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Higgs resonance: mode of the vacuum, not the cause of mass

Curvature of a Jordan potential around $\langle H\rangle$

Key Insight. In the Standard Model narrative, the Higgs field "gives mass" to particles. In the octonionic/Jordan picture this story is inverted: masses arise from the eigenvalues of a mass map $\Pi(\langle H\rangle)$, constructed from a vacuum element $\langle H\rangle \in H_3(\mathbb{O})$. The observed 125 GeV Higgs particle is then a *resonance* of this vacuum — a fluctuation mode around $\langle H\rangle$ determined by the curvature of the Jordan potential, not the fundamental origin of mass itself.

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Masses from the vacuum configuration

The octonionic model encodes internal structure in the Albert algebra $H_3(\mathbb{O})$. A vacuum configuration is a fixed Jordan element

$$\langle H\rangle \in H_3(\mathbb{O}),$$

and the mass map is a linear operator

$$\Pi(\langle H\rangle) : V_{\text{int}} \to V_{\text{int}},$$

acting on the internal space of one generation. Its eigenvalue equation

$$\Pi(\langle H\rangle)\Psi_i = m_i\,\Psi_i$$

provides candidate fermion masses m_i; the Ψ_i define mass eigenstates.

In this view, mass is a property of how the vacuum sits inside $H_3(\mathbb{O})$, not a "gift" handed out by an external scalar field.

Jordan potential and vacuum stability

The vacuum $\langle H\rangle$ itself is determined by a Jordan-invariant potential $V_J(H)$ on $H_3(\mathbb{O})$:

$$V_J : H_3(\mathbb{O}) \to \mathbb{R}, \qquad H \mapsto V_J(H),$$

invariant under an F_4 action on the Albert algebra. The true vacuum is a minimum of this potential,

$$\frac{\partial V_J}{\partial H}\bigg|_{H=\langle H\rangle} = 0, \qquad \frac{\partial^2 V_J}{\partial H^2}\bigg|_{H=\langle H\rangle} > 0 \text{ (in suitable directions)}.$$

Fluctuations δH around $\langle H\rangle$ see a quadratic approximation

$$V_J(\langle H\rangle + \delta H) \approx V_J(\langle H\rangle) + \tfrac{1}{2}\,\delta H \cdot \mathcal{M}_J \cdot \delta H + \cdots,$$

where $\mathcal{M}_J$ is the Hessian (second derivative) at the minimum.

The Higgs as a curvature mode

Among the many possible fluctuation directions δH there is a distinguished one that largely preserves the internal alignment of $\langle H\rangle$ but changes its *magnitude*. This direction corresponds to the traditional electroweak order parameter and gives rise to the observed Higgs resonance.

Its mass is set by a particular eigenvalue of the Hessian:

$$m_H^2 \sim \frac{\partial^2 V_J}{\partial h^2}\bigg|_{h=0},$$

where h parametrises the relevant fluctuation mode. The 125 GeV resonance is therefore a curvature property of V_J at $\langle H\rangle$, not the mechanism that created the fermion masses in the first place.

Decoupling the narrative: cause vs. symptom

This leads to a clean conceptual split:

- **Cause of masses:** the spectrum of $\Pi(\langle H\rangle)$, i.e. how the vacuum embeds into $H_3(\mathbb{O})$ and how this embedding acts on internal states.
- **Symptom of the vacuum:** the Higgs resonance as one particular fluctuation of $\langle H\rangle$ encoded in the curvature of V_J.

Experimentally we discovered the symptom first and back-inferred the presence of a nontrivial vacuum. The octonionic/Jordan model reverses the logical order: it starts from a structured vacuum in an exceptional algebra, derives the mass map and only then identifies the corresponding resonance.

What remains of the Standard Model picture

The familiar elements of the Standard Model story are not thrown away; they are reinterpreted:

- There is still an order parameter playing the role of the Higgs vacuum expectation value.

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- Gauge boson masses still depend on this order parameter through couplings to internal directions.
- The 125 GeV scalar resonance still appears as a fluctuation of this order parameter.

What changes is the underlying language:

- Instead of a fundamental scalar field added by hand, we have a Jordan element $\langle H \rangle$ in $H_3(\mathbb{O})$.
- Instead of ad-hoc Yukawa couplings, we have a linear mass map $\Pi(\langle H \rangle)$ whose structure is fixed by exceptional symmetry.

Why this matters for the bigger picture

The Higgs day clarifies two broader points in the Advent story:

1. It shows how a cornerstone of the Standard Model (the Higgs mechanism) can be embedded into a more rigid algebraic framework without losing contact with experiment.
2. It supports the general thesis that many "fundamental fields" are better viewed as collective modes of an exceptional vacuum, determined by internal geometry rather than arbitrary Lagrangian terms.

If future measurements further constrain Higgs couplings and self-interactions, they will test not only the Standard Model but also any candidate for the underlying exceptional vacuum structure that produces the observed 125 GeV mode.

References

[1] P. W. Higgs, "Broken symmetries and the masses of gauge bosons," *Phys. Rev. Lett.* **13**, 508–509 (1964).

[2] P. Jordan, J. von Neumann and E. Wigner, "On an algebraic generalization of the quantum mechanical formalism," *Ann. Math.* **35**, 29–64 (1934).

[3] [Internal notes on $V_J(H)$, mass maps and Higgs curvature: `unified-agebra.tex; chap11_neu.tex; appM_neu.tex`.]

The Higgs is not the cause of mass but a resonance of an exceptional vacuum: a single curvature mode of a Jordan potential on $H_3(\mathbb{O})$.

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