Effective Field Theories in QCD

N. Ripunjay Acharya[1,2], with Feng-kun Guo[2] & Ulf-G. Meißner[1]

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[2]ITP, CAS Beijing

Les Houches, 04 July, 2017

EFTs in QCD: Acharya

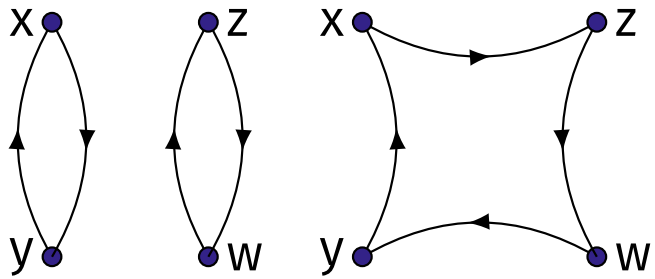
Chiral Perturbation Theory with the topological θ term:

- θ-dependence of the lightest meson resonances in QCD.
- hep-ph/1507.08570

$$\mathcal{L}_\theta = -\frac{\theta}{64\pi^2}\epsilon^{\mu\nu\rho\sigma}G^a_{\mu\nu}G^a_{\rho\sigma}$$

Partially Quenched χPT to separate and calculate disconnected Wick contractions in $\pi\pi$ Scattering.

- Connected and disconnected contractions in pion-pion scattering
- hep-ph/1704.06754



Lattice QCD

Gabriela Bailas

UNIVERSITÉ Clermont Auvergne

Laboratoire de Physique de Clermont

Why study LQCD?

Because LQCD = QCD!

LQCD is currently the only known way to treat the full QCD lagrangian non-perturbatively from first principles.

We can extract, for example: **mass**, **decay constants** and **form factors** for the ground state.

Lattice QCD = theoretical physics + technical knowledge

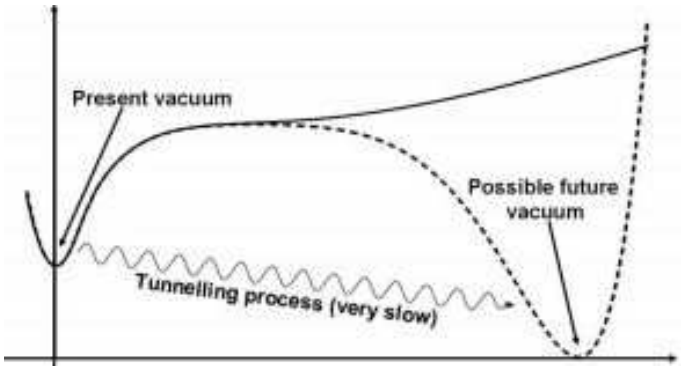
Previous work: **Phenomenological implications of the intrinsic charm in the Z boson production at the LHC** **(arXiv:1512.06007)**

SYMMETRIES AND EFT METHODS
in
high-energy physics and cosmology

M.P. Bogers • UiS • mark.bogers@uis.no

Motivation

The S.M. Higgs mass of 125 GeV, leads to an unstable Higgs potential. This is severe during inflation due to higher quantum tunneling rate.



- The addition of a term ξ: $\frac{1}{2}\xi R H^\dagger H$ leads to RGE:

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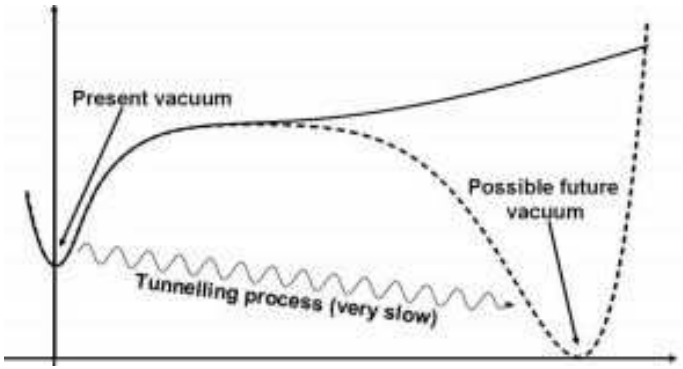

- The addition of a term ξ: $\frac{1}{2}\xi R H^\dagger H$ leads to RGE:
- $$\frac{\xi_H(t)-\frac{1}{6}}{\xi_{H,0}-\frac{1}{6}} = \left(\frac{2\pi^2}{2\pi^2-3\lambda_{H,0}t}\right)^{\frac{1}{2}}, \quad \mu_H^2 = \mu_{H,0}^2\left(\frac{2\pi^2}{2\pi^2-3\lambda_{H,0}t}\right)^{\frac{1}{3}}$$

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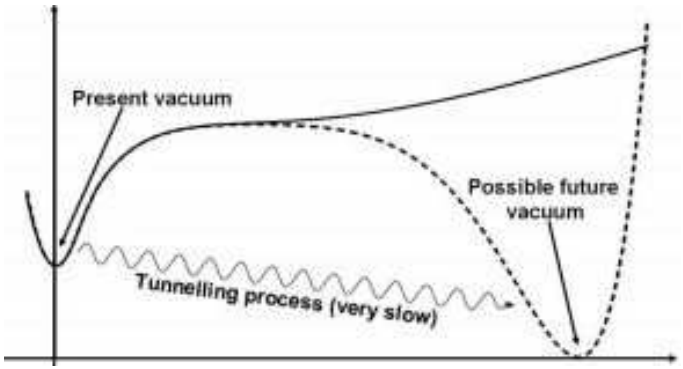
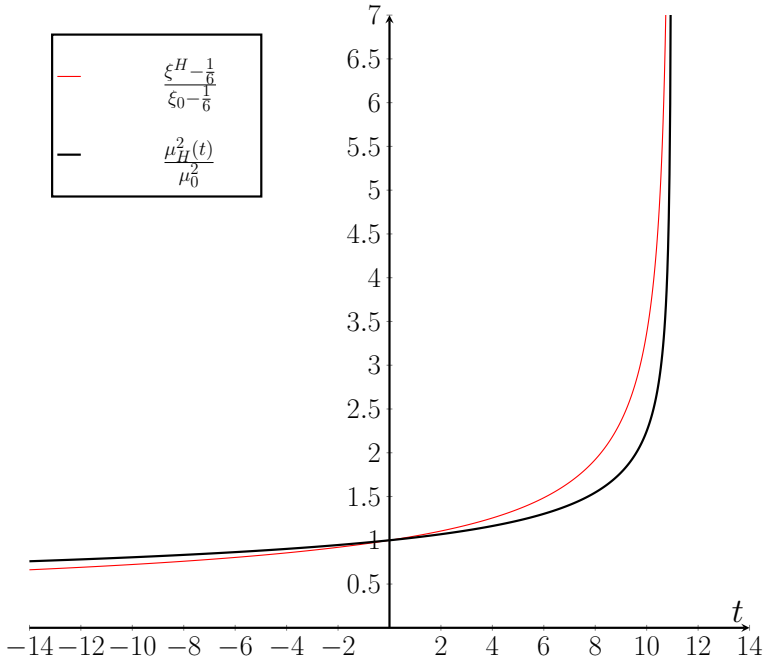


- The addition of a term ξ: $\frac{1}{2}\xi R H^\dagger H$ leads to RGE:
- $$\frac{\xi_H(t) - \frac{1}{6}}{\xi_{H,0} - \frac{1}{6}} = \left(\frac{2\pi^2}{2\pi^2 - 3\lambda_{H,0}t}\right)^{\frac{1}{2}}, \quad \mu_H^2 = \mu_{H,0}^2 \left(\frac{2\pi^2}{2\pi^2 - 3\lambda_{H,0}t}\right)^{\frac{1}{3}}$$
- Hence, the ξ term proves to be more significant for large ϕ than the $\frac{1}{2}m^2\phi^2$ term:

Results-Further Questions



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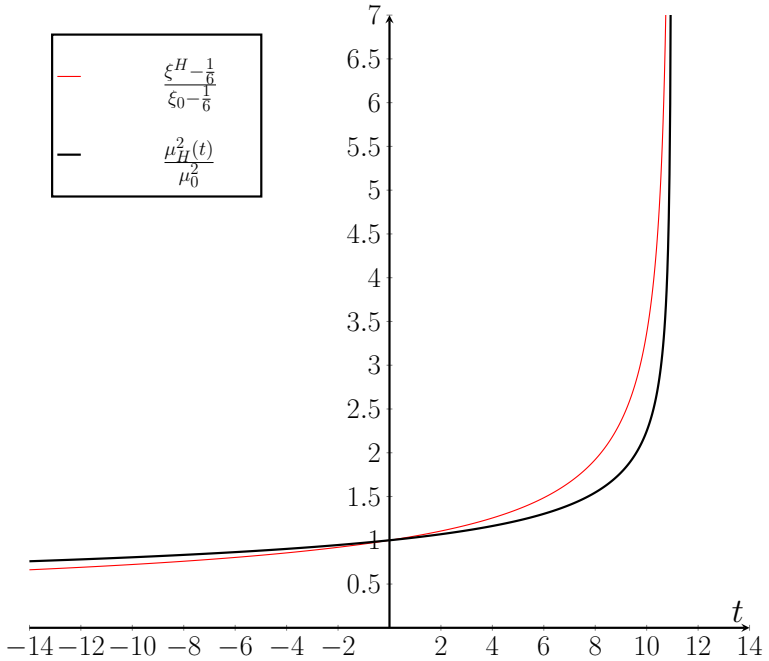
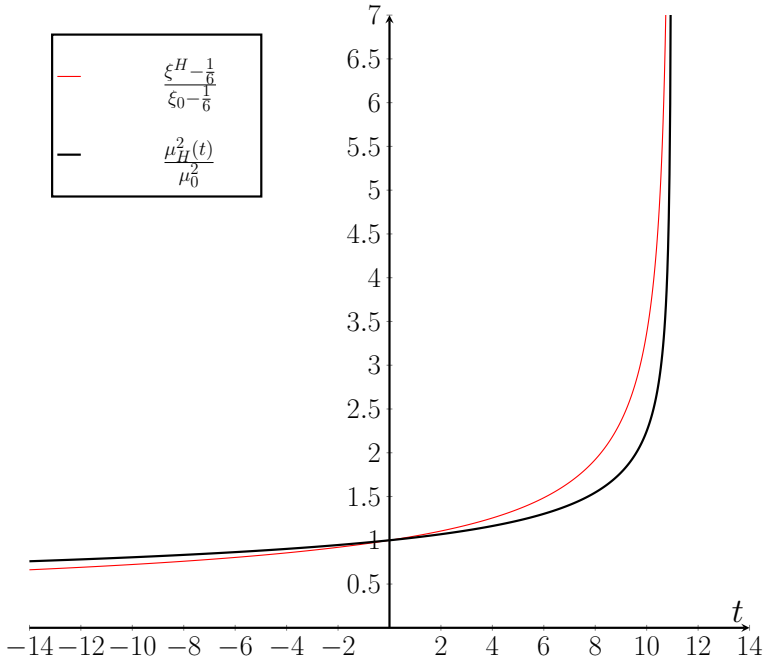


Success!! The ξ term IS more significant as energy increases $\rightarrow$ the instability can be solved at high energy!

Results-Further Questions



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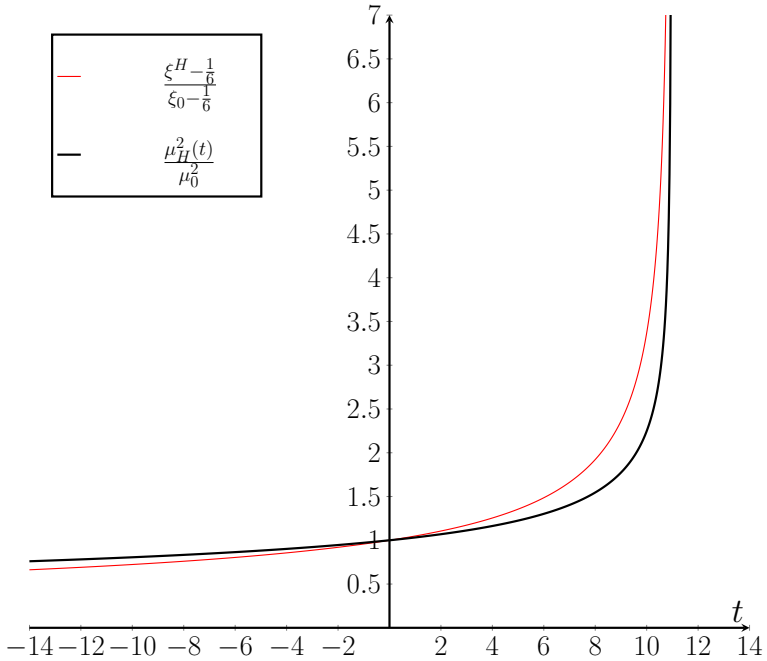

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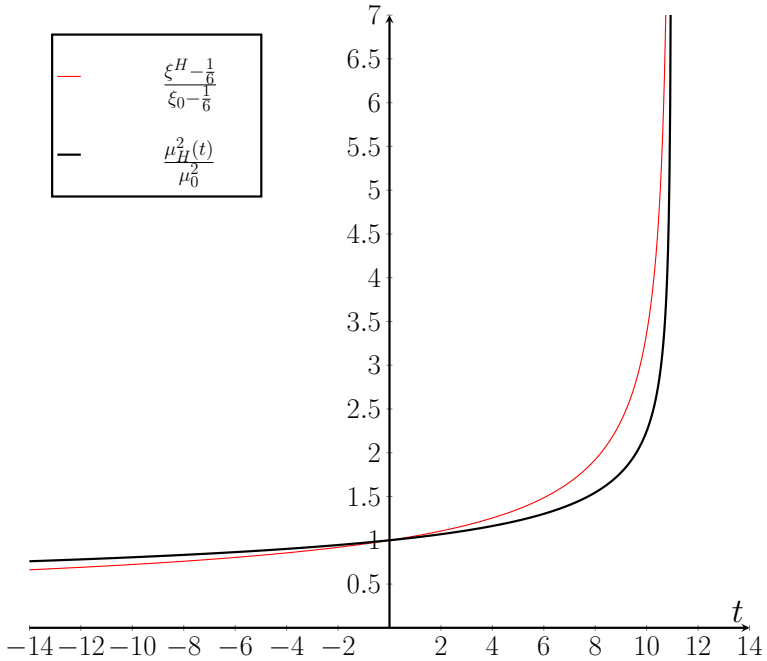

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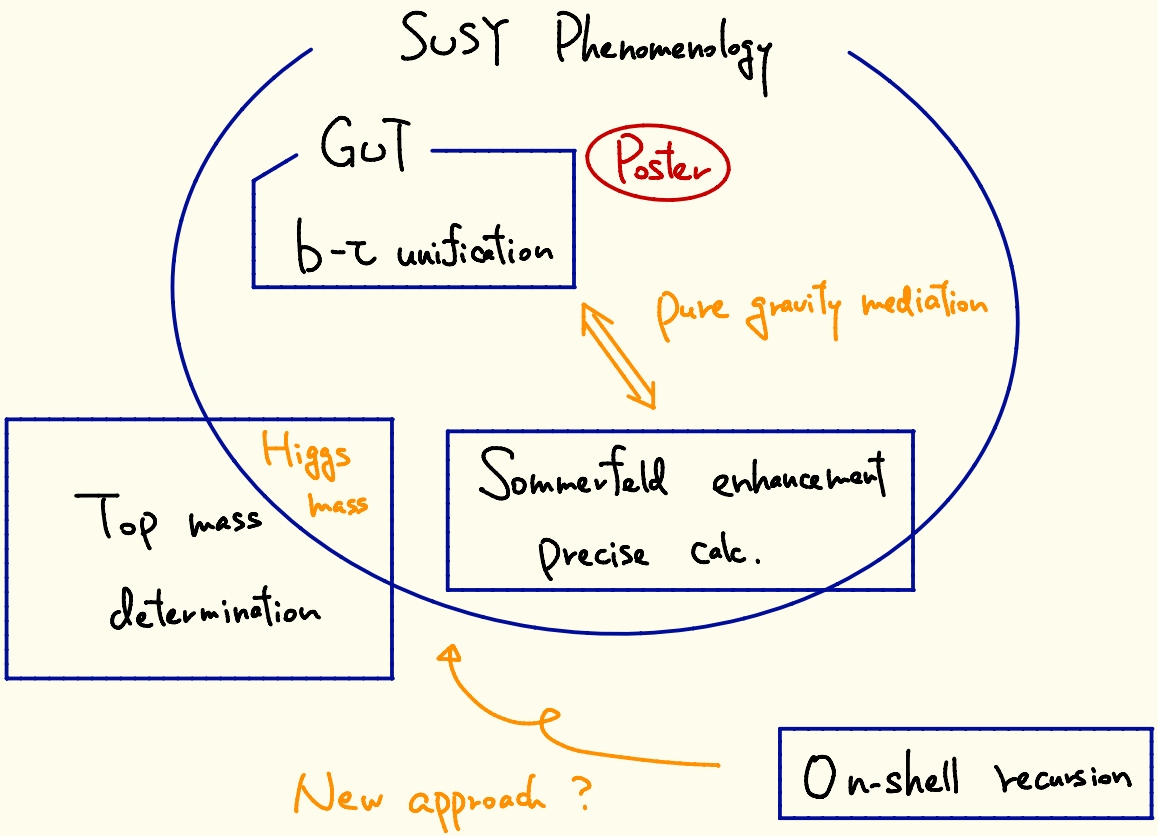
- What happens when gravity is not just a static background? What is the result of allowing R to fluctuate ?
- Is the result dependent on the choice of frame (Einstein - Jordan)?
- Is there an alternative - more general approach ?

My research interest

(So Chigusa, Univ. of Tokyo)



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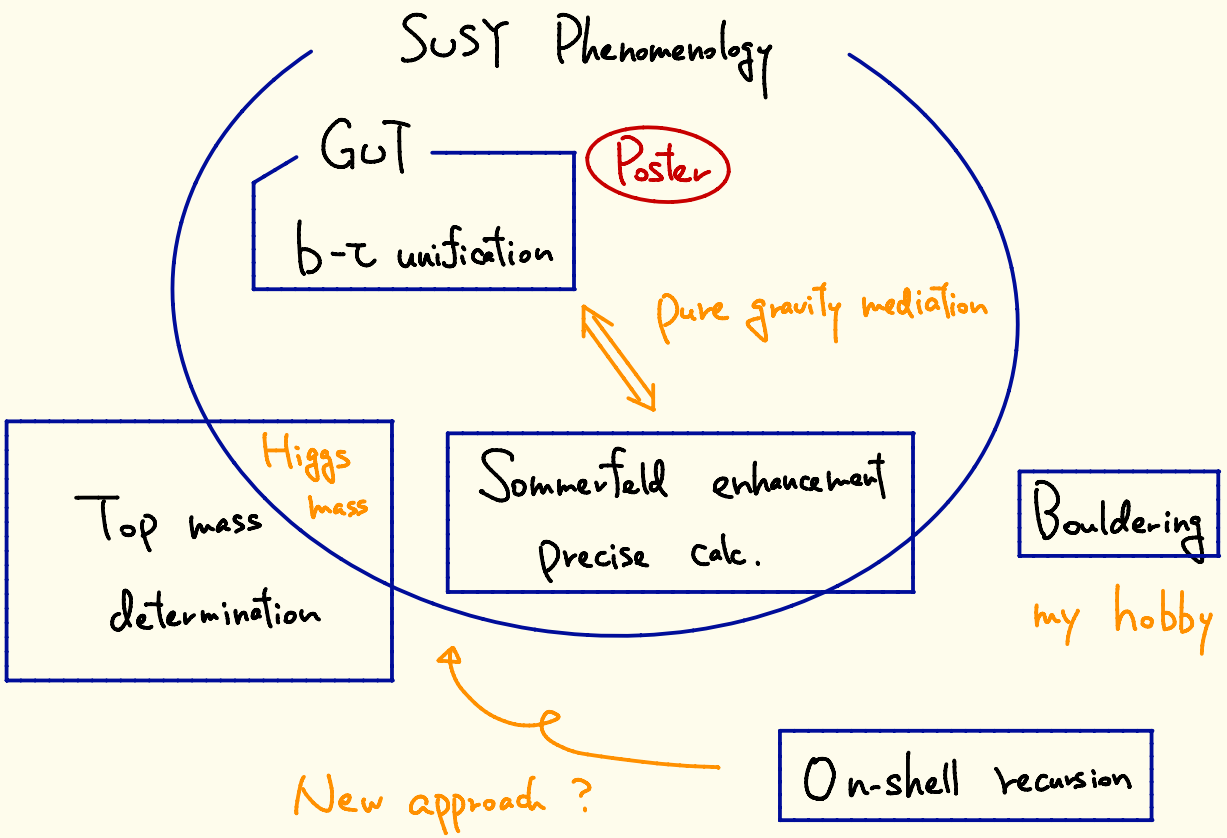
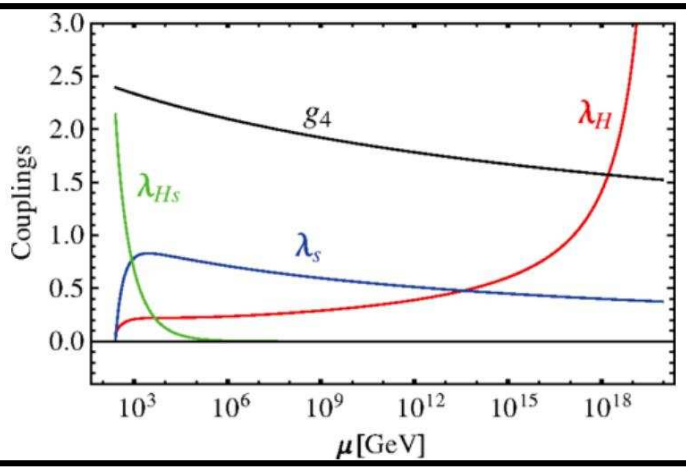
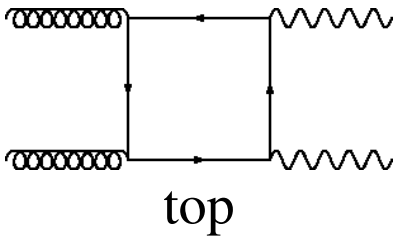


DONGJIN CHWAY (Seoul National University)

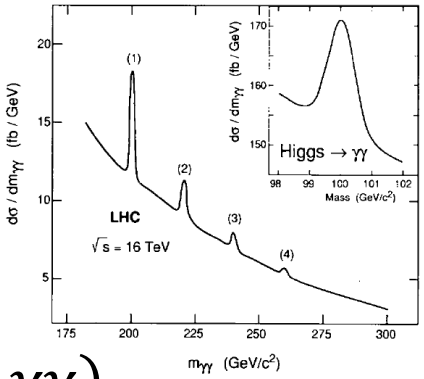


Cosmology and Collider Phenomenology of
Radiative Electroweak Symmetry Breaking Model
Perturbative All the Way to the Planck Scale
arXiv:1308.0891 (PRL, 113, 051801)

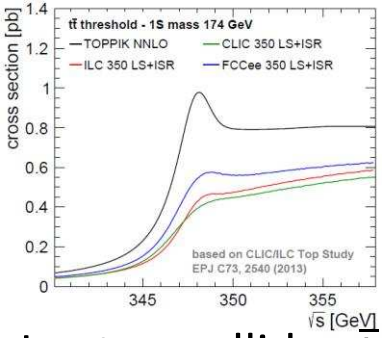
Many scales: m_h, m_s, kT, …
and Confinment of the hidden gauge sector



Pancheri, Revol, Rubbia (92)



Vos, Abbas, Beneke, *et al* (16)



Lepton collider $t\bar{t}$ production

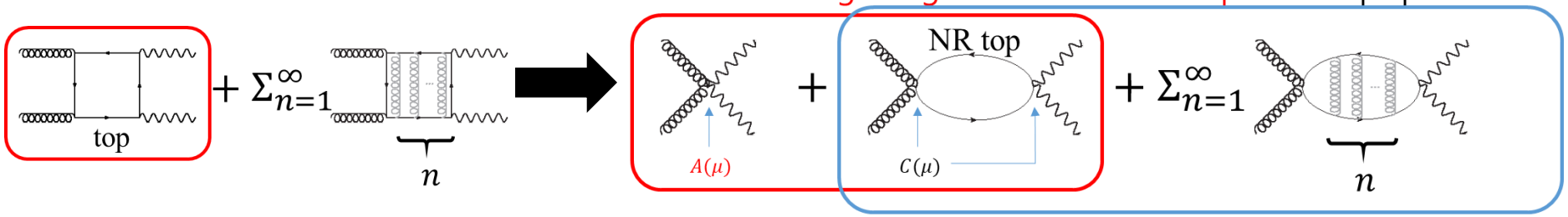
$$\sigma(pp \to \eta_t \to \gamma\gamma)$$
$$= PDF_{gg}\sigma(gg \to \eta_t)\frac{\Gamma(\eta_t \to \gamma\gamma)}{\Gamma_{\eta_t}}$$

$$\mathcal{M}^*_{light\ quarks}\mathcal{M}_{top}$$

arXiv:1512.08221 (PRL, 117, 061801) arXiv:1612.05031 (PRD, 95, 115004)
(DC, Radovan Dermisek, Tae Hyun Jung, Hyung Do Kim)

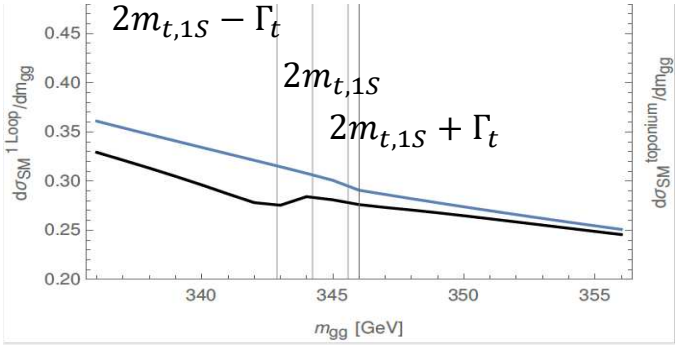
DONGJIN CHWAY (Seoul National University)

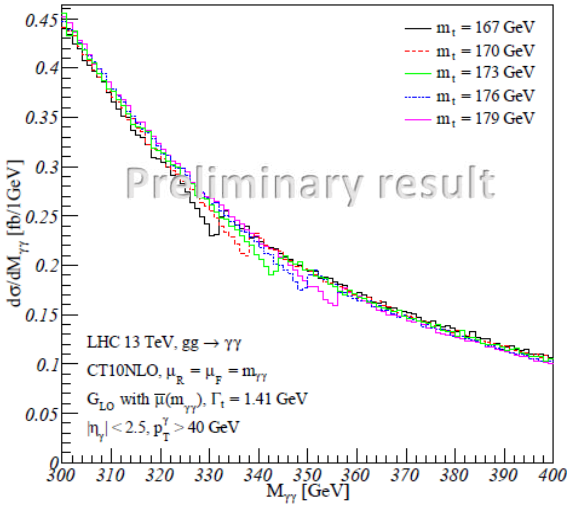
EFT from integrating out the relativistic part of top quark



Self-consistency equation leads to
Schroedinger equation with Coulomb potential

This structure near the threshold mostly comes from the 1S state.





Unlike $pp \to t\bar{t} \to bW\bar{b}W$

-No jet
-Annihilation channel

-Pile up
-Small number of events

Optimistic LO ballpark estimate on the top mass with $\pm$1 GeV (100 MeV) precision:
13 TeV LHC 2 ab^{-1} (100 TeV HC 2 ab^{-1}),assuming 1 GeV diphoton resolution.

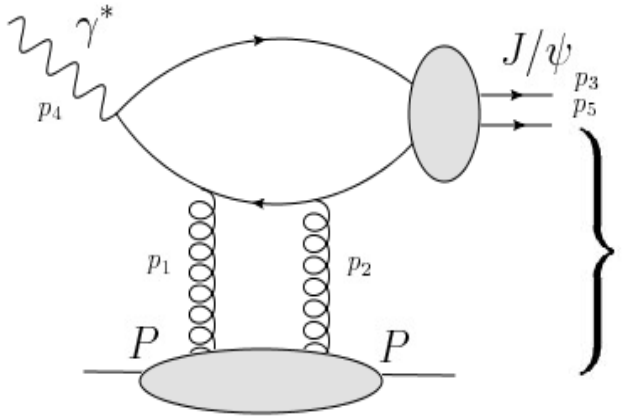
PDF and α_s uncertainty and NLO including ISR should be taken into account.

Exclusive LHC Pheno and small x PDFs

Chris Flett

In collaboration with Thomas Teubner (Univ. of Liverpool) and Stephen Jones (MPI, Munich)

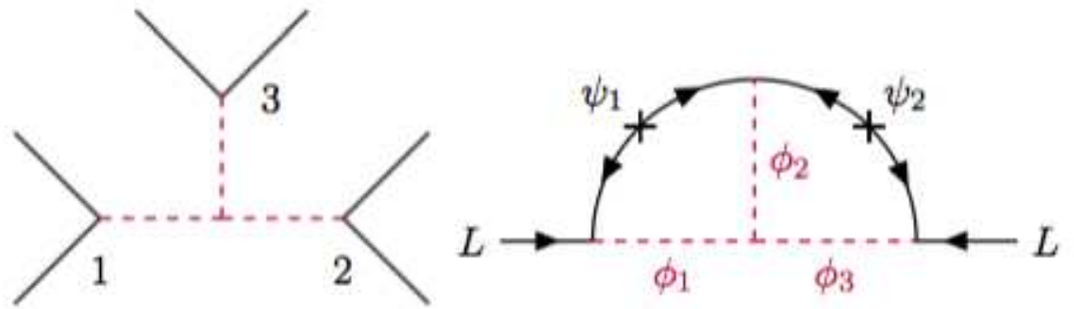
- Inclusive/DIS type events do not constain small x regime of PDFs
- In 1993, Ryskin showed forward cross section for *exclusive* J/psi production via ultraperipheral pp collisions was a sensitive probing process PP -> P + J/psi + P of the *gluon* PDF.
- Want to generalise previous literature to electroproduction and use xFitter as a means of incorporating existing small x photoproduction data to constrain gluon PDF

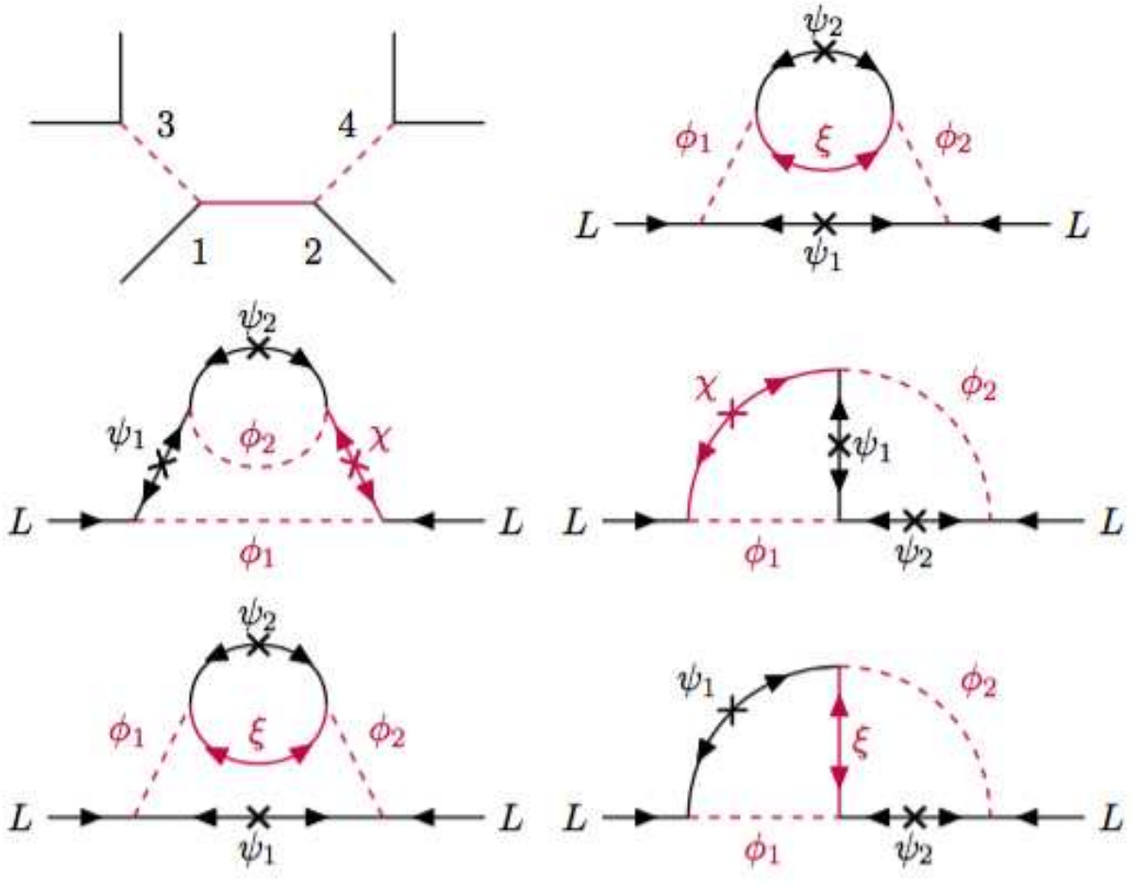


Research interests

John Gargalionis – University of Melbourne
Supervisor: Raymond Volkas

- **Radiative neutrino mass:** design a systematic process for opening up $\Delta L = 2$ effective operators to produce renormalisable models of radiative neutrino mass
  - **Connections:** purported violations of LFU in *B*-meson decays, leptogenesis, dark matter, SUSY, unification, …
- **Machine learning on jets:** train neural network on real, low-level data from the LHC (CMS open data). Current aim: distinguish quark and gluon jets (work with Matthew Dolan)

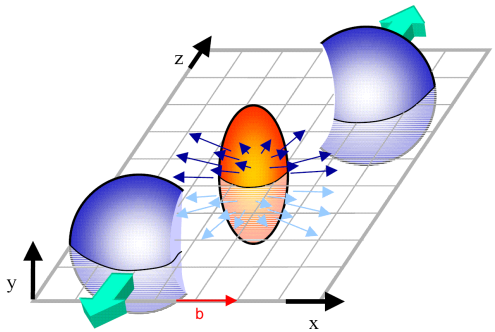




Caspar Hasner

TU Munich

- **Dark Matter**
  - Indirect Detection
  - Weakly Interacting Massive Particles
  - Mass ~ TeV
- **Soft Collinear Effective Theory**



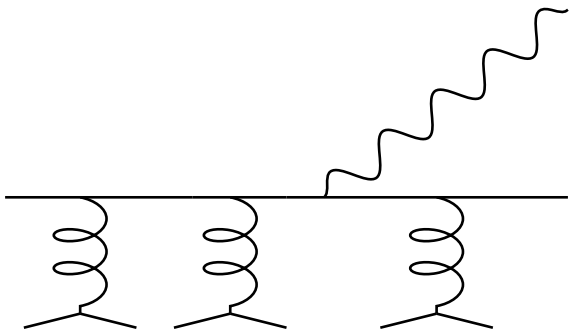
- Quark-gluon plasma (QGP) is produced in heavy-ion collisions.
- Want to extract shear viscosity of the QGP from experimental observables.

$$\frac{\eta}{s} \sim \frac{1}{4\pi}$$

- Might hope to get information about the viscosity of QGP through photons and jets.

My research

- Both photons and jets are subject to the LPM effect at leading order in g_s.



- Need to do the calculation for QGP that's not in thermal equilibrium (Keldysh-Schwinger formalism).

- Some difficulties:
  - Resumming diagrams without using the KMS condition
  - Controlling exponential growth of soft gluon modes in an anisotropic plasma.

Greg Jackson

After June: **Universität Bern, CH**
[Before June: **University of Cape Town, RSA**]

Contact → jackson@itp.unibe.ch

b
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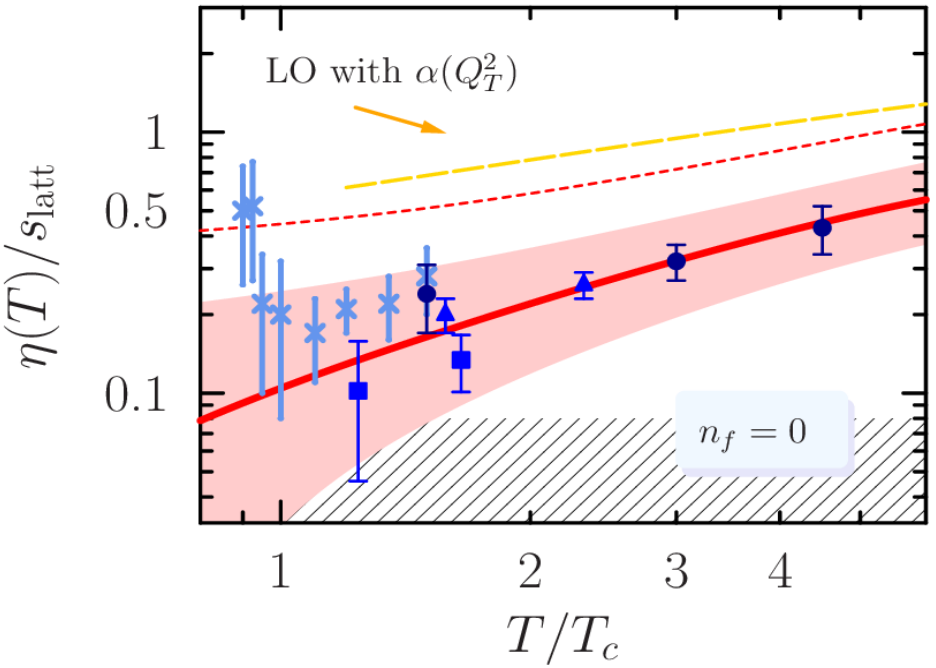
DEPARTMENT OF
PHYSICS
UNIVERSITY OF CAPE TOWN

QCD @ finite-T

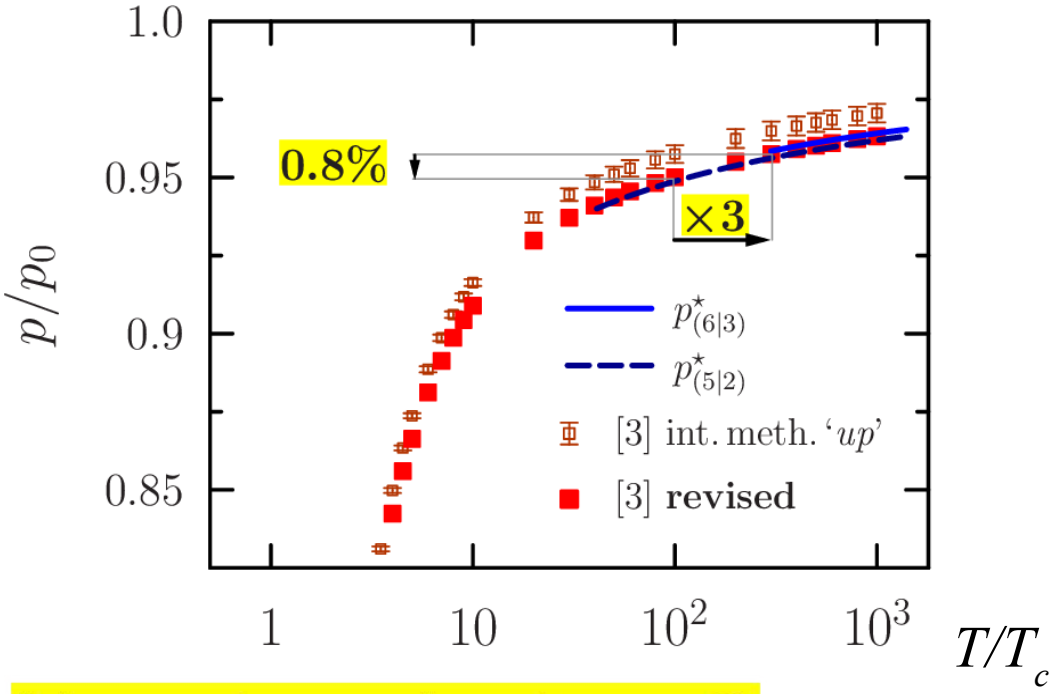


[1704.06284]

Transport coeffs.

[1610.08530]

Equation of State



How strong is strong?