A2: The Hierarchy, Fine-Tuning and Naturalness Problem From a Philosophical Perspective

PostDocs: Enno Fischer (since 10/2021), Josh Rosaler (until 04/2021)
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Recent and current activities:

1. Are there fundamental parameters? ("Josh's last paper") [5 min]
2. Forward Justification of Naturalness [10 min, Enno]
3. Problems in Physics [5 min, Radin]
4. The Life Cycle of Principles [10 min, Enno, Radin, RH]

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Dogmas of Effective Field Theory: Scheme Dependence, Fundamental Parameters, and the Many Faces of the Higgs Naturalness Principle

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or: Are there fundamental parameters?

Quantum Field Theory

$$\mathscr{L} = \bar{\psi}\gamma^\mu \partial_\mu \psi - m\,\bar{\psi}\psi + q\,\bar{\psi}\gamma^\mu \psi A_\mu + \ldots - \mu^2\,\phi^\dagger\phi - \lambda\,(\phi^\dagger\phi)^2$$

fields: $\psi, \phi, A_\mu, \ldots$ Electron, Higgs, Photon, …

parameters: $m, q, \mu, \lambda, \ldots$ naively (LO): masses, charges

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But: calculation of quantum effects to observables involves divergent integrals:

$$\sigma(e^+e^- \to \mu^+\mu^-) = \int d^4p\, f(p) = \infty$$

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Solution: parameters are also ∞! Physical interpretation?

Wilson's interpretation

QFT has an (upper) energy cut-off Λ (unknown physics, space-time granularity, …):

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$$125.3^2 = 13{,}847{,}675{,}622{,}542{,}958{,}387{,}877{,}249{,}586{,}934{,}827{,}357.4 - 13{,}847{,}675{,}622{,}542{,}958{,}387{,}877{,}249{,}586{,}934{,}811{,}657.3$$

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Naturalness problem assumes that m_H, Λ and $m_{H,\text{phys}}$ are physical.

Josh's argument:

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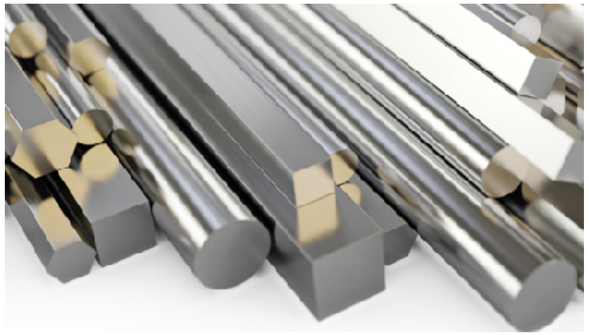
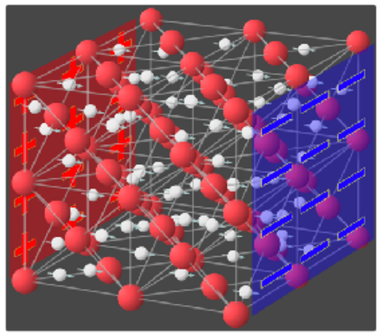


$\Lambda \sim 1/a$



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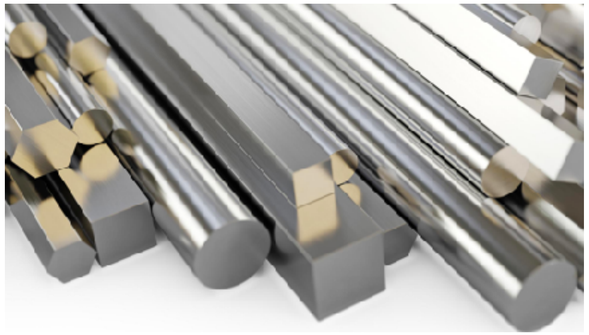

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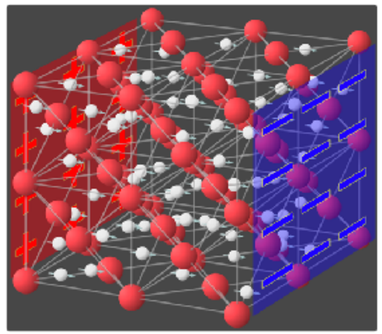

My (provocative) bottom line:
The discovery of the Higgs indicates that there are no fundamental parameters in nature. The only physical quantities are observables.