$$

$$(T_h-\partial_2 U(\rho_h,\frac{\sigma_h}{\rho_h})\phi_T)_{L^2}=0$$

Nothing new is added in continuity
Entropy adds: Pr and γ

23.1.3.2 Coding

The first thing is to use a Galerkin Method for projecting PDEs into a finite-dimensional function space. (can base off of Firedrake, FEniCS, Galerkin, or another) M_{ii} in mesh.f90

The second thing to do is to initialize the parameters and states(use mesh to calculate field) in states.f90 (Pr, Re, γ for constants; initialize ($\rho_h, \sigma_h, m_h, \eta_h, T_h, u_h$)

Then functionals: calculates pointwise functional derivatives of the Total Hamiltonian and Entropy. in functionals.f90 (Update $\rho_h, \sigma_h, m_h, u_h$)

EOS.f90 is used to update the thermodynamic points(η_h, T_h)

Time step the program, by using Gauss-Legendre implicit Runge-Kutta methods in time_integration.f90

Run the Program(using the driver and makefile)

Input the outputs in io.f90

Some notes: $(f, g)_{L^2} = \int_\Omega f(x) \cdot g(x)$

An example would be, for a point in the momentum equation $(\phi_m, \partial_t m_h)_{L^2}$, or the mass matrix times the derivative of momentum functional as a function of time. Thus it makes it so $\phi_m = M_{ii} = dx$ thus, $(\phi_m, \partial_t m_h)_{L^2} = dx \cdot \frac{m_h}{\partial t}$

23.1.3.3 Future Work

The paper presents several ways to improve, or at least look into improving through future work.

Mainly, they mention that many different structure preserving methods exist and may be more suitable.

I also need to figure out how to make this codebase work for more examples

23.1.4 Metriplectic Framework for Dissipative Magneto-Hydrodynamics

23.1.4.1 My Introduction

In my time trying to figure out how to numerically solve metriplectic equations, someone beat me to dissipative magneto-hydrodynamics. Oh well, I can build off of.

Beyond that, the abstract introduces the paper better than I could, " The metriplectic framework, which permits to formulate an algebraic structure for dissipative systems, is applied to visco-resistive Magneto-Hydrodynamics (MHD), adapting what had already been done for non-ideal Hydrodynamics (HD). The result is obtained by extending the HD sym metric bracket and free energy to include magnetic field dynamics and resistive dissipation. The correct equations of motion are obtained once one of the Casimirs of the Poisson bracket for ideal MHD is identified with the total thermodynamical entropy of the plasma. The metriplectic frame work of MHD is shown to be invariant under the Galileo Group. The metriplectic structure also permits to obtain the asymptotic equilibria toward which the dynamics of the system evolves. This scheme is finally adapted to the two-dimensional incompressible resistive MHD, that is of major use in many applications."

23.1.4.2 Notes on introduction

They have an interesting word choice, "with its noble descendants of path integral representations," or Algebrization of dynamical systems appears to be the final destination of that virtuous route.

MSTDOF means "microscopic, statistically treated, degrees of freedom"

In this introduction they derive the metriplectic existence quite simply. Starting with the poission bracket

$$\dot{f} = \{f, g\}$$

In this case

$$0 = \{S, H\}$$

Thus it is the Casimir functionals of the Poisson bracket

$$\{C, f\} = 0 \forall f$$

From here we can define the Hamiltonian free energy.

$$F = H + \lambda C$$

Where λ is an arbitrary constant left. In MSTDOF, it is the minus of the tempeture.

To then expand the system, $\langle\langle f, g\rangle\rangle$ via F. So that $\langle\langle f, g\rangle\rangle = \{f, h\} + (f, g)$ and (f, g) is symmetric, bilinear and semi-definite.

Evolution is then given by

$$\dot{f} = \langle\langle f, F\rangle\rangle$$

(the symmetric bracket (f, g) will be defined so to cancel out the presence of the coefficient λ, removing it from the equations of motion).

(f, g) is defined so that H is conserved.

$$(H, f) = 0 \forall f$$

Thus metriplectic evolution reads:

$$\dot{f} = \{f, H\} + \lambda(f, C)$$

The Casimir to mimic entropy undergoes an evolution described by:

$$\dot{C} = \lambda(C, C)$$

Now, I like this introduction. Clearly showing the basic understanding on Metriplectic dynamics.

23.1.5 METRIPLECTIC FORMULATION OF VISCO-RESISTIVE MHD

The system observed is fully ionized plasma. Where dissipation takes place due to the finite viscosity and resistivity of the fluid. Also, heat conductivity is finite. Here is the SO(3)-covariant form.(expressing physical equations in a way that is invariant under rotations in three-dimensional space)

$$\begin{aligned}
\partial_t \rho + \partial_i(\rho u^i) &= 0 \\
\partial_t B^i + \varepsilon^{ijk}\partial_j E_k &= 0, \quad \partial_i B^i = 0 \\
\partial_t(\rho u^i) + \partial_j(\rho u^i u^j + p\delta^{ij}) &= \varepsilon^{ijk} J_j B_k + \partial_j(\eta\, \partial_j u^i) \\
\partial_t s + \partial_i(s u^i) &= \frac{\eta}{T}\partial_i u^j \partial_i u^j + \frac{\kappa}{T^2}\partial_i T \partial_i T + \frac{\mu}{T} J^i J^i
\end{aligned}$$

There is quite a bit to this equation, but I will move on.

One thing I will add is a new notation. $\dot{H} \overset{\partial}{=} 0$, it simply means that means that $\dot{H}$ and 0 only differ by a boundary term.

They then describe the poission bracket for ideal MHD(when dissipation does not happen, thus traditional poission bracket).

This equation has multiple Casimir observables. The paper mentions:

$$C[\rho, s] = \int_{\mathbb{D}} \rho \varphi(s) d^3x$$

Which within is both the total mass and entropy.

$$M[\rho] = \int_{\mathbb{D}} \rho d^3x$$

$$S[\rho, s] = \int_{\mathbb{D}} \rho s d^3x$$

Thus, mass and entropy are conserved. There are some other, but obviously for this purpose, use the entropy.

Taking the dissipative equations from the to combine $D = (\vec{D}^\rho, \vec{D}^v, \vec{D}^B, \vec{D}^s)$ something called an 8-uple. So we must want to define our metriplectic bracket as $\psi = (\psi, D)$ where ψ is the dynamic variables.

Uhm.. I just realized this wasn't the paper I thought it was. Good read, but I don't think I will continue these notes.

23.1.6 A least Action principle for visco-resistive Hall Magnetohydrodynamic with metriplectic reformulation

23.1.6.1 Abstract

The abstract persented says,

"We present a new variational formulation for Viscous and resistive Hall Magnetohydrodynamic. We first find a variational principle for ideal HMHD by applying the physical assumptions leading to HMHD at the lagrangian level, and then we add the viscous and resistive terms by the means of constrained variations. We also provide a metriplectic reformulation of our formulation, based on two canonical Lie-Poisson brackets for the ideal part and metric 4-brackets for the dissipative part."

They then go into all of these, I will begin with the Metriplectic for notes alone.

23.1.6.2 Metriplectic bracket, Hamiltonian and Entropy for Viscoresistive Hall MHD

They use the Inclusive curvaturelike tensor found in Morrison's recent work. Where the dissipation is included using a 4-bracket that have the same symmetries as a curvature tensor.

They take the assumption that the viscous tensor can be found to be

$$\sigma = \Lambda \nabla u_i$$

Where Λ is symmetrize and positive.

23.1.7 Variational discretizations of viscous and resistive magnetohydrodynamics using structure-preserving finite elements

23.1.7.1 Abstract

We propose a novel structure preserving discretization for viscous and resistive magnetohy drodynamics. We follow the recent line of work on discrete least action principle for fluid and plasma equation, incorporating the recent advances to model dissipative phenomena through a generalized Lagrange-d'Alembert constrained variational principle. We prove that our semi discrete scheme is equivalent to a metriplectic system and use this property to propose a Poisson spliting time integration. The resulting approximation preserves mass, energy and the diver gence constraint of the magnetic field. We then show some numerical results obtained with our approach. We first test our scheme on simple academic test to compare the results with estab lished methodologies, and then focus specifically on the simulation of plasma instabilities, with some tests on non Cartesian geometries to validate our discretization in

the scope of tokamak instabilities.

This paper

23.2 part 2

23.2.1 Coding(1D fluid)

23.2.1.0.1 Introduction My first step to creating my codebase is to create it for the simplest form. This is specifically made for the purpose of figuring things out, documenting it, and such things. So, I will be writing down each file.

23.2.1.0.2 mesh_1d Obviously, this mesh program creates the mesh for the program. The size N, the nodes x_nodes and the mass matrix M_{ii}. The rest are self explanatory but I will go into what the mass matrix is. It represents the discrete inner product of basis functions.

$$M_{ii} = (\phi_i, \phi_j)_{L^2} = \int_\Omega \phi_i(x)\phi_j(x)dx$$

So, M_{ii} becomes a metric tensor for program. It turns continuous inner products into discrete sums over coefficients.

It can be approximated through the ”lumped mass matrix” where $M_{ii} = dx$ Though, I use the trapezoidal mass matrix:

$$M_{ii}(1) = 0.5d0 * dx$$

$$M_{ii}(N) = 0.5d0 * dx$$

$$M_{ii}(2 : N - 1) = dx$$

For more information visit, `https://arxiv.org/pdf/2008.03883`

Listing 23.1: mesh_1d.f90

```
module mesh_1d
  implicit none
  private
  public :: initialize_mesh, x_nodes, dx, N, Mii

  ! Parameters
  integer, parameter :: N = 100          ! Number of spatial grid points (nodes)
  real(8), parameter :: L = 1.0d0        ! Length of the domain

  ! Mesh data
  real(8), dimension(N) :: x_nodes       ! Coordinates of each mesh node
  real(8) :: dx                          ! Uniform cell spacing

  ! Mass matrix (diagonal approximation here, for full FEM use full M)
  real(8), dimension(N) :: Mii           ! Lumped mass matrix diagonal

contains

  subroutine initialize_mesh()
    integer :: i

    dx = L / (N - 1)

    ! Initialize node positions
    do i = 1, N
      x_nodes(i) = (i - 1) * dx
    end do

    ! Lumped mass matrix: each diagonal entry is dx
    Mii = dx
```

```
    ! Uncomment below to use trapezoidal mass matrix
    Mii(1) = 0.5d0 * dx
    Mii(N) = 0.5d0 * dx
    Mii(2:N-1) = dx

  end subroutine initialize_mesh


end module mesh_1d
```

23.2.1.0.3 states_1d States then initializes the constants and fields. First the constants(parameters) used throughout the code. Re, Reynolds numbers. γ, compression of the fluid. Pr, Prandtl number, ratio of viscous to thermal diffusion.

Then, it initializes the discretion fields of entropy, momentum, mass, temperature, and specific entropy.

This should be modularized for the future to make this codebase iterative.

Now, what exactly to do. I think for this, have constants in a separate one. Then for the fields, I am not sure at this moment.

Listing 23.2: states_1d.f90

```
module states_1d
  use mesh_1d
  implicit none
  private
  public :: m_h, rho_h, sigma_h, eta_h, T_h
  public :: initialize_states

  ! Field arrays
  real(8), allocatable :: m_h(:)        ! Momentum
     density
```

```
  real(8), allocatable :: rho_h(:)      ! Mass
     density
  real(8), allocatable :: sigma_h(:)    ! Entropy
     density
  real(8), allocatable :: eta_h(:)      ! Specific
     entropy (diagnostic)
  real(8), allocatable :: T_h(:)        ! Temperature
      (diagnostic)
  real(8), parameter, public :: gamma = 1.4
  real(8), parameter, public :: Pr = 0.71
  real(8), parameter, public :: Re = 1000.0

contains

  subroutine initialize_states()
    implicit none
    integer :: i

    ! Allocate fields
    allocate(m_h(N))
    allocate(rho_h(N))
    allocate(sigma_h(N))
    allocate(eta_h(N))
    allocate(T_h(N))

    ! Set initial conditions (example: Gaussian
       density bump)
    do i = 1, N
      rho_h(i) = 1.0d0 + 0.2d0 * exp(-100.0d0 * (
         x_nodes(i) - 0.5d0)**2)
      eta_h(i) = 1.0d0
      sigma_h(i) = rho_h(i) * eta_h(i)
      m_h(i) = 0.5d0
      T_h(i) = (0.4d0) * eta_h(i)  ! Ideal gas !
         Uses EOS
    end do

```

```
  end subroutine initialize_states

end module states_1d
```

23.2.1.0.4 projection_matrix_1d Here the creation of two subroutines to simplify future calculations. First, initialize_projection_ma that simply creates matrix. Next, apply_weak_derivative(f, d_proj). This does:

$$proj = \sum_{i=1}^{n} (\sum_{j=1}^{n} D_{i,j}) * f$$

Where f is the observable. For future work, I think all I need to do for this one is create multiple for different dimensions.

Listing 23.3: projection_matrix_1d.f90

```
module projection_matrix_1d
  use mesh_1d
  implicit none
  real(8), allocatable :: D(:,:)
  public :: initialize_projection_matrix,
     apply_weak_derivative

contains

  subroutine initialize_projection_matrix()
    integer :: i
    real(8) :: dphi_dx
    if (allocated(D)) then
      deallocate(D)
    end if

    allocate(D(N, N))
    D = 0.0d0

    dphi_dx = 1.0d0 / dx

```

```fortran
    ! Loop over elements and assemble D
    do i = 2, N-1
      ! Local contributions from basis functions
         over each element
      D(i, i-1) = -dphi_dx / 2.0d0
      D(i, i  ) =  0.0d0
      D(i, i+1) =  dphi_dx / 2.0d0
    end do

    ! Optional: Neumann (zero derivative) at
       boundaries
    D(1,:) = 0.0d0
    D(N,:) = 0.0d0
  end subroutine initialize_projection_matrix

  ! Applies D to f to compute (phi_i, partial_x f)
  subroutine apply_weak_derivative(f, d_proj)
    implicit none
    real(8), intent(in)  :: f(N)
    real(8), intent(out) :: d_proj(N)
    integer :: i

    d_proj = 0.0d0
    do i = 1, N
      d_proj(i) = sum(D(i,:) * f(:))
    end do
  end subroutine apply_weak_derivative

end module projection_matrix_1d
```

23.2.1.0.5 mass_1d

Listing 23.4: mass_1d.f90

```fortran
module mass_1d
  use mesh_1d
  use projection_matrix_1d
  implicit none
```

```
contains

  subroutine compute_mass_flux(N, rho_h, u_h, rho_rhs)
    integer, intent(in) :: N
    real(8), intent(in) :: rho_h(N), u_h(N)
    real(8), intent(out) :: rho_rhs(N)
    real(8) :: flux(N)
    integer :: i

    ! Compute flux
    do i = 1, N
      flux(i) = rho_h(i) * u_h(i)
    end do

    ! Apply weak derivative
    call initialize_projection_matrix()
    call apply_weak_derivative(flux, rho_rhs)

    ! Divide by dx
    do i = 1, N
      rho_rhs(i) = -rho_rhs(i) / dx
    end do

    ! Boundary conditions
    rho_rhs(1) = 0.0d0
    rho_rhs(N) = 0.0d0

  end subroutine compute_mass_flux

end module mass_1d
```

23.2.1.0.6 momentum_1d

Listing 23.5: momentum_1d.f90

```
module momentum_1d
  use states_1d, only: Re
```

```fortran
  use mesh_1d
  use projection_matrix_1d
  implicit none
contains

  subroutine compute_momentum_rhs(N, rho_h, m_h, sigma_h, eta_h, T_h, rhs_m)
    integer, intent(in) :: N
    real(8), intent(in) :: rho_h(N), m_h(N), sigma_h(N), eta_h(N), T_h(N)
    real(8), intent(out) :: rhs_m(N)
    real(8) :: u_h(N), du_proj(N), mu(N), dmu_proj(N), deta_proj(N), dT_proj(N)
    integer :: i

    ! Compute velocity
    do i = 1, N
      if (rho_h(i) > 1.0d-12) then
        u_h(i) = m_h(i) / rho_h(i)
      else
        u_h(i) = 0.0d0
      end if
    end do

    ! Apply weak derivatives
    call initialize_projection_matrix()
    call apply_weak_derivative(u_h, du_proj)
    do i = 2, N-1
      mu(i) = m_h(i) * u_h(i)
    end do
    call apply_weak_derivative(mu, dmu_proj)
    call apply_weak_derivative(eta_h, deta_proj)
    call apply_weak_derivative(T_h, dT_proj)

    ! Compute RHS
    do i = 2, N-1
      rhs_m(i) = 0.0d0
```

```
      rhs_m(i) = rhs_m(i) - m_h(i) * du_proj(i) * dx
      rhs_m(i) = rhs_m(i) + dmu_proj(i) * dx
      rhs_m(i) = rhs_m(i) - rho_h(i) * deta_proj(i) * dx
      rhs_m(i) = rhs_m(i) - sigma_h(i) * dT_proj(i) * dx
      rhs_m(i) = rhs_m(i) - (1.0d0 / Re) * du_proj(i) * dx
    end do

    ! Boundary conditions
    rhs_m(1) = 0.0d0
    rhs_m(N) = 0.0d0

  end subroutine compute_momentum_rhs

end module momentum_1d
```

23.2.1.0.7 entropy_1d

Listing 23.6: entropy_1d.f90

```
module entropy_1d
  use states_1d
  use mesh_1d
  use projection_matrix_1d
  implicit none
contains

  subroutine compute_entropy_rhs(N, sigma_h, u_h, T_h, rhs_sigma)
    implicit none
    ! Dummy arguments
    integer, intent(in) :: N
    real(8), intent(in) :: sigma_h(N), u_h(N), T_h(N)
    real(8), intent(out) :: rhs_sigma(N)

```

```fortran
  ! Local variables
  real(8) :: flux(N), dx_u(N), dx_T(N)
  real(8) :: visc_prod(N), heat_prod(N), heat_grad
     (N), heat_term(N)
  integer :: i

  ! Compute flux
  do i = 1, N
    flux(i) = sigma_h(i) * u_h(i)
  end do

  ! Apply weak derivatives
  call initialize_projection_matrix()
  call apply_weak_derivative(flux, rhs_sigma)
  call apply_weak_derivative(u_h, dx_u)
  call apply_weak_derivative(T_h, dx_T)

  ! Viscous and thermal terms
  do i = 1, N
    visc_prod(i) = (dx_u(i)**2) / T_h(i)
    heat_grad(i) = dx_T(i) / T_h(i)
    heat_prod(i) = (dx_T(i)**2) / (T_h(i)**2)
    heat_term(i) = (gamma / (gamma - 1.0d0)) * (
       heat_prod(i) - heat_grad(i) / dx)
    rhs_sigma(i) = rhs_sigma(i) - (1.0d0 / Re) *
       visc_prod(i) * dx
    rhs_sigma(i) = rhs_sigma(i) - (1.0d0 / (Re *
       Pr)) * heat_term(i) * dx
  end do

  ! Divide by dx
  do i = 1, N
    rhs_sigma(i) = -rhs_sigma(i) / dx
  end do

  ! Boundary conditions
  rhs_sigma(1) = 0.0d0
```

```fortran
    rhs_sigma(N) = 0.0d0

  end subroutine compute_entropy_rhs

end module entropy_1d
```

23.2.1.0.8 velocity_1d

Listing 23.7: velocity_1d.f90

```fortran
module velocity_1d
  use states_1d
  use projection_matrix_1d
  implicit none
contains

  subroutine compute_velocity(N, rho_h, m_h, u_h)
    implicit none

    ! Dummy arguments
    integer, intent(in) :: N
    real(8), intent(in) :: rho_h(N), m_h(N)
    real(8), intent(out) :: u_h(N)

    ! Local variables
    integer :: i
    real(8), parameter :: eps = 1.0d-12   ! Small number to avoid division by zero

    ! Compute velocity safely
    do i = 1, N
      if (rho_h(i) > eps) then
        u_h(i) = m_h(i) / rho_h(i)
      else
        u_h(i) = 0.0d0
      end if
    end do

```

```fortran
  end subroutine compute_velocity

end module velocity_1d
```

23.2.1.0.9 EOS_1d_thermal

Listing 23.8: EOS_1d_thermal.f90

```fortran
module eos_1d
  use states_1d
  implicit none
  private
  public :: compute_temperature, compute_eta



contains

  ! ------------------------------------------------------------------------
  ! Compute temperature T from specific entropy eta
  ! T = (gamma - 1) * eta
  ! ------------------------------------------------------------------------
  function compute_temperature(eta_h) result(T_h)
    real(8), intent(in) :: eta_h
    real(8) :: T_h

    T_h = (gamma - 1.0d0) * eta_h
  end function compute_temperature

  ! ------------------------------------------------------------------------
  ! Compute specific entropy eta from temperature
  ! eta = T / (gamma - 1)
```

```
  ! ------------------------------------------------------------

  function compute_eta(T_h) result(eta_h)
    real(8), intent(in) :: T_h
    real(8) :: eta_h

    eta_h = T_h / (gamma - 1.0d0)
  end function compute_eta

end module eos_1d
```

Listing 23.9: time_integrator_1d.f90

23.2.1.0.10 time_integrator_1d

```
module time_integrator_1d
  use mesh_1d
  use states_1d
  use velocity_1d
  use eos_1d
  use mass_1d
  use momentum_1d
  use entropy_1d
  implicit none
  private
  public :: advance_one_step

contains

  subroutine advance_one_step(dt, u_h, rhs_m,
     rho_rhs, rhs_sigma)
    real(8), intent(in) :: dt
    real(8), intent(INOUT) :: u_h(N), rhs_m(N),
       rho_rhs(N), rhs_sigma(N)
    integer :: i

    ! Step 1: Compute velocity
```

```fortran
    call compute_velocity(N, rho_h, m_h, u_h)

    ! Step 2: calculate tempeture
    do i = 1, N-1
      T_h(i) = compute_temperature(eta_h(i))
    end do
    ! step three: calculate Eta
    do i = 1, N-1
      eta_h(i) =compute_eta(T_h(i))
    end do
    ! Step 4: Compute Galerkin RHS terms
    call compute_momentum_rhs(N, rho_h, m_h, sigma_h
       , eta_h, T_h, rhs_m)
    call compute_mass_flux(N, rho_h, u_h, rho_rhs)
    call compute_entropy_rhs(N, sigma_h, u_h, T_h,
       rhs_sigma)

    ! Step 5: Advance in time (Euler / RK1)
    do i = 1, N
      m_h(i)     = m_h(i)     + dt * rhs_m(i)
      rho_h(i)   = rho_h(i)   + dt * rho_rhs(i)
      sigma_h(i) = sigma_h(i) + dt * rhs_sigma(i)
    end do

  end subroutine advance_one_step

end module time_integrator_1d
```

23.2.1.0.11 io_1d

Listing 23.10: io_1d.f90

```fortran
module io_1d
  use mesh_1d
  use states_1d
  use velocity_1d
  use time_integrator_1d
  implicit none
```

```
  private
  public :: write_state_to_csv

contains

  subroutine write_state_to_csv(filename)
    implicit none
    character(len=*), intent(in) :: filename
    integer :: i
    logical :: wait
    real(8) :: u_h(N)
    integer :: ierr

    ! Ensure the output directory exists
    wait = .true.  ! Command should run
       synchronously
    call execute_command_line("mkdir -p output",
       wait, ierr)
    if (ierr /= 0) then
       print *, "Error: Could not create output
          directory!"
       stop
    end if

    ! Compute velocity u = m / rho
    call compute_velocity(N, rho_h, m_h, u_h)

    ! Open file for writing
    open(unit=10, file=filename, status="replace",
       action="write", form="formatted")

    ! Header
    write(10, '(A)') 'x,rho,m,sigma,u,T,eta'

    ! Data
    do i = 1, N
```

```
      write(10, '(F12.6,1x,F12.6,1x,F12.6,1x,F12.6,1x,F12.6,1x,F12.6,1x,F12.6)') &
        x_nodes(i), rho_h(i), m_h(i), sigma_h(i), u_h(i), T_h(i), eta_h(i)
    end do

    close(10)
  end subroutine write_state_to_csv

end module io_1d
```

Listing 23.11: momentum_1d.f90

23.2.1.0.12 1D_Thermal_driver

```
program omega_x_driver_1d
  use mesh_1d
  use states_1d
  use time_integrator_1d
  use io_1d
  implicit none
  real(8) :: dt, t, t_end
  integer :: step = 1
  real(8), dimension(N) :: u_h, rhs_m, rho_rhs, rhs_sigma
  character(len=100) :: fname

  dt = 1.0d-3
  t_end = 1.0d0
  t = 0.0d0

  call initialize_mesh()
  call initialize_states()
  u_h = 0.0d0
  rhs_m = 0.0d0
  rho_rhs = 0.0d0
  rhs_sigma = 0.0d0   ! Explicitly initialize rhs_sigma here
```

```
  do while (t < t_end)
    call advance_one_step(dt, u_h, rhs_m, rho_rhs,
       rhs_sigma)
    t = t + dt
    print *, 't = ', t

    if (mod(step, 100) == 0) then
        write(fname, '(A,I4.4,A)') "output/state_",
           step, ".csv"
        call write_state_to_csv(fname)
    end if

    step = step + 1
  end do
end program omega_x_driver_1d
```

23.2.1.1 Plans

I have now create it in its most basic form, here are my next steps.

Break states up into constants and fields(multi-dimensional fields)

Make operators folder for projection, weak derivative, boundary conditions

Add checks(mainly energy conservation)

Upgrade time integration,(figure out)

Make different spacial discretization

More boundary conditions

Add more physics

Though, the main thing I need to work on is module registry + driver pattern.

23.3 part 3

23.3.1 Notes

23.3.1.1 Notes on module FORTRAN

I should have a main driver like:

Listing 23.12: Omegax.f90

```
program Omegax
        use Driver_module
        implicit none

        call Driver_init()
        call Driver_evolve()
        call Driver_finalize()

end program Omegaz
```

There should also be a a config file, saying which modules should be used, and a python script capable of parsing this registery file. Config would also be where parameters would be stored.

23.3.1.2 Diminsionaless programing

In the config file I can have a section to input the diminsions.

Then have all variable allocatable based upon the diminsions

then have an allocation based upon such diminsions(either preprocessor or generic shape handling)

Instead of hardcoding loops, create cases for different diminsions.

Generaliz derivatives and fluxes.

Also, while physics sections should be generalized, initializing between 3D, would be beneficial.

23.3.1.3 Generalize

Due to Metriplectics dyanmics complex mathematics, a fully generalized system, like FLASH-X, is impossible. This is because it is a dynamical theory based upon Hamiltonian Mechanics, rather than forces in Newtonian.

I am thinking the way to fix this is to create a symbolic python code to be able to generate the function I need.

Also, since these would be in py

23.3.2 Plan

I think the steps I am going to take are:

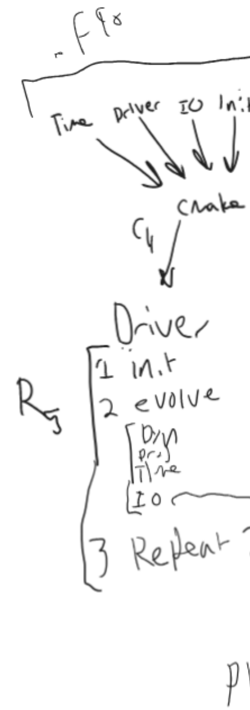
1: Develop a python code that can generate the math I need, I would also like for it to be able to read a LaTeX code for it.

2: I need to look into how to create a Config file for my problem at hand

3: Fix integration for this new system

4:

23.3.3 New Structure



Here is the basic idea of what it should look like and do:

Chapter 24

Axiom

24.1 *Structure

24.2 LaTeX

24.2.1 Division of Structure

In this program I have used this structure to divide the book up:

```
\part{}
\chapter{}
\section{}
\subsection{}
\subsubsection{}
\subsubsubsection{} % custom made
\paragraph
\subparagraph
```

I may have to learn new ways to divide in the future, but I will try to aviod that.

24.2.2 Commands

Here are some commands that I will have here for reference:

```
\begin{verbatim} writes things exactly, used mostly
for writing LaTeX commands in this method
\label{} → Set a reference point
\ref{} → Refer to numbered items

\pageref{} → Refer to page number

\nameref{} (requires hyperref) → Refer to name/title
of chapter/section

\autoref{} (requires hyperref) → Smart referencing
(automatically adds \Chapter", \Section")
\begin{equation} ... \end{equation} → Numbered
equations

\[ ... \] → Displayed, unnumbered equations

$ ... $ → Inline math

\frac{a}{b}, \sqrt{x}, \sum, \int → Standard
math symbols

\begin{align} ... \end{align} (from amsmath)
→ Multi-line aligned equations

\begin{cases} ... \end{cases} → Piecewise functions

\bra{}, \ket{}, \braket{} →
Use physics package for quantum notation

\tensor{} → Use tensor package
```

```
for tensor indices

\dv{}, \pdv{} → Derivatives (from physics)
\begin{figure}[h!] ... \end{figure} →
Insert figures

\includegraphics[width=0.8\textwidth]{file}
→ Image inclusion (graphicx)

\caption{} / \label{} → Caption and reference

\begin{table}[h!] ... \end{table} → Tables
```

I also have begin{lstlisting} to write both FORTRAN and make. I will likely add python and Julia

Chapter 25

Category-Theoretic Metriplectic

25.1 Plans

25.2 Papers

Here I will begin with a list of papers to use for my research in this study

- Baez, Weisbart Yassine — Open systems in classical mechanics

- John C. Baez Christopher L. Rogers — Categorified Symplectic Geometry and the String Lie 2-Algebra (2008/2009)

- Alan Weinstein — Symplectic categories (survey/paper, 2009)

- Brendan Fong — Decorated Cospans (2015) related work (Baez–Fong, Baez–Fong–Pollard)

- John C. Baez — expository / historical pieces on n-categorical physics
- P. Guha — Metriplectic structure, Leibniz dynamics and dissipative systems
- Work on double categories / structured cospans for open dynamical systems (Courser thesis; Kenny Courser; "Open Systems: A Double Categorical Perspective")

25.3 Review of Metriplectic systems

25.4 Understanding of Category-Theoretic Systems

25.5 My work

Chapter 26

Website

26.1 Brainstorm

I had thought of a couple of ideas, but had forgot to write them down. I guess I will just explain my final one.

My plan is to have it so it can parse one of my daily org files for a schedule, then can paste that schedule into the website to view. I would like to allow for checking things off, in progress, notes, and some other things I will get into at a later point.

I would also like to access my book easily through the website

26.2 2/16/2026

I meant to document what all I did and why through my journey, but I hadn't. Thus, at the moment I am finished.

Part IV

Essays

Chapter 27

Introduction

This part is used as a collection of essays on whatever topic. Whether it be philsophy, physics, economic, whatever.

Chapter 28

Post-Surgery

28.1 Overview

28.2 1/9/2026 Essay: Cultivation in Degregation

As mentioned in previous chapters, the development of virtue stands at the cornerstone of the existence of man. Thus, how to develop it is key.

The question of how to develop virtue, what virtues to develop, etc; differ from person to person. I will focus on myself for this essay, on a practical development, rather than in the abstract general way I would traditionally go for.

Specifically, I will focus on my recent 'degregation' in many fields. What I mean is I have been struggling with health problems that caused constant pain, nausea, and brain fog. To combate this I used "quick" and "automatic" gratification. Watched lots and lots, of Instagram videos and YouTube shorts. With quick and simple comedy TV in the background. While it is difficult to divide what is caused by using these simple causes of gratification and what is caused by my still recovering body, but I am having trouble focusing, get tired easily, less intrinsically motivated, and other similar malignities.

I have a belief that a person can create themselves based upon their habits. Thus, that is what I design to do, create myself in the image of my highest values. I desire that I am someone who enjoys challege for it own sake(especially intellectual challenge), persistent high energy, optimistic outlook, pro-social tendencies, high focus, and the continual push towards greater virtue in all fields of life.

To reach these goals I have decided to pick up "The Karamazov Brothers," a book I had abandoned earlier due to my declining condition. I did this not only for enjoyment, but to accomplish my goal. To slowly focus my mind on something that lasts longer than a minute, to remind myself of my enjoyment of intellectual type activities and engage my mind in something that could challenge it, and to reconnect myself with my faith.

I am also reading "Numerical Hamiltonian Problems," trying to learn to code a website, code personal pet projects, watch educational and long-form youtube videos rather than shorts, exercise each day, and write each day. I do all of these things to re-develop my attention, enjoyment of effort, regain my energy, and to develop my skills.

Developing myself on the social side of things is a bit more challenging. Currently as of writing this essay I am still isolated from my peers, but I have a plan. Teaching Sunday school, volunteering for church outreach groups, returning to my scout troop, participating in JROTC volunteer activities, teaching karate, and so much more. Things to redevelop my enjoyment and understanding of social responsibilities and natural altruism.

With this current plan in motion, I will start making purposeful and willful actions in order to develop in the way that I design.

28.3 2/16/2026: An alien unto myself

Chapter 29

Metaphysics

The verbal interpretation, on the other hand, i.e. the metaphysics of quantum physics, is on far less solid ground. In fact, in more than forty years physicists have not been able to provide a clear metaphysical model. — Erwin Schrodinger

29.1 Scientific Materialism and God

Despite the fact that there exist no formal term for such philosophies(I should come up with a name for it, Christian Scientific Materialism?)it in a broad stroke is most likely the most common view of meta-physics of all, though I plan to expand upon the concepts more deeply than that which is common. In essence this view can be summarized by the combination of two seemingly contradictory concepts:

First, is scientific materialism, this is the idea that there is nothing further than the material, that reality can be derived empirically through the laws of science and nature.

Second, the idea of the Christian God. That there exist an external omnibenevolent, omnificent, omnipotence, omnipresence, and omniscience as described by the Christian Bible. Later I will explain my faith in more detail, but for now this is sufficient.

You may be wondering how these concepts can be combined due to their seemingly contradictory nature. This is a simple enough question, if the material is all that exist how can a non-material God exist? The answer in all reality is very complex, but it can be simplified to the fact that I view the material world to follow the philosophy of scientific materialism but there to also be a non-material "world" that God exists within. The reality of such a non-material world is sadly beyond my grasps due to my life within the material, I make no assertion that I understand such things. Partly because by definition such things are not possible to understand, like a 4th spacial dimension. While we can understand it through analogies and abstraction based upon prior more concrete idea, but sense we have no clear or objective priors we have no capacity to do such.
You can simplify such thoughts through formal logic

Let:
X=Material
Y=Non-Material
C=Laws of nature and reality
C(X)=Matter/Energy/Both interactions(all material action)
C(X,Y)= Observable phenomena A=Scientifically explainable phenomena

$$X \Longrightarrow C$$

$$C(X) \Longleftrightarrow C(X) \models A(X) \top$$

$$\forall C(X, Y) \exists C$$

$$\nexists Y(C) \therefore \nexists A(Y)$$

29.2 Scientific Realism vs Anti-realism

What is scientific realism and anti-realism? It is the debate between whether our theories of science are ontologically real, or simple predictive models.

My view is that it depends, when it comes to macroscopic and easily observable and prove able; these theories aren't true. You may be thinking the opposite, that it is those that are most definitively true and the rest that aren't. Though I would argue these are the models; a ball don't fall; a collection of subatomic particles follow their geodistic, which is restricted by other particles and forces, and so much more. This can be applied to all things other than the most fundamental of physics. It can especially true for the softer sciences; chemist, biology, psychology, and so many more.

While I think science does study the metaphysical truth through fundamental physics and abstract mathematics, on a broad stroke it does not.

29.3 Causality

Now I am sure you are confused, I mentioned I would dive into deeper questions related to free will, determinism, what is real, divine voluntarism, occasionalism, how quantum mechanics plays within this and other 'deeper' concepts, but we must take things one at a time.

So, let us dive in. What is causality, it is very simple. It is the concept that things happen because other things had happened first. That all things have a 'cause' and that that thus causes the effect(then they later become the cause of a later thing)

I can hear you screeching that this is non-sense, who in their right mind would question something as basic as cause and effect? Why even look into it. First, that is extremely intellectually lazy, all things have debates against it, you should always look into it. Though, more importantly, there actually are debates against it.

The easiest to dismiss is Hume's skepticism, that causality is simply a human made concept. That things doesn't really happen because of another action but simply that both actions are just sequences of events. Though, I would argue that this pedantic argument of definitions doesn't truly work. On an epistemological basis, causality is easier for humans to understand, and though breaking things into chunks we may better understand the world. That either concept is equally true, but one concept as a greater pragmatic 'truth' and you can argue that that correlates to a better empirical truth. That there is even a speed of causality written in the nature of reality.(The speed of light) A bit more deeply, once you quantize to the plank time, things truly do divide. Something happens, then a next thing happens. The complexity and abnormal reality of quantum mechanics makes this argument a little fuzzy, and thus leads me to my next paragraph.

Now those unfamiliar with quantum mechanics may be confused, how does quantum mechanics may be a little confused. I will attempt to explain it to the best of my ability, but the reality of quantum mechanics is extremely complex and without a clear understanding of differential equations, discrete mathematics, linear algebra, and much more it is impossible to understand. I know many science communicators claim to teach "quantum physics and mechanics" to they layman, but this is a lie. These half backed analogies are not quantum mechanics. It does not come close, but luckily for me I am the only one reading this book I will be able to understand my attempt of analogizing(?) the philosophical question.

In essence, in quantum mechanics. Things are not local, for many reasons. The most basic is the idea that particles do not exist in the way we can imagine. They exist in multiple places at the same time[not really but useful analogy], simply with different probabilities(don't pretend to understand, nobody does, they just prove the math and accept as is.) You know what, that analogy was not enough. I will explain in more detail. Particles do not exist(not really). Simply quantum fields exist. The electron field for electrons, the photon for photons, and so on. The particles are not particles as we imagine, but excitations within the field. It is a bit more complex than that, they can act as particles when observed but that is a whole other can of worms. Now back to the matter at hand, now waves act in certain ways that is hard to explain. Due to their quantum nature they must be decomposed first through Fourier modes to under stand more clearly. This is an example of a very simple form:

$$\psi(x) = \frac{1}{2\pi} \int \phi(p)^{ipx} dp$$

Now I won't explain the equation in its entirety but I will say this. That you cannot solve it for an absolute certainty of position(not that you could get a "true" answer even if you could given that is is a Taylor Mode and not an analytical equation). Now you may think this is just a quirk of the math, but it is not. It is real for reason that could take up the entirety of this book if I truly understood them.

Next, quantum mechanics goes against causality through entanglement. Now what do I mean, when people refer to the speed of light, they are actually referring to the speed of causality. To explain this is relatively simple with a good understanding of Special Relativity. It is obvious that the universe is invariant to position and velocity(this has been previously proven thoroughly through experiments in high speeds, specifically through electromagnetism but others can apply), but for this to be true there must be a finite constant cosmic speed(because it requires a Lorenz transformation[there is more explained why this si the only answer but I will leave this hear because I have much much more physics to talk about in a philosophy book.]) This is the speed of causality, the speed of information. If something were to go above this speed it would in essence go back in time. This can be proven rather simply through simple algebra:

$$t' = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}(t - \frac{vx}{c^2})$$

From here you can look at the square root and easily find that if $v > c$ then γ(the value of the first part with the $\frac{1}{\sqrt{1-\frac{v^2}{C^2}}}$ would be imaginary. Thus the t value(of time would then become negative, this obviously breaks causality.

Finally, back to quantum mechanics, as you know entanglement transfers information at faster than the speed. This seems to break causality.

Now I could keep on talking about arguments between quantum physics and causality, but I will only talk about one more. Virtual particles. Now first of all, what are virtual particles. Virtual particles are non-existent but existent particles that exist within the math of quantum field theory(and thus above my pay grade) but I will attempt to explain it. The idea in essence is that due to the uncertainty principle there exist small amounts of excitements within their fields. These excitements are not enough for an actual particle to exist in the way we imagine, but occasionally a particle can appear, primary through the use of ”borrowing” energy from another particle or through creating a negative particle(not to be confused with anti-particles those are negatively charged, these have negative energy/mass) These virtual particles are especially important to particle interactions, what I mean is the fact that when two particles are "close" enough together they excite the fields around them to create bosons(force carriers) to cause the actual interaction. As an analogy, imagine two electrons, when close enough together they excite the fields around them to create a virtual photon, the photon then interacts with one electron(and also effects the other electron negatively[it is almost impossible to explain]) and cause the electromagnetic repulsion between the two. Now, back to philosophy, what in the world does this ramble have to do with causality. That is a great question. It is that all of our interactions are based upon something that isn't real. Electrons don't actually create virtual photons, these photons don't create negative photons. Despite having a tangible effect, they don't actually exist. How can something cause another thing if when you break it down to its component parts, particles are behaving 'irrationally' being effected by mathematical objects.

Now after I have listed the critiques, you are probably very aware about how you assumption of the obvious state of causality was intellectually lazy, but you probably also realize I wouldn't have written all of this unless I have an answer to these critiques, or at the very least a possible answer. In all reality I could be wrong about this and causality could be false. Though I am never wrong, so that must not be true.

The uncertainty of particles doesn't necessarily falsify causality, it simply evolves it. We previously see causality as something that is caused by a specific thing, but it can be caused by a probability of things(if that make sense).

Next I will talk about virtual particles, and yes I hear you saying that I should go in the order of which I introduced the ideas, but I do not care. Now, virtual particles. How does causality work with things that are not 'real'? Now the most astute among you might claim, why would causality not apply, and you are exactly right! You all may feel a sense of betrayal, that it was simply a trick of the light. But now, listen carefully, this is how philosophy works. Though asking questions that are hard to understand, questions that play tricks on our language, on our mind. Though these questions we refine our thoughts. This is the problem with modern philosophy, they confuse critiques with criticism. While criticism has a place within philosophy, it should not be as big as it is now. Now before I continue I will define why I consider a critique and a criticism as different things. A criticism takes a part an idea, concept, action, or really anything for the sake of taking it down. This can be justified if such ideas have no worth and the criticism is an attempt to prove it. A critique is a question used to refine a thought not destroy it.(though if the critique can not be resolved then it may.) This critique of virtual particles is not supposed destroy causality by any means, but like the earlier critiques, it is meant to refine our thoughts. It asks us to question what a cause is, what can be a cause. Can virtual particles be causes, modern science suggests yes, but this requires a refinement of our concept of causality. Of what is 'real.' In a later section I will delve into this in a future section, but now I will leave you to ponder.

Now finally, to entanglement. Does this refine our definition or break it? It breaks it, but due to the evidence surrounding causality, including the fact that the special and general relativity are simply logical derivatives of the idea of a finite special to causality suggests that our idea of entanglement is flawed not our idea of causality. Now what is the answer? In short, nobody knows. There are many theories trying to come up with a solution. These include Einstein-rosen bridge, superdeterminism, and local hidden variables theory. Though since these ideas are both extremely complex and offer little beyond the problem at hand I have elected to move on. Now you may say that my Faustian arrogance has lead me astray to ask questions I can't answer, and to that I say… No dummy.

Now you may think we are done, we are not. We haven't even mentioned the nature of God in causality and the teleological nature of Hamiltonian mechanics. There is also further refinements of time which must be discussed to even further define causality.

29.4 Divine Law Theory of Causation

You thought I was done with with causality. You thought wrong.

Now, what is the Divine Law Theory of Causation. It is very simple, it is that God predefines the laws of physics and nature. This differs from the ideas of occasionalism. Occasionalism is that all actions are the conscious decision of God, that the uniformity of the laws of nature is simply a coincidence.

Now, why do I choice Divine Law Theory of Causation? While I do not attempt to venture into the idea that I can even begin to comprehend the machinations of the God most high. Though in my mind the idea of predetermined laws make more sense, a more efficient method for God. Though this is not my primary reason for this belief. As I will mention latter in this chapter I will explain several beliefs of my predicated upon divine law theory of causation. Also, it is more in-line with scientific materialism

29.5 Material, Immaterial, and Reality itself

Now we are getting to the meat of things. What makes something real? What makes something itself? How do we define such things?

These are all great questions that I will go through one by one.

I will begin with what makes something real. While it is easy to look at things in the materialistic view, that of which that can be observed and have an observable effect is "real." No this has some implications, what about what about God(this is based on my assumption that he is 'real') but more importantly what about things that have an effect but of the concept of virtual particles.

First, the immaterial. Given the fact that by definition, these things are beyond us I will ignore them because we cannot gain any intuition from it. Just remember that it must be included within the concept of real, simply we are unable to define it accurately.
M= Material
I=Immaterial
$\mathbb{R} = Real$

$$M \wedge I \subset \mathbb{R}$$

Finally, back to virtual particles, I have kept you in suspense enough. How do we satisfy the existence of virtual particles? Just as we have several times before, say it with me, we must refine the definition. Now, how to do this. We must first realize that at the subatomic level, no particles are particles in the way we describe it, as I mentioned earlier they are simply excitations within a field. They are energy in a specific manner. rom here we can divide the material into two types; true material and partial material. The true material refers to what we generally consider matter, and the the partial(photons, gluons, and other massless but still interacting objects.) Which leads me to my final definition; material is that with observable effect[observable does not just simply mean seen, it can be any form of observation].

29.6 Identity

While many have abstract ideas on the identity of object, I will simple say that all subatomic particles are identical and thus it is not hard to define, and the others are simple as humans(another word defined by humans) define it. Good day gentlemen

29.7 SpaceTime

Space and time, the two things most clearly and least clearly understood at the same time. Things that we know do to our interactions with it every second(ha-ha) of our lives but still don't truly understand.

Many philosophers have questioned the reality of space and time. Are they simply human made? I would suggest not, the mathematical empiricalism and importance of them in higher level physics points to their real nature.

You can see this clearly through special relativity, there is an implied "proper" time at which things like electromagnetism operate correctly and without it our modern view of physics collapses.

Now you may ask about quantum mechanics, where such ideas of concrete space and time become fuzzy. Where particles exist within multiple place, some theories suggests 'time travel"(not real time travel) and other. Though, as I have mentioned before, I think his more evolves our ideas matter than our ideas of space and time. Also, there are examples of the objectiveness of space and time through things like quantum field theory(combines special relativity) and the Plank constants. You can't have constants of space and time without an objective reality of space and time. Now, what is the Plank length and time. They are the units of which distance and time become quantized, and some suggest the smallest units possible. Now, that seems like an odd idea, especially considering how much smaller it is that anything real and the random constants within it $c, G, \hbar$. Speed of light(or causality), gravitational constant, and reduced Plank constant. This is because as you get smaller and smaller there is a new uncertainty, a 'plank' uncertainty. Beyond this the uncertainty becomes absolute. That the realities of a new quantum gravity take hold The easiest way to look at this is through finding at what point the wave-length of light(our primary method of observation) becomes a black hole.

29.8 Interpretation of Quantum Mechanics

The long awaited further explanation of my views on quantum mechanics. Throughout this chapter, I have hinted at these ideas of interpretations of quantum mechanics. Also, throughout this I have primary relied on the Copenhagen interpretation of quantum mechanics. Which may lead several into seeing this as my view of quantum mechanics, it is not(I will elaborate further later.) Though let us first go through the different interpretations of quantum mechanics.

The Copenhagen interpretation. In essence the Copenhagen, the most popular view among scientist, is that quantum physics is impossible to understand through our classical views of metaphysics. That our theories of quantum mechanics works, and to ponder further is a waste of time given its impossibility. It takes our ideas of wave functions and entanglement as reality, not because it is real reality, but because the model works. That at the end of the day physics is not the study of reality in the way metaphysics is, but the study of models of the universe.

Though this explanation isn't really fair, so I will expand upon it. The key concepts are things like wave-particle duality, that particles are both particles and waves and that things like observation can effect how they interact with itself(yes particles interact with themselves) and with other things.[Though observation is never truly defined] Quantum superposition, something we all know fairly well and requires no further explanation. That quantum physics is probabilistic by nature, and truly probabilistic not governed by hidden laws berried beneath. There is a lot more to it but given that I have already explain part of it previously and how popular it is, you can fill in the gaps on your own. While this theory has been extremely important for our modern views, and important to explaining how quantum mechanics works without esoteric 'nonsense' it has a couple flaws like observer dependence and the fact that it quite literately states that it is not the ontological truth but rather a model.

Next, the many worlds theory. One of the popular interpretations by the general public. Basically, it is that when probabilities collapse; whether it is an interaction, wave-particle duality, superposition, or many of the several other things; the universe splits into two(or however many are used to describe the 'whatever'). That one universe has one and the other has the other. This is quite outlandish idea; for its reliance on the observer and the fact that there is no mechanism of 'universe splitting.' One thing I would like to add, is that I have always hated how people use the idea of a multiverse in this context, it is multiple verses it is one with multiple observable components. A better term, generated by Sir Roger Penrose and a Latin Professor that he was friends with(which I think is absolutely amazing, he made up a new word because he didn't like the word being used) he now calls is an omnium(meaing of all)

An even more outlandish theory is many-minds... which is exaclty what it sounds like... yeah

The Pilot wave interpretation is that there are hidden variables; that just as things like coin flips, brownain motion, plasma instabilities, and so much more seem random from the outside, if you really break them down they aren't. Now what are these hidden variables. Now what is this hidden variable, you might ask. Well lets take a step back and explain a bit deeper. First, lets define a quantum wave function, this is different to the excitations of quantum fields mentioned earlier. The wave-function is a complex variable(I mean complex as in in the complex field not challenging to understand) that depends on the particles position and can be used for several things. It can de described:

$$i\hbar\frac{\partial\psi(r,t)}{\partial t} = (-\frac{\hbar^2}{2m}\nabla^2 + V(r))\psi(r,t)$$

where $\hbar$ is obviously the reduced Plank constant. r is the position vector. ∇^2 is the Laplacian operator. m is mass. v is the potential energy. t is time.

Once you have the wave function you can do several things with it, square it for probability distribution, collapse the wave function, etc. But I am getting away from myself, you want philosophy so I will get back on that.

Basically, pilot wave theory suggest that this wave function influences this particle more than we think, and thus can lead to the particle's behaviors being deterministic through equations like this for velocity, v:

$$v = \frac{j}{\psi}$$

Now, in all reality the equation is obviously bigger; must expand j and ψ, but I didn't want to write it out(also there are expanded versions for relativistic and whatnot.) though back to what we had in mind, what did we have in mind, oh yeah super-determinism. Basically, quantum mechanics is deterministically not probabilistic.

One final thing I will say about pilot wave theory, is that some people suggest that the many worlds interpretation and pilot wave theory are one in the same just describing from different points.

Next, we have environmental decoherence theory. Sadly, I know very little about this one at the moment, I will attempt to learn more to better understand it better(for its own sake and given that it could convince me) But it is basically that like how a coin isn't truly random, neither is the quantum world. That there are density matrices made by interactions that effect future actions leading to a theoretically deterministic world.At the moment I don't really understand the mechanisms so I can't prove, disprove, critique, or criticize.

Lastly, Objective collapse theory. The objective collapse theory is similar to Copenhagen, with it's more literal view of quantum mechanics. Though, it has two differences. It has a true literal and ontological belief that goes further into everything within it. Also, it does not rely upon the observer. It relies upon 'random' collapses of wave-functions, such as gravity, scholastic field, or the interactions of other particles.

This is all well and good, and I do truly suggest you try to figure it out yourself(even though you don't exist), but this is a book MY philosophy. So what do I believe you might ask. I find the objective collapse theory to be best with the pilot function being a close second. Now why do I believe this?

First, for reasons I will explain later; the idea of non-determinism is important to other theories of mine and thus I need it for them to function. Though I am sure you all don't think that is enough, so I will go further. Second, in all reality given we cannot empirically prove any of this it doesn't really matter.

Three, given that it doesn't really matter, objective collapse theory makes the most intuitive and philosophical sense to me intuitively. Four, you know what, I give up(for know) these justifications are kind of weak, even in my eyes. I plan to do more research and come up with further justifications. Right now it is basically which sounds right.

29.9 *Other Questions in the MetaPhysics of Quantum Mechanics

...(will update later)

29.10 Quantum Consciousness, Arminianism, Super-Gödel thinking, OR Orch, why I even decided to write this book, and how long can I make the title for a section within a chapter

As much as I love how hilarious the title is; with its length, random buzz word, and joke on the end. I also kind of hate it; quantum consciousness seems like some esoteric nonsense. It feels like I am admitting to believing in a specific theory just to justify my religious beliefs, but this chapter will attempt to prove that that isn't the case. That it is rigorous, while maybe not on a true empirical scale, at least on a formal logic one.

While there are many reasons for the creation of this book, the main ones is to evolve this very idea. It was that I had this idea at one point and it challenged a lot of previous thoughts, thus I wanted to evaluate my philosophical thoughts from the ground up, then apply that.(While it was the original reason, I plan to continue this book much further and continue it.

Let me first explain what my theory is in broad strokes. It is the belief(more so a belief than a full theory given its unprovable nature, unscientific background, and basis on the belief in an omni-potent God unconstrained by the confines of physics, formal logic, or even abstract-mathematics.) It is that our consciousness and free will is preserved by God through the use of quantum mechanics. This theory in it-of-itself in not groundbreaking, original, or even scientific in nature, but I intend to go about explaining some possible mechanisms of this(though sadly, by definition this theory will be unprovable, which I will explain why in a second.)

First, is there any justification for this idea of quantum consciousness? There is some, it is weak but existent nonetheless. It is related to Gödel's incompleteness theorem. Gödel incompleteness theorem has two part. First, "For any consistent formal system F that is capable of expressing elementary arithmetic, there exists a statement G in the language of F such that if F is consistent, then G is true, but G is not provable within F." The second is, "For any consistent formal system F that is capable of expressing elementary arithmetic, the consistency of F cannot be proven within F." This claims that formal logic has its own limits; you cannot prove an axiom with itself and you cannot prove a derivative with an axiom alone, you must prove such axioms with other axioms(because you cannot prove an axiom with itself.) Now what does this have to do with free will, well to have free will you must first have some form of consciousness, something outside of our ideas of formal logic. We have some proof of this, the fact that we are able to derive pure math at all seems to prove that we are not algorithmic based, something beyond. Now there are a lot of arguments against this, namely that our ability to do mathematics comes from our informal thinking rather than beyond-formal logic thinking. In all reality, I like this explanation better, but I place Penrose's argument of consciousness here as a sample of somewhat scientific rigure rather than simply religious thought.

You may now be asking how this super-Gödel thinking proves free will. It doesn't, but it implies as deeper idea of consciousness allows us to theoretically side-step determinism in order to 'allow' free will. Now, before we get into how God can protect free will, and why I think he would, let us first explain some possible mechanics of explaining this seemingly unexplainable phenomena. Though before that, let me say the fact that by definition it goes beyond Gödel's theorems, we by definition can't prove it so take all of this with a grain of salt. It is an idea, not a law, not even a true theory, and idea.

Let us first go through the most popular explanation, the reason I even came up with this idea. Sir Roger Penrose's OR Orch(I seem to be mentioning him a lot) Essentially it is that microtubals, a potion of the brains neurons, and theoretically a part of consciousness, are highly subjective to quantum 'strangeness' in a way that most other complex structures aren't. That the interactions of quantum mechanics can somehow safe guard conciseness and allow super-Gödel thinks and even possibly free will.

While this idea is specifically for objective wave collapse theory, it also works for things like environmental decoherence and kind of work for many-worlds, but not for Copenhagen and pilot-wave.

For Copenhagen, no extra theories are required, by definition the idea of consciousness in 'beyond science' and thus no extra loop-holes are needed.(they don't specify what an observer is so therefore other explanations are possible, but they hold no further ground than this one.)

Now how does quantum 'brains' lead to free will. It doesn't, not in the most literal meaning, but it does give us extra wiggle room. While most modern views see our view of determinism as falsifying free will, but these theories give us room to say that there are other possible answers; dualism, God's choice, beyond material, and others.

I would say that God, by some manner, protects free-will. Whether it through some hidden ideas of quantum mechanics or it is that our consciousness is beyond the material and effects the material through the quantum world. I don't know, as I mentioned earlier, I am not even confident it is correct. It is an idea.

Now you may or may not be asking, why would God use quantum mechanics to protect consciousness, if by definition he is beyond formal logic and thus wouldn't need such things. While I cannot comprehend the machinations of God, I would suggest that a possible explanation would be to create our logically, self-fulfilling world that we are able to comprehend(for the most part) and live in a true free will.

Now to end, I want to reiterate how theoretical and disconnected from regular science this is, most of my ideas are at least respected by a decent portion of the scientific community, this is not. It is an idea, nothing more. This is an exercise to see if it holds weight, it currently does not seem to.

29.11 Compatibilist Free Will

Even though I wrote a whole lot about quantum libertarian free will. I don't necessarily believe in that. I view the world as either semi or super-deterministically and that that doesn't actually effect free will. Though I still wanted to examine the idea in more detail nonetheless.

29.12 *Super-determinism, semi-determinism Retro-causality, and Chaos theory

29.13 Role of God

I have already gone over the role of God in many ways; creator of the universe, its laws of nature, protecting free will, but now I wil go further.

The first question is the relation of miracles, in the Christian faith, we believe that our God is a personal God that creates miracles for us. Now how does he do that if he predetermined the laws of nature?

Well that is fairly simple, God is omnipresent, meaning he not only knows what you are going to pray for before he created the universe, but he also knows how to create such miracles from the creation of the universe. Thus he 'created' the miracles when he created the universe itself; with knowledge of all that will ever transpire.

How does the divine foreshadow effect our idea of free will. Well, God is beyond our free will, he is beyond whatever quantum mechanisms protect our free will, so he can know without interfering with our free will.

Is something good because God says it is, or because it is objectively. It is because it God says it is, beyond God there is not mechanism for the creation of truly objective morals, there are logical models based upon subjective values, but they cannot stand upon themselves. God makes them right because he is beyond formal logic.

29.14 Post-Axiomatic Nature of God

I guess pre, would be the better prefix given what I am about to say, but Post-axiomatic sounds better. Now back to the actual concept.

This idea is simple. That our axioms, as later examined are derived by God rather than God being subservient to the nature of these axiomatic principles, ”A line is the shortest distance between two points,” ”Existence exist,” ”consciousness in its totality,” ”A is A,” and many more. He, God, derives them. Now this twists our mind given that axioms by definition cannot be imagined without their existence. It is like inventing a new dimension for us to see, it doesn’t exist.

This concept enforces many ideas already present; God omni-(something that cannot exist with current axioms), God being beyond comprehension, that God is self defining(see non-infinite definition of words and axiomatic semantics), and being outside of causality, outside of formal logic. He creates existence(something that makes no sense in our current axiomatic understanding of ’existence’), he is three in one(against A is A), and much more.

While they don’t ’solve’ these questions in the traditional sense, they open the door in a more esoteric sense. While by definition we can never understand these concepts intuitively they do give rise to much of our understanding of God.

On to our esoteric identification(I know must of what I write is intended to be rational and examined this is one of the exceptions.) This idea of pre/post-axiomatic identification leads to our idea of faith. God, isn’t just beyond us, he is ineffable and unprovable though our axiomatic thought processes. Beyond that, this further goes into my idea of the ”non-material.” We can further define this as that of which is based upon our known axioms and that of which is not.

29.15 Metaphysics of cosmology

While I could go on and on about physics of things like the big bang, entropy, arrow of time, anthropic principle and how they could theoretically effect our views of metaphysics. I don't need to, my belief in God nullifies such arguments. That all possible incites have already been satisfied by God and thus have little need for exploration.

29.16 Ontology of Information and Entropy

Once again, we must first define what our concepts are rigorously.

A classical perspective. Within this concept information is the physical quantities that en essence give you traditional information. That allow you to decode past events and even future ones. Entropy is the inverse of this affect. Geometric instabilities and 'randomness' that hide 'information' from observers.

From a quantum perspective; quantum information even includes superpositions, wavefunctions, density matrices, and more. The quantum bits, qubits, can exist and superpositions and exist within the same quantum state(position)

In this view, entropy then becomes a byproduct of entanglement, a process that 'hides' the information from view.

There is much more on the semantics of this. Going into Geometric identities, black hole information paradox, and quantum thermodynamics. Though, for now I will move on to the more metaphysical parts.

One common debate is if information is truly fundamental or simply a human made connection. That the universe has a 'computational structure' where information is the substrate and entropy the measure of the complexity. With modern understanding of the geometric identities and the fundamentalness of information, the theory of fundamentalist seems to take the lead.

Next is the arrow of time. The second law of thermodynamics/entropy states that in isolation, states drive towards entropy. This necessitates an arrow of time. It breaks the symmetry of time.

Now many question whether or not entropy is a by-product of the arrow of time or the other way around.

The way I see it, the direction of entropy is the consequence of the already time symmetry breaking existence of dark energy, black holes, and other similar objects in this preview. That the direction towards entropy precludes low-entropy existancess.

Though this is just one theory. Holographic principle, Gravitational Entropy, Quantum Mechanics and Unitary Evolution, and more. In-fact the quantum mechanics and unitary evolution makes more sense and less problems.

The symmetric theory ignores that some forms of entropy are consequences of statistical physics that doesn't deny time symmetry

29.17 Dualism

I have already mentioned this in interpretations of quantum mechanics, but in physics many possible mathematical(and thus metaphysical) interpretation exist. Different ways to look at the world. They can't both be true, can they?

29.18 The Problem of the one-way speed of light

Quantum Mechanics is not the only physical model with inherit uncertainty. Special relativity has a similar principle. Essentially, the problem is that it is impossible to find the one way speed of light. Basically, while we can use a clock to find the two way speed of light, to find the one way would require two synchronize clocks. To synchronize clocks along a distance, the speed of light is a required number. Thus, the speed of light could theoretically be different in different directions. In one way it could be 0.75c and the other could be 1.25c or 0.5c and ∞. There is no possible way to actually prove it. Not only does this theory not prove it, but by definition changing the directional speed of light would change the transformations, effectively making everything equal. Just like changing the coordinate system(there are some versions where it does change things, it will get to that)

Now why does it matter if the observables stay the same? There are several reasons I will get into.

One is the question of scientific realism and instrumentalism. A kind of epistemic humility about how one of our singular most verified theories is simply convention. Not ontological truth, simply convention. That there could be hidden mechanisms causing these changes and speed and we could have no way of knowing.

Beyond that, the different theories based upon this fact offer wildly different views upon the ontological nature of space and time. Einsteinian, space and time are relative and this relativity causes the physical views we see. Lorentzian, there is simultaneity and objective time. Relationalism, time is a network of relations and the speed of light is a consequence of that relation not the opposite. Block, everything happens at the same because simultaneity is frame dependent and so is the speed of light. Presentism, there is an objective present, but the nature of light diseludes human observation by its nature. There are many other theories beyond this, but I think it envelopes the idea.

Lastly, there are some theories that while equivalent in most situations(situations that we have empirical data for) but is different. Different in not just ontological but physical differences. Differences that could lead to a unified field theory.

29.18.1 *Phase-space and the Euclidean Mind

29.19 *Ontology of Numbers

29.20 Reality and the Abstract

When reading this chapter, one can easily get a esoteric/gnostic sense of reality. Of pure abstraction with little regards to reality. Though this is not the case. In fact I find the abstract "non-material/pre-axiomatic" world as inconsequential. The only true consequence being God, but he matter because he influences the material. The focus on this abstraction being the fact that the ideas of reality are largely explored and are easily understood and so large amounts of writing and exploration on the topic is relativity inconsequential.

The focus on abstract, structuralism, post-axiomatic is simply to satisfy my need for cognition(as later explored) rather than being core parts of who I am. These theoretical ideas that I am not even sure if they are right or not(post-axiomatic God, Consciousness, etc) are explored not because they are core to who I am and what I believe(maybe the God one) but because it is fun. chapterEpistemology

”Man is neither infallible nor omniscient; if he were, a discipline such as epistemology—the theory of knowledge—would not be necessary nor possible: his knowledge would be automatic, unquestionable and total.” — Ayn Rand

29.21 Limited Objectivism

Before I begin upon explaining this, I must first specify the influence of Ayn Rand is limited to Epistemology. It has not influenced my politics nor ethics. Now lets begin with the philosophy.

In a short simplified sense, objectivistic Epistemology is the inverse of transcendental idealism(though despite what many say, not the opposite). Both philosophies take both reason thought and empirical data as useful tools in the accumulation of knowledge.

Though they differ in importance and direction. Transcendental idealism takes reason as the most fundamental and such abstract thought can then be applied to the outside world through empericalism. Objectivism takes the inverse, that we create our abstract models based upon our interactions with the world. Now these may seem like small differences, but the expand themselves through their logical conclusions. I could explore how they differ in more detail, but I will focus on objectivism.

Now, where did the limited part come from. As I have mentioned before, I am a religious person. I believe there are something beyond our sense and possible our mortal comprehension, therefore we are limited by such things when acquiring knowledge. I do believe what we are capable of discovering is ’objective’ and just as metaphysically true as what we can’t, but that does not take away the fact that some abstractions are beyond us.

29.22 Consciousness and Reality

A common continental question, is the question upon whether our consciousness truly models objective reality. While these questions can be useful when directed in a purposeful and specific way; though most people don't direct it in a useful way, but rather in a simply abstract way with little refinement of knowledge than the ability to trick others through strange and useless question.

Now, why do I think this is a useless question? Well, for several reasons I will address categorically. Now I will prefis this by saying this is a criticism, not a critique, I may later may later add a more refining critique but for now it is an acknowledgment of the stupidity of this, and to show that all derived concepts have no true analytical framework.

The most basic argument against this is the pragmatic thesis. In essence, it doesn't matter that reality is consistent with the observations of the mind, the mere fact that our observations closely associate enough for practical purposes is reality enough. There is no purer form of reality than this functions.

Though, this isn't enough for me, I think it could be enough if it was all there was but I want more. I do believe in truly objective reality and not just our semi-subjective observations of reality.

A refinement of the pragmatic argument to include the existence of an objective world would be a question of statistics. If a further world with separate physical laws existed it wouldn't work with our vast and extreme observations. Though, this wouldn't work with some more extreme theories wouldn't work with more radical and complete ideas, like Recreant's dream theory. Though, this implies that whatever objective reality is it must not be capable of interacting and effecting our reality. This can be attributed to nothing that could interact with our world, or our world is independent of the interactions of reality by its own definition. This may seem like a minor and obvious reduction but nevertheless it such reductions are the essence of philosophical discussion.

Next, such dream theories are useless. Derive no further discussion, only exist as a way to trick people up and thus serve no purpose. For these, the original pragmatic argument is all that can be derived secularly.

Now, you may say this is a good way to question our scientific premises. An argument against scientific realism, but in reality it doesn't change anything. Scientific realism stands or doesn't regardless of the 'validity' of such theories.

My final secular argument is that such philosophical arguments are harmful. That philosophy should not start with doubt but rather with perception. Such perception must be doubted, but doubt existing in its own self-containerized munition is useless. It defines nothing and leads to strange and possibly dangerous ideas. For instance Desecrate lead to Spinoza who lead to Hegel, who lead to Italian idealism, who lead to Giovanni Gentile the philosophical founder of fascism. Now, you may criticize that this was one complex branch, you could also derive similar lines through Aristotle or just any philosopher far back enough, and this is a good argument. Though, there is a clear line, also to other dangerous ideas like communism, NAZIsm, and so much more. These things are predicated on these strange cartesian/continental questions that derive no true thought, and thus should be understood in this way. Simply as pathetic and dirty tricks and shouldn't be see as true paths to knowledge. While yes, we should still engage sometimes, truly placing it on equal footing(or higher as we have been) is dangerous for our collective understanding reality and derived sense based upon it.

Though, many of you may have noticed I specify secular. There is a religious argument as well. If God created the reality as reality, then it is by definition reality. The only argument otherwise is that God doesn't exist(either entirely or he is not God)

29.23 Nature and Validation of Axioms

First, like always, we must define axioms thoroughly. The dictionary definition is "a statement accepted as true as the basis for argument or inference." For instance, our understanding of scientific realism is the understanding of the fact that our observations of reality are accurate(there are some observations that can be morphed due to other things that are observable.)

A simplified and more observable definition can then be defined to say that an axiom is a statement that either cannot be proved or cannot be proved currently that is used within a greater statement that can be proved upon its edifice. These axioms, while don't require 'proof' generally desire some type of reasoning even if it is not objective or purely analytical in nature. For instance, the above arguments for the objective nature of reality aren't true objective proof, they still exist as semi-arguments. While we cannot prove the objectivity of reality with true and objective reasoning, some reasoning can be applied to get some kind of 'proof' of the statement so that further studies can be applied based upon that said axiom.

29.24 Non-infinite Definition of words and Axiomatic Semantics

In the field of axioms, there becomes a problem. Part of the reason that 'some' words cannot be further defined. They are defined by themselves, they can only be intuitively understood, and even there is a limit.

A great example is existence, because to define this thesis, you need an antithesis. That doesn't exist(non-existence by definition needs to exist to be something and thus cannot exist because it would need to exist to be in existence.), so therefor existence is defined by itself.

This brings up a great deal of problems, paradoxes, and much more that will be explored.

29.25 Induction & Deduction

In the expansion of human knowledge there are two main ways in which they can be reached; induction and deduction.

Deduction is by taking premises/axioms and derive conclusions based upon this. Induction is the opposite, from observing 'effects,' define whatever knowledge is desired.

This can be seen in physics, deduction is taking a fundamental theory and applying it in a new way to find novel uses, predict, or whatever may be needed. Induction would be taking data to come up with a way to model reality or come up with an entirely new theory.

Both of these are extremely important. Without induction we could never go beyond basic logic, but without deduction we can never find objective truth. The way I have found to be the most useful is to use induction to attempt to find our 'axioms' and then use these to deduct the reality around us, though this is only really works for my fields of interest. In other fields, like psychology this strategy would fail.

29.26 The Problem of Induction

Nothing can be proven true. As controversial of an idea as this may seem, it isn't. This basic axiom is the foundation of modern scientific epistemology. That theories can only be proven wrong, never correct. That is why they will always remain theories.

Now, you might think something as foundational as something like Newton is true. Though, there are questions through MOND(Modified Newtonian Mechanics) and others. Given, Newtons empirical evidence, there would need to be a lot of evidence for MOND for it to be taken anywhere near the same level

Chapter 30

Ethics

”Finally, brothers and sisters, whatever is true, whatever is noble, whatever is right, whatever is pure, whatever is lovely, whatever is admirable—if anything is excellent or praiseworthy—think about such things.” — Philippians 4:8

30.1 Introduction to ethics

Many that know me, know the question I love to ask, ”what is your moral philosophy?” I love this question for many reasons. First, it intrigues people, they love to talk about their own morals and beliefs, but engages their curiosity with these newish words. Second, Morality is something that is both simple and fundamental enough that everyone has thoughts of it but still complex enough that it can have engaging discourse. Three, it get to explain stuff, most people haven’t heard of virtue ethics, deontology, egoism, etc.

Despite this fundamentalness to ethics, many questions are still unanswered, which fundamental theory? Many questions are raised for each theory that must be addressed? Even people question if Morality is even objective or not?

30.2 Virtue Ethics

My fundamental theory is virtue ethics

Virtue ethics is based upon the idea that Morality is derived from living a virtuous life rather than the adherence to rules or a logical stance. That you must pick a set of virtues and live by those principles.

Now why do I choice this over the other types of theories of morality and ethics. To understand this I will first criticize(yes criticize not critique) other theories then I will defend virtue ethics.

First, deontology. Deontology comes from the Greek word deon meaning duty. That you have a duty to follow certain 'rules.' That morality is based upon a set of rules and concepts rules and concepts to follow. Say, don't kill, don't steal, give to others.

My problem with this is not that it is too ridged, but that it is impossible. It would be impossible. You can't make rules for all possible interactions so must theories of deontology tend to just be contorted virtue ethics. Also, that both the action and consequences should be included when making an ethical decision but generally rules can lose this complexity.

Next, egoism. Yeah no

OK, fine, I'll do a little more. Most theories of egoism fall into either three camps; nonsense hedonism(which needs no criticism), logical consequentiality based concepts, or altruistic egoism. First, the consequentialism type eventually leads to normal consequentialism but with more steps to find the conclusion so I will focus on that when I get to it.

Next, consequencialism. Frist, for consequencialism to work a set of values must first be prescribed(so it isn't fundamental) there are others like utilitarianism but they aren't selfjustifying nor truly justified by other means. There are some that exist but I will show that to analyses all in-depth is a waste of time. My reasoning is that both actions and consequences should be analyzed. Why, good question... Well, first there is religion obviously. Though a more secular reasoning is that ethics is used as a binding agent, people emotionally don't bind well to 'immoral' actions, and those that do tend not to bode well with other things.

Now for justification of virtue ethics. The first and most important is that I am a Christian, from my analysis most Christian ethics is highly tided in virtue ethics. The fruits are virtues. Most sins are vices. Most ethical advice is based upon abstract virtues rather than a simple value(consequentialism) or rule(deontology). While there are many rules, most of them are based upon the virtues later mentioned rather than justified by themselves.

Next, on a more secular level, virtue ethics are far more complete and level for people to analyze, create, and apply to your life. They can included anything you want to have in them without creating paradoxes and problems(as long at the two concepts are not are paradoxical in it of themselves)

I will show this through the future sections that go through a list of virtues and why I feel they should represent my ideas.

One final thing I will talk about, is something that may be a strength or weakness depending on how you look at it. Virtue ethics has a much more 'subjective' connentation. A lot of virtues that I value another may not, also these virtues can be analyzed in your own way.

The way I see it, some virtues are fundamental and should be applied to all given they are principles derived by God, others I feel as personal virtues and feel no sense that they should be forcefully applied to others(though I feel things would be better for all that way.)

In essence, the idea of virtue ethics is to pursue perfection of the mind, body, moral thought, etc in order to create a purity of intention. This is the goal, not absence of sin, but the perfection of moral intentions. To create yourself in the image of your own ideal and to pursue it. That morality isn't just a responsibility but ontological alignment. To pursue the ideal of Jesus.

30.3 Stewardship

Throughout the rest of this chapter, many times I reflect on morality as my values. Values that are observed because of some 'internal promise.' This is because it is the way I have naturally thought, though I am trying to evolve past this.

I have always seen the internal promise as more pure than any other form of moral enforcement, though I have found this not to be true in the highest extent.

This obsession with dignity and following through with my own values alone is cornered in the vice of pride. It sits upon it, being thus controlled by it, and by proxy then so am I.

Now I have found, not responsibility, but existence in stewardship. In stewardship to the will of God, his grace, his mercy, his creation, and most importantly each other.

You see, God brought Adam and Eve into the world, as images of himself: builders, molders, and beings capable of reason. A creation to tend the garden, name and care for the animals, and to care for each other. This was the reason for humanities existence.

After the fall of mankind, humanities purpose shifted, but not much. We are still arbiters of his will and creation, by authority he has given us. Though, because of the imperfections made by us, our responsibility is to fix them. To perfect the world around us through the words that God has authored for us.

For God himself has given us this divine commission; though he hasn't left us to do it alone. He gives us gifts, hope, and healing. He feeds us and nurtures us so we made be sanctified in his love for us.

Now in practice, this becomes our purpose of moral perfection. Both for ourselves and for those around us. To create, not only pure intentions for ourselves but for the society and people around us. I will discuss this more throughout this book, especially this chapter, but here I will leave with this.

Though our actions, we may be able to co-create with God to bring Heaven on Earth. Bring about social holiness caused by our own actions with others. This is the purpose of Christianity, of ourselves. Only secondary to a relationship with God.

30.4 Categorical Good

Based upon my religious beliefs I propose this axiom, ”that all of reality is designed in such a way in that ”good” can be logically inferred and the actions to find this good is what we call virtue.”

$$\forall x(R(x) \to \exists P(I(P, G(x))) \land \forall A(V(A) \Longleftrightarrow \exists y(L(A, y) \land G(y))))$$

In essence, there exists a good for all categories(ex. communication, get information delivered clearly). Thus, there are good ways to do this, virtue(ex. use precise language when needed but don't use overtly complex language when not). Finally, not only can iterations of this build up an idea for how to ”be a good person” based upon a complex model of different circumstances throughout life, but that what virtues exist reveal what makes a person ”good” by what God has consciously divined, giving the actor ”wisdom”. This is all centered around the Stewardship given to us by God as mentioned in the previous section.

Obviously, this isn’t a purely religious view. Aristotle came through with an idea very similar idea, but even his idea had a pantheistic view, and other secular versions generally make it an unquestionable axiom without further backing other than the fact it creates a non-paradoxical system. Also, this system allows further development, like founding it in stewardship or having all things reveal ”wisdom” to further develop virtue.

30.5 Cardinal Virtues

Now, while my cardinal virtues have basis in the traditional cardinal virtues of the catholic faith they are not the same. The name comes from the fact that cardinal comes from the Latin word ’cardo’ which means hinge. In essence all other virtues hinge on these concepts.

Here is a short list of the main ones

- Temperance: Excess in most matters proves detrimental; self-control is paramount in one’s life.
- Prudence: Deliberation is essential before action in all circumstances.
- Fortitude: Mastery over one’s emotions is a paramount virtue, as the inability to do so inflicts harm upon oneself and others.
- Faith: Maintain strong belief not only in God but also in oneself and one’s values and beliefs; these should remain immutable unless confronted with supreme evidence.

- Duty: One has obligations to oneself, family, others, and one's values, which should drive one's life. Duty to oneself includes ambition and adherence to personal values; duty to family involves support and politeness; duty to others is similar but to a lesser extent.

- Individualism: Embrace self-reliance, self-respect, and ambition, and adhering to personal values.

As you can see all of these virtues are simple and widely acknowledged and don't require much additional justification. The only true exception being individualism....

30.6 *Salient Virtues

30.7 The Philotimic Virtue

Now Philotimic is a word I have made up, I will go into more detail about what exactly it means later, for now assume it means pride.

Now, I hear your vapid and lost mind screaming, "isn't pride a vice, what are you doing" Though I will examine why I think pride in some forms is a virtue not a vice(at least certain types of pride)

First to examine we must first define pride and what it is. One definition is ,"feeling of deep pleasure or satisfaction derived from one's own achievements, the achievements of those with whom one is closely associated, or from qualities or possessions that are widely admired." or "consciousness of one's own dignity." Now what does this mean and how do they fit together.

Let us start with the first one, a deep feeling of pleasure in ones own achievements. This can manifest itself in many ways;

work, morality, intellectual achievement, and so many others. Beyond that it can effect people's actions in both positive and negative ways. Let's start with negative, it can lead to obsession with ones own capacity and the product of such. On the flip side, a healthy obsession will lead to personal growth on whatever they feel pride in. Also, it can give them confidence in their own capacity. An example would be with morality, if they feel pride in their own sense of morality it can lead to self-assurance in their own senses leading to them being able to apply and do them, but it can lead to close-mindedness and looking at just your own thoughts and nothing more.

Now lets look at the second definition, consciousness of one's own dignity. Meaning that they are aware and influenced by concepts of their own dignity. The belief that somethings are within their ability and others are beneath them.

Now what I mean by philotimic, as essentially the positive aspects of this. That to have philotimic virtue is to take your own life seriously. To be principled, to be absolute. Not just in behaving moral in a moral and dignified manner, though this is definitely a part of it. In fact, even within this manner this virtue is partly about fanatical pursuing such moral perfection. Though, outside of this there are many things. Most notably is having such fanatic belief in things beyond morals, other values like being early, being prepared, working hard, being mature, and being other similar concepts. That while there are values that God doesn't arbitrate, but you do, and thus you should keep them to almost the same esteem.

This concept, as mentioned earlier is about taking your own dignity, self-esteem, self-respect, virtue, and above all life seriously. Because that is what you should do, take it seriously in a dignified and ridged manner. To never compromise upon even the most minimalist value, because to compromise on such things is far worse than any other conceivable interaction.

Another concept within it is control. Control over your inner-mind. Your thoughts, emotions, temperament, and even personality being bent to the will of your own 'ego.' Not ego in the regular sense, but as in the inner consciousness of your own self. The self of morality, values, reason, and more(more closely related to the idea of 'superego')

In essence, recursively creating your own self based your higher values rather than letting your environment impact your supposed values.

Philotimia in its highest sense, is not merely pride, but the love of what is worthy of love. To find what is worthy of such esteem and pursue it with fanaticism and create your soul around such values. To take responsibility for your own existence, morality, self-esteem, and so much more.

An even further simplification is it is taking upon yourself the responsibility to be human. The responsibility to think, to fear God, to live accordance with your values, to have values, and to live in the image of your highest self. Not only that but bend the world into the image of your highest self.

One thing I will add, is in the conflict of universal morality(derived by God) and personal values. This conflict doesn't really exist. Both of these values exist in my mind. While universal morality is obviously stronger, this doesn't dissipate the importance of personal values. The largest differentiator is others; for universal morality, others disobeying. is an infringement of morality, while for personal values only you 'break them,' no one else.

30.8 *The Internal Promise and Dignity

30.9 Good Life and Eternal Struggle

There are two parts to this. Obviously the good life and the eternal struggle as defined in the title. This are both extremely connected, as I will show momentary.

First, the good life. To live a virtuous life is to live a good life, but there is challenge. One, you should train yourself to desire this good and enjoy it. as defined in the philotimic virtue, take this training upon yourself rather than simply passively let culture and external figures train for you. While yes, culture can do a good job, training yourself creates a better feedback loop and consequence; beyond that, training yourself is your own moral responsibility as a human being.

Find this good to be your highest desire, so that you not only can but will naturally follow it and ignore sin and vice around you. To desire it fanatically. While many consider fanaticism to be a bad thing, in the pursuit of virtue, it isn't just a good thing but a lack of it is evil.

Beyond that, this struggle will be enteral. Virtue by its very nature is never perfected. Therefore, you should always struggle. To take this further, you should love the struggle against it.

30.10 *Personal Virtues, Values, and God's Morality

30.11 Intentions

In my theory of morality, intentions matter just as much as the action in it of itself. "The LORD does not see as man does. For man sees the outward appearance, but the LORD sees the heart." 1 Samuel 16:7.

I could go on and on, but this idea is relatively intuitive and while many don't consciously think this way it isn't far from our minds.

30.12 *Morality and Religion

30.13 *The Ethics of Knowledge

30.14 Recursive Connection of Civilization & Virtue

Our capacity towards civilization and virtue are strictly linked in a depth rarely acknowledged.

Let's begin with the start, for civilization to happen, we must be able to do it well. This is the heart of virtue, while virtue can be connected with any doing any good thing well, the ability to be civilized and do civilization "well" is the very heart of it.

Now, how do we do civilization well? To make sure people do not become distrustful, honesty should be brought about. To bring about any positive outcome, discipline becomes a need.

To expect pro-social activities, empathy is not only an ideal but a requirement. While I won't explore every angle, it is clear where this leads. Our modern ideas of culture and morality is primary based upon how to build a civilization, a society.

Though, how to develop virtue on a mass scale? Society. Through community virtue is developed, the most obvious being how we enforce guilt and pride into those that exhibit virtues and vices. To teach them young, how ethical theory works.

A bit deeper, through habits. Virtues are all about who we are, our attributes, our character, presence, intellect, and much more. We become who we are through our habits; habits of action, ideas, thoughts, and much more. Society creates these habits, even when we don't realize this. To explore this idea, I will present a case study: a commonly criticized culture rule is to not curse. It may seem illogical, they are words, sometimes not even directed at the person offended. Now, before I begin on this analysis, I will say that this particular analysis will focus on social rules as habit forming$\Longrightarrow$ virtue forming. It will ignore the dozens of other reasons and arguments.

From this idea of it being illogical, you can clearly see the reason by what the person is actually doing. They are *tempering* their own *impulses* for the sake of *social harmony* and *empathy* towards others. Having *interpersonal tact* and learning from *moral authority and teachers* without rebelling because you didn't see the big picture. These habits are both skill and virtue building so we may be civilized adults. This is also why it is so extremely emphasized during childhood.

Now, while these parts are extremely important, they aren't simply circular self-defining concepts. Virtues exist beyond civilization and their primary justification being to mimic Christ and fulfill our duty to steward his creation.

30.14.1 *Social Rules and Morality

30.14.2 *Culture as Moral Education

30.14.3 Intensity of Duty*

While on a strictly moral view, ethics and their virtues are extremely important. I have gone over again and again, how these ideas should be pursued fanatically, but individually. While they should be taught to others, expecting purely moral actions from other is not something to be expected from them.

Virtues of civilization are another story. Some lenience is required, but to much leads to a denegation, a slippery slope. Things like duty, respect, loyalty,

Chapter 31

Personal Philosophy

”Only through the radical examination of one’s own life and the reality surrounding may one gain authority over it. Through such authority their own happiness becomes clear. To have the freedom to be responsible for themselves and the integrity of their own mind. This is the principle and highest form of human action, to divine their own morality and values then shape themselves and reality into the image of their highest values.” — AJ Cason

31.1 *God as Foundation

31.2 Will as Identity

All throughout history, the question of identify has been constant. Who we are: are we are personality, outward actions, inward thoughts, natural impulses, cognitive style?

I propose a different method, we are our will. That is our method of identity. This proposition has many consequences.

Before I get to that, I must define your will. Your will is your highest self within you, that which pushes you to your highest ideals. The image that burns within you of what you could become, that whispers how you may achieve it. That is your will, your will to your own power over yourself.

First, it allows acting through purpose to be acting authentically. Many people find paradox between our need to live 'authentically'(a moronic ideal) and fulfilling their purpose and duty to others and themselves. Though, from my view these are the same. To act and bend your personality to your personal will, to fulfill your duty, isn't unauthentic, but rather the purest form of authenticity.

To 'act' and author yourself is your responsibility as a human, a creation of God the most high that has been made in his image as a being with a conscious mind. Don't live passively letting your whims and childhood define you, but rather your will is your definition.

Second, a devotion to your will is your responsibility. To 'falter' is to kill yourself and let a husk(personality, impulses, etc$_{t}aketheplaceofthehumanmindthatGodhasputwithinyou.Toletthefleshcontrol$

This can be observed through giving up, compromising, complaining, etc. These are evils. People seem to accept complaining as a natural reaction to 'unfairness' and that you are nothing more than your "childhood traumas," don't become this subhuman husk. Become more, become a thinking human.

Four, to let others to your thinking for you is to outsource your soul. To degenerate God's creation. Think for yourself, think logically and analytically, derive your 'first principles' clearly.

31.3 *Fanatical Ethics

31.4 The Duty as an Actor

As mentioned in ”Will as Identity” you must in a sense become an ”actor” in your life. What I mean by this is that you must control your reactions(be civilized and dignified) to fulfill your duty.

Be cheerful within the misk of irksome tasks and weighty responsibilities, hold your head up high, never complain, don’t profane what is sacred, and so much more.

One, through ”acting” you will become that in which you pursue, virtuous. You will become happy, become moral, become dignified, become who your will decides you must be. It is through this ”act” you will become that image of your highest self within you.

31.5 *The Aesthetic Pursuit of Truth

Chapter 32

The Structure of Motion: A Philosophical Journey Through Hamiltonian Mechanics

"The Hamiltonian formalism of mechanics, especially in its canonical form, has been an inexhaustible source of inspiration for modern theoretical physics." — Albert Einstein

32.1 Introduction

This chapter is planned to be an extreme examination of Hamiltonian mechanics, especially from a philosophical, logic, and abstract way. Eventually, it will go from the basic logic and axioms underlying it, to the metaphysics and epistemology that are derived, and finally to advanced and modern usages. The primary purpose of this exercise is for me to find the gaps in my knowledge and gain a more intuitive and deep understanding of these concepts.(It was also written in 10th grade before the rest of the book so may not have the same standards.)

The reasoning for this is due to the extremely complex and abstract nature of such mechanics. To see the world through 'flows' instead of forces.

32.1.1 Physical Reality and Frameworks

Now, there are many theories, models, descriptions, framework, and so much more. Though, what really differentiates them? What makes one thing one and the other the other. While I won't truly go into extreme linguistic detail for every single one, I will go into moderate detail within the art to get the general idea down.

Let's focus on frameworks, because that is what a Hamiltonian is(others define it as schemes which is another great word and arguably more accurate, but I will refer to it as a framework because it has a more intuitive grasp). It is an entirely different framework than Newtonian. It comes from an entirely different perspective, looking into geometric identities rather than the causal relation of forces and such interactions. Also, other theories and identities are derived through it, independent of the actual reality of it. For instance, the flow of electromagnetic interactions, relativistic, or even gravitational are all derived from this concept of the flow of energies through sympathetic geometry.

Even beyond that, Hamiltonian mechanics can represent any function that changes; statistics, viruses, and many others. This is due, to that Hamiltonian's is a pure mathematic relational concept rather than based upon physical axioms. For instance, Newtonians is based upon the axiom of inertia. Though, I will add one interesting involvement is the idea of privileging Hamiltonian over Lagrangian and stating that Lagrangian is a subset of Hamiltonian rather than its own framework.

Then this begins to ask our questions of scientific realism vs anti-realism(I found out the more neutral language is instrumentalism). Basically, what makes such theories more fundamentalist, predictive modeling or metaphysical truth. Further, this now engages the complexities of mathematical axiomatic reduction or physical.

Let's start with realism vs instrumentalism. I have already made my stance clear, having metaphysical truth in important but not in the way that non-metaphysical schemes should be thrown away. Though, this then brings about the question of what frameworks have greater metaphysical truth, but I will later look into this in later sections.

This now leads to the question of mathematical abstraction vs physical realism. Though, one thing I will add is that the physical axioms of Newton's laws are based upon falsified ideas like absolute space and time(but you can get around such semantics by employing Whewell's axioms of Mechanics[1st: "Every change is produced by a cause." 2nd says that: "Causes are measured by their effects." Finally, the third remain unchanged from Newton's formulation.] Now back to the main event, I feel that the structuralism of Hamiltonian is better due to the fact that when you break down physics to the quantum the classical forces, inertia, and such break down and you can see that the structure is what remains. That while forces still interact as abstract 'causes of change" through bosons, their classical and 'physical' realism fails to encapsulate their extreme complexity.

32.1.2 Philosophical Context*

The Kantian influence on Sir Hamilton is clear....

32.1.3 Notion of Time, States, and Trajectories

Let's start with time. I have already explained my thoughts on time, but here I will deepen my explanation. Time, is the factor on which states evolve. It is then evolution of entropy. This axiom is very simple and intuitive. While objective empirical proving the nature of time is extremely challenging due to its abstract nature. For a more in-depth analysis of the nature of time visit Chapter 1, section 3&7.

One thing I will discuss is time reversibility. Now, Hamiltonian mechanics works best for time reversal symmetries(it can still work in some use cases but rarely.). In fact, time reversal symmetry is a corner stone of much of modern physics, especially quantum mechanics, but this interferes with our intuitive grasp of reality, the second law of thermal dynamics, and even dark energy; in essence the emergent properties of reality seem to interfere with our 'fundamental mathematical' derivations. So I will examen these questions; both for their own state and because it continues our question of the fundamental nature of reality. I will also attempt to discuss imaginary time with regards to quantum mechanics.

Actually, upon further thought the nature of time will be further developed through after the derivation of analytical mechanics.

Next will the on trajectories; now like many other ideas presented within this book, that may seem simple but the derivation of the ideas will be thorough and show its true complexity. Within Hamiltonian mechanics, the trajectories hold special geometric identities due to the nature of motion, but what can we derive from this simple observations

32.1.4 Introduction to Phase Space

Another question that arises from a Hamiltonian view of metaphysics is Phase Space. The fact that, according to our theories, phase space almost seems real, but yet it is so very different than what we observer. Or, we think so.

Obviously, there is the idea of the conflict between the teleology that comes as a consequence and our view of causality. I will address this in a second.

A simpler idea is that, from a perspective view, change becomes fundamental and any identity becomes simply emergent. This isn't truly new, simply more emergent in phase space, so I will move on.

One new thing, is that Phase Space allows for entropy irreversibility. Traditional theories find time reversibility to be a corner stone, this going against it.

This is due to the fact that entropy increases

$$S = -k_B \Sigma_i p_i log p_i$$

Where the volume of the phase space stays the same

$$Vol(\phi_t(\Omega_M)) = Vol(\Omega_M)$$

Lastly, the 6D phase space seems very different to ours. Having generalized position and momentum coordinates is odd. An instrumentalist view makes this simple, but a scientific realism makes this difficult. Sadly, I don't have the knowledge to come up with.

32.1.5 Teleology vs Causality

My privileging of causal relations has already become clear, but now I will justify my thoughts through a Hamiltonian view point. While many claim that the nature of Hamiltonian mechanics necessitates a teleology, and my stated view on structuralism seems to contradict my views on causality, but I will address these claims categorically.

First, the nature of Hamiltonian mechanics necessitates a teleological view of the natural world. This statement will seemingly logical, lacks the tautological strength required of such an extreme statement. For one, Hamilton himself had a clear belief in causality(while this obviously isn't enough, I will explain why he and I see it that way.) First, the concepts of causal forces(forces are by definition causation principles) can be derived through the inverse gradient of potential energy. Second, the connection of the 'principle of least' action and teleology is flimsy at best. This is because their main argument is based upon intuition of mathematic alone not physical realism(I know this goes against stated structuralism but I will come back to that), the reason I state this against due to the fact that, mathematical intuition in the face of metaphysical truth. For instance, as stated earlier the teleological 'energy' is found as a derivation of causal force. Finally, returning to our arguments placed in the first chapter.

32.1.6 Role of Variational Principles in Mechanics

32.2 Axiomatic Mechanics

32.2.1 Axiomatic Derivation of ...

32.2.1.1 Introduction

For any mathematical physical axiomatic derivation, a mathematical derivation is first required. I won't go super in depth but I will still go over it for rigors sake. I may go back and do a deeper dive but for now I will simply put these things.

32.2.1.2 Axiom of Real numbers

Why needed: Physical quantities like position, velocity, time, energy, and action are represented by real numbers. The calculus used in mechanics relies on the properties of real numbers.
Key axioms:

- Commutative, associative, and distributive properties for addition and multiplication.
- Existence of additive and multiplicative identities (0 and 1).
- Existence of additive and multiplicative inverses (for non-zero numbers).
- Completeness axiom: Every non-empty set of real numbers with an upper bound has a least upper bound (ensures continuity, critical for calculus).

Role: These axioms enable arithmetic operations, inequalities, and the construction of functions like the Lagrangian $L(q, \dot{q}, t)$.

32.2.1.3 Axiom of Euclidean Geometry

Why needed: If the system involves spatial coordinates (e.g., particles moving in 3D space), Euclidean geometry provides the framework for defining positions and distances.
Key axioms(informal):

- Points, lines, and planes exist.

- A straight line can be drawn between any two points.
- Distance between points is defined (e.g., via the Pythagorean theorem).

Role: Defines generalized coordinates q (e.g., Cartesian or polar coordinates) and kinetic energy terms like $\frac{1}{2}m\dot{x}^2$. Note: For abstract systems (e.g., in generalized coordinates), geometry may be less critical, but it's foundational for physical intuition.

32.2.1.4 Axiom of Set Theory (Basic)

Why needed: Sets are used to define the domain of variables (e.g., time $t \in \mathbb{R}$, coordinates $q \in \mathbb{R}^n$) and functions.
Key axioms(informal):

- Existence of sets: Sets can be formed to represent collections of objects (e.g., possible paths of a system).
- Union, intersection, and Cartesian product: Allow combining and manipulating sets.
- Axiom of choice (implicitly): Ensures a choice of path exists in variational problems.

Role: Provides the language for defining functions, spaces, and the configuration space of a system.

32.2.1.5 Axiom of Calculus (Differential and Integral Calculus)

Why needed: The principle of stationary action involves integrals (action $S = \int L\,dt$) and derivatives (in Euler-Lagrange equations).
Key concepts (built on axioms of real numbers):

- Limits: Define continuity and differentiability of functions like $L(q, \dot{q}, t)$.
- Derivatives: Partial derivatives (e.g., $\frac{\partial L}{\partial q}$) are used to describe rates of change.
- Integrals: The Riemann integral defines the action S.
- Fundamental theorem of calculus: Links derivatives and integrals, essential for variational calculus.

Role: Enables the formulation of the action and the variation $\delta S = 0$.

32.2.1.6 Axioms of Variational Calculus

Why needed: The principle of stationary action requires finding the path that makes the action stationary, which is a problem in variational calculus.
Key axioms(informal):

- Functional: The action S is a functional (a function of functions, e.g., paths $q(t)$).
- Variation: Small changes in the path $\delta q(t)$ are used to compute δS.
- Stationary condition: The path satisfies $\delta S = 0$, leading to the Euler-Lagrange equations.

Role: Provides the mathematical machinery to derive the equations of motion from the action.

32.2.1.7 Axioms of Linear Algebra (Basic)

Why needed: For systems with multiple coordinates or degrees of freedom, vectors and matrices describe generalized coordinates q_i and momenta p_i.
Key axioms:

- Vector space axioms: Addition and scalar multiplication of vectors (e.g., coordinates in $\mathbb{R}^n$).
- Linearity: Operations like partial derivatives in Hamilton's equations are linear.

Role: Supports the formulation of the Hamiltonian $H(q, p, t)$ and phase space (the space of (q, p)).

32.2.1.8 Axioms of Variational Calculus

Why needed: The principle of stationary action requires finding the path that makes the action stationary, which is a problem in variational calculus.
Key axioms(informal):

- Functional: The action S is a functional (a function of functions, e.g., paths $q(t)$).
- Variation: Small changes in the path $\delta q(t)$ are used to compute δS.
- Stationary condition: The path satisfies $\delta S = 0$, leading to the Euler-Lagrange equations.

Role: Provides the mathematical machinery to derive the equations of motion from the action.

32.2.1.9 Physical Assumptions (Not Strictly Mathematical Axioms)

While not mathematical axioms, certain physical assumptions are mathematically formalized:

- Time is continuous and one-dimensional ($t \in \mathbb{R}$).(Though Hamiltonains can work in other forms)
- Energy is well-defined: Kinetic energy T and potential energy V are functions of coordinates and velocities.
- Differentiability: The Lagrangian L is sufficiently smooth (at least twice differentiable) to allow partial derivatives
-

Role: These ensure the mathematical framework applies to physical systems.

32.2.2 Axiomatic Derivation of Hamiltonian Mechanics

Two hundred years ago, William Rowan Hamilton reformulated classical mechanics using the **principle of stationary action**, a single axiom that unifies the dynamics of physical systems. This principle states that the path taken by a system between two times makes the action S stationary.

The **action** is defined as:

$$S = \int_{t_1}^{t_2} L(q, \dot{q}, t)\, dt,$$

where $L = T - V$ is the **Lagrangian**, with T as kinetic energy, V as potential energy, q as generalized coordinates, and $\dot{q}$ as their time derivatives.

The system follows the path where $\delta S = 0$. Varying the action:

$$\delta S = \int_{t_1}^{t_2} \left(\frac{\partial L}{\partial q} \delta q + \frac{\partial L}{\partial \dot{q}} \delta \dot{q} \right) dt = 0.$$

Integrating by parts on the second term:

$$\int_{t_1}^{t_2} \frac{\partial L}{\partial \dot{q}} \delta \dot{q} \, dt = \frac{\partial L}{\partial \dot{q}} \delta q \bigg|_{t_1}^{t_2} - \int_{t_1}^{t_2} \frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}} \right) \delta q \, dt.$$

Since $\delta q = 0$ at t_1, t_2, we get the **Euler-Lagrange equations**:

$$\frac{d}{dt} \left(\frac{\partial L}{\partial \dot{q}} \right) - \frac{\partial L}{\partial q} = 0.$$

Hamilton defined the **Hamiltonian** as:

$$H(q, p, t) = \sum_i \dot{q}_i p_i - L(q, \dot{q}, t),$$

where $p_i = \frac{\partial L}{\partial \dot{q}_i}$ are generalized momenta. Typically, $H = T + V$.

Using the Legendre transform, the dynamics are governed by **Hamilton's equations**:

$$\dot{q}_i = \frac{\partial H}{\partial p_i}, \quad \dot{p}_i = -\frac{\partial H}{\partial q_i}.$$

Example: For a particle in gravity, $L = \frac{1}{2} m \dot{h}^2 - mgh$. The momentum is $p = \frac{\partial L}{\partial \dot{h}} = m\dot{h}$. The Hamiltonian is:

$$H = \frac{p^2}{2m} + mgh.$$

Hamilton's equations yield:

$$\dot{h} = \frac{p}{m}, \quad \dot{p} = -mg,$$

reproducing the equation of motion $m\ddot{h} = -mg$.

The principle of stationary action simplifies dynamics, applies to diverse systems, and underpins modern physics, including quantum mechanics and relativity. Hamilton's work remains a cornerstone of theoretical physics.

32.2.3 *Hamiltonian Mechanics ad a Geometric Theory

32.2.4 *Poisson Brackets and the Algebra of Dynamics

32.2.5 *Canonical Transformations: Symmetry, Simplicity, an Structure

32.3 Philosophical Implications*

32.3.1 *Time in Essence

32.3.2 *Hamiltonian Constraints and the Problem with Time

32.4 Modern Hamiltonian

32.4.1 Modern Research

32.4.1.1 *Hamiltonian Formulation in Plasma Physics

32.4.1.2 *Hamiltonian and Metriplectic Mechanics

32.4.1.3 *Symplectic Integrators: Preserving the Structure of Nature

32.4.1.4 *HNNN(Hamiltonian Neural Networks)

32.4.2 Fun Mess Around

32.4.2.1 Non-Canonical Poisson Brackets

A Poisson bracket is a bilinear, antisymmetric operation $[F, G]$ that defines the time evolution of a functional F via $\dot{F} = [F, H]$,

where H is the Hamiltonian. Non-canonical brackets arise when the phase space variables (e.g., density, velocity, magnetic field in MHD) do not follow the standard canonical structure $\{q_i, p_j\} = \delta_{ij}$.
Properties: The bracket must satisfy:

- Antisymmetry: $[F, G] = -[G, F]$
- Leibniz Rule: $[F, GH] = [F, G]H + G[F, H]$
- Jacobi Identity: $[F, [G, H]] + [G, [H, F]] + [H, [F, G]] = 0$

For this I will be defining my own Poisson bracket specifically for plasma thrusters.

For this I will obviously need to define the variables. Things like:

- Mass density: $\rho(\mathbf{r}, t)$
- Velocity field: $\mathbf{v}(\mathbf{r}, t)$
- Magnetic field: $\mathbf{B}(\mathbf{r}, t)$
- Entropy or internal energy: $s(\mathbf{r}, t)$ or $\epsilon(\rho, s)$

Now define the Hamiltonian, for this I will use the pre-established ideal-MHD, but in all reality for plasma thrusters I should use a more expanded model.

$$H[\rho, \mathbf{v}, \mathbf{B}, s] = \int \left(\frac{1}{2}\rho v^2 + \rho\epsilon(\rho, s) + \frac{B^2}{2\mu_0} \right) d^3x$$

Next, I must define the phase spaces and constraints. Incompressibility or magnetic field divergence.

Next I propose a bracket system, with many of them being

$$[F, G] = \int \sum_{i,j} \frac{\delta F}{\delta \xi_i} J_{ij} \frac{\delta G}{\delta \xi_j} d^3x$$

Such that Ideal MHD is:

$$[F, G] = -\int \left\{ \rho \left[\frac{\delta F}{\delta \rho}, \frac{\delta G}{\delta \mathbf{v}} \right] + \left[\frac{\delta F}{\delta \mathbf{v}}, \frac{\delta G}{\delta \mathbf{v}} \right] \cdot \left(\frac{\mathbf{B}}{\rho} \times \nabla \times \frac{\delta G}{\delta \mathbf{B}} \right) + \frac{1}{\rho} \left(\nabla \times \frac{\delta F}{\delta \mathbf{B}} \right) \cdot \left(\frac{\delta G}{\delta \mathbf{v}} \times \right. \right.$$

Another approach is using lie-groups. The Lie-Poisson approach is a method to construct non-canonical Poisson brackets by reducing a canonical Hamiltonian system on a large phase space (e.g., particle coordinates) to a smaller phase space of collective variables (e.g., fluid fields in MHD). It is rooted in the symmetry properties of the system's configuration space, described by a Lie group.

...

The other way is through Casmir invariants. Casimir invariants are functionals C that commute with all functionals F under the Poisson bracket: $[C, F] = 0$. They are conserved quantities that arise from the degeneracy of the non-canonical bracket and provide constraints on the system's dynamics.

Degeneracy: Non-canonical Poisson brackets are degenerate, meaning their Poisson tensor J_{ij} has a non-trivial kernel. Casimirs live in this kernel, satisfying:

$$J_{ij} \frac{\delta C}{\delta \xi_j} = 0$$

Physical Role: Casimirs represent invariants tied to the system's topology or symmetries, such as helicity in MHD, which constrain the evolution of plasma in thrusters.

Identification: Casimirs are found by solving the functional equation $[C, F] = 0$ for all F, often using the Lie algebra's cohomology.

Part V

Journaling

Chapter 33

*Introduction

Chapter 34

Plans

34.1 Now

34.1.1 Self-Education

elf-education has always been a great value of mine. As mentioned earlier, I became obsessed with learning Einstein's field equation in 3-4th grade. Beyond that I have spent much of my time reading books, watching YouTube videos, and more about topics that interest me. Though, late in 8th grade, this desire to teach myself grew a great deal. Before I can go about my future goals for teaching myself I must first go over what I have already down.(This list is not full, mainly lectures finished and books from lectures, this does not include books not finished, non-lecture based video education, research papers read, projects where I learned things for the project alone, and other similar programs)
Mathematics:

- AP Calculus AB and BC - Khan Academy
- Multivariable Calculus

- Khan Academy
- 18.03 Differential Equations - MIT OpenCourseWare
- Gilbert Strang on linear algebra - MIT OpenCourseWare
- Vector Calculus - Trevor Bazett
- Tensor Analysis - eigenchris
- Tensor Calculus - eigenchris
- Crash Course in Complex Analysis - Steve Burton
- Introduction to Applied Numerical Analysis - Richard W. Hamming
- Symplectic geometry & classical mechanics - Tobias Osborne
- Lie groups, algebras, brackets - Mathemaniac (more conceptual than mathematical)
- Differential geometry - Robert Davie
- Calculus of variations - Faculty of Khan
- Working on
  - Advanced Analytic Methods in Continuum Mathematics: Fundamentals for Science and Engineering - Hung Cheng
  - Discrete Differential Geometry - CMU
  - Differential Geometry for students of Numerical Electrodynamics - Alain Bossavit

Physics:

- 8.02 Physics II - MIT OpenCourseWare

- 8.03 Physics III - MIT OpenCourseWare
- 8.033 Relativity - MIT OpenCourseWare
- General Relativity - Stanford Online
- Introduction to plasma physics - USYD senior plasma physics lectures
- Introduction to electromagnetism - Griffiths
- Computational physics - Mark Newman
- 8.224 Exploring Black Holes: General Relativity and astrophysics - MIT OpenCourseWare
- Classical Dynamics of Particles and Systems - Thornton Marion
- Introduction to cosmology - Stanford Online
- Introduction to fusion energy and plasma physics course - PPPL
- Seminar: Fusion and plasma physics - MIT OCW
- Statistical Mechanics - Stanford Online
- Hamiltonian description for magnetic field lines in fusion plasmas: A tutorial - AIP
- Fusion economics: power density, materials and maintenance - PPPL Frontiers Colloquia
- Flash-X code tutorial, a users perspective - University of Chicago(skimmed)
- Flash-X user guide - Flash-x
- Flash4 User support(skimmed)

- Radiative Procuresses in Astrophysical Phenomena- George B. Rybicki, Alan P. Lightman
- Goldstien Classical Mechanics Lectures - Prof. Jacob Linder
- PiTP 2016 - Institute of Advanced study
- 2024 PPPL Graduate Summer School
- Hamiltonian description of the ideal Fuid - P.J.Morrison
- Quantum Mechanics with Applications - David B. Beard & George B. Beard
- ”What IS Structure, How Do You Create or Recognize It, and How Can You Use It? or Metriplectic Dynamics: Using the 4-Bracket for Constructing Thermodynamically Consistent Models.” - workshop Geometric Mechanics Formulations for Continuum Mechanics
- ”On an Inclusive Curvature-Like Framework for Describing Dissipation: Metriplectic 4-Bracket Dynamics.” - workshop Infinite Dimensional Geometry and Fluids
- Haven’t finished
  - Theoretical Physics - Georg Joos
  - Advanced MHD with Applications to Laboratory and Astrophysical Plasmas - Cambridge
  - Classical Mechanics: A Modern Perspective - Sudarshan and N. Mukunda
  - The Interpretation of Structure From Motion - Ullman, S.
  - Radiative Processes in Astrophysics - George B. Rybicki & Alan P. Kightman

  - Symplectic geometry & classical mechanics - Tobias Osborne

Coding:

- Computational physics - Mark Newman
- Python Numerical Methods - Berkeley
- Applied Numerical Methods - Crice Carnahan, H.A Luther, James O.Wilkes

Other:

- Management in engineering - MITOpenCourseware
- Principles of microeconomics - MITOpenCourseware
- Dynamic leadership: using improvisation in business - OpenCourseware
- Logic 1 - OpenCourseware
- Policy for science, technology, and innovation - MITX
- Reducing The Danger Of Nuclear Weapons And Proliferation-MITOpenCourseware

34.1.2 Research

- Egg drop simulation
- Numerical Methods for 3D compressed Plasma using Lattice Boltzmann(paper written)
- Simulated Annealing for plasma thrusters
- High Altitude EMP for primordial black holes(never finished)

- Flash-x simulations:
  - Basic Sedov
  - Running simple MHD simulation of my own design
- A Hamiltonian Framework on ICF Implosions Rocket Equation Based on Rayleigh-Taylor Instabilities
- Contributed to PlasmaPY
- Relativistic Rocket Equation(Newtonian)
- Relativistic rocket equation(Hamiltonian)
- Finite difference MHD Model in Fortran
- Computes velocity based upon Navier Stokes equation adapted to magnetic and electric fields
- Outputs graphical color field of velocity
- Asteroid game
  - Classical
  - Time
  - Survival
  - Newtonian(player and asteroids have gravity)
  - Dark Matter(Invisiable gravity fields)
  - Relativistic(time dilation, spacial contraction, black holes, etc)
  - Proximal Policy Optimization “AI” played game
- Hamiltonian based plasma thruster Fortran Numerical Code
- N body simulation

- Fluid based N-body simulation
- Death Star
  - Basic gravitational ‘planet’
  - MHD Plasma beam hitting
  - Basic evaporation and kinetic energy transfer
- OpenMHD usage
- Usage Gkyl
- Omega-X project
  - Inspired by FLASH-X, attempting to build a multi-physics plasma physics codebase using Metriplectic forumism rather than Lagrandian and Newtonian
  - I have successfully implemented the 1D thermofluid metriplectic discretization onto a discontinuous Galerkin subspace using an L^2 projection. Integrated using implicit midpoint rule.
  - Working on module registry & driver pattern

34.1.3 Other activities

I also had some other activities that I have done in high school, I won’t go too much in them.

- SVA
- Boy Scouts
- Church activities
- JROTC
- FCA

- OA
- Etc

The OA, Order of the Arrow, I will continue into college.

34.2 Pre-University

34.2.1 Independent Learning

One thing I need to do is nail calculus completely. I am going to be taking the AP calc BC test without taking the course.

Beyond that, I am completing differential geometry. Once done I will finish Symplectic geometry. Then lie (brackets, algebra, group, and theory)

I also want to get into functional analysis.

I should also learn C++ beyond what I have done in the past.

34.3 Undergrad

34.3.1 Classes

34.3.1.1 Requirments

34.3.1.1.1 General

I have tested out of many of the general education requirements, so here is the remaining bit:

- Written communication(pick 1)
  - Honors ethical theory
  - Haslam knowledge

- Oral communication
  - A survey in Contemporary Physics
- Arts and humanities(pick 2)
  - Haslam Knowledge
  - honors intro to philosophy
  - Professional responsibility
- Civilization(pick 2)
  - Honors development of Western civilization
  - Honors history of world civilizations
  - University Honors
  - World Religions

34.3.1.1.2 Academic Physics Major

- Prerequisites
  - Intro Computer Science
  - Differential Equations 1
  - Matrix Algebra
- Core
  - Fundamentals of modern physics
  - Mechanics 1
  - Thermal Physics
  - Electronics Lab
  - Intro to quantum mechanics
  - Modern optics
  - Electricity and Magnetism

  - Survey in modern physics
  - Modern Lab
- Academic
  - Mechanics 2
  - Intro to quantum 2
  - Electricity and magnetism 2
- Recommended
  - Mathematical Methods for scientist
  - Partial Differential Equations
  - Complex Variables
- Thesis in physics

34.3.1.1.3 Applied Maths Major

- Computer Science
- Core
  - Diff equations
  - Matrix Algebra
  - Intro to abstract mathematics
  - Math proficiency
- Breath
  - Honors abstract algebra 1
  - Honors Analysis 1
  - Numerical Analysis
  - Stochastic processes

- Applied breath(physics courses)
- Depth
  - Numerical Algebra

34.3.1.1.4 Computer Science Minor

- Intro comp sci
- data structures
- Logic design
- Numerical Algorithms
- Numerical Analysis
- Numerical Algebra
- Parallel Programming

34.3.1.1.5 Electives

- PHYS 441 - Introduction to Computational Physics
- PHYS 494 - Special Topics in Physics
- 2nd PHYS 493 - Research and Independent Study
- PHYS 531 - Mechanics(Maybe, graduate)
- PHYS 541 - Electromagnetic Theory(Maybe)
- PHYS 571 - Mathematical Methods in Physics I(maybe)
- PHYS 573 Numerical methods in physics(maybe)
- PHYS 615 Astrophysics(maybe)
- PHYS 643 Computational Physics(maybe)

- MATH 462 - Differential Geometry
- MATH 467 - Honors: Topology
- MATH 536 - Partial Differential Equations II
- MATH 567 - Riemannian Geometry I
- MATH 568 - Riemannian Geometry 2
- MATH 572 - Numerical Analysis II
- MATH 577 - Optimization
- MATH 579 - Seminar in Numerical Mathematics

34.3.1.1.6 Total

- Honors ethical theory(x)
- honors intro to philosophy(x)
- Professional responsibility(x)
- Honors development of Western civilization(x)
- Honors history of world civilizations(x)
- Intro Computer Science(x)
- Differential Equations 1(x)
- Matrix Algebra(x)
- Fundamentals of modern physics(x)
- Mechanics 1(x)
- Thermal Physics(x)
- Electronics Lab(x)

- Intro to quantum mechanics(x)
- Modern optics(x)
- Electricity and Magnetism(x)
- Survey in modern physics(x)
- Modern Lab(x)
- Mechanics 2(x)
- Intro to quantum 2 x
- Electricity and magnetism 2 x
- Mathematical Methods for scientist(x)
- Partial Differential Equations x
- Complex Variables x
- Thesis in physics (x)
- Intro to abstract mathematics x
- Honors abstract algebra 1(x)
- Honors Analysis 1 (x)
- Numerical Analysis x
- Stochastic processes (x)
- Numerical Algebra(x)
- data structures(x)
- Logic design(x)
- Parallel Computing (x)

- 35(-1, -4, maybe) main(13-15 electives)
- MATH 462 - Differential Geometry(1)(x)
- MATH 467 - Honors: Topology(2)(x)
- PHYS 441 - Introduction to Computational Physics(15)
- PHYS 493 - Research and Independent Study(3)(x)
- PHYS 531 - Classical Mechanics(4)(x)
- PHYS 541 - Electromagnetic Theory(5)(x)
- PHYS 571 - Mathematical Methods in Physics I(6)(x)
- PHYS 573 - Numerical Methods in Physics(7)(x)
- MATH 515 - Analytical Applied Mathematics I(8)(x)
- MATH 567 - Riemannian Geometry I(9) x
- MATH 568 - Riemannian Geometry II(10) x
- MATH 569 - Seminar in Topology and Geometry(11)
- MATH 574 - Finite Element Methods(12)
- MATH 578 - Introduction to Scientific Computing(13) (x)
- MATH 585 - Optimal Control Theory(14)
- PHYS 599 - Seminars(x)
- PHYS 593 - Independent Study(x)

34.3.1.2 Schedule

physics general math comp sci

34.3.1.3 First Year

1. Honors ethical theory
2. Honors intro to philosophy
3. Professional Responsibility
4. HR: Western Civilization
5. HR: World civilization
6. Intro computer science
7. Diff equations 1
8. Matrix Algebra
9. Fundamentals in modern physics
10. mechanics 1
11. Intro to abstract mathematics
12. PHYS 503 - Physics Colloquium

34.3.1.4 Second Year

1. Thermal Physics
2. Electronics Lab
3. Intro to quantum mechanics
4. Modern optics

5. Electricity and Magnetism
6. Survey in modern physics
7. Modern Lab
8. Mechanics 2
9. Intro to quantum 2
10. Electricity and magnetism 2
11. Partial Differential Equations
12. Numerical Analysis

34.3.1.5 Third year

1. Honors abstract algebra 1
2. Honors Analysis 1
3. Stochastic Processes
4. Numerical Algebra
5. Mathematical Methods in physics
6. Research & independent study
7. Differential Geometry
8. Honors: Topology
9. Classical Mechanics, grad

10. PHYS 541 - Electromagnetic Theory, grad
11. MATH 515 - Analytical Applied Mathematics I
12. Independent study and research

34.3.1.6 Fourth year

1. Thesis in physics
2. MATH 567 - Riemannian Geometry I
3. MATH 568 - Riemannian Geometry II
4. Numerical methods in physics
5. data structures
6. Logic design
7. Parallel Computing
8. PHYS 599 - Seminars
9. PHYS 513 - Problems in Theoretical Physics I
10. MATH 578 - Introduction to Scientific Computing
11. MATH 534 - Calculus of Variations
12. MATH 537 - Mathematical Principles of Continuum Mechanics I

34.3.1.7 Others

1. PHYS 514 - Problems in Theoretical Physics II
2. MATH 585 - Optimal Control Theory
3. MATH 574 - Finite Element Methods
4. PHYS 615 - Astrophysics and Cosmology(grad required)
5. PHYS 643 - Computational Physics(grad required)
6. MATH 515 - Analytical Applied Mathematics I
7. MATH 571 - Numerical Analysis I
8. MATH 572 - Numerical Analysis II

34.3.1.8 Possible summer

1. Graduate Reading in Mathematics
2. Research and independent study
3. graduate reading in physics
4. Special Problems

34.4 *Grad

34.5 *Early career

34.6 *Late Career

Chapter 35

Journal

This section will hold daily journaling. Essentially it will be day-to-day notes and plans. These will then be synthesized into the previous chapters in this book.

35.1 2025-11-27

35.2 Emacs

This is my first journal write using EMACS, for that has been my project at the moment. Creating a doom Emacs with Org-mode enhancements, AUCTeX/pdf tools. Org-roam(graph+server), Org-bable for multiple languages(FORTRAN, python, Julia, Jupyter, and shell), LSP for coding, Magit(for git), projectile/treemacs(for using projects), a daily journal that auto inserts into my LaTeX book, and create Org nodes and graphs for chapters and journals.

For the most part I have this set up. I need to edit AUCTeX so that it uses latexmc rather than latex, so that it will run multiple times for the book-like structure. I think I have more dependencies I need for the languages. I still have more to learn to get comfortable with this program. Also, I am not sure that the program auto inserts my journals.

```
print("2+2 =", str(2+2))
```

35.3 2025-11-29

35.4 Axiom

As is very obvious, I am making a transfer from now on. I will have this section for day-to-day journaling and notes, while the previous sections for more concise and developed thought. I won't change the already made stuff. This new This takes me to Emacs, I have figured out how to incorporate Org files into my LaTeX book.

I do need to work on attaching it to the table of context. I believe I should have this completed by the end of the day.

35.5 Emacs

I am learning much about how to use Emacs, as I have mentioned above I have been working to better understand and use Emacs. I have created two new function's. One to make IDs for Org files written outside of Emacs and also to turn Org files into LaTeX to use.

35.6 Media

35.6.1 Zettelkasten

I was originally having this section be a Zettelkasten-like notes taking. Though after more consideration, I have reconsidered. While a similar linking will be useful, I am unlikely going to have the same extreme modularity that is accustomed to the system. Thus, I am unlikely to use it fully, but some use is likely.

35.7 2025-12-03

35.8 Links to Book Chapters

- coding Axiom `roam:Omega-X` `roam:plans` `roam:personal_analysis`

35.9 Emacs

35.9.1 Emacs updates

For this journal, remember that the command is SPC n r d t. Beyond that I have fully completed the Org → LaTeX file. Though, as useful as these programs can be it does raise the question of if I should use it. I have begun to question its usefulness.

35.9.2 Emacs vs Vim

I have found that as I have created these things, I have realized I can substitute a lot of the programs by simple scripting and vim. While Vim's speed and ease of use has its use. I do think the scripting of Emacs it also quite fast, ease of moving between files, and even the spell check. Beyond that the integration of things coding languages is potentially very useful once I gain the hang of it.

35.9.3 Org vs Tex

One question I have been looking into is whether I should write my notes directly in LaTeX or continue to write in an Org file and export to LaTeX after the fact. **Org**

Pros	Cons
Org babel to run commands	Easy errors
Org-capture to quickly make notes	whitespace inconsistenc
Graph view	Hard to write math witl
Easy connections	Difficulty with more complex LaTeX
Easy to use syntax	Degregation of performace ov
Easy to use Hierarchy	

Tex

Pros	Cons
Absolute control	more verbose
none of the easy errors	Have to script new stuff
Can be scripted to simulate Org-capture-like	No babel
More freedom of use in LaTeX commands	

35.9.4 Future

Currently my plan is to have continue to use Org for journaling, though I may revisit this idea later on.

With this I will continue to learn how to use Org/LaTeX integration and use. Also some of syntax of Org. I also need to learn more about running code and using it in Emacs. I currently only use it for notes.

- note-book enviorment(like jupiter)
- build-up the graph view
- Agenda
- linking
- task automation

35.10 Omega-X

35.10.1 Arguments

Currently, I have the poor practice of setting variables in a module and ignoring using arguments or such things. I plan to rectify this. This is for several reasons; to protect from errors and to allow for MPI(my next step).

35.10.2 Updates

I need to continue on a couple of sets. Create a IO files, finish the evolution driver, and have ways to analyze the data.

35.11 Future Ideas

I have a couple ideas for future projects:

35.11.1 Categorical Metriplectic

Using category theory to set up a fully and complete formal theory of the Metriplectic system. This is highly ambitious considering my limited knowledge in category theory, but it is a field that is thoroughly explored and thus I believe it is within my reach to accomplish.

35.11.2 Cason Brackets Dynamics(name pending)

I believe I can integrate metriplectic systems to Nambu mechanics. As far as I know this is a completely novel goal and thus would be my own. Let's see with the names: Cason Formalism, Cason Mechanics, Cason dynamics, Cason framework, Cason Analysis, Casonian Dynamics, Casonian Mechanics, Cason's Method, Cason's Dynamics, Casonic Dynamics, The Cason Principle, Cason Bracket Dynamics, Cason system, Cason Framework for hybrid Dynamics. I know this seems overtly narcissistic, trying hard to come up with a name based upon my own; I don't really care.

35.11.3 Metriplectic PINN

I have read several papers using Metriplectic dynamics to create PINN(Physics-informed-neural-networks).

35.12 Media

35.12.1 Star Trek

I forgot how much I like Star Trek next Gen, especially Picard.

35.13 Self-analysis

35.13.1 Stress \ TV

For some reason, watching TV where the show lets you in on how stupid an idea is and yet the character does it stresses me out. Especially with lying and illicit activity. When they lie and it spirals out, then they lie more. I don't like it. Messes with me.

35.14 2025-12-04

35.15 Links to books

- plans

35.16 Projects

I have recently come into more free time and would like to use it to my advantage to increase my abilities and capacity; though, I am having trouble considering what to do, in what order, and how to block my time.

35.16.1 Formal projects

The actual projects I want to work on are continuing:

- FORTRAN Omega-X project([Omega-X]finish it, develop parallel computing, develop TUI, continue documentation, profile it, add higher order methods, more time stepping methods, add modules for working with additional systems, data analysis, visualization, GPU acceleration, etc)

- Cason Bracket dynamics: synthesis Nambu and Metriplectic and incorporate into Omega-X

- Categoric Theory of Metriplectic Dynamics: Self explanatory

- Metriplectic PINN: PINN based upon PINNs

- Emacs Building: I want to build workflows and other things in Emacs to make stuff easier for me(coding workflow, see data, writing book stuff)

35.16.2 Skills

There are several skills I want to continue to develop:

- Julia coding: right now in the basics

- C++: similar to Julia

- Emacs: I want to get more comfortable with the key-bindings and creating commands to make things simple

- Parallel computing: most clearly can gain this through my Omega-X project

- Org/LaTeX: Learing how to use both org and tex so they work together.

35.16.3 Plan

I am thinking schedule it:

1. develop a plan for the day in Org, experiment with Org/TeX integration to gain that experience in that regard.
    - Incorporate Julia whenever possible
2. Theoretic study - work on one a day
    - Categoric Theory of Metriplectic Dynamics
    - Cason Bracket Dynamics
3. Programming Project - work on one maybe two a day
    - Develop Omega-X project
        - finish it
        - develop parallel computing
        - develop TUI
        - continue documentation
        - profile it
        - add higher order methods
        - more time stepping methods
        - add modules for working with additional systems
        - data analysis, visualization
        - GPU acceleration
    - Develop Emacs tools
        - Create Julia REPL in Emacs and keybinding to make it simple
        - custom LaTeX keys
        - Set FORTRAN build and run
4. Skill Development - work on one or two a day
    - Julia
        - symbolic Poisson/Nambu brackets solver

  - ODE solver using the SciML interface
  - GPU-accelerated metriplectic evolution
  - Category theory for dynamics
- C++
  - Simple library
  - SIMD-accelerated
  - learn expression templates
  - GPU version using CUDA or HIP
  - Plug-in architecture
  - simple MHD solver
- FORTRAN
  - Coarrays
  - Polymorphic OOP with type-bound procedures
  - Generics (Fortran 2023)
  - MPI
  - GPU Offloading
  - Memory alignment + SIMD-aware design

35.17 2025-12-05

35.18 Links to Book Chapters

-

35.19 Plans for Today:

I have been currently working on my school work; getting caught up with that. I have also conntacted NSCC about the dual enrollment program to make sure I am not missing anything.

For my next steps:

- Programming Project: Omega-X
  - First: I am going to build a type binding for Omega-X's ininitilize subdriver.
  - Second: formalize $\text{declare}_{\text{vars}}$ module to work for this new update
  - Third: Move C++ binding to a safe place(C++/FORTRAN?[either fits])
- Theoretic study: Catogoric Metriplectic:
  - Create LaTeX notes sections
  - Write list of possible papers to read
  - Read one and write notes
- Programming/skill: EMACS building/Julia
  - Develop Julia REPL in EMACS
  - Play around with it once in

35.19.1 Omega-X Notes

As I mentioned in the above section my first task is to develop a type system for $\text{driver}_{\text{init.F90}}$. To create the types:

```
module types_make
     !individual types
      type :: name_of_type_1
        real :: variable_in_type_1
      end type name_of_type_1

      type :: name_of_type_2
```

```
        real :: variable_in_type_2
      end type name_of_type_2

      ! higher level type
      type :: higher_level_type
        type(name_of_type_1)
        type(name_of_type_2)
      end type higher_level_type
end module types_make
```

The to use it:

```
program use_types
        use types_make

        type(higher_level_type) :: H_T_L

        ! initialize fields
        H_T_L_of_type_2%variable_in_type_2 = 1.0
```

I ended up doing less than I imagined. I created the type system and corrected the arguments for many things. My next steps should be to develop the

1. $declare_{vars}$
2. fix uses of modules
3. Change python code to work with new type arguments.

This is what I can do tommorow.

35.19.2 Emacs Build

While working on Omega-X I figured I should focus on FORTRAN integration before Julia, I also saw a cool calculator thing I will set up and shouldn't take long.

Calculator:

- Get in M-x calc or C-x * or M-x full-calc
- It is in reverse polish notation: operators follow their operands
- t to get to trail
- i to enter
- u to undo
- DD to redo
- TAD to swithc
- DEL to delete one

There is also a LaTeX embeded system:

- C-x * e → Enter calc-embedded mode.
- C-x * r → Replace the marked expression with its result.
- C-x * q → Quick evaluation of inline expressions.

calc-embedded C-x * e Enter embedded mode on the current region (or insert delimiters if none). calc-embedded-word C-x * w Evaluate the word at point as a Calc expression. calc-embedded-activate C-x * a Activate embedded formulas in the current buffer. calc-embedded-new-formula C-x * n Insert a new embedded formula at point. calc-embedded-select C-x * s Select the next embedded formula in the buffer. calc-embedded-edit C-x * e (when inside formula) Edit the embedded formula in Calc. calc-embedded-update C-x * r Replace/update the formula with its evaluated result. calc-embedded-update-all C-x * u Update all embedded formulas in the buffer. calc-embedded-clear C-x * c Clear (remove) the result part of an embedded formula. calc-embedded-clear-all C-x * C Clear results for all formulas in the buffer. calc-embedded-duplicate C-x * d Duplicate the current formula. calc-embedded-next C-x * n Jump to the next embedded formula. calc-embedded-previous C-x * p Jump to the previous embedded formula. calc-embedded-reload C-x * l Reload Calc settings for embedded mode.

Now I have created the FORTRAN stuff:

1. Fortran-lang LSP

2. Fortran-indent improvements and compile.el

3. custom build commands

4. Org babel

35.19.3 Categoric Metreplectic

35.20 2026-01-03

35.21 Links to Book Chapters

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35.22 Emacs

35.22.1 TABS

I have recently added the tab like system. Here are the commands: New tab tab-new C-x t 2 Close tab tab-close C-x t 0 Switch tab tab-next / tab-previous C-x t o / C-x t O Rename tab tab-rename M-x tab-rename Duplicate tab tab-duplicate M-x tab-duplicate

So that's that.

35.23 2026-02-05

35.24 Links to Book Chapters

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35.25 Plans

As I mention in "Self-development" at this time I am working to return to normal. For this I have to re-establish and create habits to be the person I want to be.

35.25.1 9:00 - 11:00

- Wake-up
- Prepare for the day
- Hair-cut

35.25.2 11:00 - 1:00

- Exercise
- Eat Lunch

35.25.3 1:00 - 4:00

- Do Calculus review exam

35.25.4 4:00 - 5:00

- Read
  - The Karamazov Brothers
  - Numerical Hamiltonian

35.25.5 5:00 - 5:45

- Eat

35.25.6 5:45 - 6:00

- Math discussion post

35.25.7 6:00 - 7:00

- Project
  - Numerical Hamiltonian
  - Website
    * One idea is to create a kinda to do website based upon my schedule of that day.
  - Writing
  - Other

35.25.8 7:30 - 8:30

- Blank period for extra time to push things back

35.25.9 8:30 - 10:00

- Watch TV