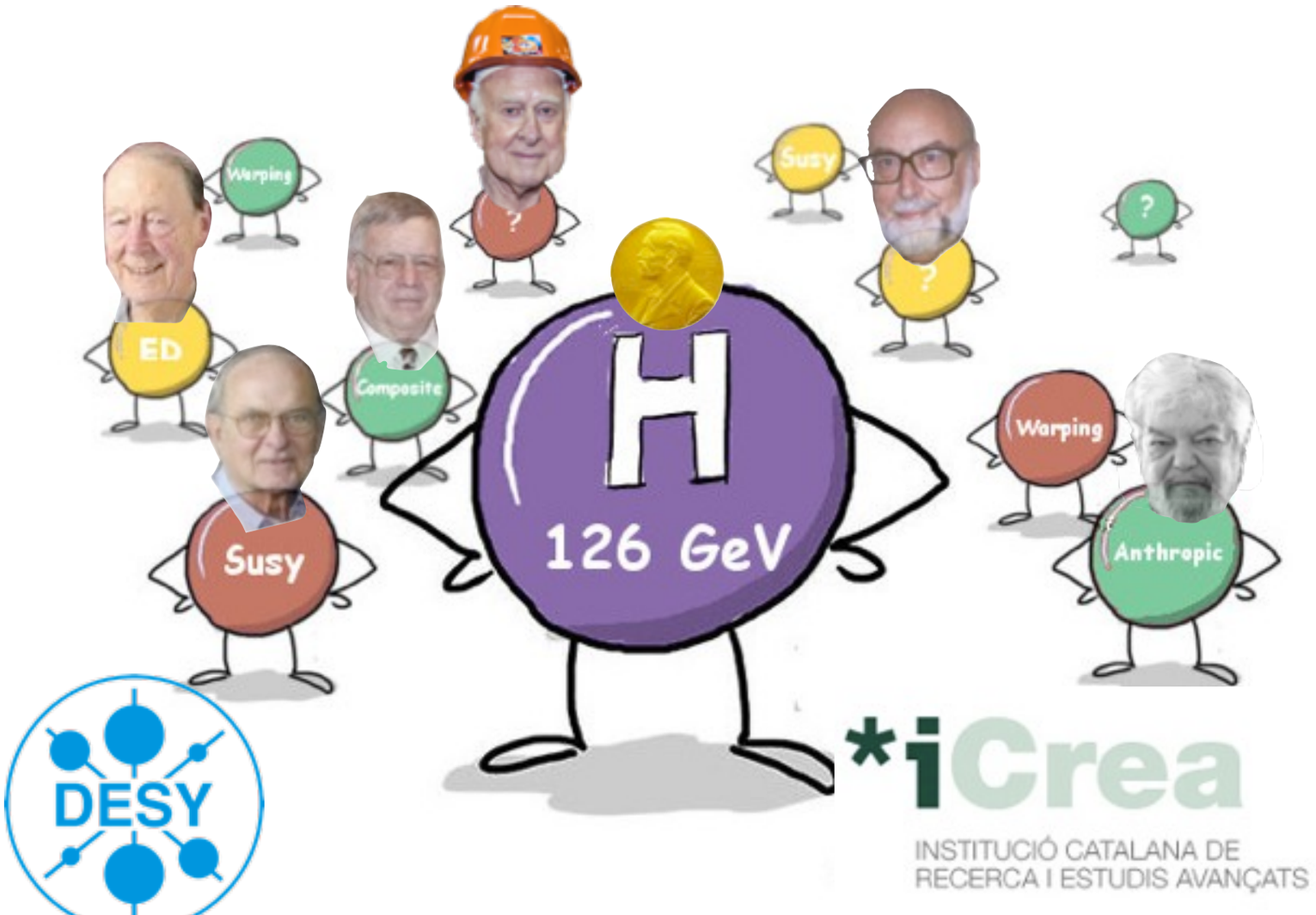
Beyond the Standard Model

CERN summer student lectures 2015



Exercises

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Units

- Show that
  - $[\hbar]=M.L^2.T^{-1}$ and $[c]=L.T^{-1}$
- Derive the formula of the Casimir force using dimensional arguments
- Check the consistency of the classical/quantum correspondence at the dimensional level:
  - $E \to i\hbar\frac{\partial}{\partial t}$ & $p \to i\hbar\frac{\partial}{\partial x}$
- Show that
  - $1s \approx 1.52 \times 10^{27}\ \hbar/\text{TeV}$
  - $1m \approx 5.1 \times 10^{18}\ \hbar c/\text{TeV}$
  - $1kg \approx 5.61 \times 10^{23}\ \text{TeV}/c^2$
- Planck units:
  - Using the Newton constant, $\hbar$ and c, construct a mass scale, a length scale and a time scale
  - Compare the density matter of the universe today ($10^{-29} g/cm^3$) with the Planck scale

Units

- Schwarzschild radius & Compton wavelength:
  - The Schwarzschild radius of an object of mass m is the measure of its mass in Planck units. The Compton wavelength is defined as $\hbar$/(mc).
  - Compute the Schwarzschild radius and the Compton wavelength of an electron, a proton, the top quark, a fly, a strawberry, a human body, the earth, the sun, a neutron star, a stellar black-hole, a supermassive BH, a micro-BH. What do you conclude?
  - Compute the Schwarzschild radius of a micro-BH assuming that the Planck scale has been reduced to 1 TeV. What do you conclude?

- Classical/Quantum electron:
  - classical radius: using e, m_e and c, construct a length scale
  - Bohr radius: using e, m_e and $\hbar$, construct a length scale

Wave equations

- Derive the Schrödinger equation from the classical expression of the energy
- Derive the Klein-Gordon equation from the relativistic energy equation
- Derive the Klein-Gordon equation from the Dirac equation