String Phenomenology

Gary Shiu
University of Wisconsin

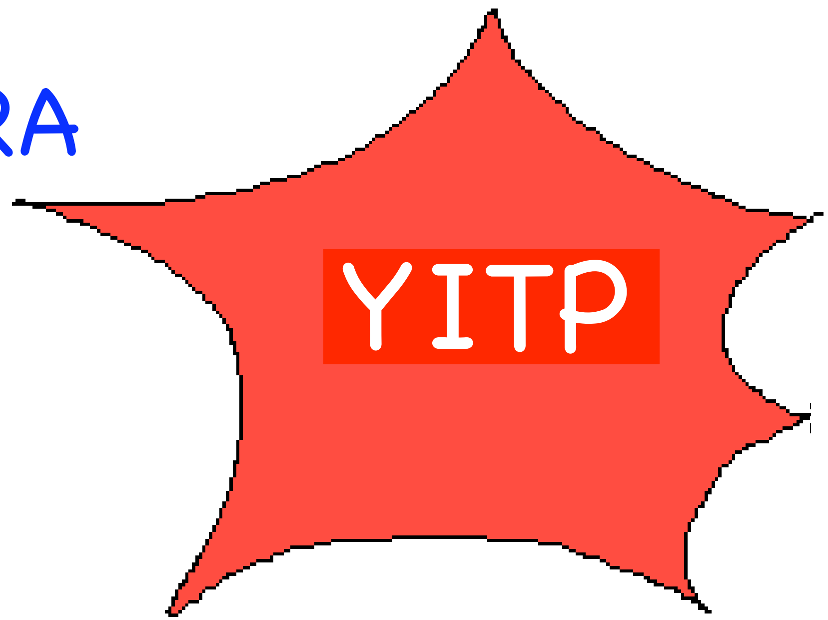
YITP@40 Symposium

YITP's "Theory Space"

QCD/Collider Physics

Strings/SUGRA

Statistical Mechanics



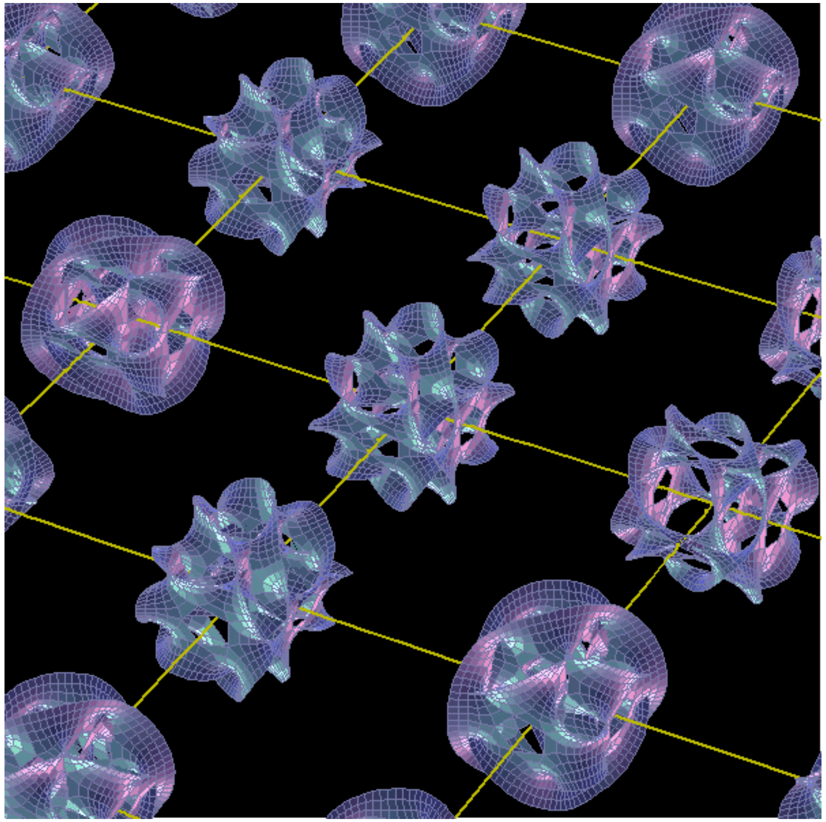
Neutrinos

Standard Model & Beyond

Cosmology

+ a lot more ...

String Phenomenology



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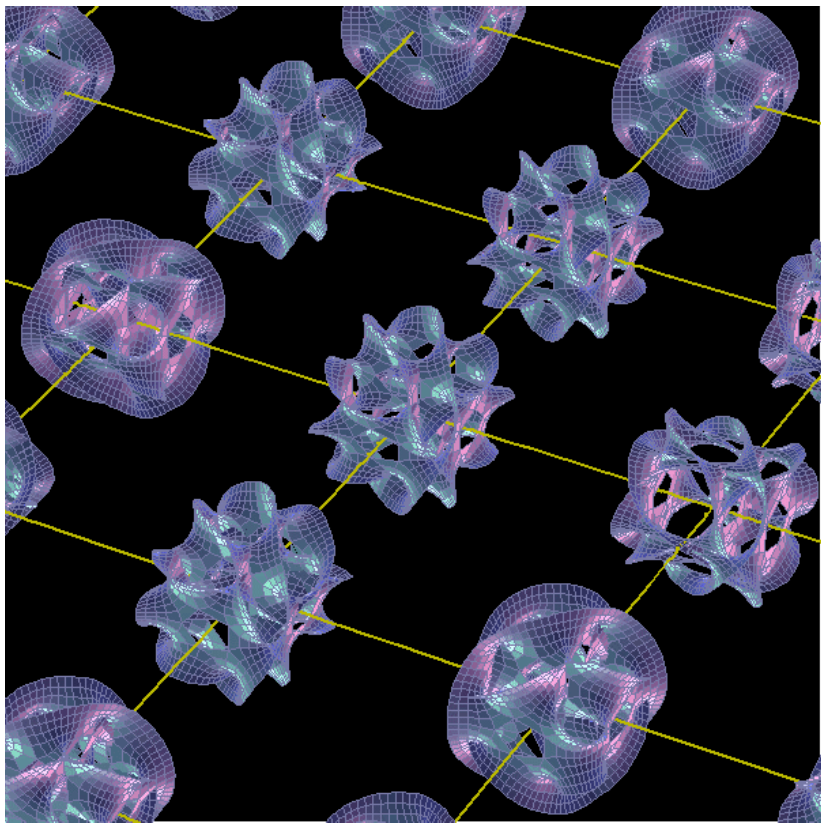

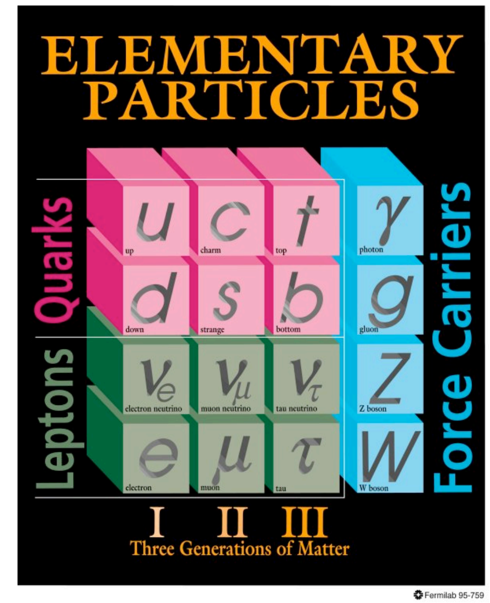

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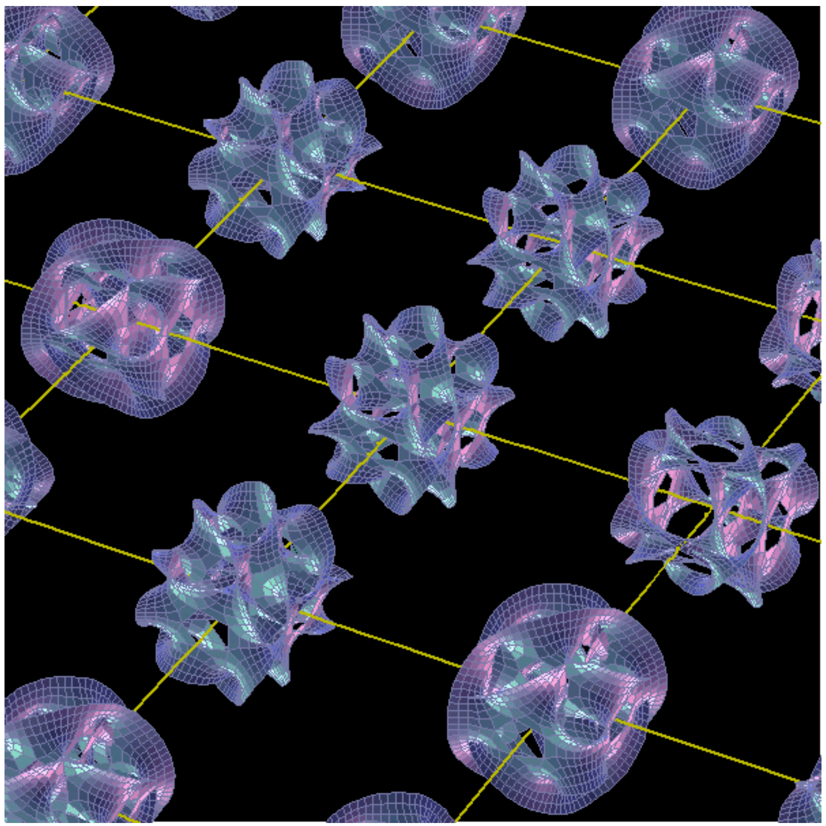
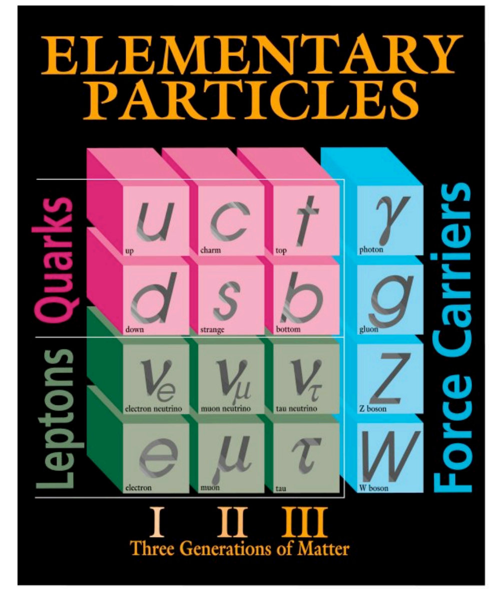
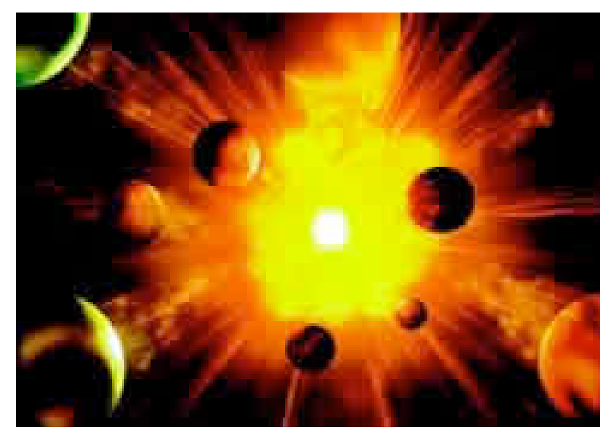




Fermilab 95-759



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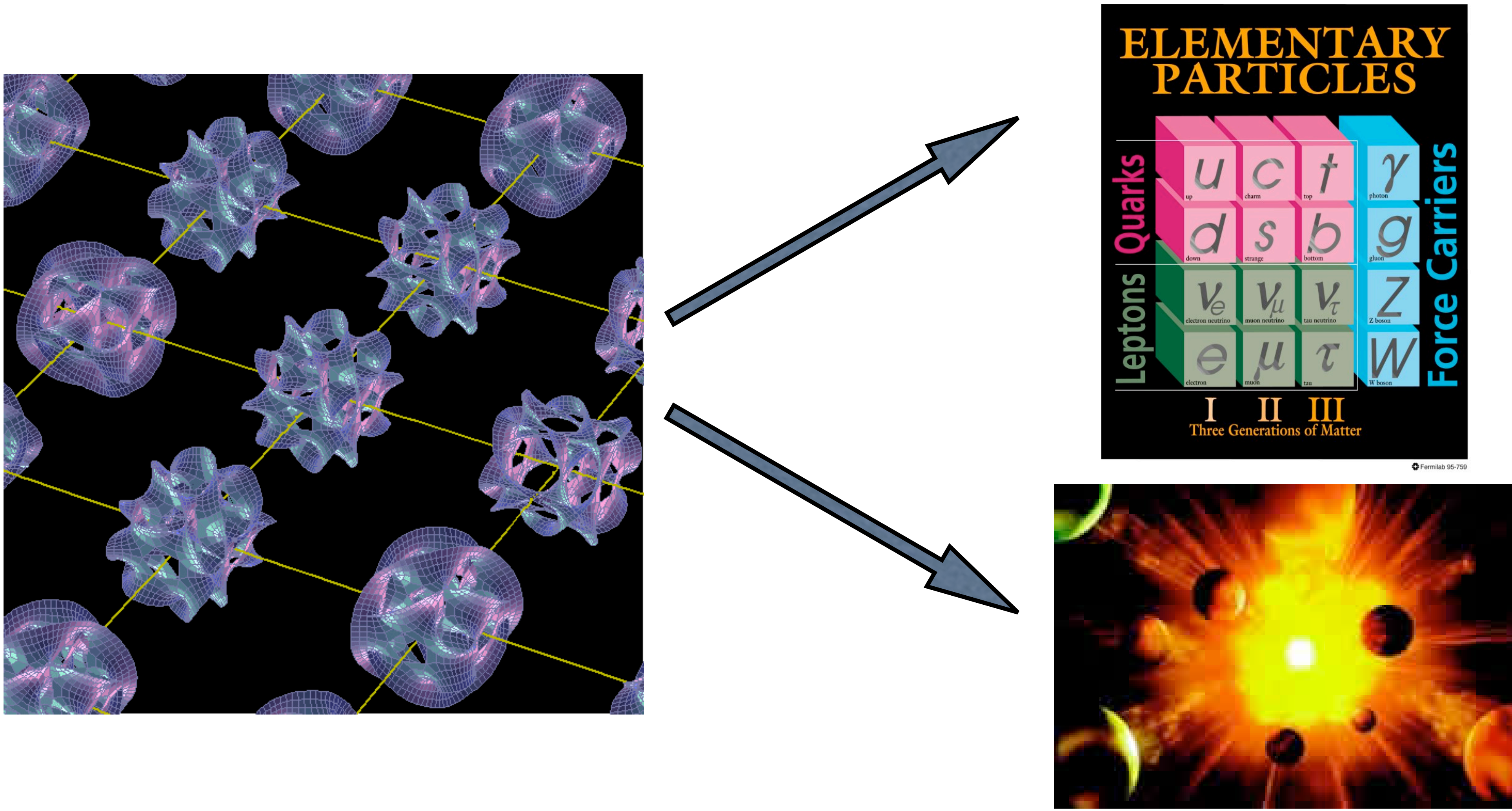
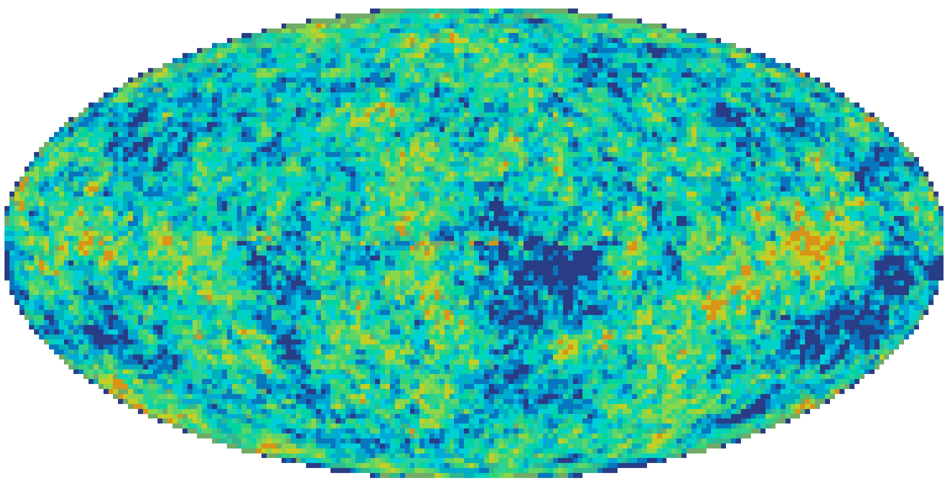


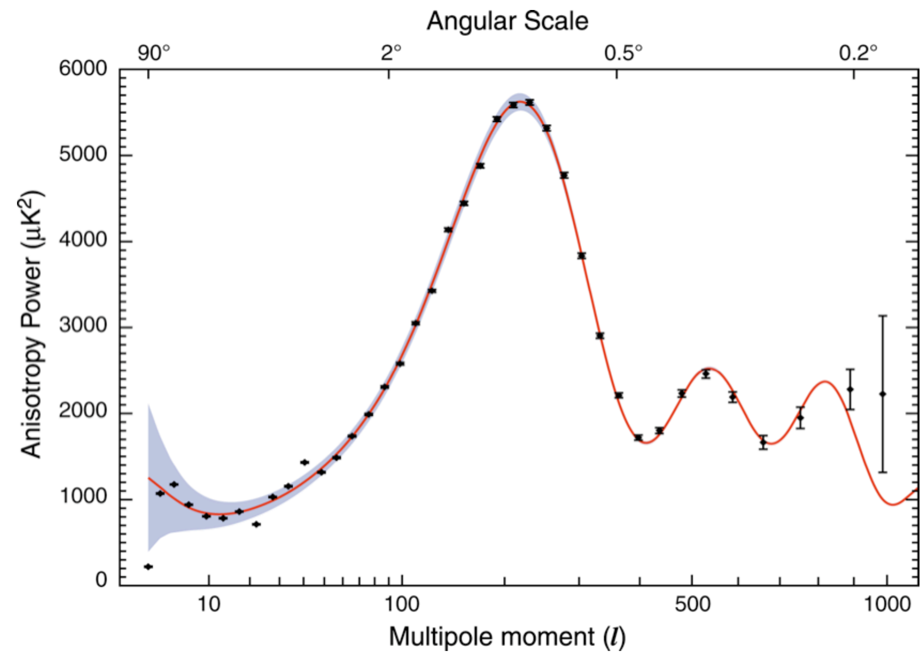
How do we test these ideas?

Cosmic Microwave Background

- Almost scale invariant, Gaussian primordial spectrum predicted by inflation: good agreement with data.



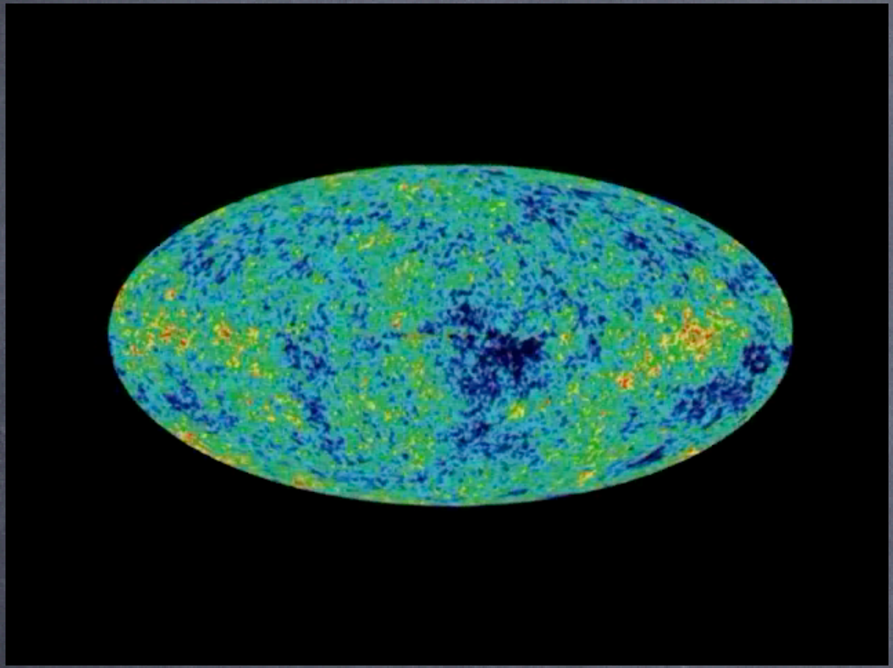
WMAP

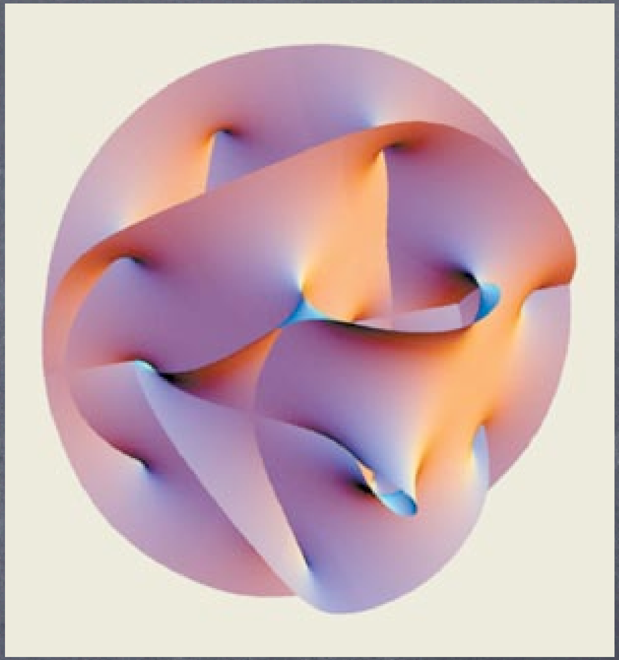


- A tantalizing upper bound on the energy density during inflation:

$$V \sim M_{GUT}^4 \sim (10^{16}\text{GeV})^4 \quad \text{i.e.,} \quad H \sim 10^{14}\text{GeV}$$

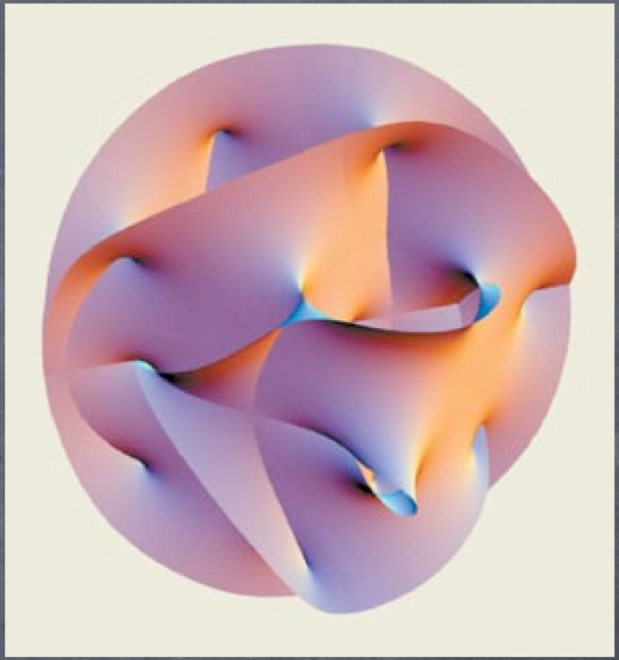
WMAP & Beyond





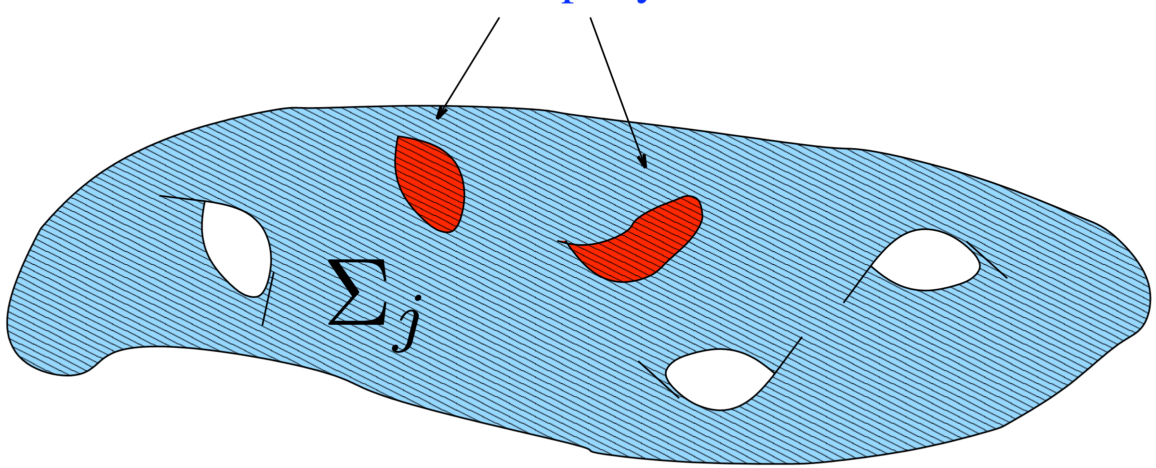
Can we learn from the CMB (or other cosmological measurements) details of string compactification?

LHC & Beyond



Can we learn from the LHC (and beyond)
details of string compactification?

Flux Compactification



$$n_j = \int_{\Sigma_j} F$$

Analogous to turning on a B-field: $\text{Energy} \sim \frac{1}{8\pi} \int (E^2 + B^2)$

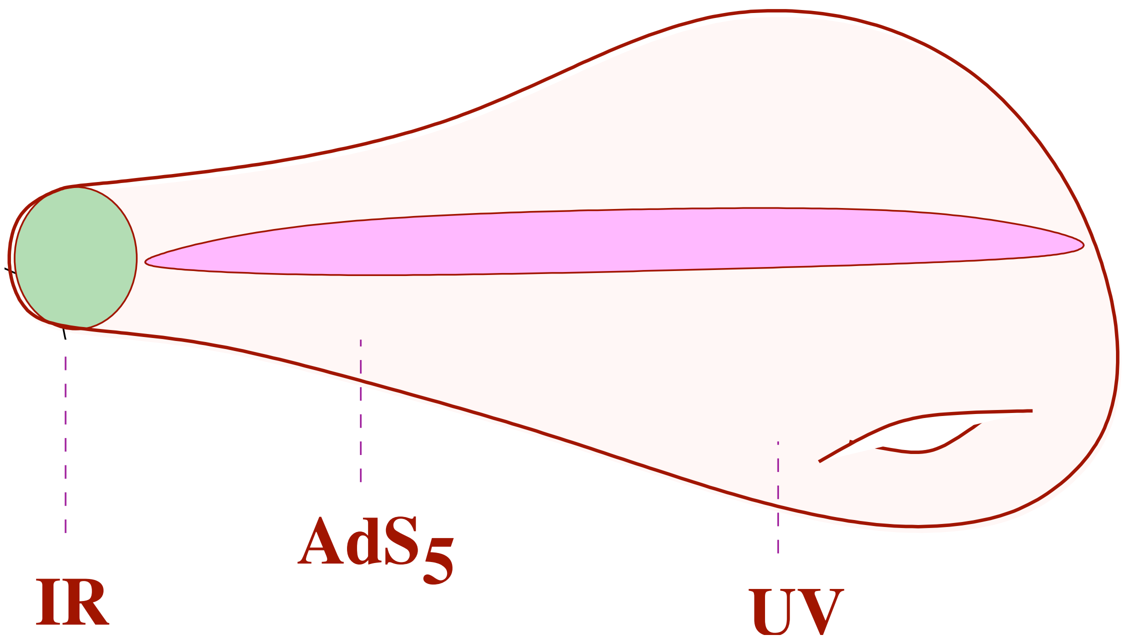
In Type IIB: $W = \int_{\mathcal{M}} G \wedge \Omega$ Gukov, Vafa, Witten

Energy cost depends on detailed geometry: $V_{n_1, n_2, \cdots, n_k}(\phi_i) \Rightarrow \text{moduli lifted}$

[Dasgupta, Rajesh, Sethi]; [Greene, Schalm, GS]; [Giddings, Kachru, Polchinski]

Warped Throats

Fluxes back-react on the metric:



e.g., warped deformed conifold

Klebanov, Strassler

leads to Randall-Sundrum hierarchy

Giddings, Kachru, Polchinski

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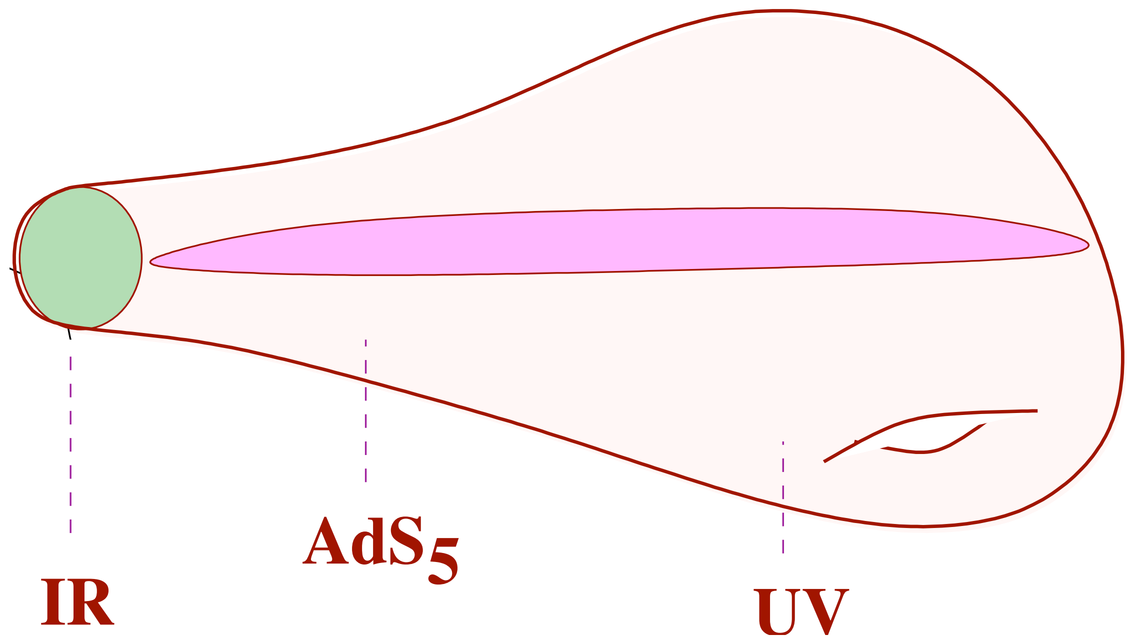


e.g., warped deformed conifold

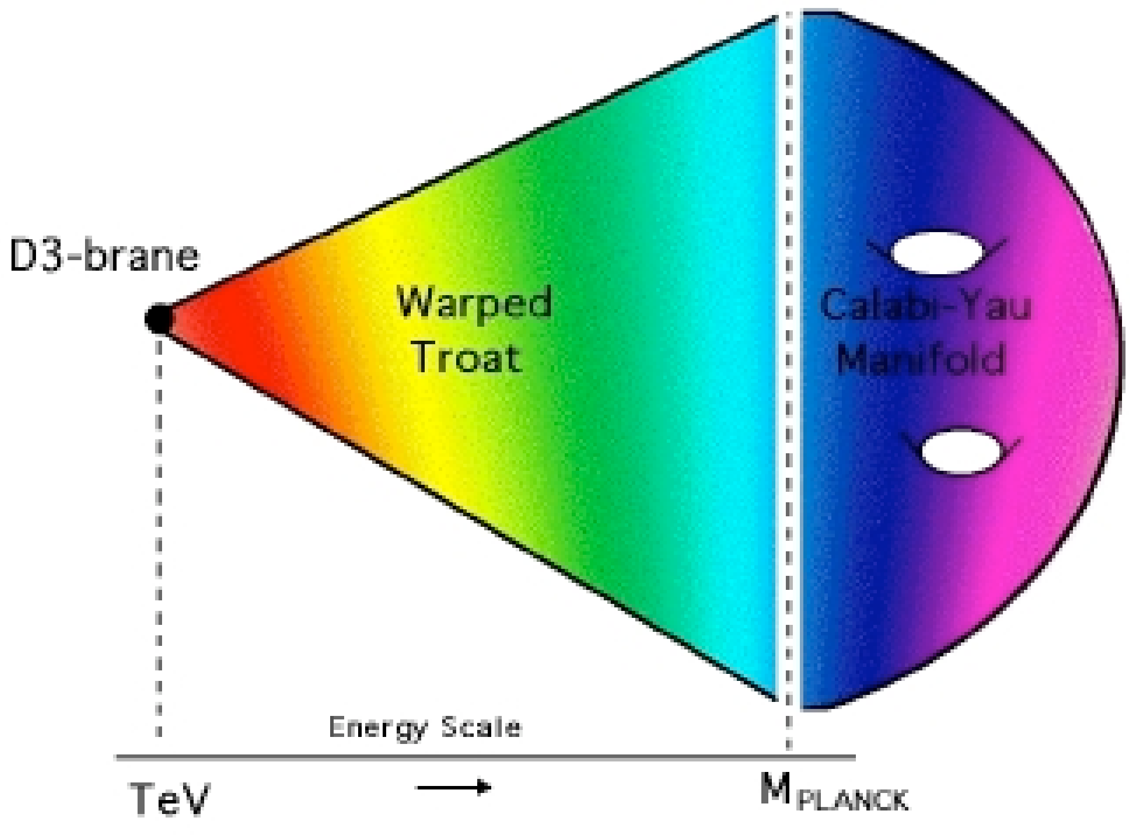
Klebanov, Strassler

leads to Randall-Sundrum hierarchy

Giddings, Kachru, Polchinski

A variety of warped throats with different isometries and IR behavior.

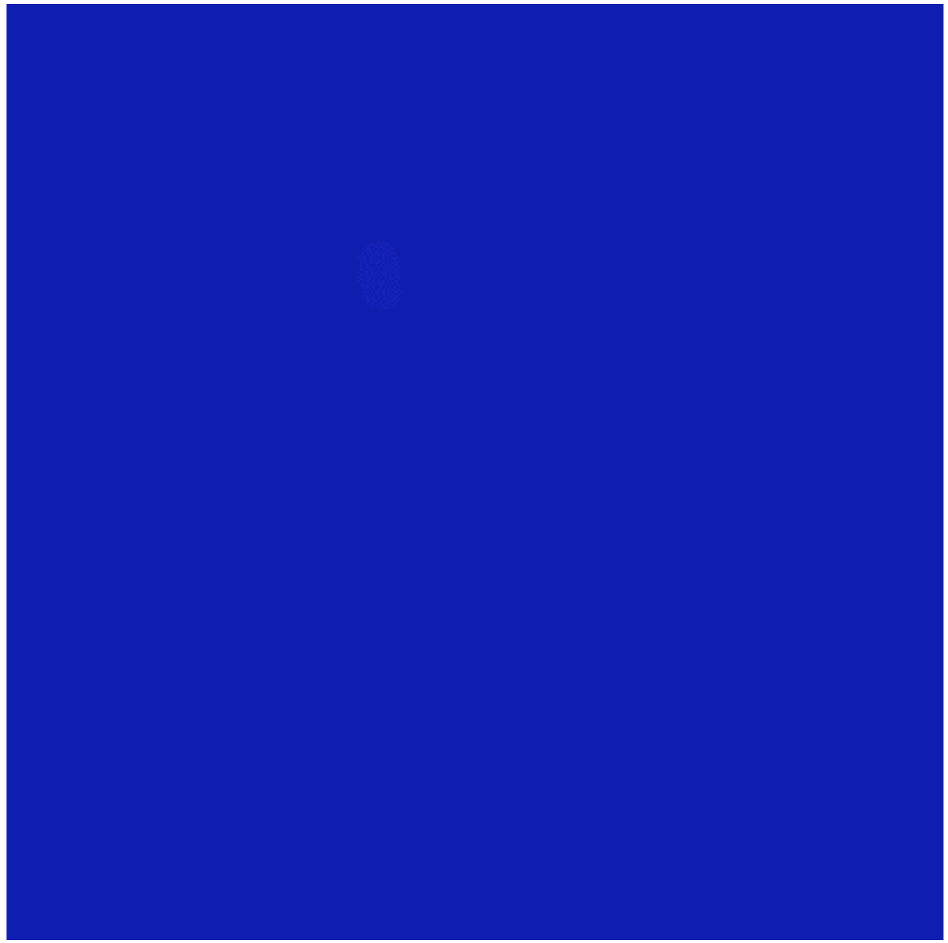
Standard-like D-brane Models



Marchesano, GS;
Verlinde, Wijnholt;
Cascales, Garcia del Moral, Quevedo, Uranga;
Blumenhagen, Cvetic, GS, Marchesano; ...

Brane Inflation

$D\overline{D}$ Inflation



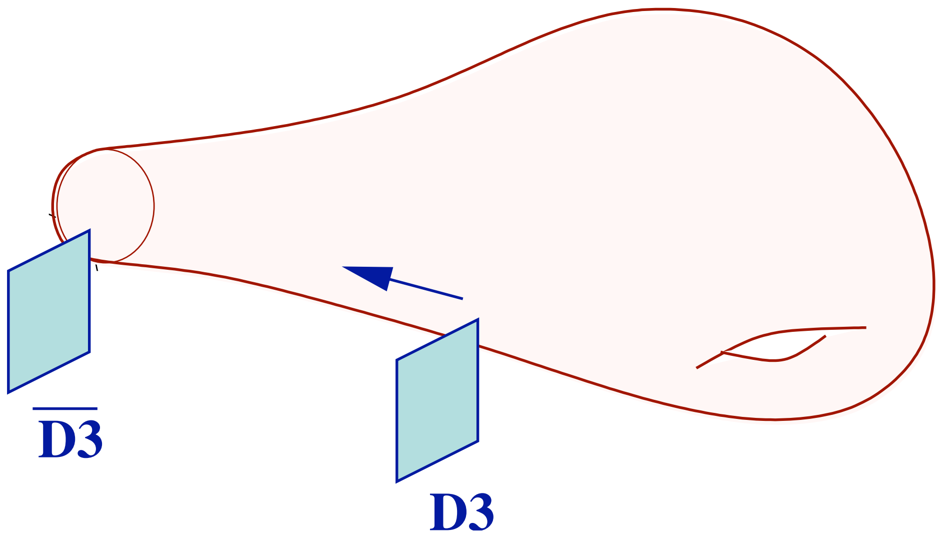
Dvali and Tye

...

Reviews:

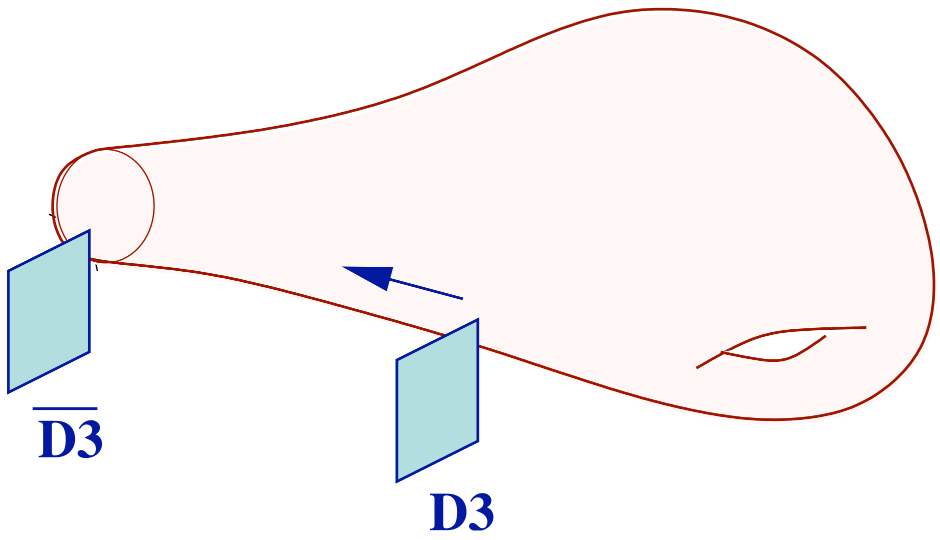
[Quevedo, hep-th/0210292];[Burgess, hep-th/0606020];[Tye, hep-th/0610221];
[Cline, hep-th/0612129];[Kallosh,hep-th/0702059], ...

Brane Inflation in Warped Throats



Brane Inflation in Warped Throats

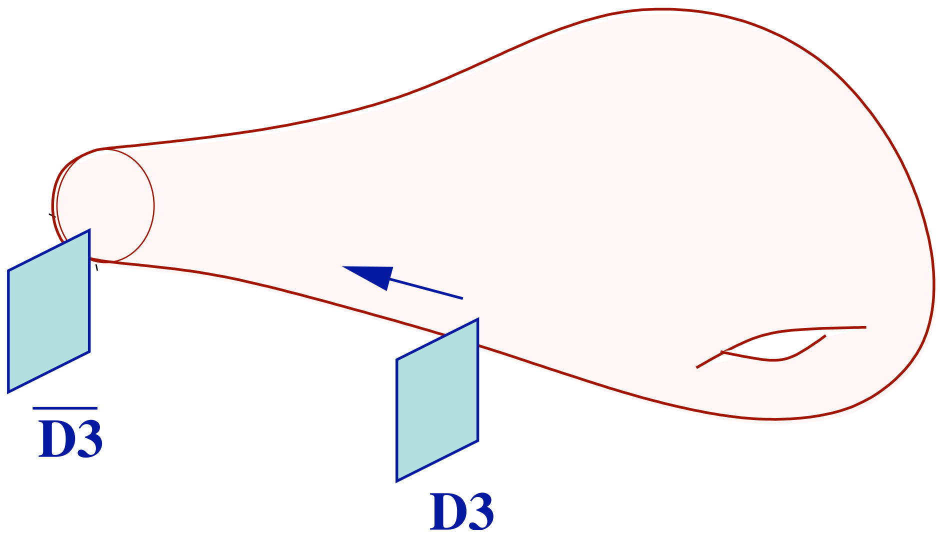
Slow-roll



Brane Inflation in Warped Throats

DBI

Silverstein, Tong



Brane Inflation in Warped Throats

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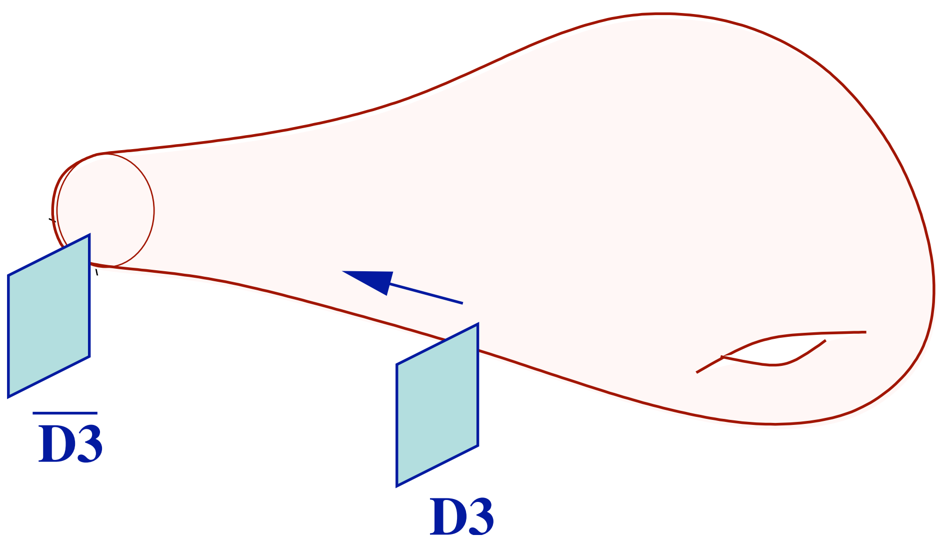

$$S = -\int d^4x \sqrt{-g}\left(f(\phi)^{-1}\sqrt{1 - f(\phi)\dot{\phi}^2} - V(\phi) - f(\phi)^{-1}\right)$$

Brane Inflation in Warped Throats

DBI

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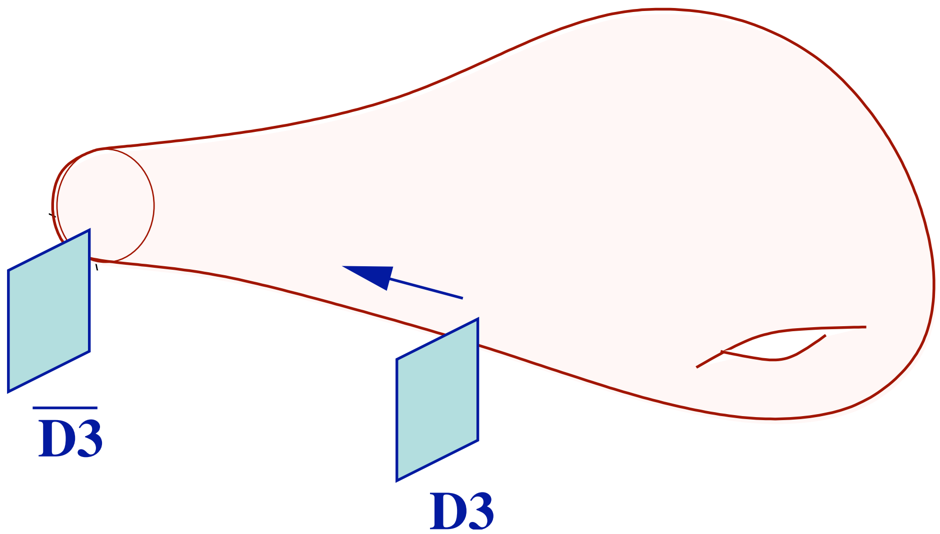

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Speed limit: $\dot{\phi}^2 \leq f(\phi)^{-1}$

Brane Inflation in Warped Throats

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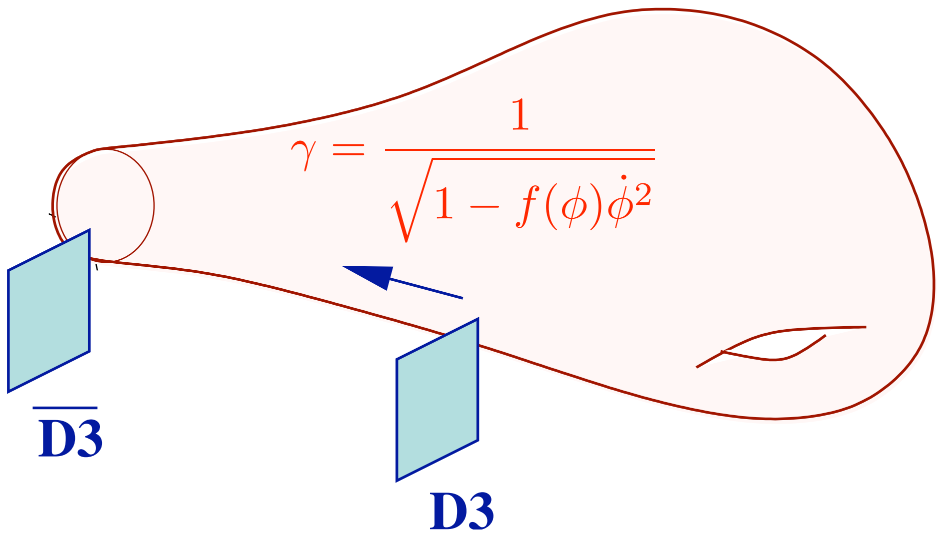

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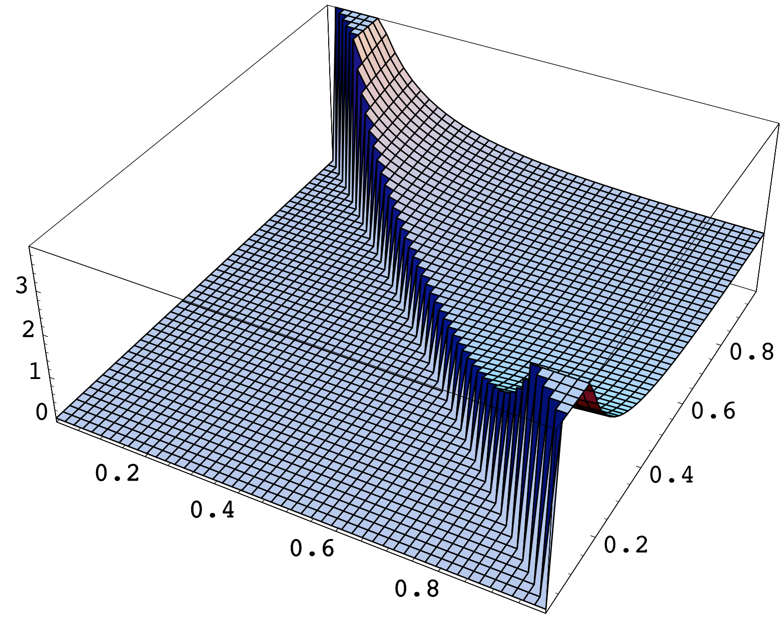
Speed limit: $\dot{\phi}^2 \leq f(\phi)^{-1}$

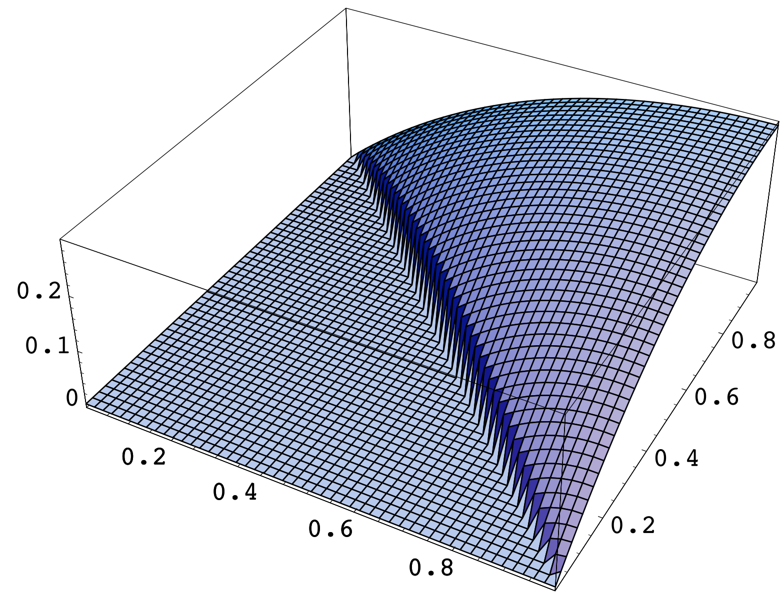
Non-Gaussianities

Large 3-point correlations that are potentially observable.

Moreover, distinctive shape. [Figures from Chen, Huang, Kachru, Shiu]



Slow-roll $(f_{NL} \sim \epsilon)$



DBI $(f_{NL} \sim \gamma^2)$

Non-Gaussianities

Large 3-point correlations that are potentially observable.

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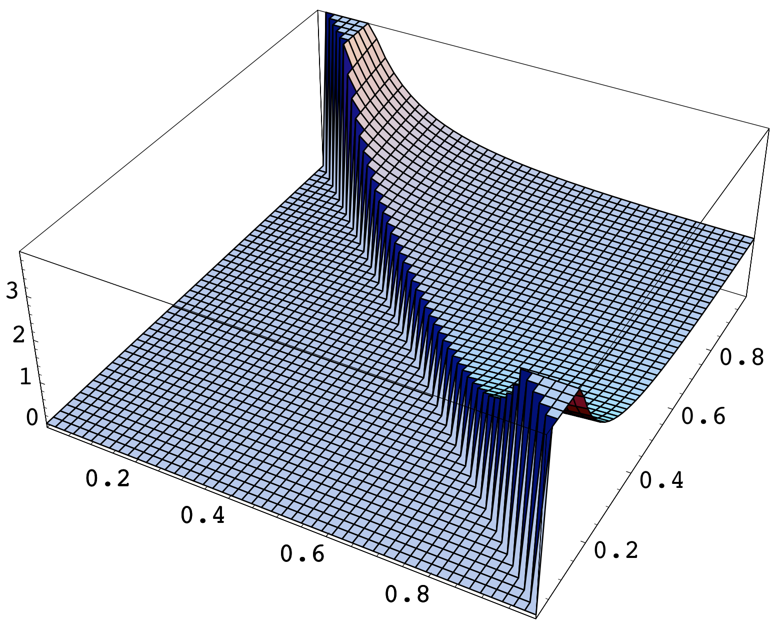
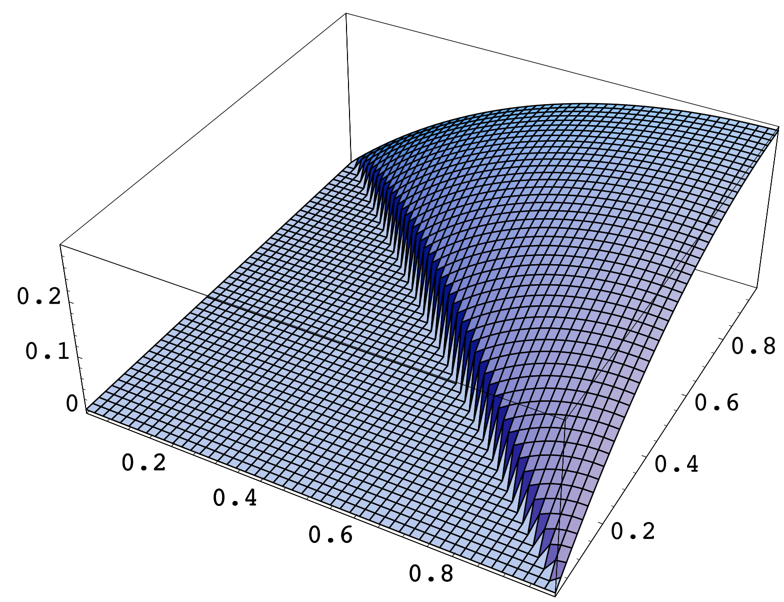
$$-54 < f_{NL} < 114 \text{ (WMAP3)} \quad f_{NL} \sim 5 \text{ (PLANCK)}$$



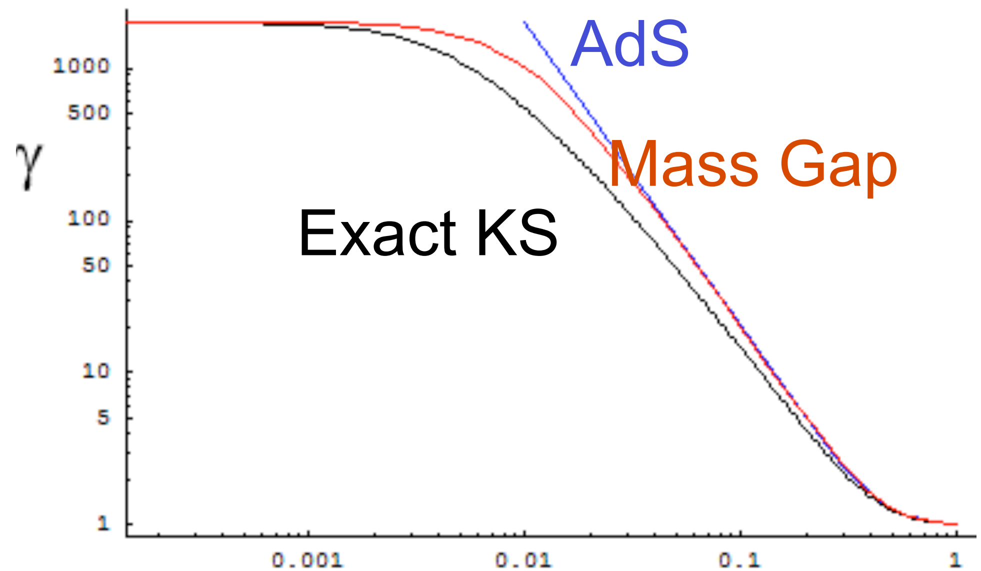


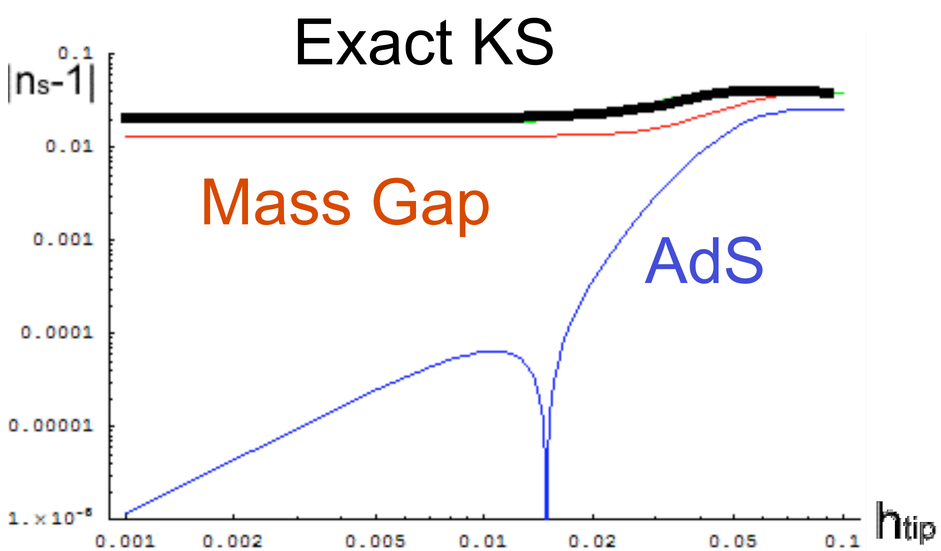
Slow-roll $(f_{NL} \sim \epsilon)$ DBI $(f_{NL} \sim \gamma^2)$

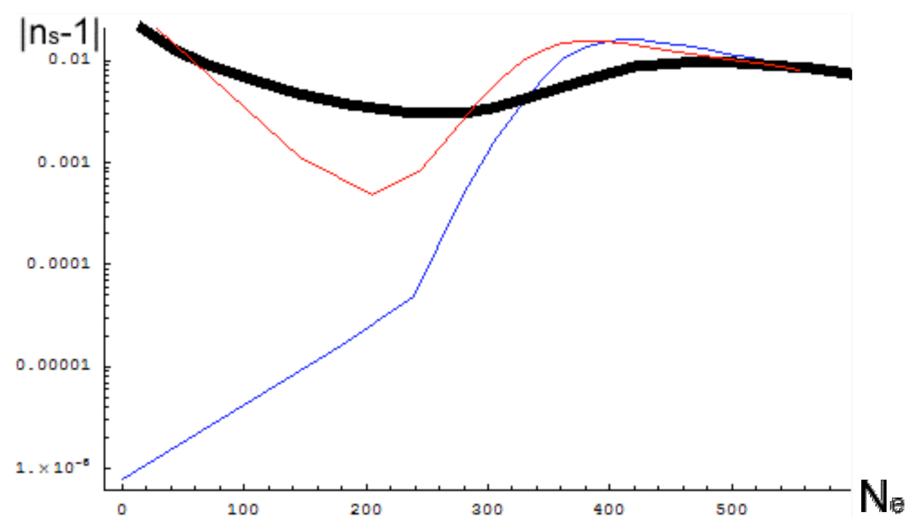
Probing the Warped Geometry

Spectral index depends on warp factor through:

$$\gamma = \sqrt{1 + 4M_p^4 H'^2 f(\phi)}$$



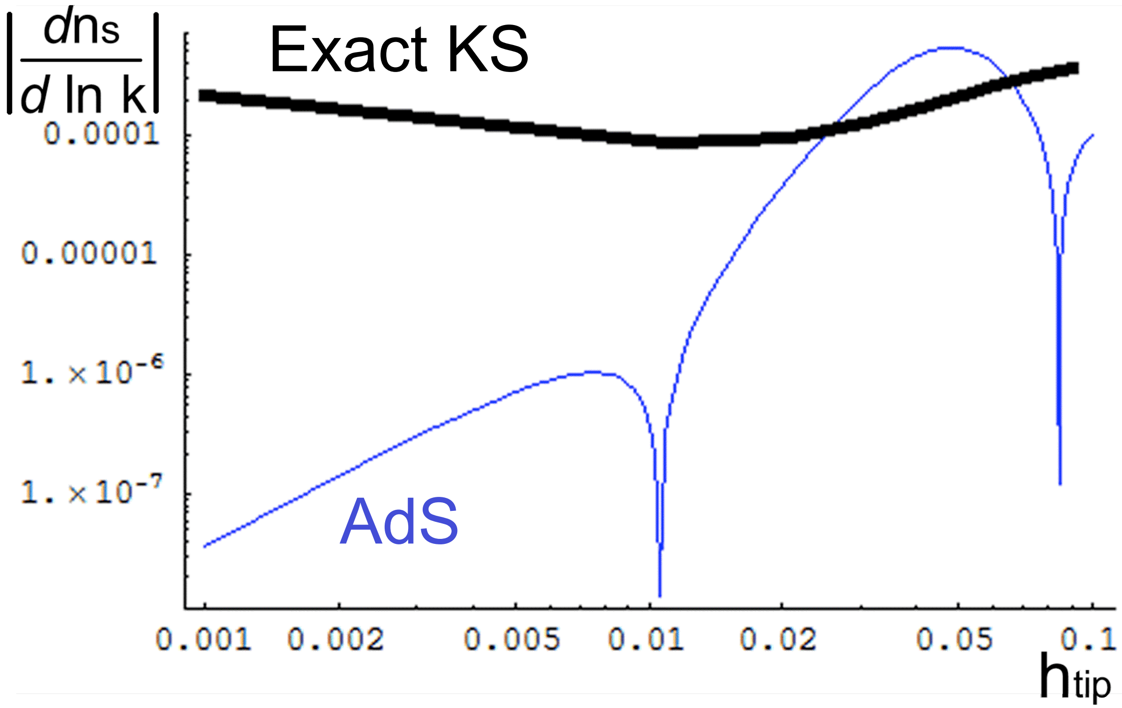




GS, B. Underwood, PRL

Probing the Warped Geometry

Running of spectral index:

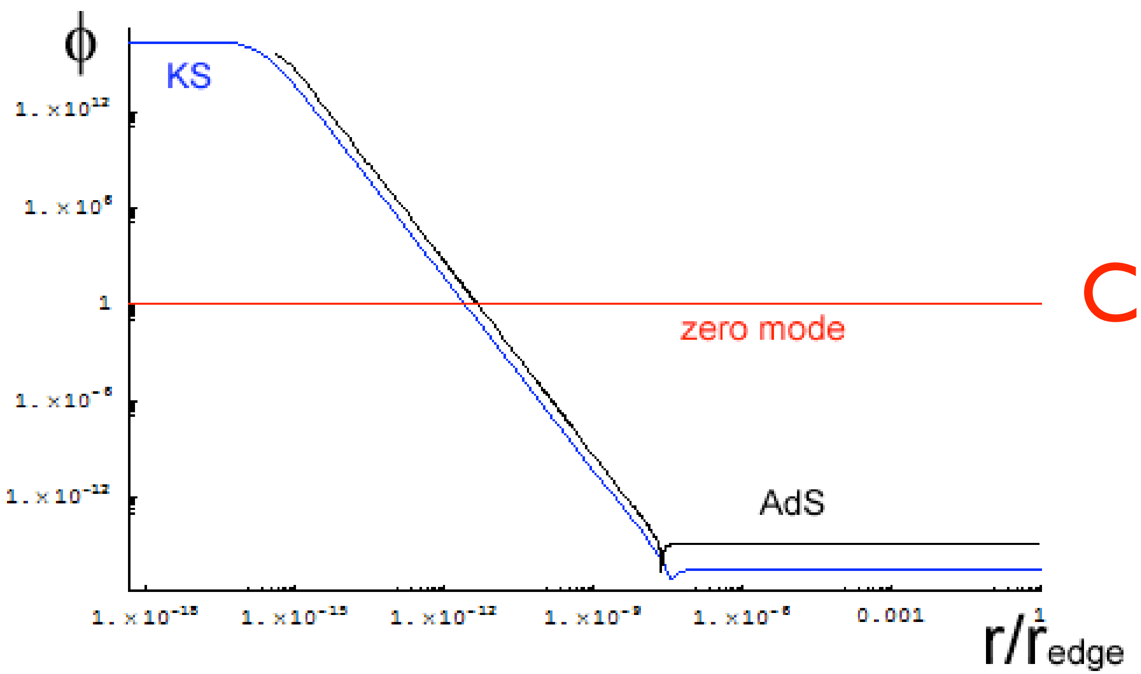


GS, B. Underwood, PRL


Warped throats
at the LHC & Beyond

Search for Warped KK Gravitons

GS, Underwood, Walker, Zurek (to appear)



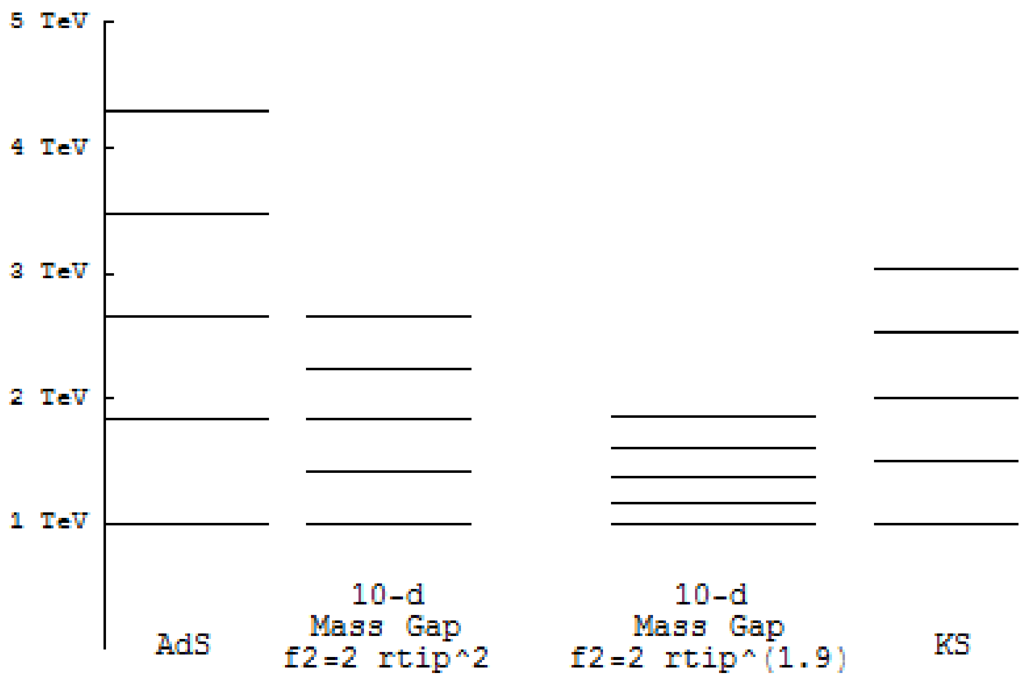
Couplings to KK gravitons only TeV suppressed

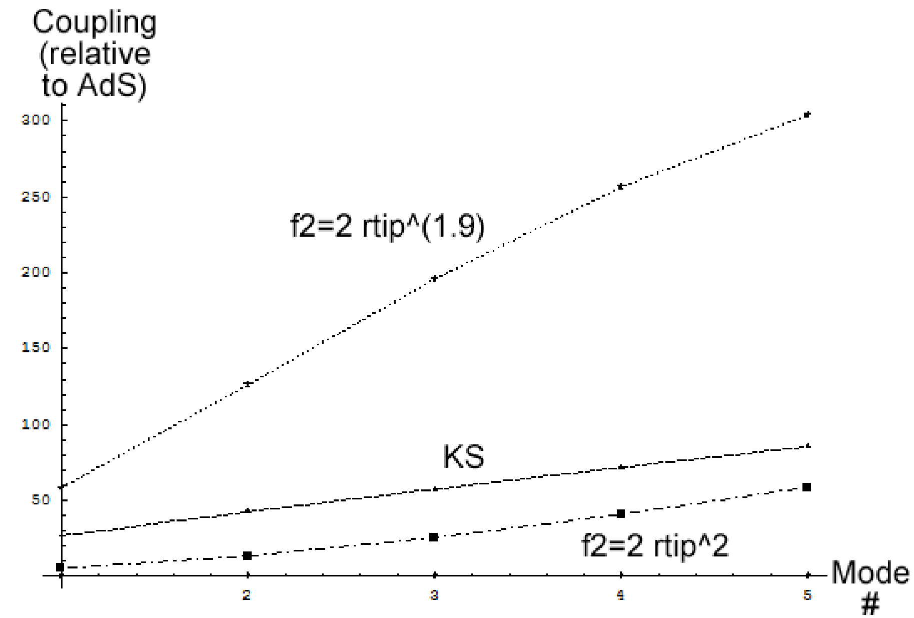
Much work on LHC signatures of KK gravitons for RS:

Davoudiasl, Hewett, Rizzo; Fitzpatrick, Kaplan, Randall, Wang; Agashe, Davoudiasl, Perez, Soni; ...

Warped KK Spectrum and Couplings

GS, Underwood, Walker, Zurek (to appear)





Warped KK Spectrum and Couplings

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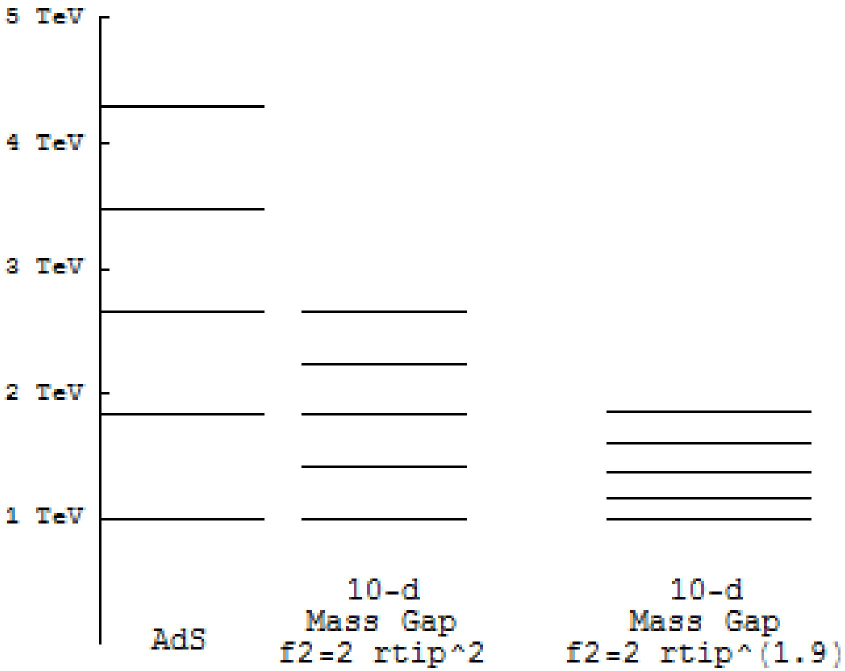
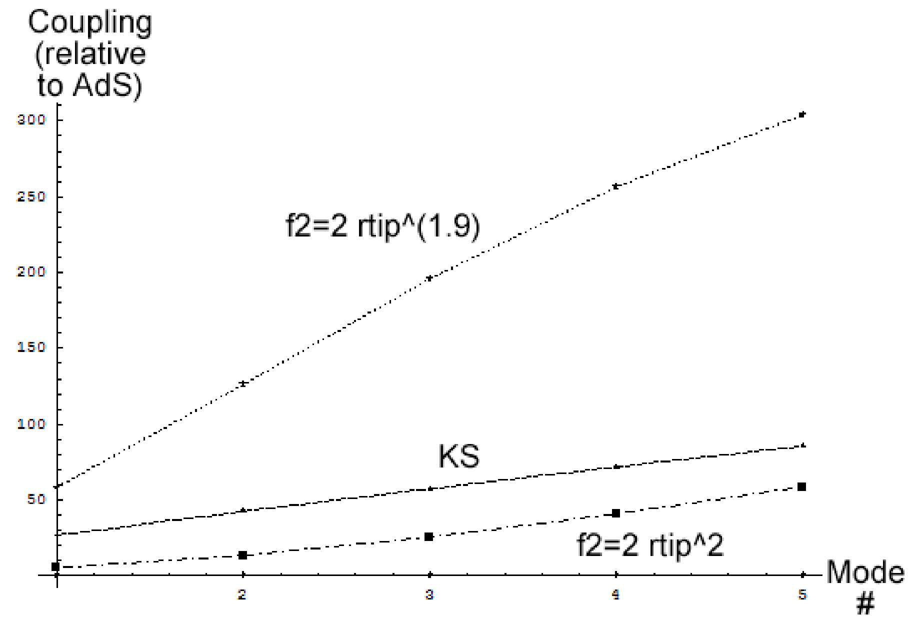
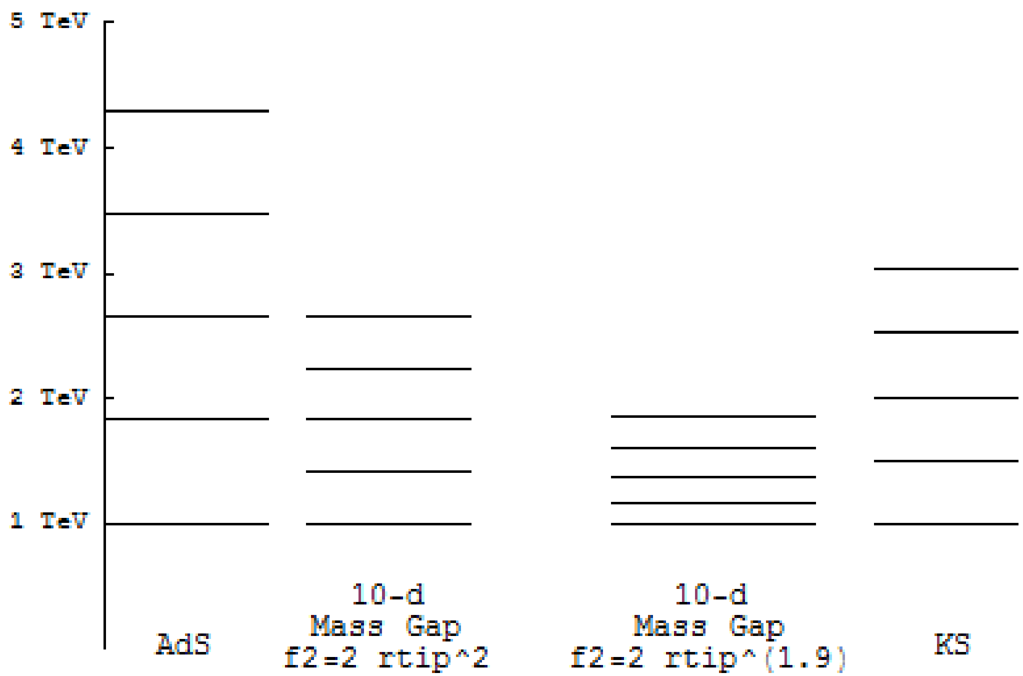


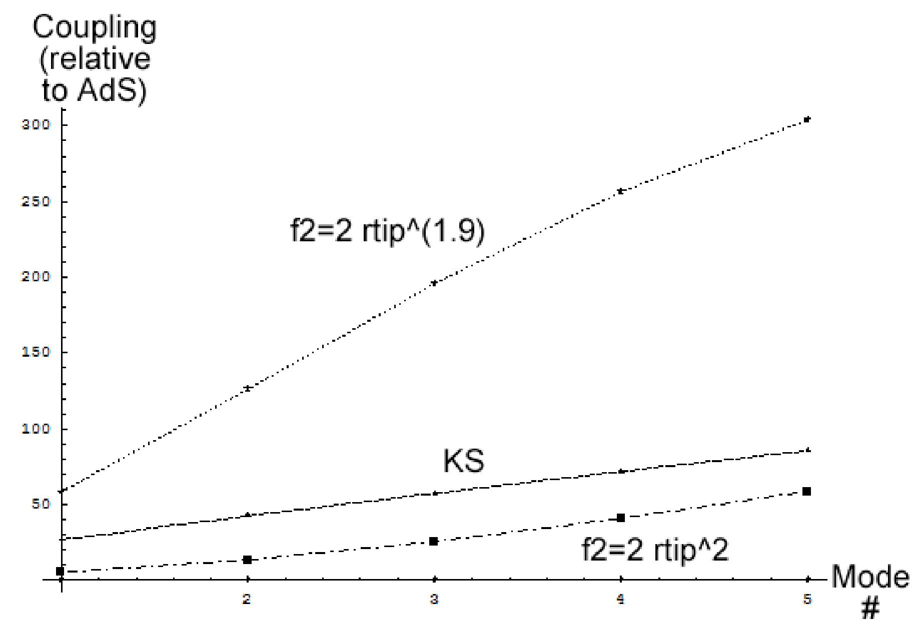


In comparison to RS, the KS geometry has:

Warped KK Spectrum and Couplings

GS, Underwood, Walker, Zurek (to appear)





In comparison to RS, the KS geometry has:

- Smaller KK spacing

Warped KK Spectrum and Couplings

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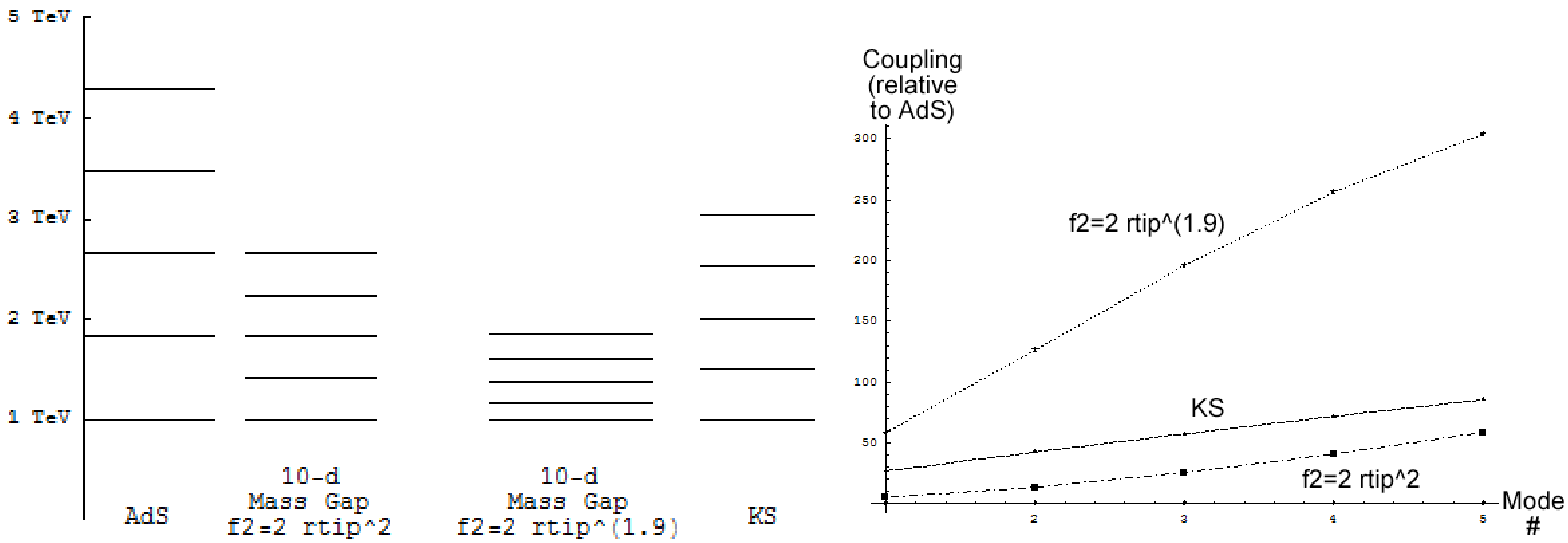
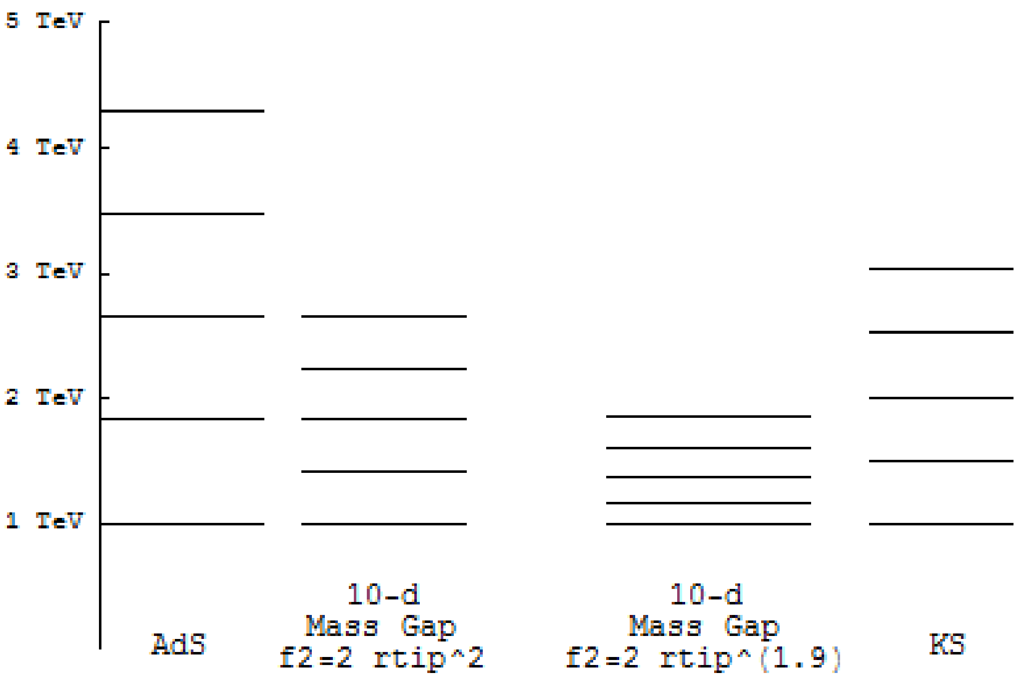


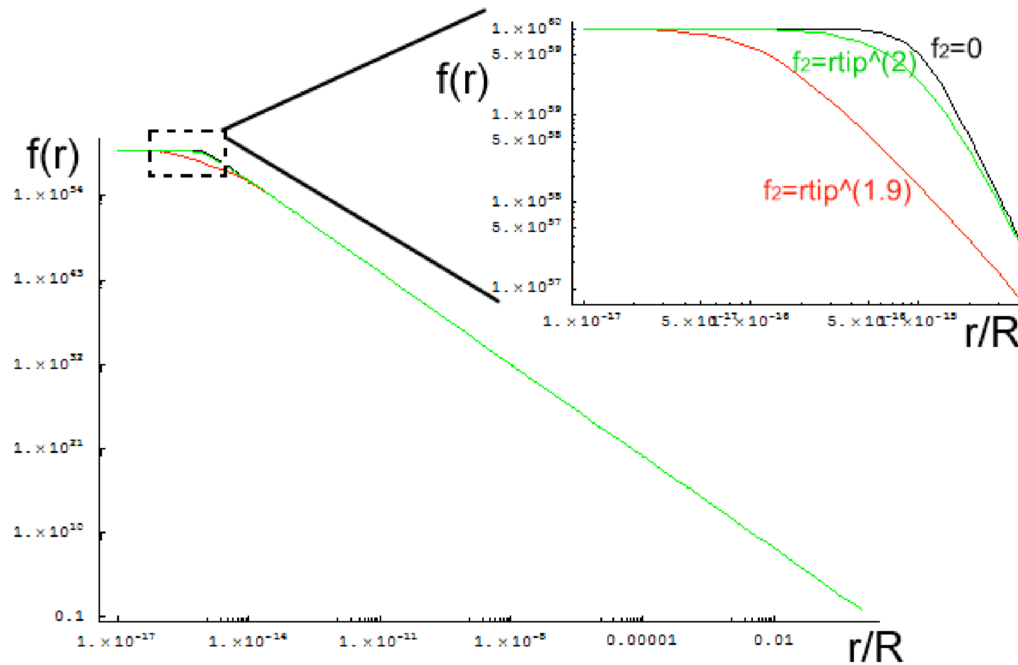
In comparison to RS, the KS geometry has:

- Smaller KK spacing
- Stronger & mode-dependent couplings

Warped KK Spectrum and Couplings

GS, Underwood, Walker, Zurek (to appear)





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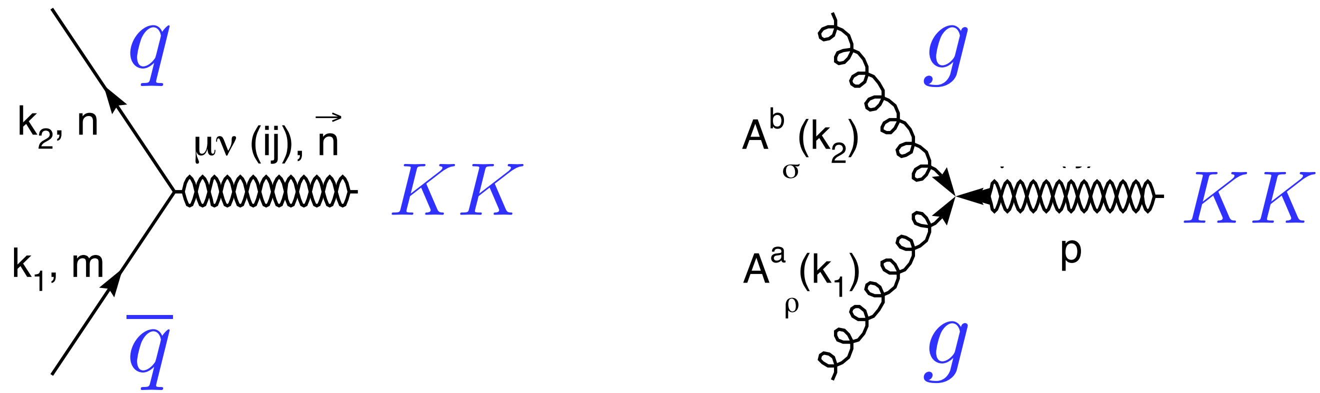
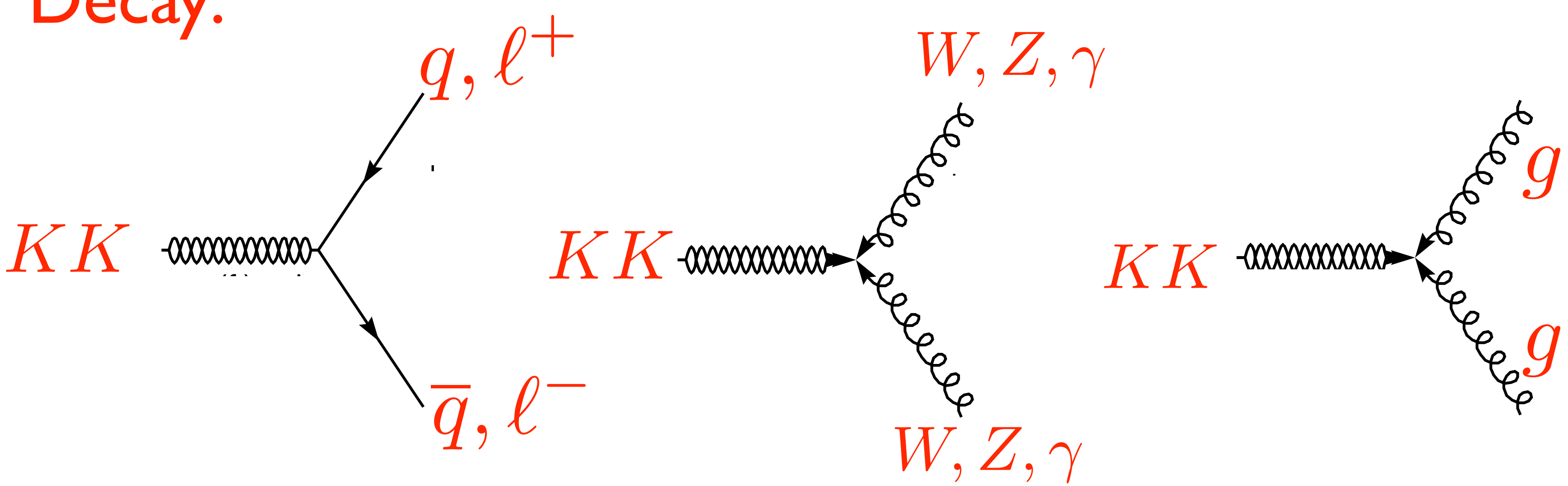
KK Gravitons: Production and Decay

Production:



Decay:



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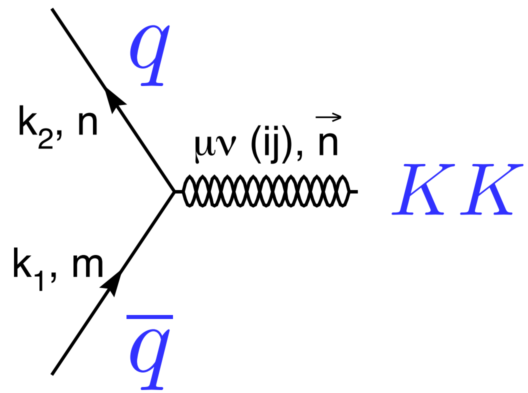
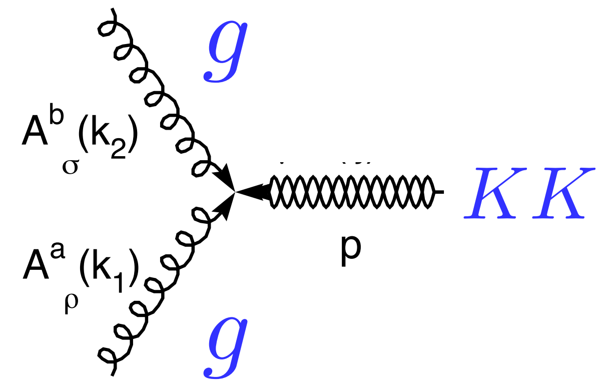
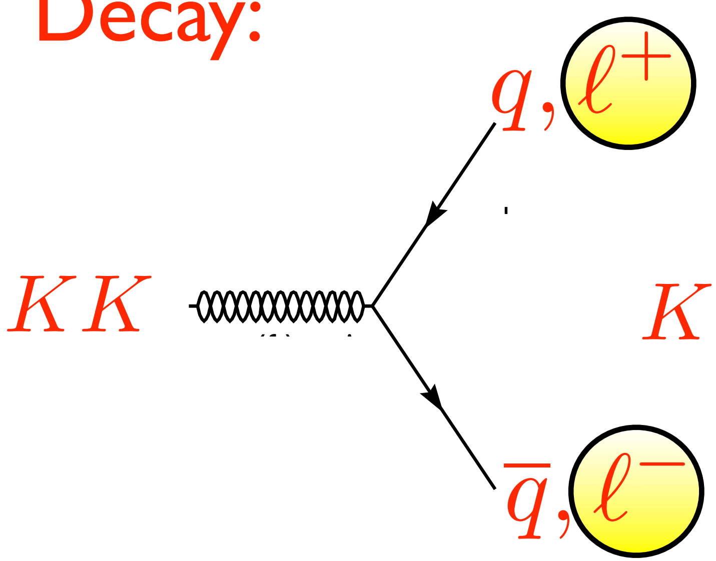
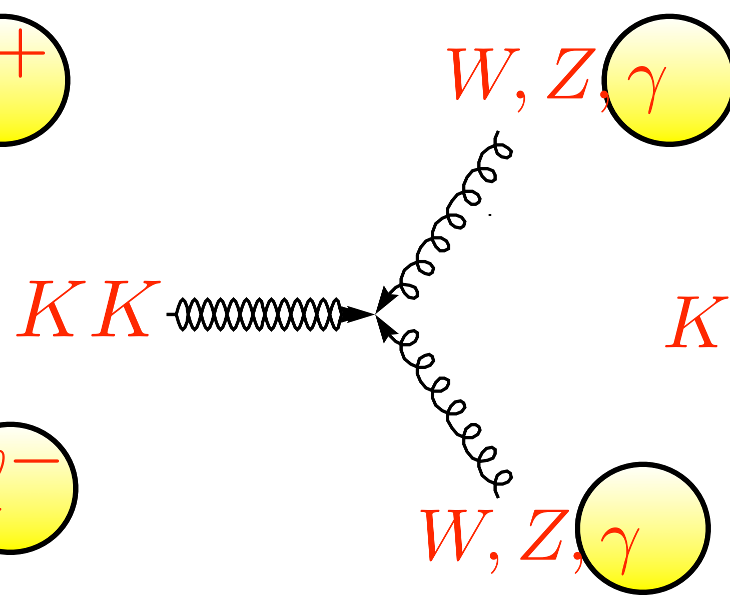
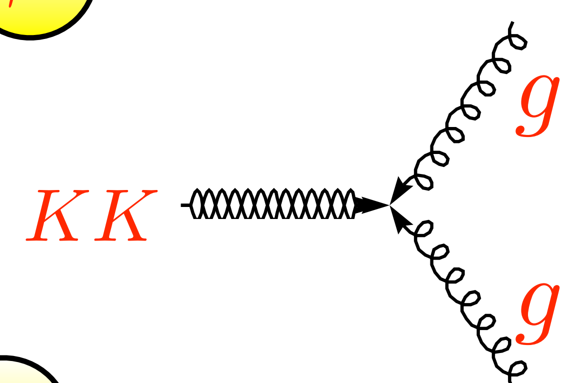




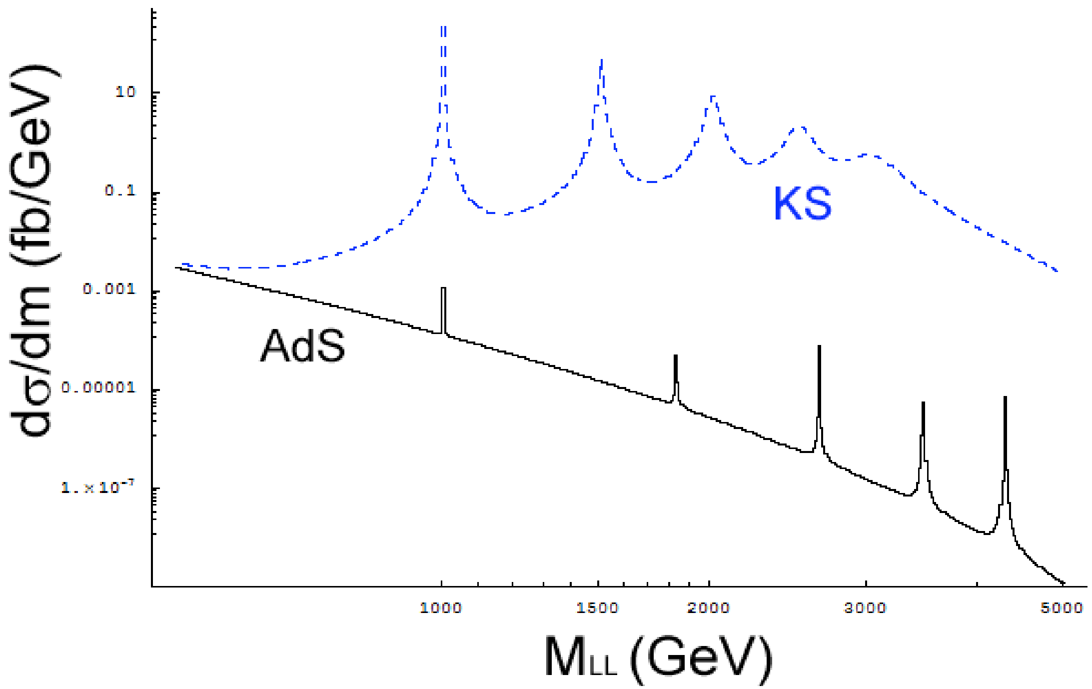
Decay:







KK Graviton Resonances



- Closer spacing between resonances
- Higher and broader peaks:

$$\sigma \sim \Lambda^{-4} \qquad \Gamma \sim \Lambda^{-2} M_{KK}$$

- Relative heights between different KK resonances

Happy Birthday, YITP!