מכון ויצמן למדע
WEIZMANN INSTITUTE OF SCIENCE

The Flavor of the Multiverse

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Work in Progress
Based on discussions with Oram Gedalia, Gian Giudice and Gilad Perez

Outline

- Brief intro - the multiverse and the hierarchy problem
- Weakless universe
- Weakful vs. weakless and flavor in the multiverse

The Multiverse

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huge number of universes, each one has its own laws of physics

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Agrawal, Barr, Donoghue & Seckel hep-ph/9801253, hep-ph/9707380

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➡ anthropic solution to the hierarchy problem

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  - The Higgs VEV take its natural value: $v^* \simeq M_{\rm Pl}$
  - The same QCD scale as the observed: $\Lambda^*_{\rm QCD} = \Lambda^{\oplus}_{\rm QCD}$
  - 3 light fermions: $y^*_f = y^{\oplus}_f v^{\oplus}/v^* \quad f = u, d, e$
  - All the other fermions are heavy: $m^*_f > \Lambda^*_{\rm QCD}$
  - Decreasing the Baryon asymmetry by two orders of magnitude than in our universe.

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- Stars shine by fusing protons and deuterium.
- Type Ia supernovae can still produce heavy elements.

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$$\Rightarrow \quad p_y\left(y\right) \propto \int d\epsilon dQ p_\epsilon(\epsilon)\, p_Q(Q)\, \delta\left(y - \epsilon^Q\right) \propto \frac{\log^n y}{y}$$

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for heavy quarks $$\frac{\int_{\Lambda_{\text{QCD}}/v^{\oplus}} p_y(y)dy}{\int_{\Lambda_{\text{QCD}}/M_{\text{Pl}}} p_y(y)dy} \lesssim 1$$

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$$\frac{\int_0^{\Lambda_{\text{QCD}}/v^{\oplus}} p_y(y)dy}{\int_0^{\Lambda_{\text{QCD}}/M_{\text{Pl}}} p_y(y)dy} \approx \begin{cases} 6.7^{-n-1} & n < -1 \\ 1 & n \geq -1 \end{cases}$$

Gedalia, Jenkins & Perez, arXiv: 1010.2626

Weakful vs. Weakless

$$r < \left(\frac{v^{\oplus}}{M_{\rm Pl}}\right)^2 \times \begin{cases} 6.7^{-2n-2} & n < -1 \\ 1 & n \geq -1 \end{cases}$$

$\Rightarrow$ $r \ll 1$ for $n > -21$

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but we live in a weakful universe

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$$p_y\left(y_1, y_2, y_3\right) \propto \left(y_1^2 - y_2^2\right)^2 \left(y_2^2 - y_3^2\right)^2 \left(y_3^2 - y_1^2\right)^2 y_1 y_2 y_3$$

Haba & Murayama,
hep-ph/0009174

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⇒ $r \gg 1$

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⇒ $r \gg 1$ The weakful wins!

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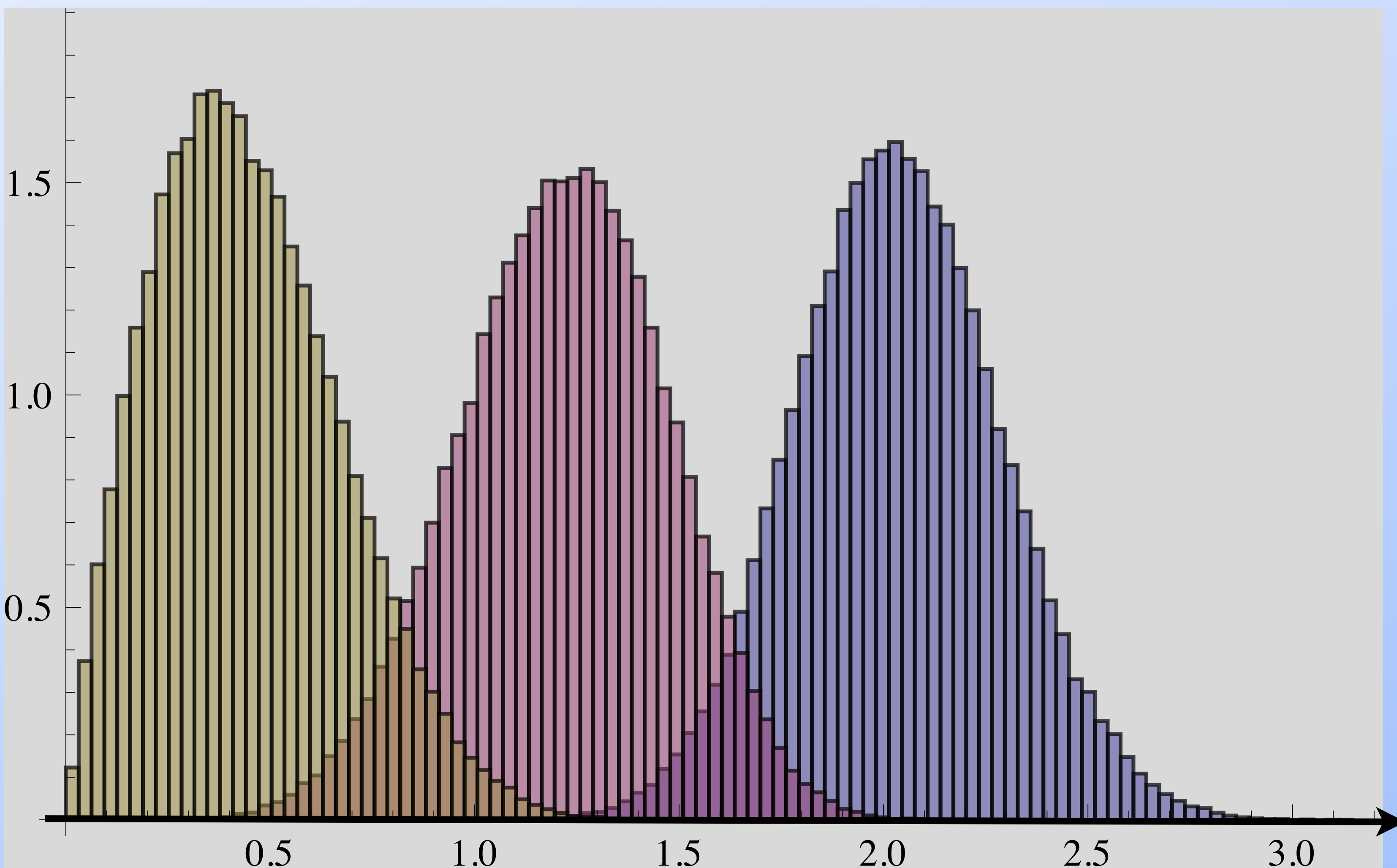

smallest e-val.
middle e-val.
largest e-val.

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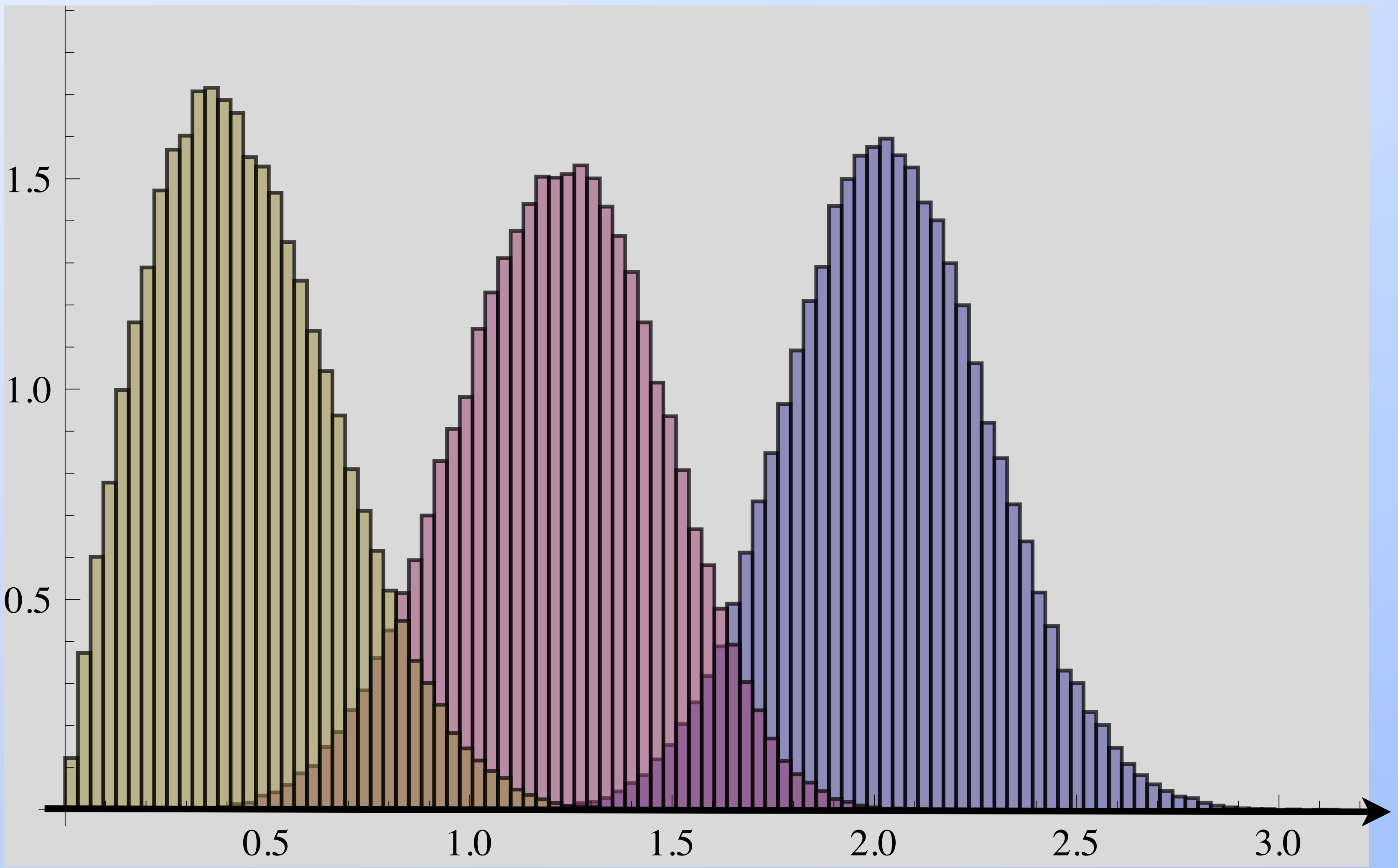

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but not enough

Outlook

- Still work in progress

Backup