

VERSF in plain language

How the proposed picture of reality connects to the mathematics

No physics background needed • 10 October 2026

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1 Start with the world around you

Hold a cup in your hand. It has a shape, it resists your fingers, it occupies a place, and it has a history. It was made, used and perhaps chipped. A picture of reality needs to explain how there can be things with these properties at all.



A familiar cup brings the questions together: matter, shape, resistance, place and history.

We can work backwards. The cup is made of atoms, tiny arrangements containing electrons and a central nucleus. The nucleus contains protons and neutrons, which contain quarks. But listing smaller ingredients leaves another question: why do those ingredients exist, and why do they behave in these particular ways?

The familiar cosmic story

The hot Big Bang account describes an early universe that was much hotter and denser than today. As it expanded and cooled, conditions allowed particles to combine into increasingly lasting structures. Much later came stars, planets and objects like your cup. This account is supported by evidence including the universe's expansion, its leftover early light and the abundance of light elements.

It does not provide a settled explanation of the ultimate origin of everything. Nor does saying "particles emerged" explain why nature has these particle types, masses and interactions. Those are among the deeper questions VERSF is trying to address.

The VERSF question

Could space, time, particles and forces be connected expressions of a more basic organisation? VERSF explores a picture in which distinguishable structure, the changes it can undergo and the lasting traces of those changes help explain the world we experience.

The next four chapters tell that proposed story before introducing the mathematical tools. They move from the underlying possibility of structure to differences, records, space and time, persistent patterns, and finally familiar matter. This is an order of explanation, not a measured timetable of separate events.

A few ordinary meanings

A particle is a small-scale physical entity such as an electron; it need not be a tiny solid ball. An interaction is how physical things affect one another. A field describes a physical quantity throughout a region, like temperature across a weather map. A model gives precise rules for calculating what should happen.

The origin story below presents VERSF's proposed interpretation. Specific calculations support particular steps under stated assumptions; a complete derivation of our universe is still the goal. The guide will show where the mathematical work fits into that goal.

2 From underlying possibility to a difference that lasts

What does VERSF mean by the void

Start by setting aside the picture of empty space. An empty room already has distances, directions and time passing. In the foundational VERSF account used here, the void names the proposed ground of possibility before those familiar features are defined. It is not a dark room, a hidden gas or a reservoir into which energy can be poured.

This is the deepest starting point of the proposal: what makes a structured reality possible at all? It is a philosophical starting point, with stated assumptions. The void paper explicitly leaves the physical origin of the first differentiation open.

Why a difference matters

Imagine a page with no marks and then a page with two different marks. With the second page, there is something to distinguish and a relationship to describe. "Distinguishable" simply means that alternatives can, in principle, be told apart by an appropriate physical process. It does not require a person looking.

The page only illustrates the idea of a difference. A real page already has space and matter, so it cannot show how the void becomes structured. The step VERSF needs to explain is precisely how a ground with no such structure can support the first physical distinction. Giving that step a name does not yet explain its mechanism.

A changing difference and a kept difference

Move a finger through the air and then press it into soft clay. Both involve change, but the clay can retain a trace. That gives us an everyday picture of the distinction between change and a physical record of change.



A touch ends, but its impression remains. A record is a physical trace.

VERSF calls the keeping of a physical distinction commitment. The word implies no intention or decision. Its cosmological account distinguishes reversible ordering, called ticks, from irreversible commitments, called bits. Irreversible means the change cannot be fully undone within the physical

limits being considered. A tick here is not a second on a clock, and a bit is not a tiny computer hidden inside matter.

A record can later be damaged or erased; “kept” does not mean indestructible. What matters is that a trace has entered the physical history and that recovering the earlier situation is constrained by the whole process, including the surroundings.

Where entropy enters

Entropy gives a way to describe alternatives and their distribution. A shuffled deck illustrates how many detailed arrangements can fit one broad description. In VERSF, entropy and its changes help describe the organisation and commitment of distinctions. Entropy is not a material poured into the void.

This gives the story its first problem to solve: how can differences become physical, and which of them can leave lasting consequences? The admissibility and record calculations later in the guide address parts of that problem.

3 How space and time enter the story

Relationships before a ready made map

A railway map tells you which stations connect, even when the drawing gives poor distances. Connections and measured distance are related ideas, but they are not the same thing. This helps us imagine asking about relationships before assuming a complete map of space.



Connections tell us which routes are possible. Measuring their lengths asks a further question.

VERSF seeks to explain how relationships between physical differences could give rise to places and distances. Its cosmological account proposes that, as more changes leave lasting records, there is more space whose different parts can be physically told apart. The papers call this unfolding.

This is a proposed physical connection, not a consequence of merely counting things. A pile of receipts does not create extra space. The theory must supply rules relating its particular physical commitments to distances, volume and observations. Later chapters explain why geometry and a measuring rule are needed.

A history gives change a direction

Imagine a trail of footprints. The marks let later events retain evidence of earlier ones. In VERSF's proposed account, accumulated irreversible commitments provide the basis for physical history and for the direction we call past to future.

Ordinary clocks measure time by comparing repeating processes. The deeper VERSF question is how anything like a clock becomes possible in the first place. Its cosmology gives a rule linking the accumulation of lasting records to elapsed time. Counting records alone does not tell us how many seconds have passed.

Where the Big Bang belongs

In this cosmological account, the Big Bang is associated with a transition into a regime where irreversible commitments become important and a large-scale space-and-time description becomes available. "Phase transition" means a change in the kind of collective behaviour a system supports. Water beginning to form a crystal is a useful picture of new organisation appearing, although freezing itself can be reversed.

In the proposed stage where patterns form but their changes can still be undone, there is already more structure than in the featureless void. These are different steps in the explanation. VERSF still needs to explain the physical connections from the void, through those changing patterns, to the expanding universe.

What does before mean here

At this foundational level, "before" means underlying in the explanation, rather than a date on an earlier cosmic clock. We should not imagine the void waiting for billions of years, getting hotter, or finally deciding to change.

The aim is to explain how a universe acquires a physical history and spatial organisation. To connect this proposal to the observed universe, VERSF must recover the hot, expanding history that cosmological evidence describes. The origin picture and that observational task belong together.

4 Why different particles and forces could appear

A lasting thing can be an organised process

Watch a whirlpool. Water moves through it, yet a recognisable pattern persists for a while. A guitar string offers a second example: the same string can support different organised vibrations. These pictures help us imagine physical identity arising from a pattern and its behaviour.



The water changes while the whirlpool remains recognisable. An analogy for persistence through organisation.

VERSF's particle programme explores how the organisation of an underlying structure could give different physical patterns their identities. Its language of folds, resonances and modes belongs here. A fold refers to structured differentiation; a resonance suggests organised behaviour that can be sustained; a mode is a particular pattern of change.

The proposal is not that electrons are water vortices or vibrating guitar strings. A successful particle account must explain the actual properties of electrons, quarks and the other particles, including how they interact. The pattern must reproduce those measured properties.

Why some patterns last

A pattern can be disturbed, reorganised or broken apart. The theory needs to explain which changes are possible and how difficult they are. Think of a ball settled in a bowl: small nudges and large pushes can have different consequences.

This is where ridges, basins and stability enter the story. They help describe how one organisation can remain recognisable while another fades or changes. When conditions change, the patterns that can persist or be produced may change too. We must calculate this rather than assume every pattern survives.

Why more than one kind

One guitar supports more than one note because its rules allow different organised motions. Similarly, VERSF asks which patterns its rules allow, which are genuinely different and which physical properties distinguish them. Modes and eigenvalues are tools for answering those questions. An eigenvalue is not automatically a particle mass; its meaning depends on the calculation.

Why particles must be able to affect one another

Separate persistent patterns would not yet explain an interacting world. The theory also needs to describe how a change in one part affects the surrounding organisation and other patterns. That is where the field and force calculations enter.

Transport compares neighbouring descriptions. Holonomy checks the accumulated comparison around a loop. Response calculations ask how the structure reacts to a change. Together, these tools help VERSF investigate interactions and their strengths. Identifying a loop mismatch alone does not establish a force.

Gravity adds the question of how spatial and temporal relationships respond to physical organisation. VERSF seeks a shared foundation for that response and particle physics. The gauge calculations later in

this guide address specific interaction questions; they are not a complete derivation of gravity or of every particle.

5 From early patterns to the world in your hand

Cooling changes what can stay together

Imagine trying to build a house of cards on a vigorously shaking table. Slow the shaking and arrangements that kept falling apart may survive. In the early universe, energetic encounters could break apart bound structures. Cooling made lasting combinations possible.

Here the story joins the established thermal history: quarks became bound into protons and neutrons; during the first few minutes some protons and neutrons joined into light atomic nuclei. A nucleus is the central part of an atom. Much later, around 380,000 years into the standard history, electrons could remain bound to nuclei in neutral atoms. Atoms therefore appeared much later than their constituent particles.

Larger structures become possible

Gravity gathered gas into stars and galaxies. Stars produced many heavier elements, and stellar processes spread enriched material. Later generations of stars and planets formed from it. On planets, atoms could join into molecules and materials. The familiar cup is one late arrangement of ingredients with a long cosmic history.



Everyday matter has a cosmic history. This illustration is not a scale drawing or a timetable.

VERSF seeks to explain the underlying particle patterns, interaction rules and space-and-time behaviour. The known sequence of cosmic assembly gives that ambition concrete requirements.

The whole proposed picture

Start with the proposed ground of possibility. Ask how distinguishable structure can arise and how some changes become lasting physical commitments. Ask how those relationships support space and time, which organised patterns behave as particles, and how they affect one another. Then follow what those ingredients can build as cosmic conditions change.

Persistent patterns need rules for change. Interactions need meaningful comparisons. A history needs retained consequences. Familiar objects require all of these working together.

Where to go next

Chapters 6–8 explain arrangements, stability and measuring differences. Chapters 9–10 explain neighbouring relationships and round trips. Chapters 11–12 explain patterns and symmetry.

Chapters 13–15 connect records and physical responses with predictions. Chapter 16 translates a technical sentence into ordinary questions.

What remains to be connected

The sources used here do not yet provide one completed calculation from the featureless void to the full observed universe. They offer an origin proposal and mathematical investigations of particular links. The cosmology paper reports comparisons with expansion-related observations while leaving further tests of cosmic structure growth open. The first differentiation and several bridges to final particle and force predictions remain research problems.

Read the mathematics with the cup in mind: which part of explaining a world with persistent things, interactions, places and a history is this calculation helping us understand?

6 How can one underlying system make different things?

Picture a screen

A screen can show a face, a tree or a moving wave. It does not need a different kind of screen for each image. The differences come from how its parts are arranged and how that arrangement changes.



The same kind of screen supports very different images through different arrangements of its parts.

This helps picture an ambition within VERSF: to explain different physical structures through differences in underlying organisation. The screen is only an analogy. It gives us a starting question: what must we describe if we want to work out how an organised pattern behaves?

First, describe the whole arrangement

On a mixing desk, one complete choice of slider settings is one arrangement. Change a slider and you have another. The technical word for a complete arrangement is configuration.

VERSF calculations can include several things at once: the state of neighbouring parts, how they are connected, what is flowing between them and what traces earlier events have left. These details

matter because changing one while holding another fixed can produce a different result from changing both together.

What does a “fold” contribute to the picture?

Folding paper creates structure by rearranging what is already there. VERSF’s fold language helps express the idea that physical properties might depend on organisation. To calculate anything, however, a particular fold must be described precisely. The paper-folding picture alone cannot tell us how an electron behaves.

Which changes are actually allowed?

A lamp may let you adjust brightness and colour separately. Each independent control is called a degree of freedom. The collection of possible settings is called state space or configuration space. This is a space of possibilities; it need not mean extra directions in the room.

Not every arrangement we can imagine is necessarily allowed by the model. Admissibility means meeting its rules. VERSF’s Physical Admissibility Framework proposes limits on the distinctions a physical system can support and constraints on turning a distinction into a lasting record. Think of the difference between drawing a building and showing that it can be built.

Why VERSF needs these ideas

They turn “there is an underlying pattern” into questions we can answer: What specifies it? What can change? What must stay fixed? Without those answers, we cannot calculate whether the pattern lasts or how it responds when disturbed.

7 Why do the papers describe hills, valleys and ridges?

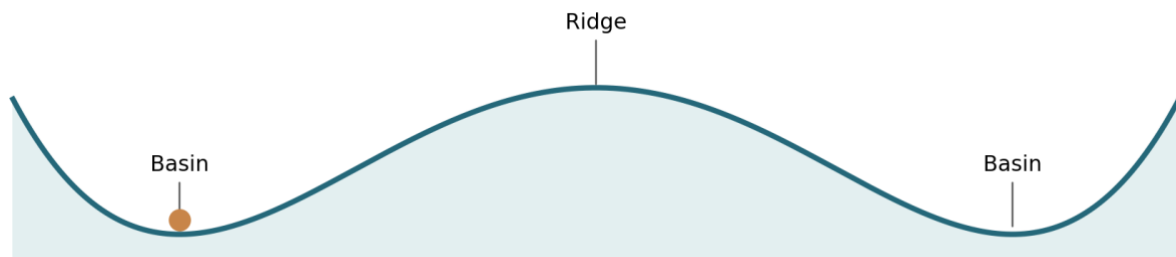
The question behind the picture

Some arrangements may be easier to reach than others. Some may last; others may quickly change. VERSF needs a way to describe those differences. A landscape is a picture of how a chosen quantity varies from one possible arrangement to another.

Imagine a ball in a bowl

Nudge the ball slightly and it tends to return towards the bottom. Push it far enough and it might leave the bowl. The shape helps us picture a pattern that can withstand small disturbances.

Now imagine two bowls separated by a raised crest. That crest is a ridge. It helps us picture why moving within one region might be easy while reaching another requires a larger change. A basin is the region leading towards a particular resting place under the movement rule being considered.



A schematic landscape: two basins separated by a ridge. The height must be defined by the particular model.

What do the heights stand for?

They must stand for something specified in the calculation. Height might represent energy: a larger number means more energy in that arrangement. In another picture it could represent probability, meaning how likely an outcome is. The earlier VERSF papers also use entropy landscapes.

Entropy concerns how possibilities are distributed and, in suitable settings, how many detailed arrangements fit the same broad description. There are many ways for a deck of cards to look shuffled and few ways for it to be perfectly ordered. The card example gives the basic idea; the calculation supplies the precise definition.

These different landscapes must be read differently. A low point on an energy map is not automatically a low point on an entropy map. VERSF has to say what the height represents before drawing conclusions from the picture.

Two useful words: slope and curvature

Gradient is the mathematical name for the steepest increase of the chosen quantity. Curvature of the landscape describes how its slope changes. A gently rounded bowl and a sharply curved bowl react differently to a nudge. When the landscape represents energy, this helps us calculate resistance to a small disturbance.

Why VERSF needs these ideas

The aim is to explain how an arrangement can remain recognisable and how it changes into another. Ridges and basins make those possibilities easier to picture. To predict what happens, the model must also specify the rule for movement. A map of hills alone does not tell us how fast a traveller walks.

8 Why is a space of possibilities called “geometry”?

Geometry is about relationships as well as shapes

Suppose a lamp has a brightness control and a colour control. You can draw a map of its settings: move right to increase brightness and up to change colour. The map describes possible states of the lamp, not places where the lamp can stand.



Brightness and colour give two independent ways to change a lamp's state.

VERSF uses this kind of reasoning for more complicated arrangements. A point can stand for a whole state. A direction can stand for a particular way to change it. This lets the calculation compare possibilities without listing every one separately.

How big is the difference?

A one-step change on a brightness dial and a one-step change on a colour dial are not automatically comparable. We need a rule for measuring differences. The technical name for such a local measuring rule is a metric.

In one VERSF calculation, the question may be how easily two states can be told apart. In another, it may be how much energy a change requires. Those are different questions. A tiny change can be easy to detect without being expensive to produce.

Coordinates and basis: the labels and the controls

Coordinates are the numbers used to locate a state on the map. A basis is a set of independent changes from which other changes can be built. For our lamp, brightness and colour provide two useful controls. Another description could use combinations of them without changing the lamp.

A manifold is a space that can be described in local map patches, much as an atlas describes different parts of the Earth. In VERSF, those patches may describe possible arrangements rather than parts of physical space. The word helps mathematicians handle complicated spaces using manageable local descriptions.

Simplify carefully

A projection keeps a particular view, like a shadow that loses depth. A quotient groups descriptions that are treated as equivalent. Describing the same temperature in Celsius and Fahrenheit illustrates the distinction between changing the description and changing the physical situation, although the mathematical equivalences can be more involved.

Why VERSF needs this: some differences in a calculation are meaningful and others come only from the way we describe things. Removing the wrong difference could erase a real effect. Keeping duplicate descriptions could make one effect appear to be several.

The purpose

This geometry gives VERSF a map and a measuring rule. It makes “a small change”, “a different pattern” and “the same answer in different notation” precise enough to test.

9 How do we compare neighbouring parts?

Watch ripples meet on water

Where two sets of ripples meet, a crest meeting a crest makes a larger rise. A crest meeting a trough can partly or completely cancel it. Phase describes where a wave is within its repeating cycle. Their relative phases help determine how the waves combine.



Overlapping ripples evoke how waves reinforce or cancel according to their relative phase.

The relationship between phases matters for waves. Contributions can reinforce one another or partly cancel, depending on how they line up. VERSF's calculations need to keep track of comparable relationships in the underlying states.

Now give each dial a different zero mark

Imagine neighbouring dials whose zero marks have been drawn in different places. You cannot compare their written angles until you know how their reference marks relate. A difference in the numbers might come from the hands or merely from the markings.

Link, connection and transport

A link joins neighbouring places in a mathematical model. It can carry a rule for comparing what is described at one place with what is described at the next. A connection is the local comparison rule. Transport means following that rule along a route.

The thing being compared might be a phase or an orientation. Transport therefore need not mean that a piece of matter is physically travelling. In VERSF's link calculations, it tells us how to relate neighbouring parts of the proposed field description.

Gauge freedom: change the markings, keep the relationship

Moving a dial's zero mark changes the written angle even if the hand does not move. If the comparison instructions are updated consistently, the underlying relationship is preserved. Gauge freedom is the more general mathematical version of this freedom to change local references.

Gauge invariant means unchanged by those permitted reference changes. VERSF needs this distinction so that a change of labels is not mistaken for a physical effect. The calculations seek relationships that survive the choice of description.

Why the order can matter

Turn a book around one direction and then another. Reversing the order can leave it facing differently. Comparison rules that have this feature are called non-Abelian. If order makes no difference, they are Abelian. The strong and weak interactions use the order-sensitive kind of mathematics.

The purpose: transport lets VERSF connect local descriptions consistently. Gauge freedom helps separate what actually changed from what was merely renamed. We can then ask what happens when the comparisons lead all the way back to the starting point.

10 What can a round trip reveal?

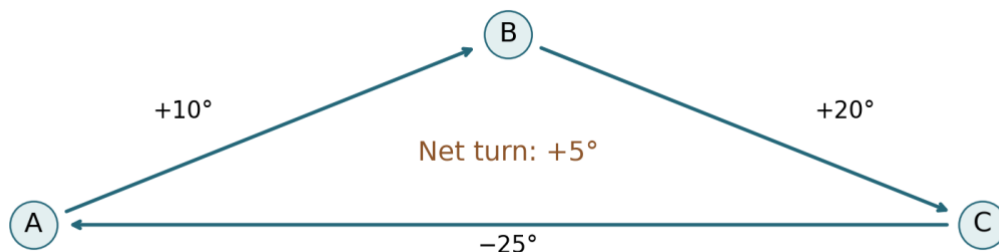
The idea behind holonomy

Follow a sequence of comparison instructions around a loop and return to the starting point. Does the compared state return unchanged? The net transformation after that round trip is called holonomy. It can be no change at all, or it can leave a mismatch.

Try a simple dial example

Imagine three places, A, B and C, with an instruction for comparing a hand from one place to the next. Going from A to B adds ten degrees. From B to C adds twenty. From C back to A subtracts twenty-five. The complete loop leaves a five-degree turn.

This is an invented teaching example, not a VERSF result. Its point is that the complete set of local comparisons can leave something behind after a round trip. Renumbering the local dials consistently does not remove that total turn.



Follow A to B to C to A. The three comparison instructions leave a five-degree turn.

What VERSF uses it for

A recent VERSF calculation examines small triangular loops. It combines the comparisons around each loop and then combines several loops in a particular alternating pattern. This tests whether the model retains information about the direction of a small phase change.

That is a more precise question than “does the structure remember something?” The calculation identifies a particular comparison and works out whether changing the underlying pattern changes its result.

Why a simpler record might miss the difference

Picture a hand pointing to the right. Tilt it a little upwards or a little downwards. Its horizontal shadow has the same length in both cases. The shadow tells you something about the hand but loses which way it tilted.

The VERSF calculation encounters a similar loss. Keeping only one part of the mathematical description can hide opposite phase changes. Retaining the fuller loop comparison reveals a distinction that the simpler summary misses. The next question is whether the physical recording process keeps that distinction too.

Curvature: the local mismatch

When such comparisons are made around sufficiently small loops, the mismatch reveals what is called the curvature of the connection. Here, curvature is about the comparison rule; it need not mean that a material surface is visibly bent.

Why VERSF needs it: this identifies a genuine field change to investigate. The later work calculation asks how much physical cost is associated with changing it. Holonomy helps specify what we are changing; it does not by itself tell us the cost.

11 Which patterns of change belong together?

Listen to a guitar string

A plucked string can move in several organised patterns at once. Describing those patterns helps us understand its sound. We do not have to treat every moving point as an entirely separate event.



A string can support several organised patterns of vibration. The painted waves are illustrative.

VERSF faces a similar problem. A change in its underlying arrangement may contain several simpler patterns. To understand the result, we need to separate those patterns and find out how the system responds to each.

Mode: a pattern of change

A mode is one organised pattern. Imagine six small platforms joined by springs. They might all move upwards together, or alternate with one up and the next down. These are different patterns, even though the same platforms take part.

Operator and matrix: the rule and its table

An operator is a mathematical rule acting on what we describe. A matrix is a table of numbers that can represent such a rule. For the platforms, the table could tell us how much restoring force appears at each platform when another is moved a little.

Eigenvector and eigenvalue: the pattern and the multiplier

Usually the rule mixes an input pattern into a different output pattern. An eigenvector is a special nonzero pattern that comes back in the same proportions. Its overall size can change, but the proportions within the pattern are preserved.

For example, a mathematical rule might turn the pair of numbers 1 and 2 into 3 and 6. The second pattern is three times the first, so three is the eigenvalue for that pattern. This example illustrates a multiplier; it is not a particle calculation. In a physical calculation, the number's meaning and units depend on the rule being used.

The VERSF connection

The recent gauge-work calculation studies six linked changes arranged with hexagonal symmetry. It separates them into regular patterns, a procedure called Fourier analysis. On the particular version of the model being studied, specified patterns correspond to parts of the descriptions of the strong interaction and the linked electromagnetic and weak interactions.

That makes the separation useful: once the physical resistance to each relevant pattern is known, it can enter the calculation of interaction strengths. Identifying the patterns alone does not determine those strengths.

Two extra words you may see

Spectrum means the collection of eigenvalues. Degeneracy means that different independent patterns share an eigenvalue. The purpose of all this vocabulary is to separate "which pattern?" from "how much response does it produce?"

12 Why can thirty-six answers reduce to four?

A small calculation can still contain many questions

With six linked parts, we could move each one in turn and examine the response of all six. That gives six times six, or thirty-six entries in a table. But some entries may have to agree because the setup treats them in the same way.

Picture six seats around a round table

Choose one of six equally spaced seats. Another seat can be the chosen seat itself, one place away, two places away or opposite. Turning the whole arrangement does not create a new kind of relationship.



From the highlighted seat, the relationships are self, one seat away, two seats away and opposite.

This is symmetry: a change of viewpoint or arrangement that preserves the relevant structure. A regular hexagon has rotational and mirror symmetries. In the paper's notation, that set of symmetries is called D_6 .

What the VERSF calculation gains

If the six-part response respects the required symmetry, and the paired responses agree when their roles are exchanged, the thirty-six table entries reduce to four independent types. The second requirement is called reciprocity.

The four types describe response on the changed part itself, on a neighbour, two steps away and opposite. This does not guess the four numbers. It tells the underlying calculation which numbers it needs to supply.

Why this matters

VERSF is trying to explain the response from its rules. Reducing thirty-six apparently separate questions to four makes that task more specific. Those four answers can then be combined to give the responses of the organised patterns described in the previous chapter.

The reduction holds for the symmetric setup being considered. If some parts are prepared differently, the same simplification cannot simply be assumed. A balanced table and a table carrying an uneven load need not respond alike.

Representation: how does a change act on this kind of thing?

Rotate your viewpoint and an arrow's written direction changes. A temperature reading does not change in that way. Representation is the mathematical name for how a symmetry acts on the particular kind of object being described.

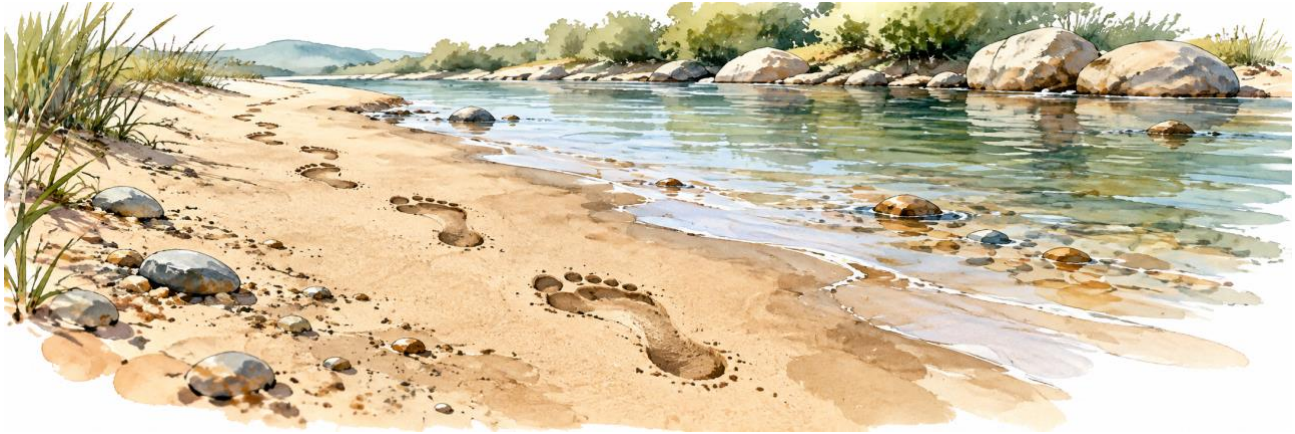
VERSF needs this because different kinds of physical structure need not respond identically. A common starting rule may need contributions that depend on the kind of structure involved. The recent work derives a definite starting set of four numbers under its assumptions, while leaving further physical identification and corrections to be established.

The purpose: symmetry reduces the number of independent questions. Representation keeps track of differences that the simplification must still respect.

13 Why does a theory of forces talk about records?

A footprint does not need a reader to exist

A footprint in mud is a physical trace. It can remain even when nobody sees it. This is the everyday sense of a record that matters here: information retained in a physical arrangement, not necessarily a note written by a person.



A physical trace can remain even when nobody is there to read it.

VERSF asks how a difference becomes a lasting, readable difference. Its recording programme treats that as a physical process. The theory must describe how the record is made, what it preserves and what changes accompany its production.

History, commitment and Fact

A history is a sequence of changes. Commitment is the term used for making a distinction retained under the model's recording rule. A completed, kept distinction is called a Fact in these papers. This connects to Chapter 2: a tick describes reversible change, while a bit describes an irreversible commitment. A Fact is the physical distinction kept through that commitment. These terms concern physical records, not a person deciding that something is true.

The connection to forces is a research question: what do the surrounding fields do when such a record is made? The configuration-dynamics paper studies proposed connections between recording events, brief changes in motion and later field behaviour. That is why records appear alongside field calculations.

A receipt cannot tell you the whole journey

A delivery receipt says the parcel arrived. A route log can also say where the van went and in which order. Both are records, but they answer different questions.

Coarse-graining means replacing detail with a summary. If a VERSF calculation needs the order or direction of changes, a summary that drops that information cannot supply it. The loop example in Chapter 10 asks exactly this kind of question: did the final record preserve the difference the underlying calculation could detect?

How much can the record tell us?

Covariance measures how recorded quantities vary together. Fisher information measures how sensitively the observations can distinguish a small change in the thing being studied. These are ways to test whether a proposed record can reveal the underlying change.

But a sensitive thermometer does not tell you how much energy a heater used. Likewise, showing that a record detects a change does not automatically establish the physical cost of producing that change. The recent VERSF papers keep these questions separate.

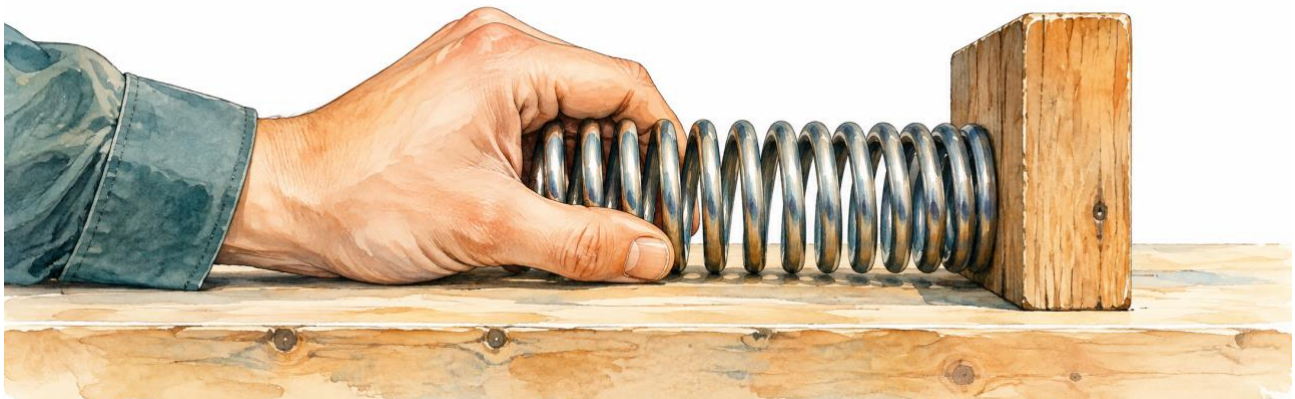
The purpose

Record analysis connects proposed internal changes to information that survives and can, in principle, be read. An additional calculation is needed to connect that information to physical work and interaction strengths.

14 How strongly does the structure resist change?

Push a spring

A stiff spring pushes back strongly when compressed. A soft spring moves more easily. Stiffness describes how strongly the restoring force changes as the spring is displaced. Physical work is energy transferred by a force acting through a distance; compressing a spring is one example.



Push the spring and it resists. A response calculation asks how much resistance a change produces.

VERSF's force calculations need an equivalent quantitative question: when the specified field pattern changes a little, what is the physical response? Knowing the pattern's geometry does not yet supply that answer.

Derivative and Hessian: measure the response

A derivative measures how one quantity changes as another is varied. For a spring, we might ask how much extra restoring force accompanies an extra millimetre of compression.

When several changes are coupled, we need a table showing how each influences the response to the others. A Hessian is a table of second derivatives: it describes how the slopes of a chosen quantity change. If that quantity is energy, it describes the local energy shape. If it is a statistical score, it describes that score instead. The same mathematics can answer different questions.

Let the other parts move too

Imagine a spring attached to a sliding support. Push the spring with the support held still. Then repeat with the support free. These are different experiments: movement of the support can change how much resistance you feel.

Clamped means the other parts are held fixed. Relaxed means the permitted parts are allowed to settle. VERSF calculations need to say which applies. Otherwise two different responses might be mistaken for conflicting answers to the same question.

Schur complement: account for the hidden adjustment

An auxiliary is an extra variable included in the calculation even though it is not the main result we want. A bath describes interacting surroundings. In a suitable small-change energy calculation, a Schur complement accounts for how the extra variables settle and gives the remaining effective stiffness.

Think: “What resistance do we feel after the other parts have adjusted?” That is the useful idea. The precise calculation has conditions, but it is not equivalent to simply ignoring those other parts.

A few related words

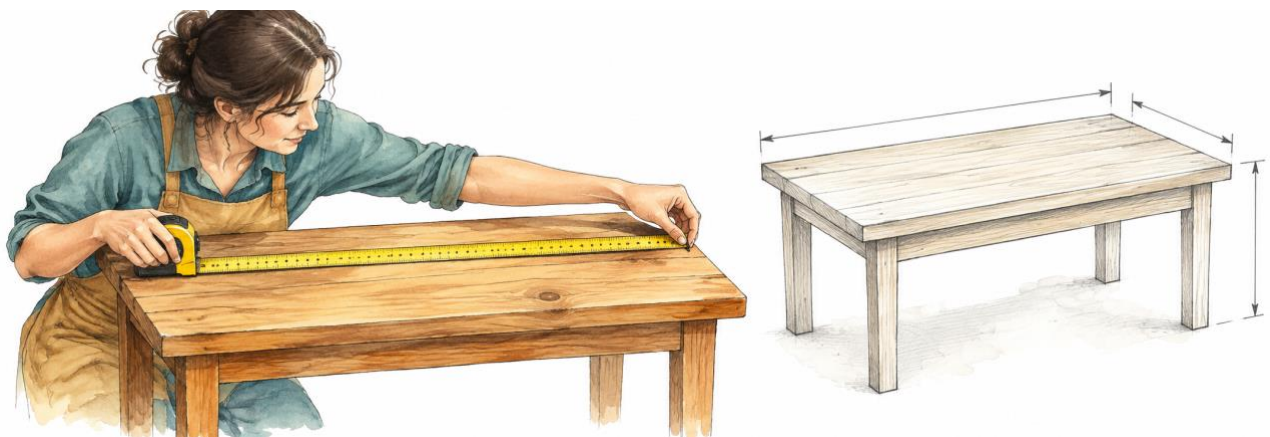
Compliance asks how far something moves for a given applied force. Screening describes a reduction of the relevant effective response. A positive energetic stiffness means a small change costs energy in this calculation. A zero response needs interpretation: it could mean a harmless change of labels or a real motion that costs nothing at the level of detail being calculated.

The purpose: calculate the physical resistance after all the allowed adjustments. This is one of the steps VERSF needs before connecting its underlying construction to measured interaction strengths.

15 How does a calculation become a prediction?

The numbers need a meaning

Suppose two people measure a table and report different numbers because one used inches and the other centimetres. Their disagreement is easily resolved. But if one measured the table’s length and the other its weight, converting units will not make them the same measurement.



A prediction and a measurement must describe the same property using compatible scales.

VERSF faces both issues. It must fix the measuring conventions, and it must establish that the calculated quantity is the physical quantity it wants to predict.

Source-derived: the rules supply the answer

In these papers, the source means the underlying model and how it has been prepared. Source-derived means calculated from those rules. If an observed answer is used to choose an unknown setting, the result is fitted or calibrated using that observation. That may be useful, but it is different from predicting the answer independently.

Normalisation and coefficients: agree on the measuring system

Normalisation fixes conventions and scales so that quantities can be compared consistently. A coefficient is a number multiplying something in an equation. A coupling is a parameter describing the strength of an interaction in the chosen convention.

The recent VERSF gauge papers seek coefficients in the mathematical description of the force fields. Those coefficients have a defined relationship to couplings. A larger coefficient does not necessarily mean a stronger interaction: the relationship has to be read from the equation.

Action: describe a whole possible history

Energy describes an important property of a state. Action is a different quantity assigned to an entire possible history. A useful picture is scoring a complete route rather than a single place. Physical equations can be obtained by examining how that score changes when the route is varied slightly. In the papers, connecting a record calculation to an action calculation therefore requires a real mathematical link.

Resolution and comparison scale

A regulator makes a calculation manageable, for example by representing it on a finite grid. Refinement asks what happens when that representation becomes more detailed. The answer should behave consistently in the appropriate limit.

Running means the change of an effective interaction strength with the energy scale at which it is described. It does not mean a drift with calendar time. Matching specifies where two descriptions are compared. These ideas help ensure that a VERSF result and an experimental result concern the same physical question.

The purpose

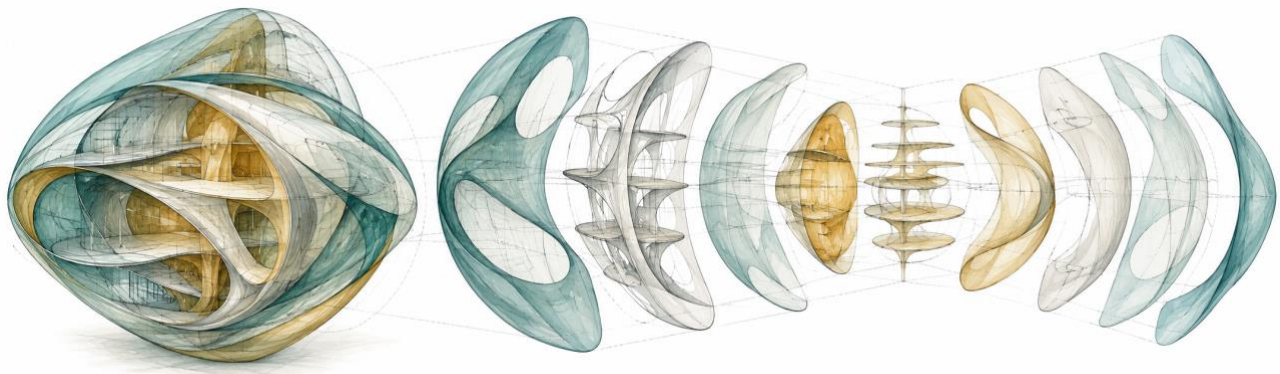
A prediction requires a complete connection: from the underlying rules, through the calculated response, to a clearly defined observation. An exact answer to one part is valuable, but it does not automatically complete all the other parts.

16 Read the difficult sentence in small steps

Here is the kind of sentence you may meet

“Compute the reduced curvature Hessian on the physical quotient.”

That looks forbidding because it compresses several instructions into a few words. Open it up and the intended task becomes more familiar:



Revealing the layers helps us understand a complex whole. A visual metaphor for reading the calculation in stages.

- Identify the field changes revealed by the loop comparisons.
- Set aside changes that merely rename the same physical situation.
- Allow the other permitted parts of the model to adjust.
- Calculate the remaining response to a small disturbance.

Why do this in VERSF? Because the resulting physical response is one proposed route to calculating the numbers that govern interaction strengths.

The main words, in one glance

Configuration: an arrangement.

Metric: a rule for measuring differences.

Transport: follow a comparison rule from place to place.

Holonomy: the net transformation after a closed round trip.

Mode: an organised pattern of change.

Eigenvalue: the multiplier for a pattern preserved by a rule.

Record: information retained in a physical arrangement.

Hessian: a table describing how a chosen quantity curves locally.

Normalisation: fix the scales and conventions for comparison.

What the calculations have produced

The tools have produced a numerical test of the forces. In CLSN-1, the fixed VERSF pattern comes close to the relative sizes of the three gauge-force strengths at a very high energy, with a remaining spread of about 2.5% after allowing one overall conversion factor. SGRI-1 then extracts a relation that does not depend on choosing that energy or common factor. Using the measured electromagnetic and strong strengths, its improved calculation predicts the weak mixing angle—a number describing how the electromagnetic and weak forces are related—to within about 1.7%. The simpler calculation misses by about 3%. The overall conversion still differs from the starting value by a factor near two, and explaining it remains a central open numerical task. These are encouraging results under the papers' stated assumptions. They do not yet amount to a complete prediction of all three force strengths: the common factor and the remaining smaller corrections still need physical explanations.

The loop comparisons, symmetry rules and record calculations explain how VERSF reaches questions precise enough to test in this way. The task now is to calculate the missing physical responses and corrections from the same underlying rules, rather than choose them to match the measured answers.