December 31, 2025

Farewell to the parameter zoo: bilan 2025

100 years after Heisenberg: from one matrix equation to an atlas of universes

Key Insight. Looking back, the calendar has told a single story in four movements: (i) a Matrix First principle with one transport equation $D\Psi = 0$ on an octonionic stage, (ii) an exceptional backbone built from $\mathbb{O}$ and $H_3(\mathbb{O})$, (iii) a reorganisation of quantum-field-theoretic language in operator and spectral terms, and (iv) a replacement of a parameter zoo by a structured universe atlas with three invariants (p_S, p_G, p_T). One hundred years after Heisenberg's matrix mechanics, this extends the algebraic heritage of quantum theory from matrices to nonassociative octonions and from flat lists of constants to a structured atlas of universes.

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At the start of the calendar (Nikolaus, 6 December), three separate theories governed our intuition:

- a Dirac equation for matter,
- Yang–Mills equations for gauge fields,
- Einstein equations for gravity.

The Matrix First perspective turns this into a single statement:

$$D\Psi = 0, \qquad D = \partial + A,$$

with $A_\mu \in \mathfrak{so}(8)$ acting on an 8-component universal state vector $\Psi \in \mathbb{R}^8$. In the unified papers this one operator D is read in two ways:

- as a generator of *parallel transport* and curvature in a $\mathfrak{spin}(3,1)$ sector, reproducing the conceptual content of general relativity (connection, curvature, geodesics, Einstein-type relations),
- and as a *Dirac-type operator* with internal gauge blocks, reproducing the operator skeleton of the Standard Model in quantum-field-theoretic language.

In that sense, the calendar has gradually made plausible that GR and QFT are not rivals to be "quantised" or "geometrised" against one another, but two compatible readings of the same underlying matrix structure.

From a zoo of inputs to a structured atlas of parameters

In a conventional presentation, the Standard Model appears to need dozens of independent inputs: gauge couplings, Yukawas, mixing angles, mass ratios, vacuum expectation values, hierarchy scales. Over the course of the four weeks, many of them have been reinterpreted as

- invariants of the F_4 symmetry atlas on $H_3(\mathbb{O})$,
- eigenvalues of internal operators (H_7, R, compressors),
- equilibrium values of internal potentials (e.g. Y_S),
- spectral data of a Dirac operator on a structured vacuum,
- functions of three universe parameters (p_S, p_G, p_T) and a choice of attractor configuration.

What looked like a parameter zoo becomes largely a shadow of one coherent geometric and spectral structure. Christmas Eve and Christmas Day framed this in the language of a universe atlas: our world is one attractor point $(p_S, p_G, p_T; E_0)$ in a structured region of exceptional configurations rather than an isolated dot in a featureless landscape.

The algebraic backbone

The backbone that supports this reorganisation consists of:

- **Number system:** the octonions $\mathbb{O}$ and their automorphism group G_2.
- **Symmetry atlas:** the Albert algebra $H_3(\mathbb{O})$ and its automorphism group F_4, providing the internal stage for quantum numbers and symmetry breaking.
- **Universal operator:** a connection $D_\mu = \partial_\mu + \Gamma_\mu + A_\mu$ inside $\mathfrak{so}(8)$, with $\Gamma_\mu \in \mathfrak{spin}(3,1)$ and A_μ in the exceptional internal algebra.
- **Universe parameters:** three invariants (p_S, p_G, p_T) attached to structural, geometric and topological/CP sectors of the atlas, plus an energy scale E that organises renormalisation and attractor flows.
- **Operators:** heptagon operator H_7, radius operator R, rotors and compressors, sector algebras and defect/associator tensors.

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- **Vacuum:** a distinguished configuration $\langle H \rangle$ and associated scales (a_0, b_0, c_0) and Y_S, whose compressor spectra generate masses and mixings.

From this small list, one can systematically derive or organise:

- the existence of three generations (triality and invariants of 3×3 mass matrices),
- the pattern of gauge couplings (via rotor norms and overlaps),
- the presence of three main scales (via spec(R) and attractor radii),
- the structure of mass matrices and mixings (via compressors and $\Pi(\langle H \rangle)$),
- candidates for dark sectors and vacuum energy contributions,
- and prototypes of Einstein-like relations in the gravitational sector.

What began in Advent00/01 as the conjecture of a "hidden simplicity" behind the zoo of fields and parameters has thus been instantiated in concrete operator language.

From many parameters to one action and a few invariants

In standard textbooks, the Standard Model Lagrangian is written as a sum of many postulated pieces with many a priori free couplings:

$$\mathcal{L} = \mathcal{L}_{\text{kinetic}} + \mathcal{L}_{\text{gauge}} + \mathcal{L}_{\text{Yukawa}} + \cdots .$$

In the octonionic formulation, this is reorganised around a single master action

$$S[D, \Psi] = \int_{M_4} \sqrt{-g} \Big(\mathcal{L}_{\text{kin}}[D] + \mathcal{L}_F[D] + \mathcal{L}_G[D] + \mathcal{L}_{\text{Defekt}}[D] + \mathcal{L}_{\text{matter}}[D, \Psi] \Big),$$

where D encodes spin connection, gauge fields and compressor/Yukawa blocks, and Ψ collects three generations of fermions as components of a single universal state vector.

Most of the "parameters" are relocated:

- to discrete choices of vacuum data $(\langle H \rangle; a_0, b_0, c_0; Y_S)$,
- to algebraic invariants of the F_4 symmetry atlas and the sector algebras,
- to the three universe parameters (p_S, p_G, p_T) and the choice of attractor region in parameter space,
- and to a small set of dimensionless coefficients in front of the operator blocks in $S[D, \Psi]$.

The parameter zoo is not abolished, but it is *structured*: many numbers are now seen as coordinates of equilibrium points in an exceptional atlas rather than unrelated dials.

What happens to QFT foundations?

The late-December sheets revisited the foundations of quantum field theory in light of this picture. Several pillars of QFT remain intact:

- local algebras $\mathcal{A}(\mathcal{O})$ and causal structure in the sense of AQFT,
- states as positive linear functionals and probabilities via expectation values,
- renormalisation-group flows and effective-field-theory logic.

The radical move lies not in overthrowing QFT, but in changing its kinematical stage:

- the internal Hilbert space is no longer an arbitrary finite tensor product but tied to the representation theory of $\mathbb{O}$ and $H_3(\mathbb{O})$,
- gauge groups are not added by hand but emerge as automorphism groups of these exceptional structures,
- mass and mixing operators (compressors, mass map) are not generic matrices but constrained by the geometry of the Albert algebra.

Operator geometry and spectral data come first; Lagrangians and Feynman rules appear as effective summaries of this deeper structure. In that sense, the exceptional programme is a conservative extension of QFT: it keeps the probabilistic core and recasts what counts as "fundamental field content" and "allowed parameter space".

Open block: gravity and the proton–Planck ratio

Not everything is solved. A central open question remains the proton–Planck mass ratio

$$\kappa = \frac{m_p}{m_P}, \qquad m_P = \sqrt{\frac{\hbar c}{G}}.$$

Together with the cosmological scale Λ, this marks a *gravitational block* that has not yet been fully integrated into the octonionic sector. The gravitation paper shows that algebraic prototypes of Einstein-type relations exist on the matrix level, and that associator-based tensors can be seen as discrete versions of curvature, *but* a rigorous continuum limit and a spectral derivation of G and κ are still open.

The spectral-action approach suggests a path:

$$S_{\text{spec}} = \operatorname{Tr} f(D^2/\Lambda^2),$$

where D encodes both spacetime and internal octonionic geometry. In a future project, this may allow G, κ and Λ to be understood as spectral invariants, closing the remaining gap—so that the last big parameters also become part of the same exceptional structure.

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A century after Heisenberg: lessons learned

In 1925, Heisenberg introduced matrix mechanics, marking the beginning of quantum theory as an algebraic theory of observables. One hundred years later, the present model can be read as a continuation of that line of thought. Compressing the Advent story into a few lessons:

1. **One operator instead of three theories.** Dirac, Yang–Mills and Einstein equations can be read as different projections and consistency conditions of a single transport equation $D\Psi = 0$ on an octonionic stage.
2. **Exceptional algebras as internal geometry.** Octonions $\mathbb{O}$, the Albert algebra $H_3(\mathbb{O})$ and their automorphism groups G_2 and F_4 provide a rigid internal geometry that organises charges, generations and hierarchies.
3. **Parameters as spectra and angles.** Many couplings, mass ratios and mixing angles are reinterpreted as eigenvalues and literal angles of rotor and compressor operators, rather than independent constants.
4. **From a parameter zoo to a universe atlas.** Three universe parameters (p_S, p_G, p_T) and an energy scale E summarise how structural, geometric and topological sectors are switched on and how our universe sits as an attractor point in a structured atlas of possible worlds.
5. **Open invitations instead of finished dogma.** Gravity, the exact values of κ and Λ, and the full spectral triple remain open problems—but now phrased as concrete questions inside a unified algebraic framework rather than as a clash between two incompatible pillars.

The core message of this Silvester bilan is not that all numbers have been computed, but that many of them have acquired a structural home. We move from *fitting* independent constants to *understanding* them as coordinates on orbits and attractors in an exceptional symmetry atlas and in the (p_S, p_G, p_T) parameter space.

The reduction of the parameter zoo is thus conceptual and structural rather than numerically complete: many patterns are explained, but precise values and quantum corrections remain an open and testable part of the programme for the century after Heisenberg.

References

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Many "free parameters" of particle physics and cosmology become invariants, spectra and attractor coordinates of an exceptional symmetry atlas. One hundred years after Heisenberg, the algebraic spirit of quantum mechanics extends from matrices to nonassociative structures and to a universe atlas labelled by (p_S, p_G, p_T) — a step towards a less fragmented understanding of constants, scales and even of the split between GR and QFT.

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