Spectral Origin of Mass: From Zero-Field Spectral Cosmology to Einstein's Equation

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10 сентября 2025 г.

Introduction

Albert Einstein's famous equation

$$E = mc^2$$

became the iconic symbol of 20th century physics, showing the deep equivalence between mass and energy. However, in this formulation, the mass m is assumed as a given property of matter.

In the framework of **Zero-Field Spectral Cosmology (ZFSC)** we propose a deeper principle: *mass itself is not fundamental, but arises as a spectral eigenvalue of a fundamental matrix H.* This idea is summarized by a simple equation:

$$m = \lambda(H),$$

where $\lambda(H)$ denotes the eigenvalues of H, which encodes the hidden structure of the zero-entropy field.

ZFSC Postulates

1. **Zero-entropy level:**
$$S \to 0, \qquad \Psi = \sum_i a_i |i\rangle.$$
The Universe at its most fundamental level is described as a probabilistic amplitude field.

2. **Mass as spectrum:**
$$m = \lambda(H).$$

3. **Particle generations:**
$$m_f^{(n)} = \lambda_n(H), \quad n = 1, 2, 3.$$

4. **Mixing rule:**
$$\text{Mix} = U_A^\dagger U_B.$$

Core Law: $m = \lambda(H)$

The formula states that mass is not a primitive attribute but a result of spectral properties of H. Just as sounds emerge from a bell, or notes from a piano, particle masses emerge from the hidden matrix structure.

Everyday Analogies

- **Piano:** instrument $H \to$ notes $\lambda(H) \to$ masses as sounds.
- **Bell:** geometry $H \to$ resonant tones $\lambda(H) \to$ masses as frequencies.
- **Prism:** structure $H \to$ spectrum $\lambda(H) \to$ masses as colors.

Connection with Einstein

Einstein's formula:

$$E = mc^2$$

becomes a corollary when substituting $m = \lambda(H)$:

$$E = \lambda(H)\, c^2.$$

Thus, particle energy is directly determined by its spectral eigenvalue.

Stepwise Derivation

1. Fundamental law: $m = \lambda(H)$.
2. Substitution: $E = \lambda(H)c^2$.
3. Quantum link: $E = \hbar\omega \;\Rightarrow$ eigenvalues as frequency quanta.
4. Geometry and gauge: structure of H encodes $SU(3) \times SU(2) \times U(1)$.
5. Classical limit: effective large-scale physics.

Hypotheses and Extensions

- Zero mode: $\lambda_0 \approx 0 \Rightarrow$ graviton candidate.
- Negative modes: $\lambda < 0 \Rightarrow$ tachyonic sectors.
- Entanglement corrections: spectral shifts via mutual information.
- Time evolution of couplings: $G_{\text{eff}}(t)$, $\alpha(t)$ varying slowly with cosmological time.

Conclusion

The equation $m = \lambda(H)$ is more fundamental than $E = mc^2$, because it explains the *origin of mass itself*. Einstein demonstrated that mass and energy are equivalent; ZFSC shows where mass comes from.

Research Outlook

1. Numerical spectral scans of large matrices H.
2. Fitting particle masses and mixing matrices to experimental data.
3. Study of tachyonic modes and their cosmological implications.
4. Modeling time evolution of effective couplings $G_{\text{eff}}(t)$.