Implications of Cosmological Measurements of N_{eff} for Light Relics

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Light Thermal Relics in Cosmology

- Radiation energy density: $\rho_r = \left[1 + \frac{7}{8}\left(\frac{4}{11}\right)^{4/3} N_{\rm eff}\right]\rho_\gamma\,, \qquad N_{\rm eff}^{\rm SM} = 3.045$

- Any thermalized relativistic degree of freedom will contribute to

$$N_{\rm eff} = N_{\rm eff}^{\rm SM} + \Delta N_{\rm eff}$$

as a function of their decoupling/freeze-out temperature T_F:

$$\Delta N_{\rm eff}(T_F) = 0.027\, g_{*,X} \left(\frac{g_{*,\rm SM}}{g_*(T_F)}\right)^{4/3} \gamma^{-4/3}$$

$g_{*,X} = 1, \frac{4}{7}, 2, \ldots$ for spin-0, $\frac{1}{2}, 1, \ldots$

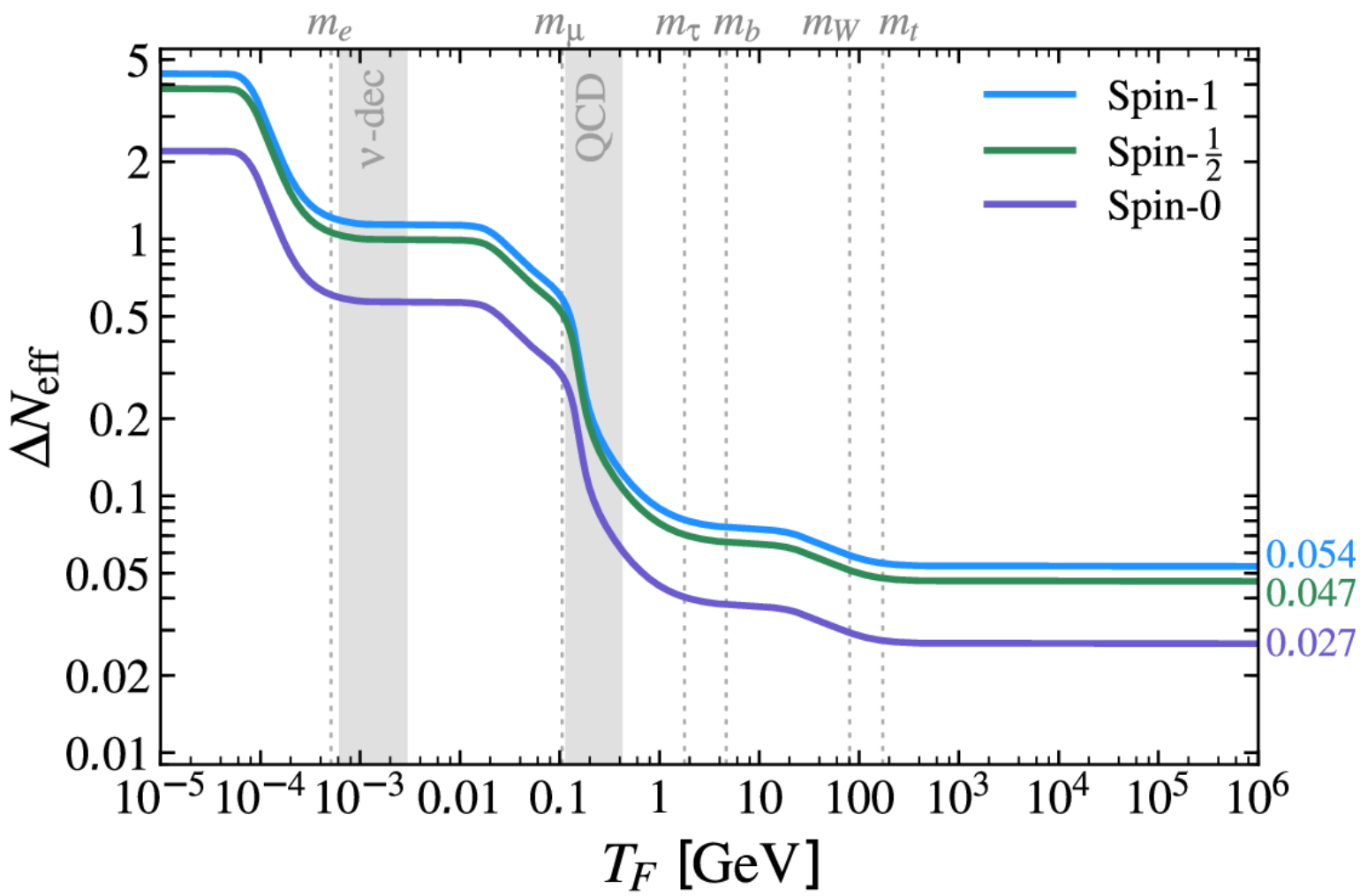
$g_{*,\rm SM} = 106.75$

effective number of relativistic degrees of freedom at T_F

entropy production

Detailed discussion e.g. in arXiv:1810.02800.

Light Thermal Relics in Cosmology



See e.g. arXiv:1903.04763.

Assumptions: negligible entropy production, minimal extension of the Standard Model.

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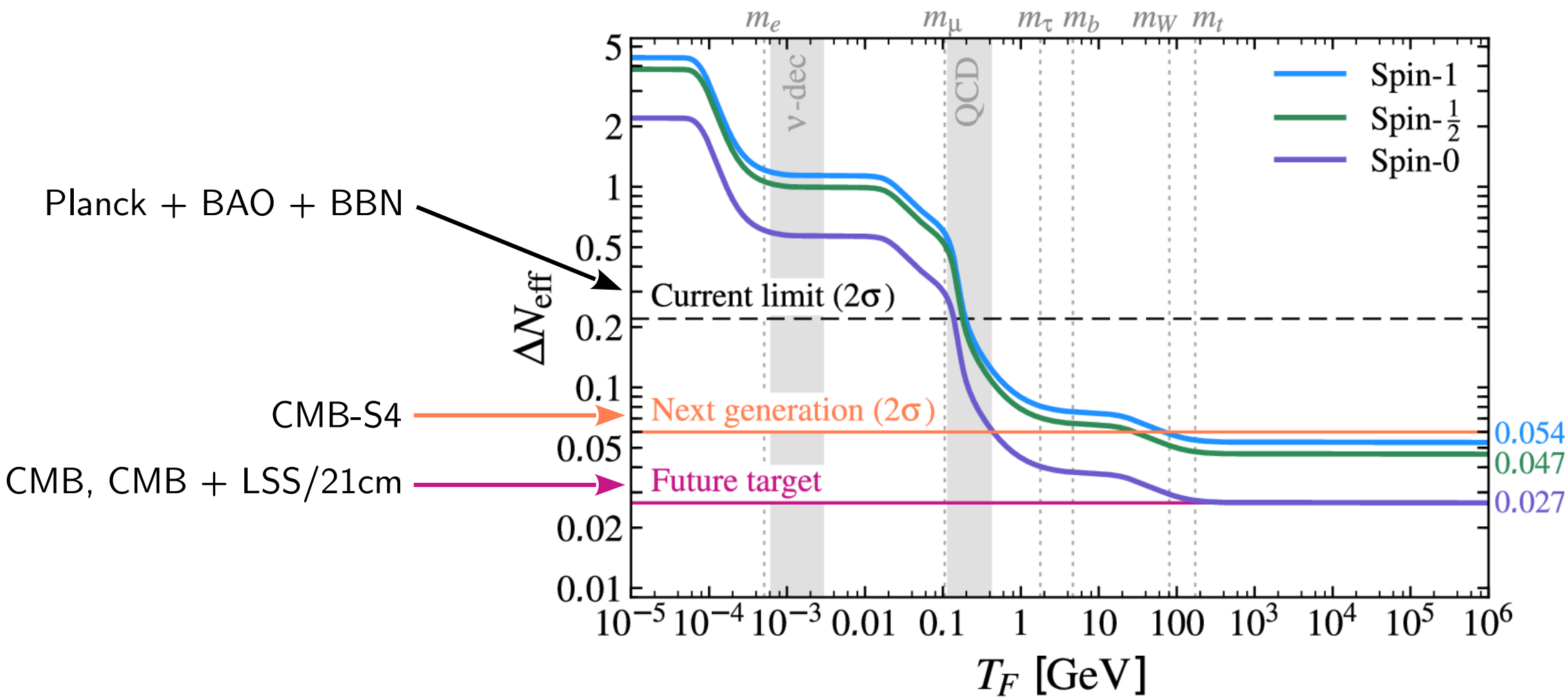

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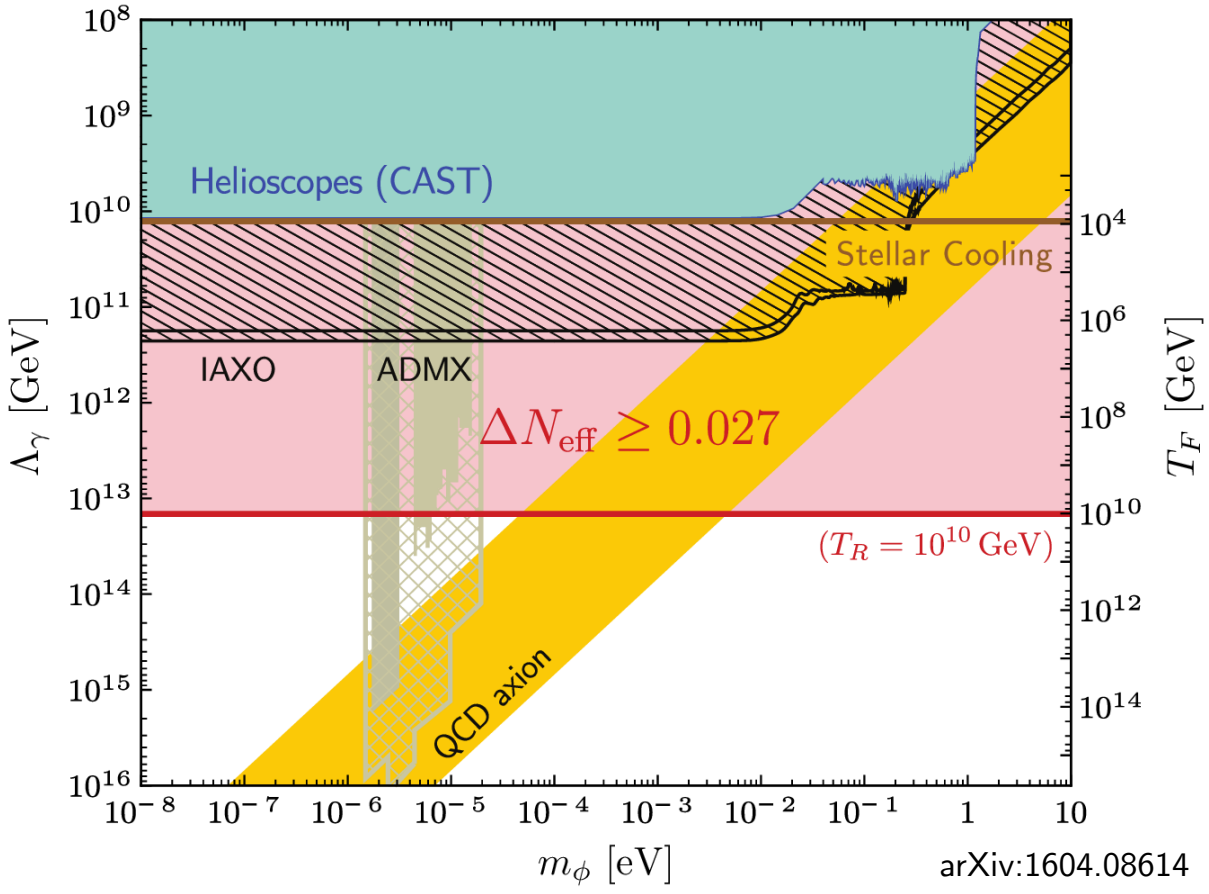
Broad and Sensitive Probe of New Physics

Example: Photon-axion couplings

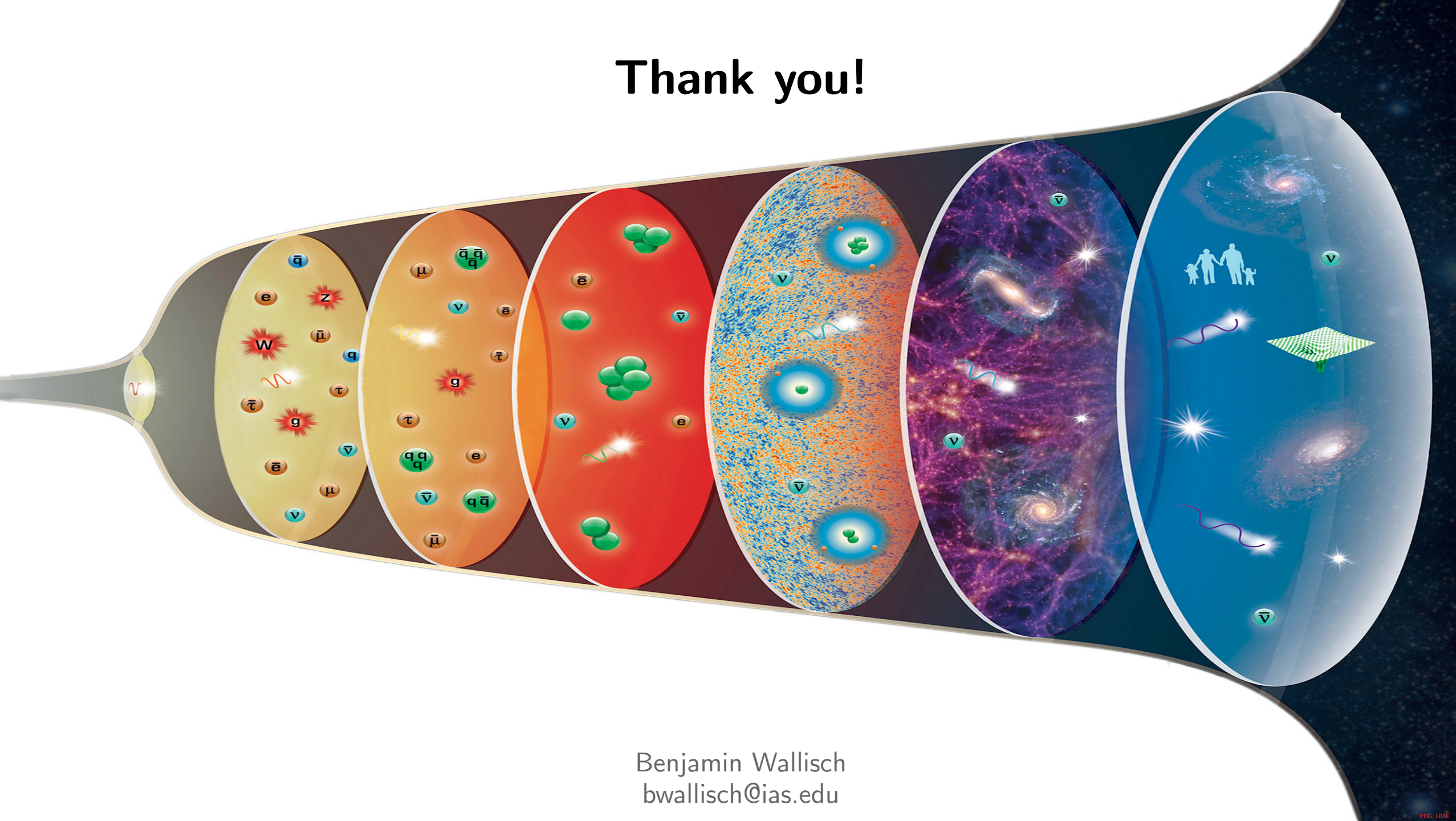


arXiv:1604.08614

and many other use cases!

See e.g. arXiv:1303.5379, 1505.05192, 1604.08614, 1701.08750, 1709.07882, 1808.07430, 2001.01490, ...

Thank you!



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