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Scales as attractor fixed points

From internal eigenvalues to the IR physics of the Standard Model

Key Insight. Three fundamental scales of the model (M_8, M_{C2}, M_{C1}) are not arbitrary fit parameters but eigenvalues of the internal radius operator R. They act as anchors for the renormalisation group (RG) flow. The familiar QCD scale is not a fourth input, but emerges dynamically in the infrared (IR) as the strong coupling runs to confinement.

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EARLIER we introduced the radius operator R with its characteristic spectrum (a_0, b_0, c_0). In a purely geometric picture, these are just lengths. In a quantum field theory, they turn into *energy scales* where the symmetry structure of the model changes.

We can identify three such scales

$$M_8 \gg M_{C2} \gg M_{C1},$$

which are fixed by the octonionic geometry. They provide the *input* for the renormalisation group (RG) flow. The physics we observe in the laboratory—including proton mass and confinement—results from running downwards from these seeds into the infrared (IR).

A four-rung ladder of regimes

The three internal scales define only part of the story. The following table summarises how they map onto physical regimes, and wie das IR als vierte Stufe dynamisch entsteht.

Scale	Physical Role
TOE $M_8 \sim 10^{14}\,\mathrm{GeV}$	**Octonionic geometry:** Full Spin(8) and triality active. R and L are defined. Mass operators are universal ($M_f \propto RLR$).
Transition $M_{C2} \sim 10^4\,\mathrm{GeV}$	**Species splitting:** Unified rotor space separates into colour and electroweak blocks. Universal operators project onto Yukawas Y_S.
EW/Higgs $M_{C1} \sim 10^2\,\mathrm{GeV}$	**Mass generation:** Higgs vev v turns dimensionless Yukawas in real masses ($M_f \propto vY_S$). CKM and PMNS mixing freeze out.
IR / QCD $\sim 1\,\mathrm{GeV}$	**Emergent regime:** RG flow drives the strong coupling to confinement (Λ_{QCD}). Hadrons form. This scale is *dynamic*, not geometric.

In words: three geometric seeds generate *four* dynamical regimes. The IR physics of QCD appears as a consequence of running, not as a new input parameter.

Why the QCD scale is not an input

It is tempting to identify the three internal eigenvalues directly with "Planck, weak and strong" scales. The model suggests a more subtle picture:

- M_8 is a Planck-like scale of the internal geometry, though numerically below the Planck mass.
- M_{C2} and M_{C1} control the splitting into colour and EW, and the emergence of flavour and mixing.

The QCD scale, $\Lambda_{\mathrm{QCD}} \approx 200\,\mathrm{MeV}$, is not itself an eigenvalue of R. It appears because the strong coupling, set at M_{C2}, runs logarithmically: at some IR scale it becomes non-perturbative and the theory confines.

This is economical: the model uses three geometric inputs to produce four physically relevant regimes. The IR scale is *forced* by the RG flow.

Attractors and stability

Dynamical systems have *attractors*: points where flow lines converge. The eigenvalues (a_0, b_0, c_0) play a similar role for the scalar fields and couplings in the octonionic model.

- They stabilise the vevs of R and L.
- They tether the RG evolution of the Standard Model parameters.

Small perturbations at the TOE scale M_8 are washed out by the long running down to the IR. This helps explain why low-energy physics and mass hierarchies look so robust, despite their origin in a high-scale octonionic geometry.

References

[1] K. G. Wilson, "Renormalization group and critical phenomena," *Phys. Rev. B* **4**, 3174–3183 (1971).

Three internal scales (M_8, M_{C2}, M_{C1}) fix the geometry; the IR world of hadrons and confinement is generated dynamically by RG flow.

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