A HIKE

THROUGH THE SWAMPLAND

Miguel Montero
IFT UAM-CSIC

Puzzles in QG Landscape, Perimeter

Oct 23 2023

WARMING UP

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and I will throw some **questions** that hopefully lead to
discussion later on

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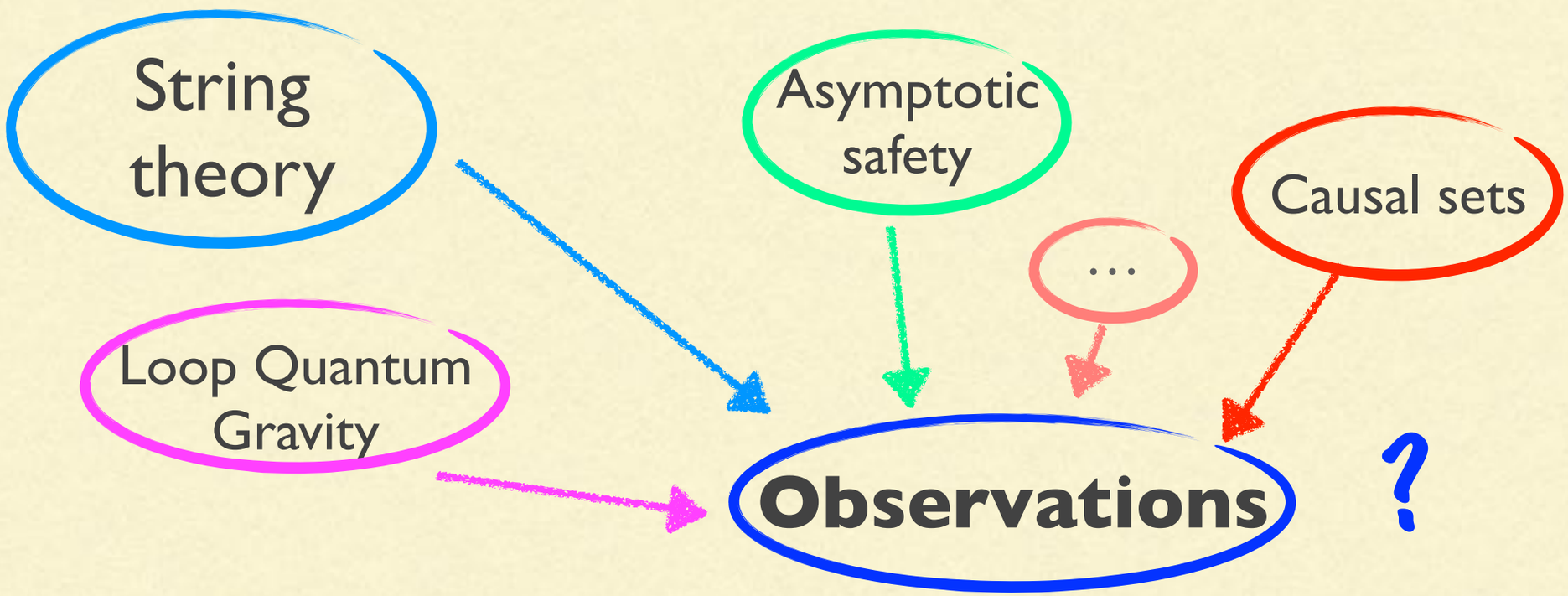

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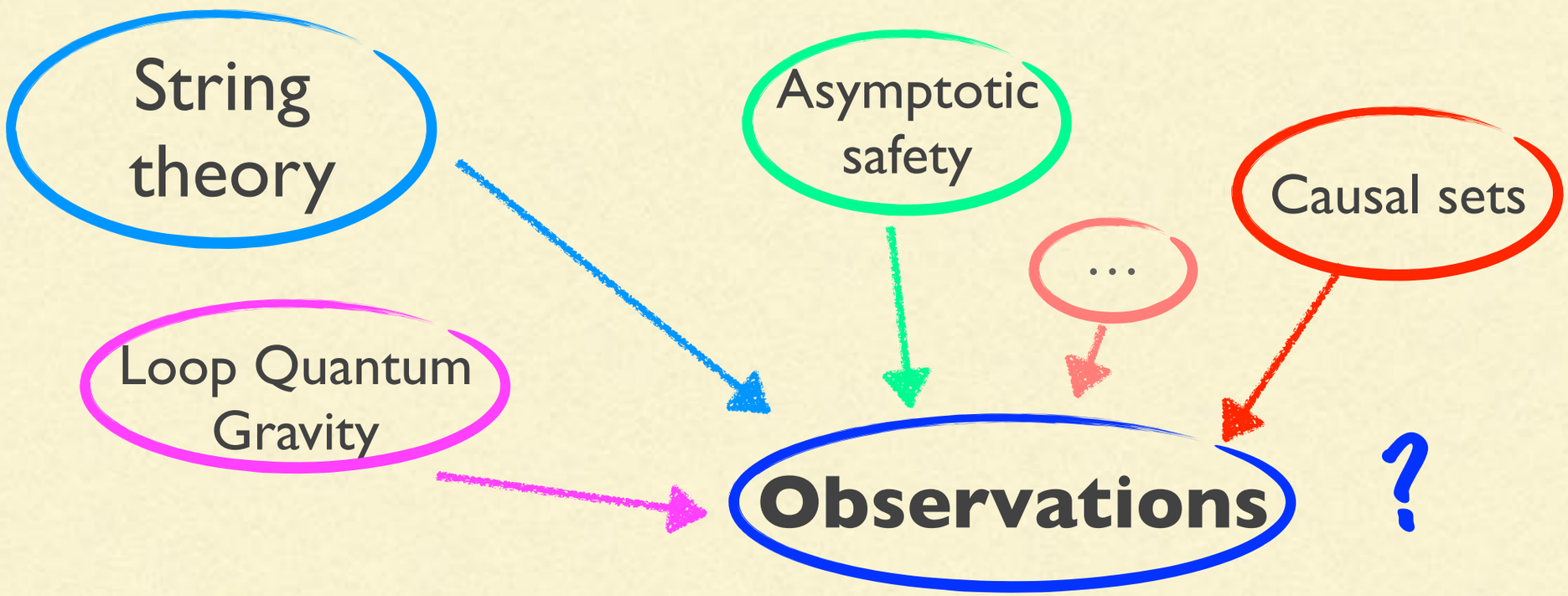

Is it **even possible** to say anything interesting in the deep IR?

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In **quantum** gravity, however, this is not so clear…

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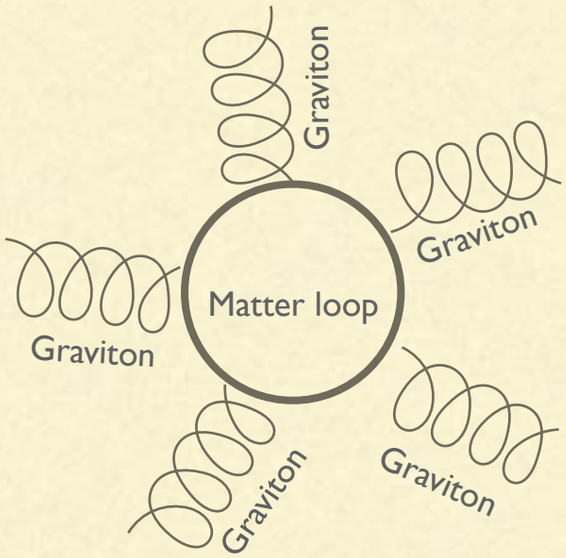

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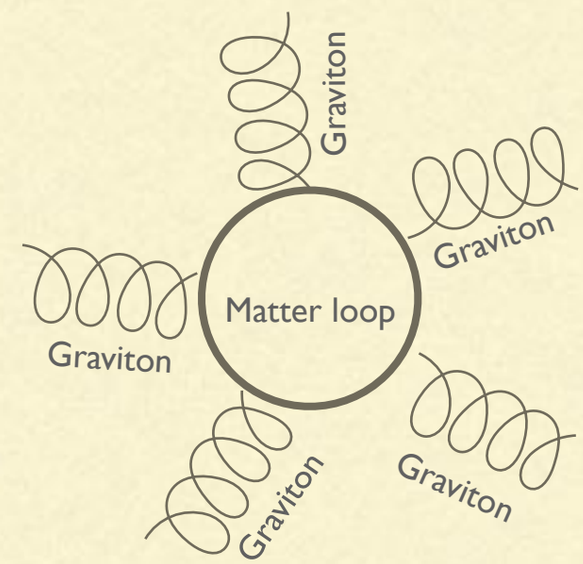
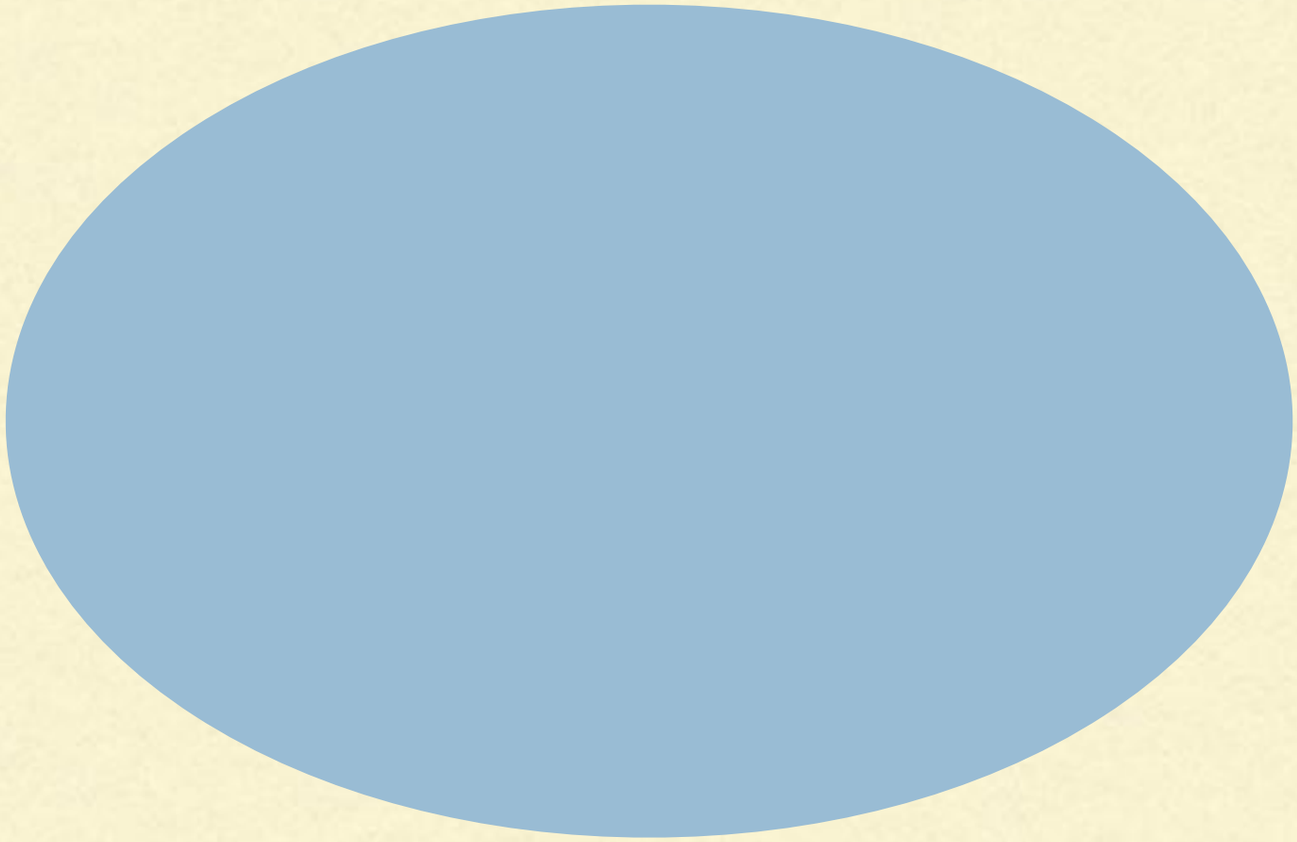


Since everything talks to everything else, there might be $\mathcal{L}_{EFT}$ that can't be coupled to QG at the quantum level

(i.e. they do not arise as the deep IR description of any consistent QG)

Let us draw the abstract space of all EFT's



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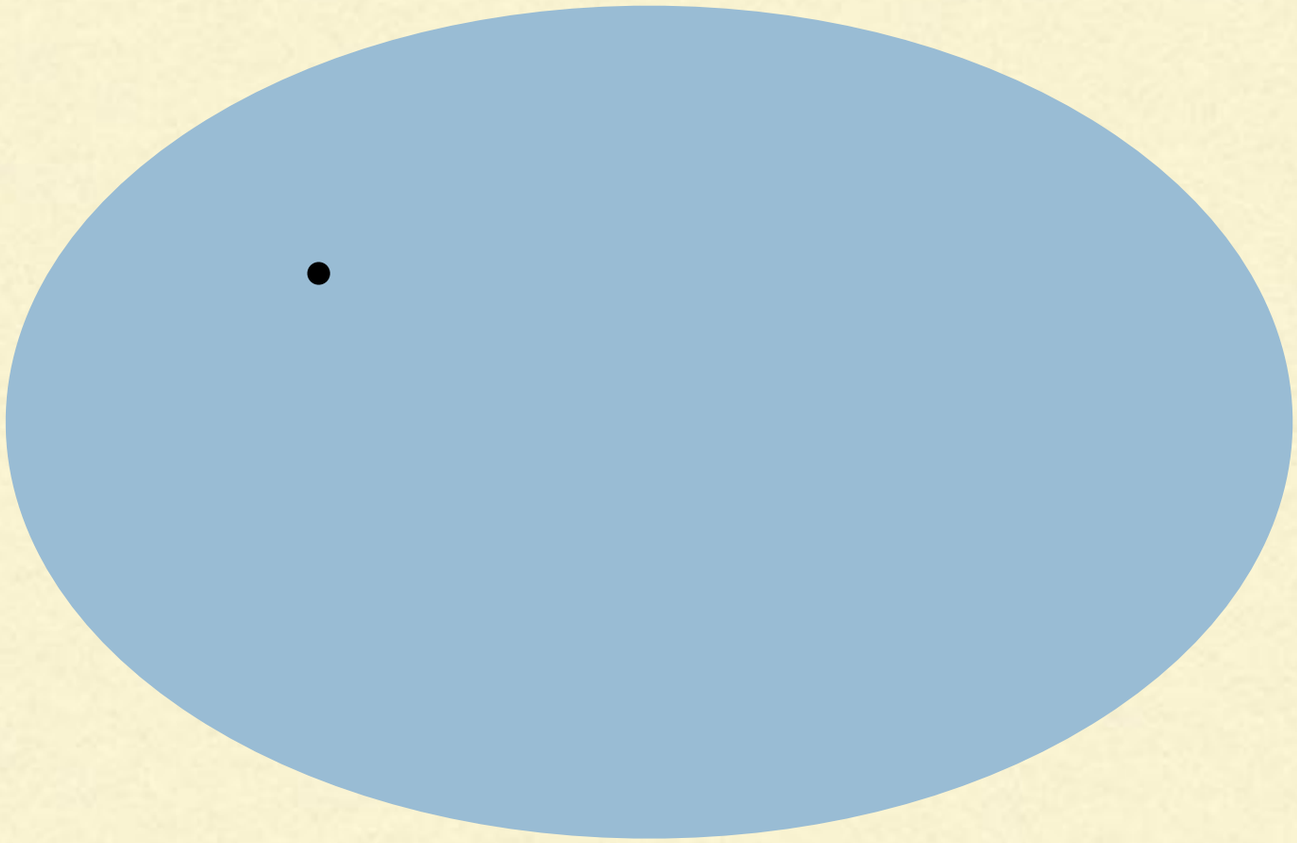

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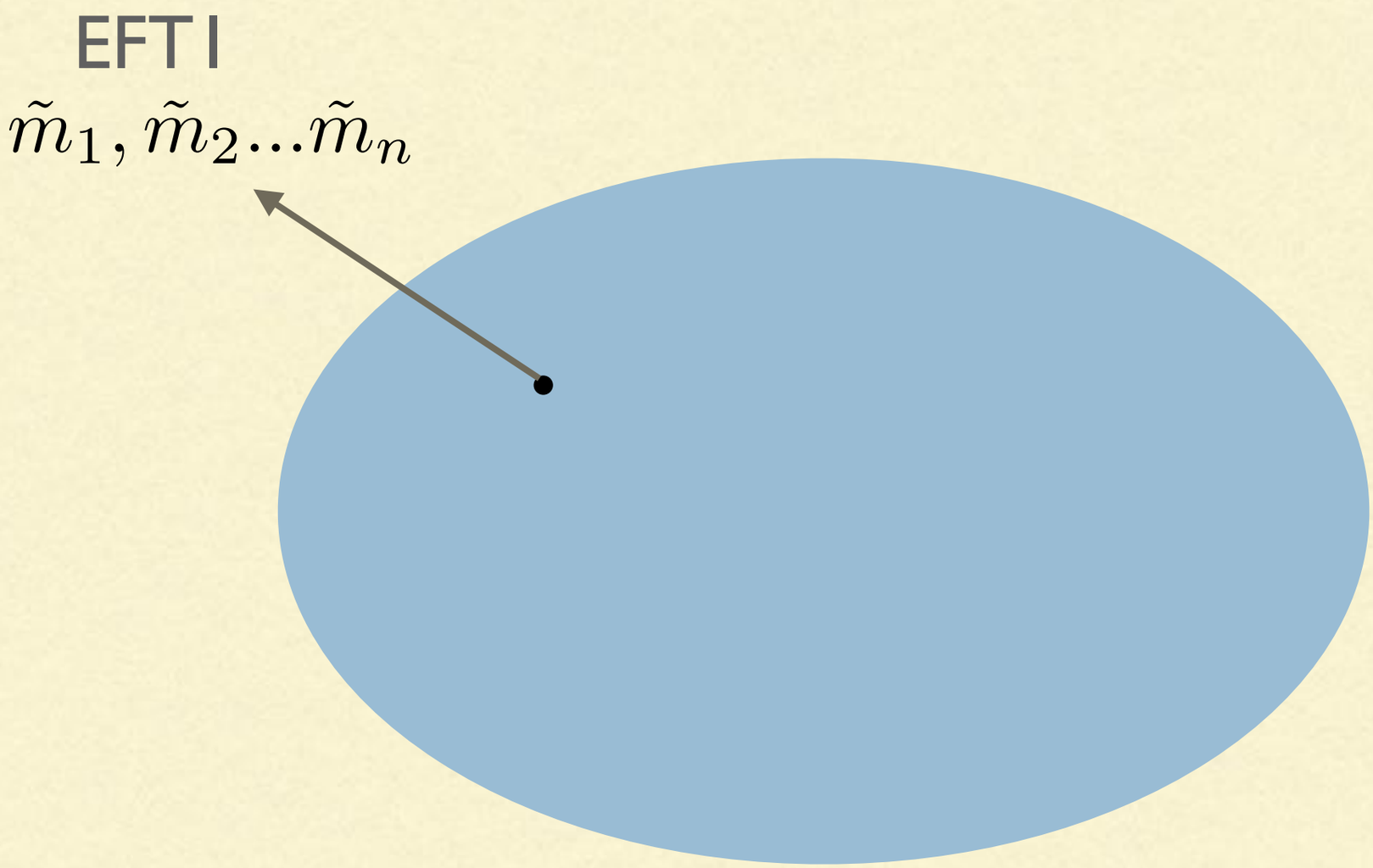

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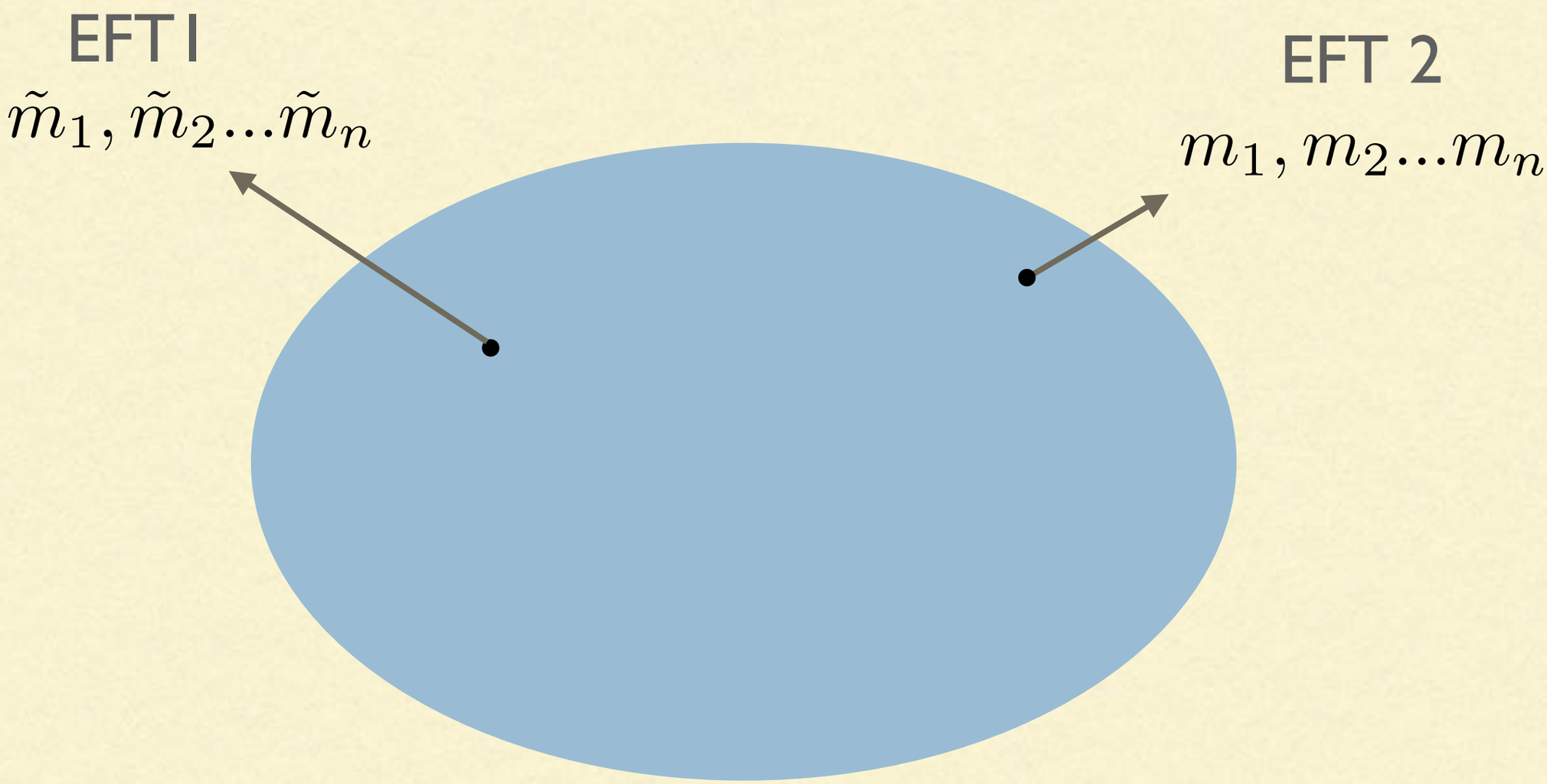

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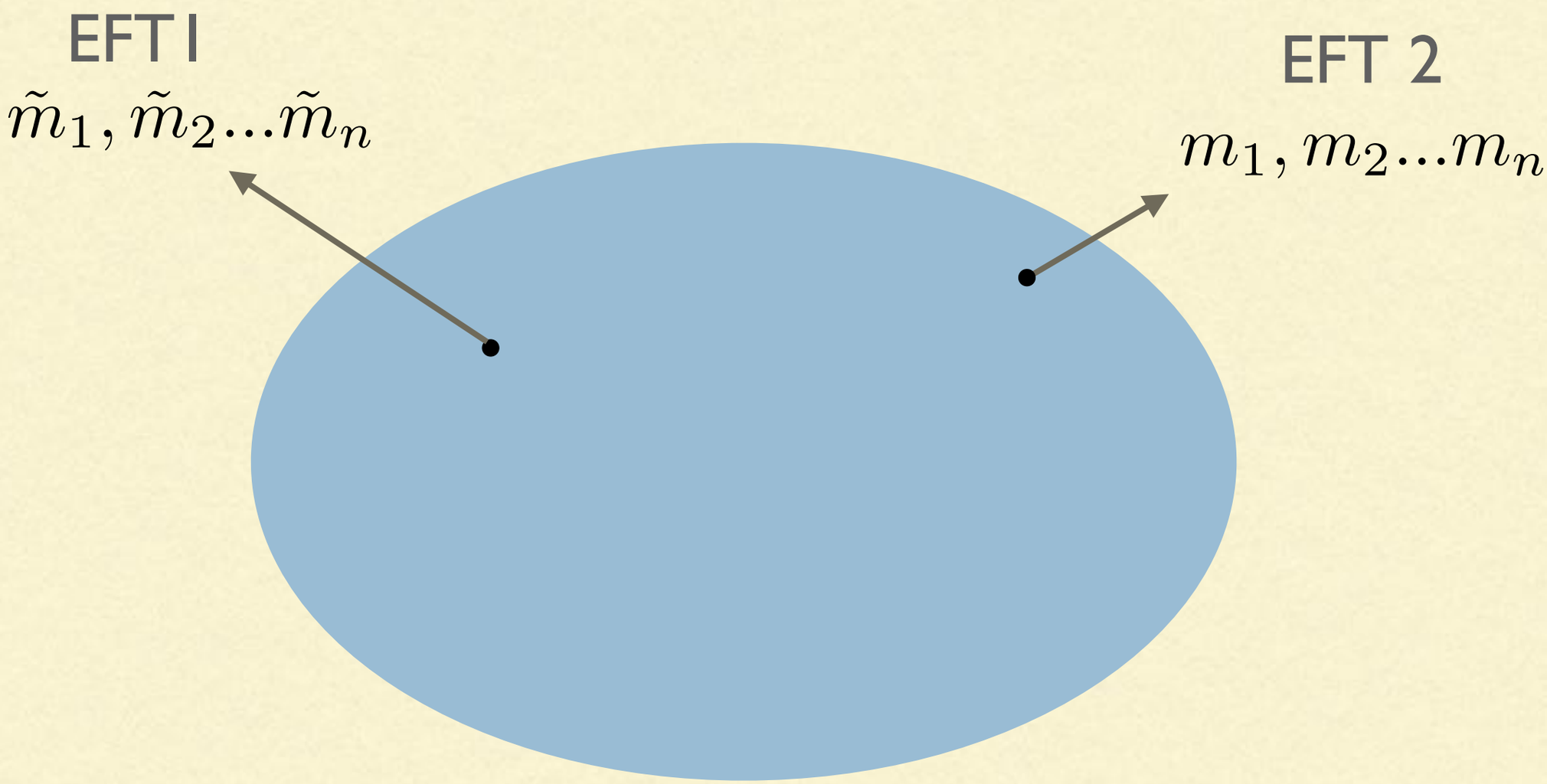

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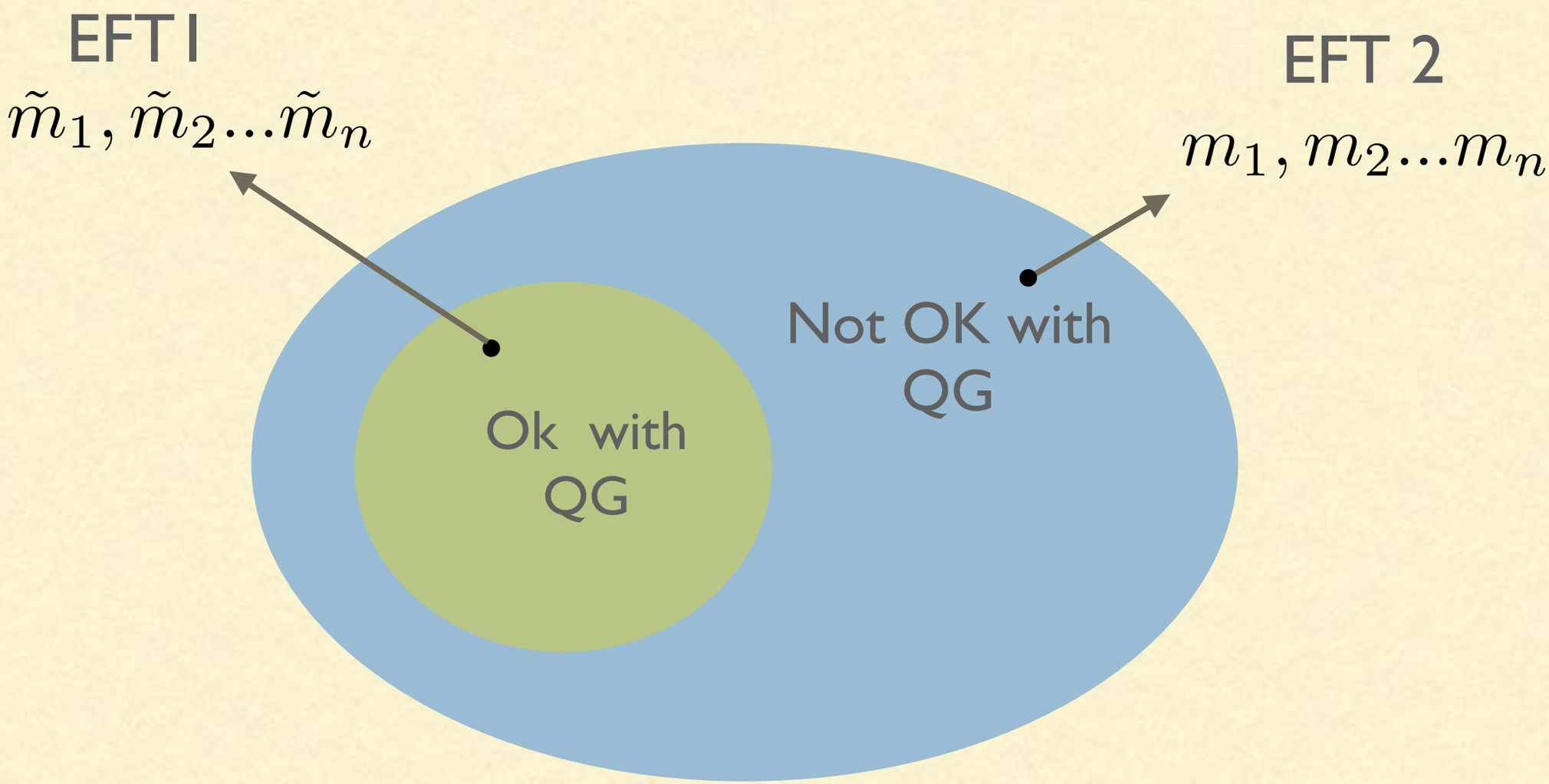

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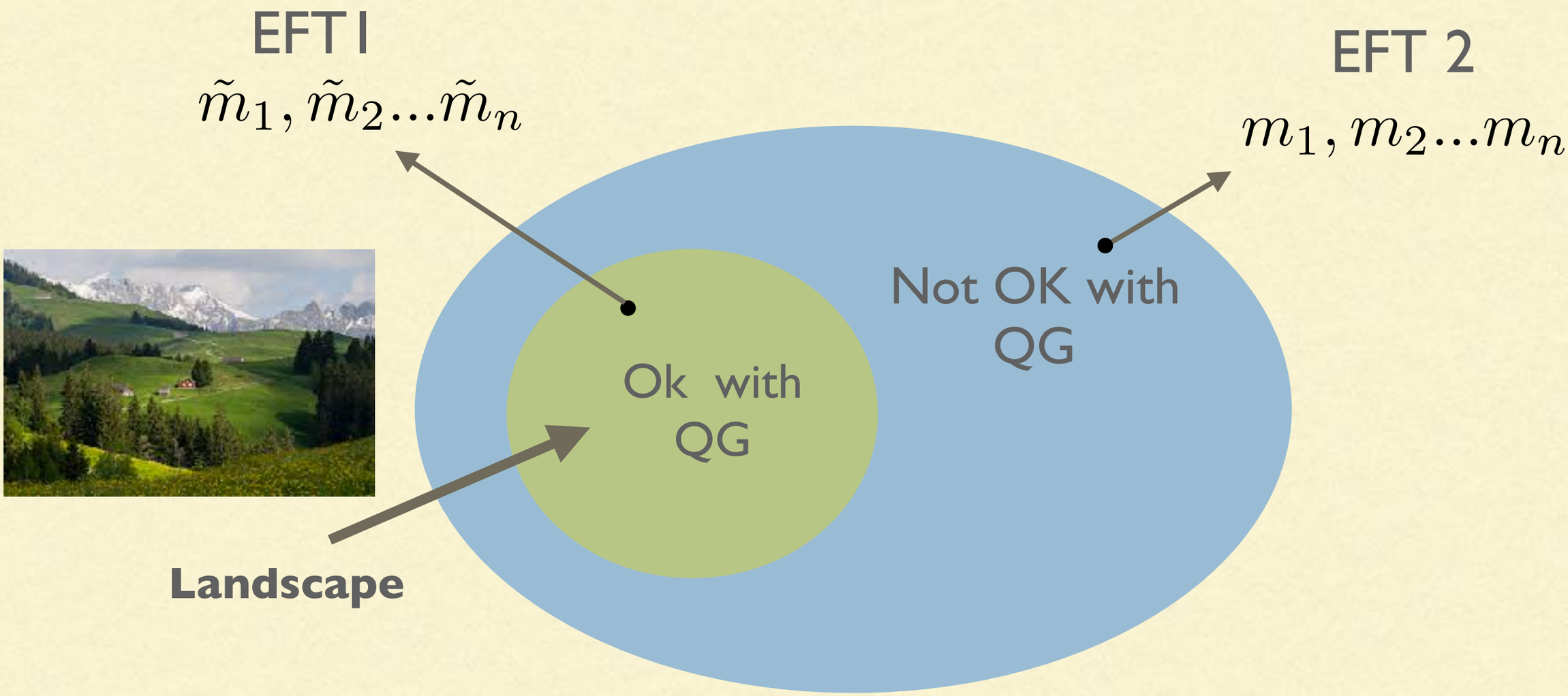

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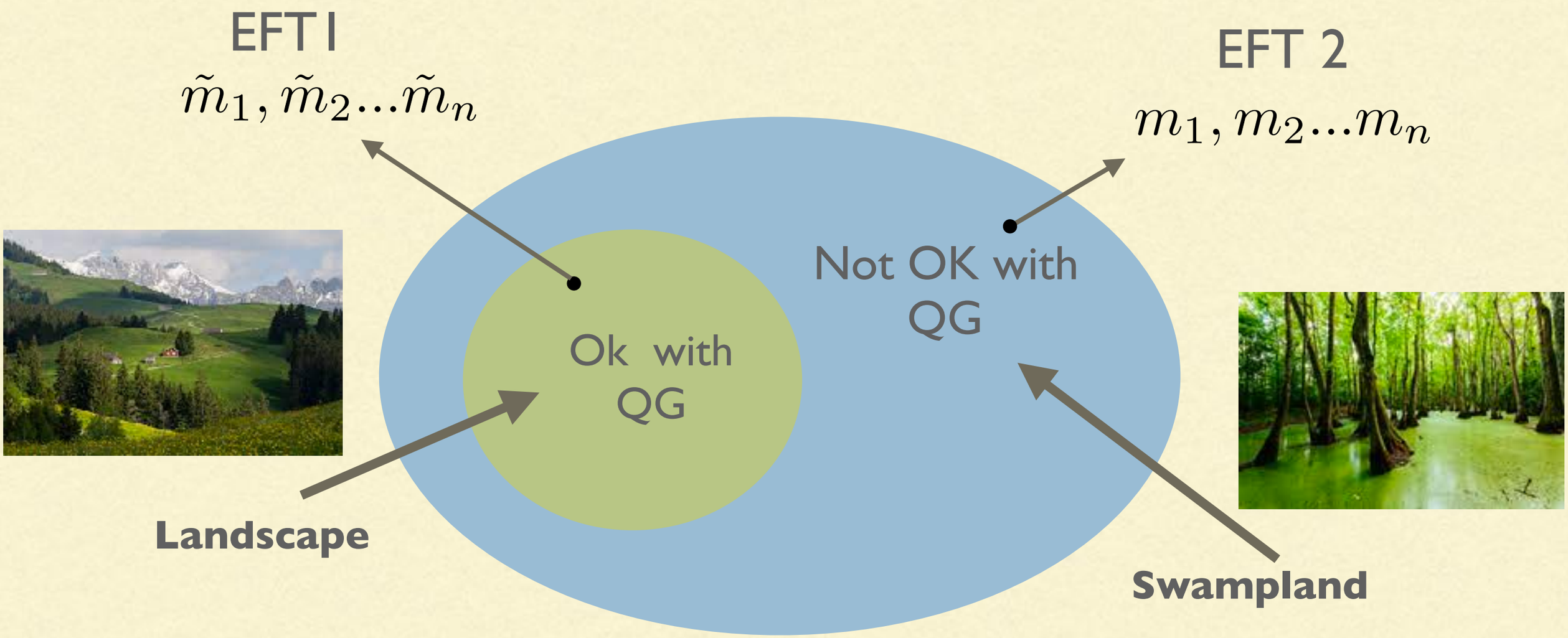

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Data obtained from the biggest theoretical lab there is in QG: **String Theory**

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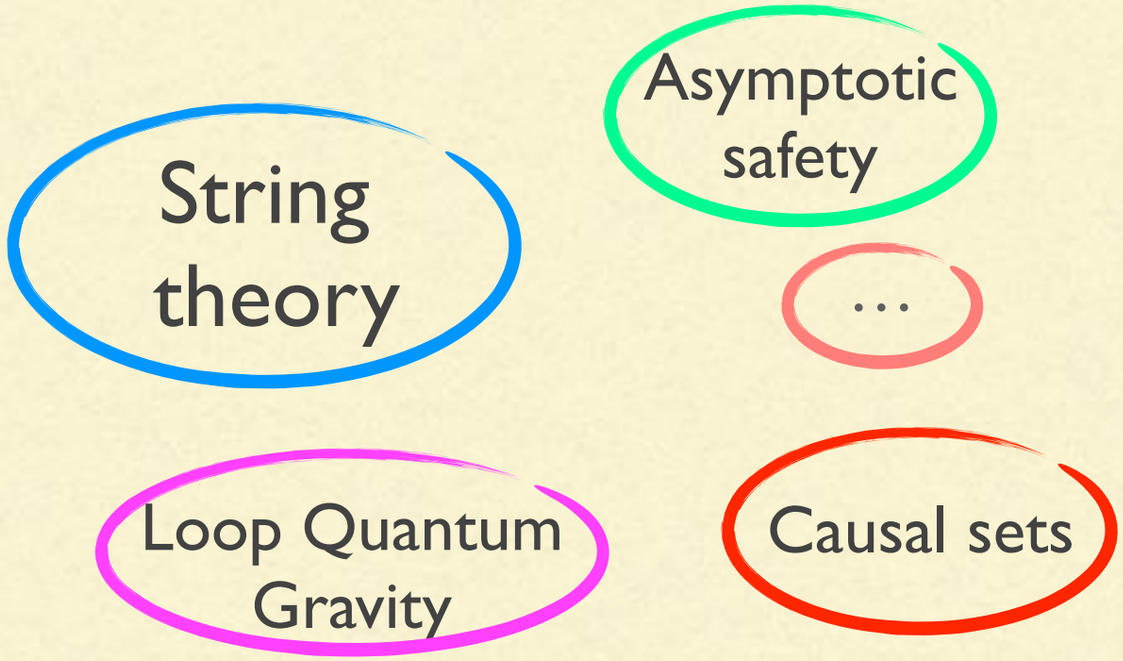

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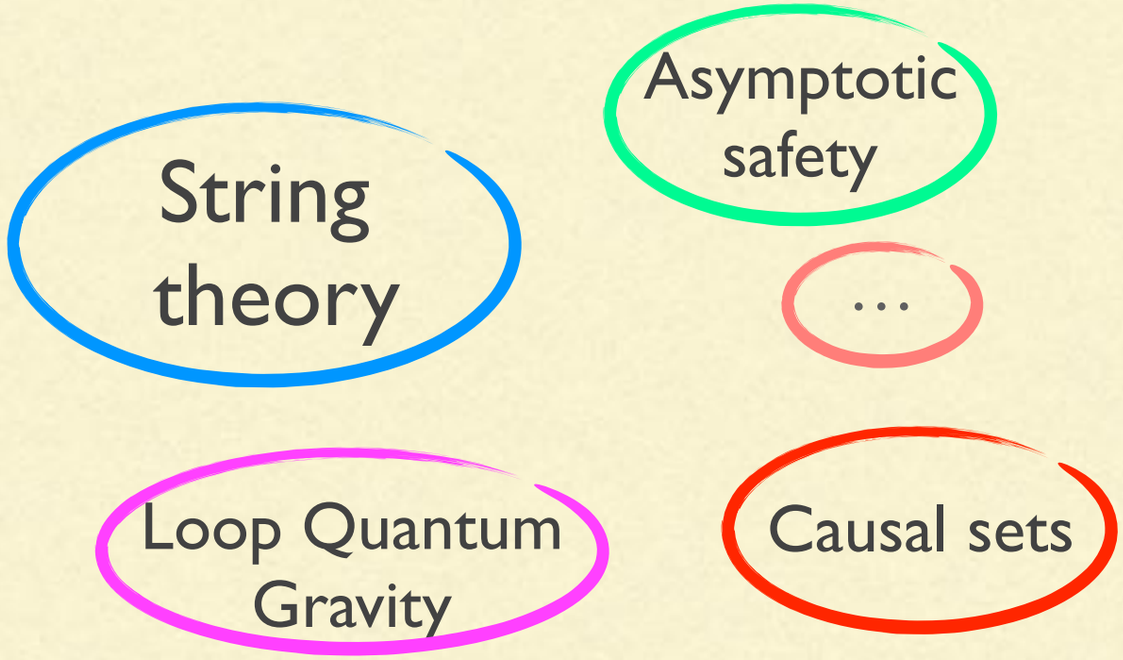

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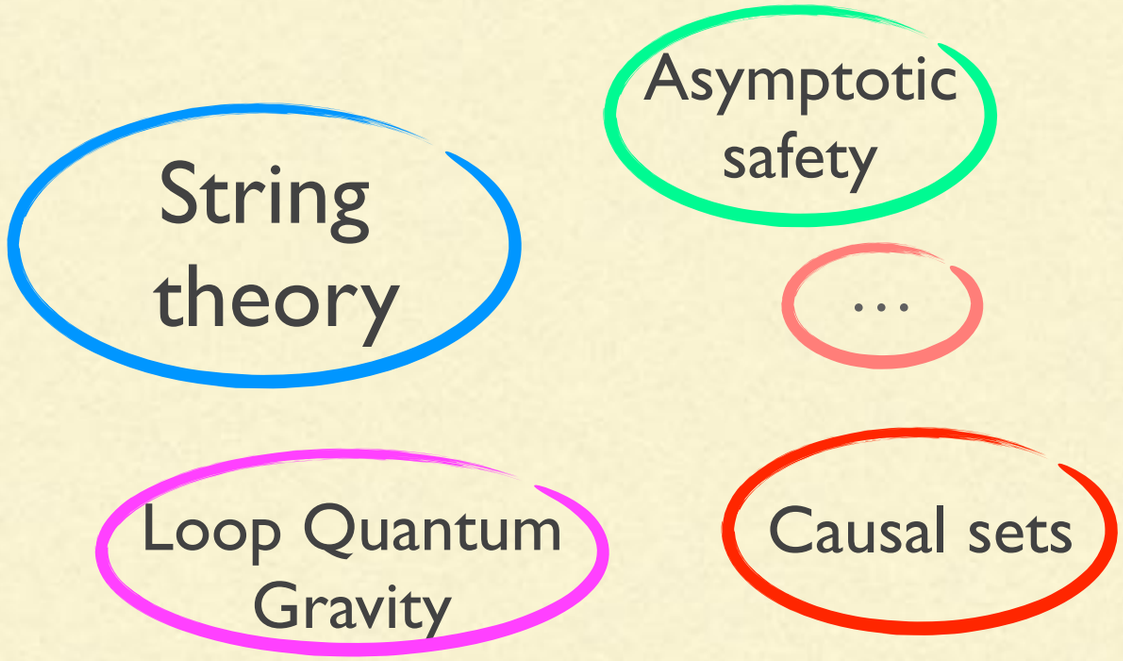

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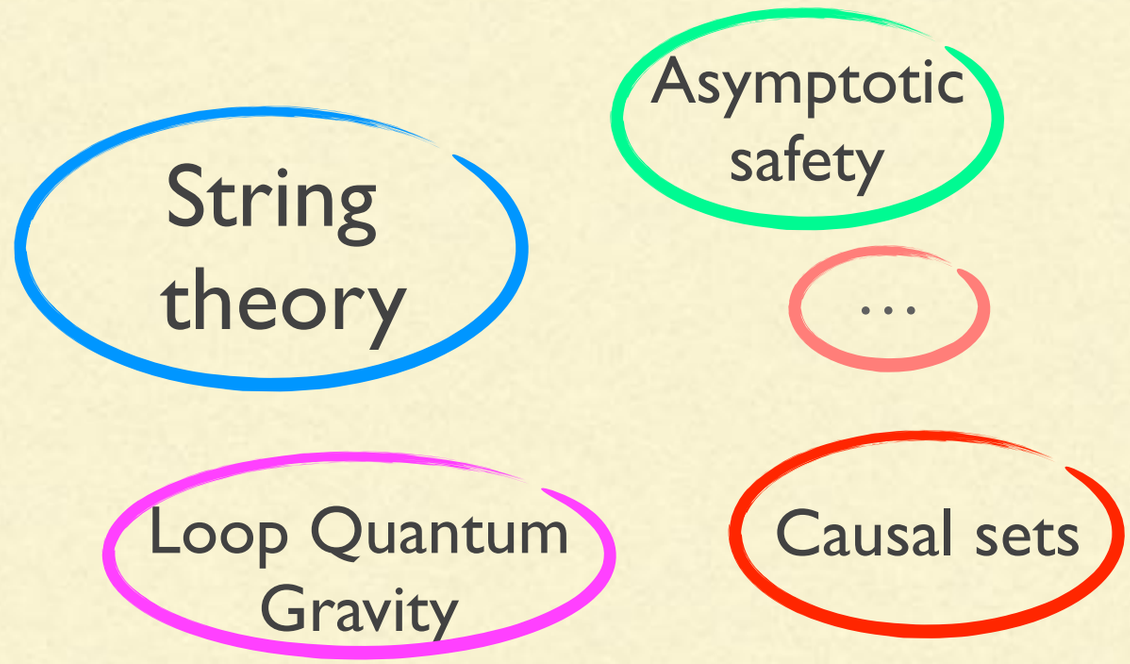

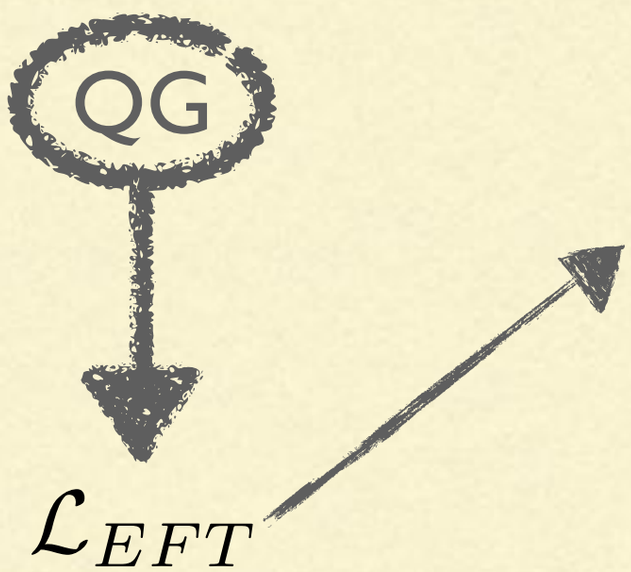

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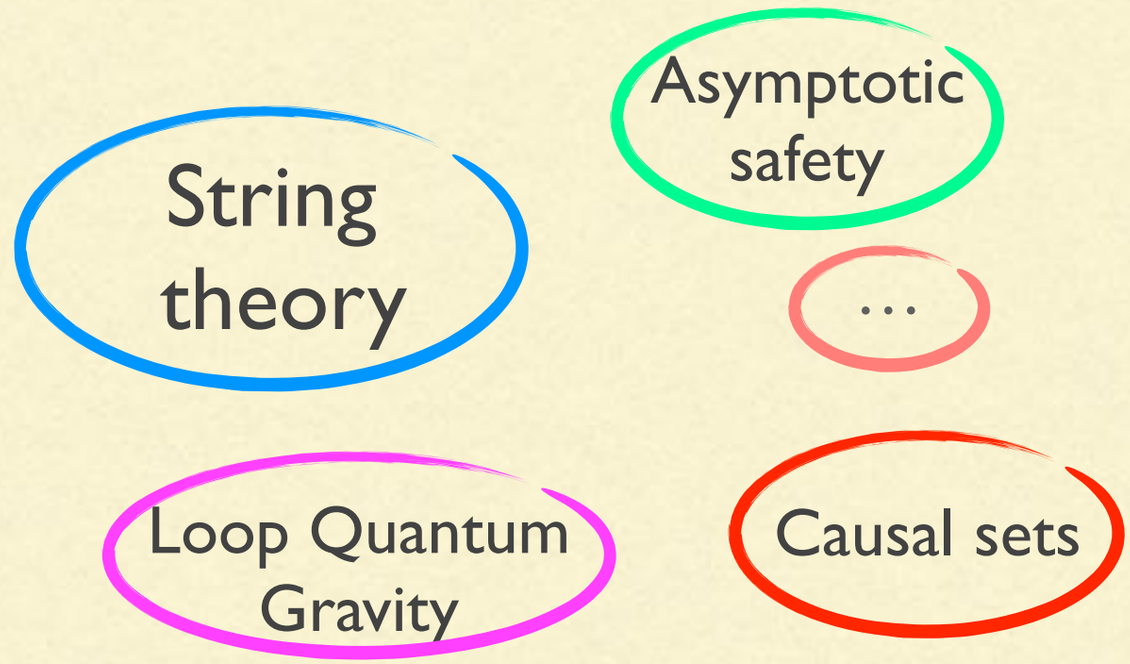

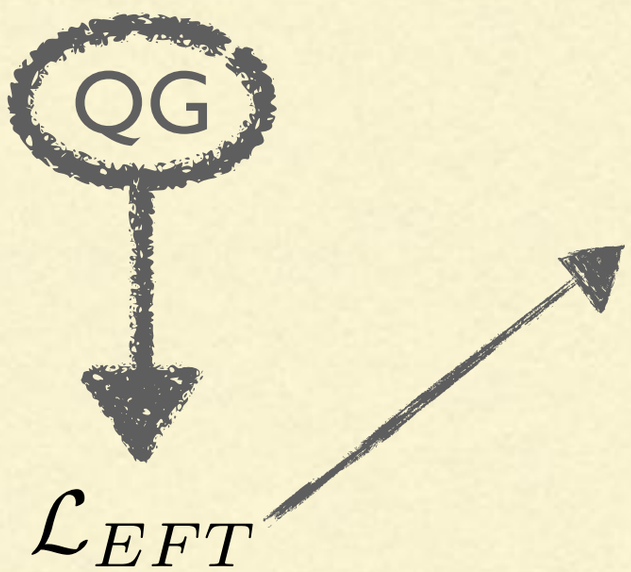

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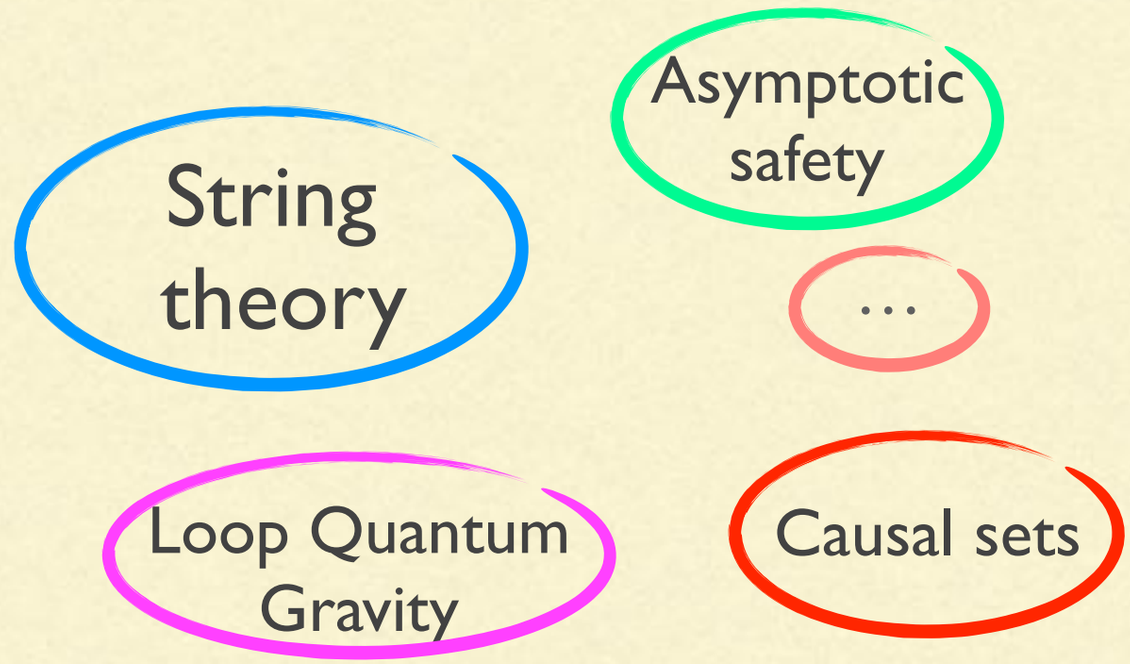

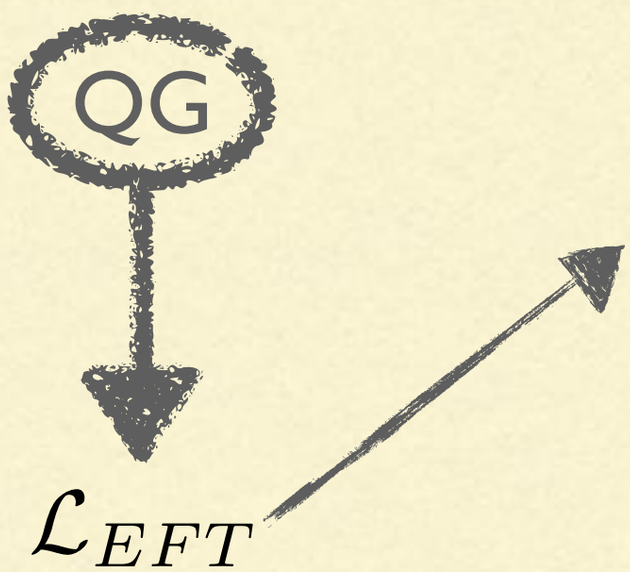

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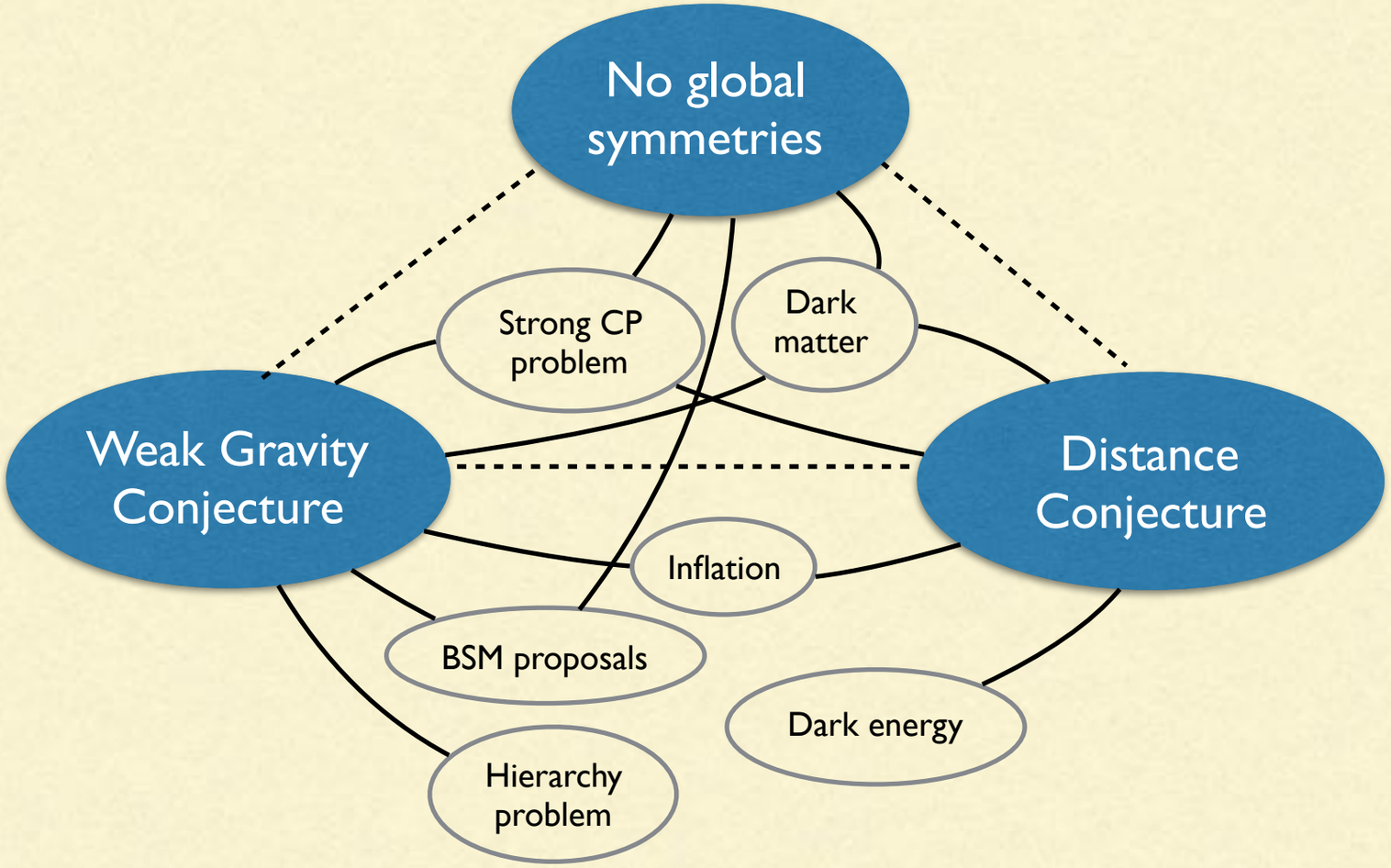

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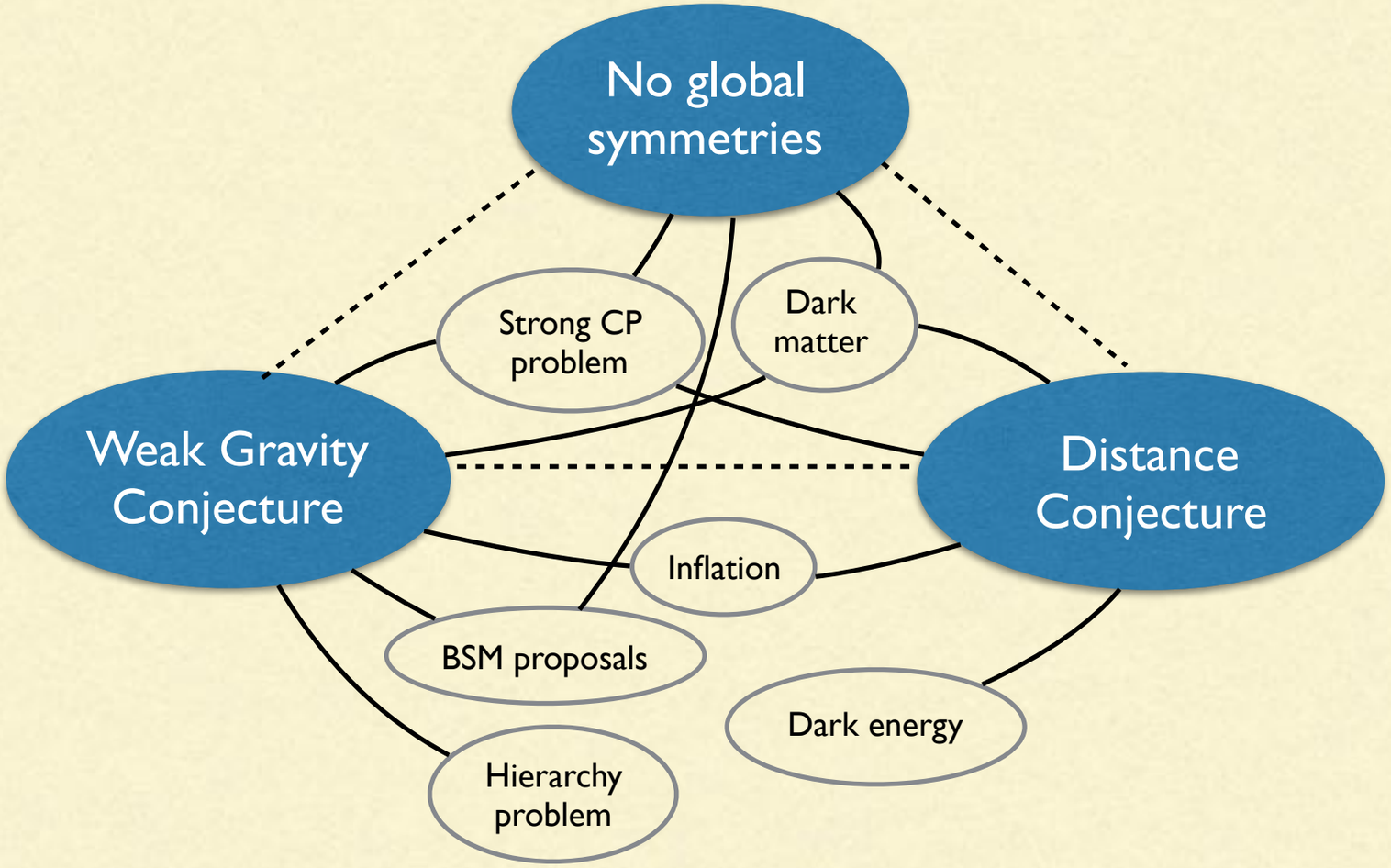

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But applied to generalized symmetries + supersymmetry, it becomes **very strong**

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Working on lower dim, less SUSY!

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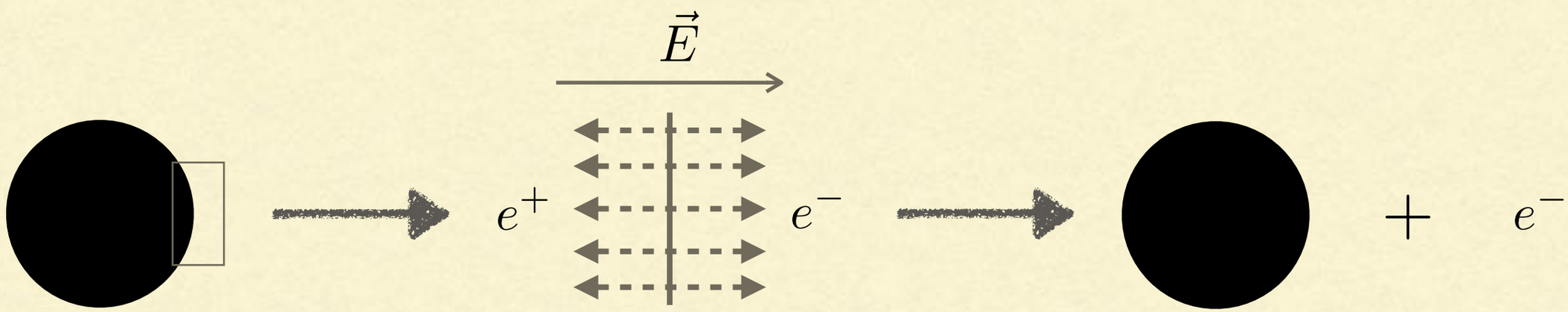
Satisfied in real world by **electrons**, and related to kinematics of black hole evaporation



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[Arkani-Hamed, Motl, Nicolis, Vafa '06, Heidenreich-Reece-Rudelius '16, MM-Shiu-Soler '16]

Proof of some version of the statement in AdS/CFT
[MM '18]

Proof attempts via unitarity/positivity bounds

(though some hurdles, see [Henrisksson, McPeak, Russo, Vissi '22])

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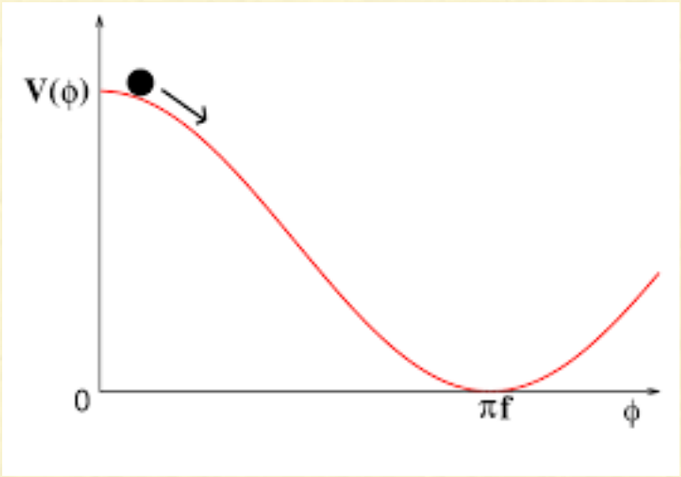
and models of **natural inflation**



$$V(\phi) \sim e^{-\frac{M_P}{f}} \cos(\phi/f)$$

puts upper bound on
cosmological observables

The Distance Conjecture

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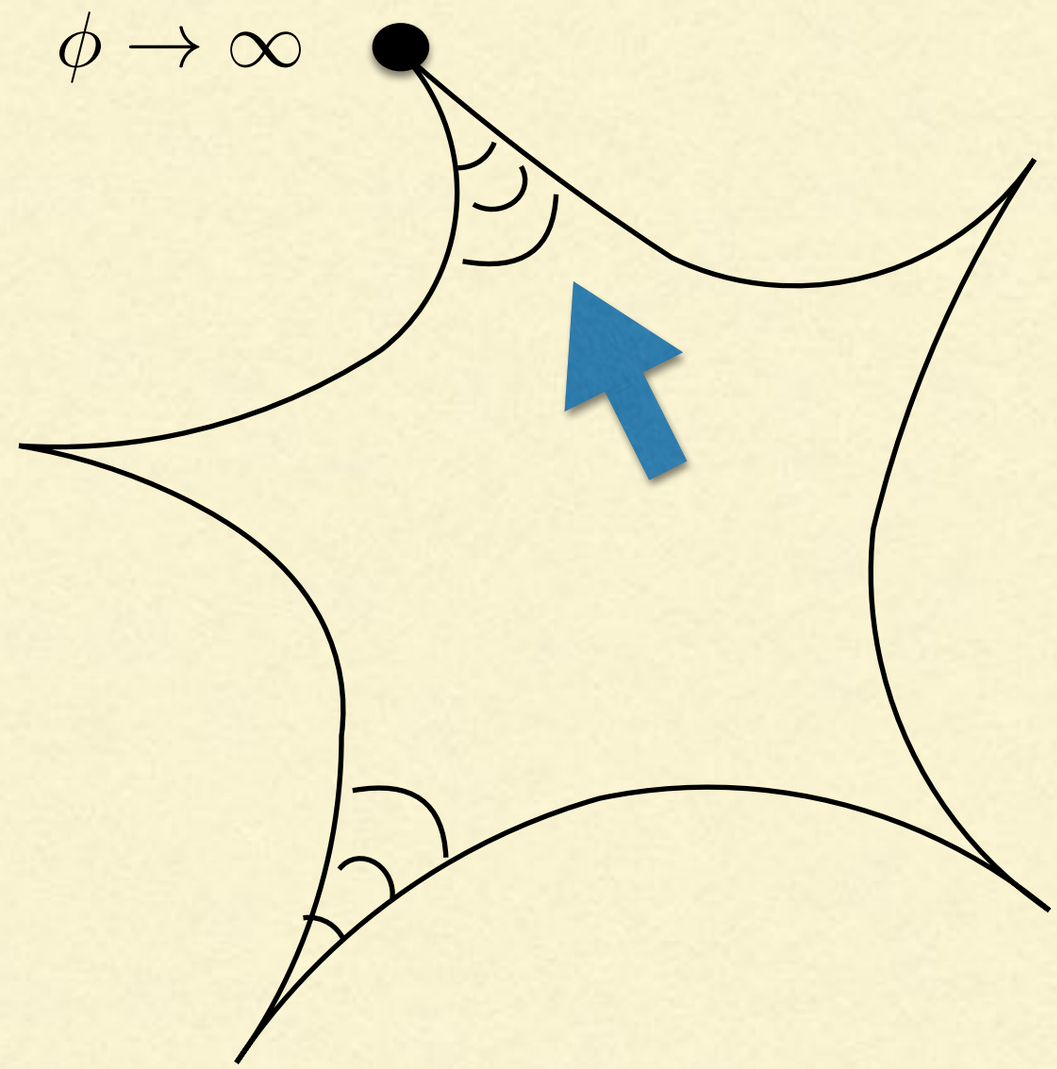

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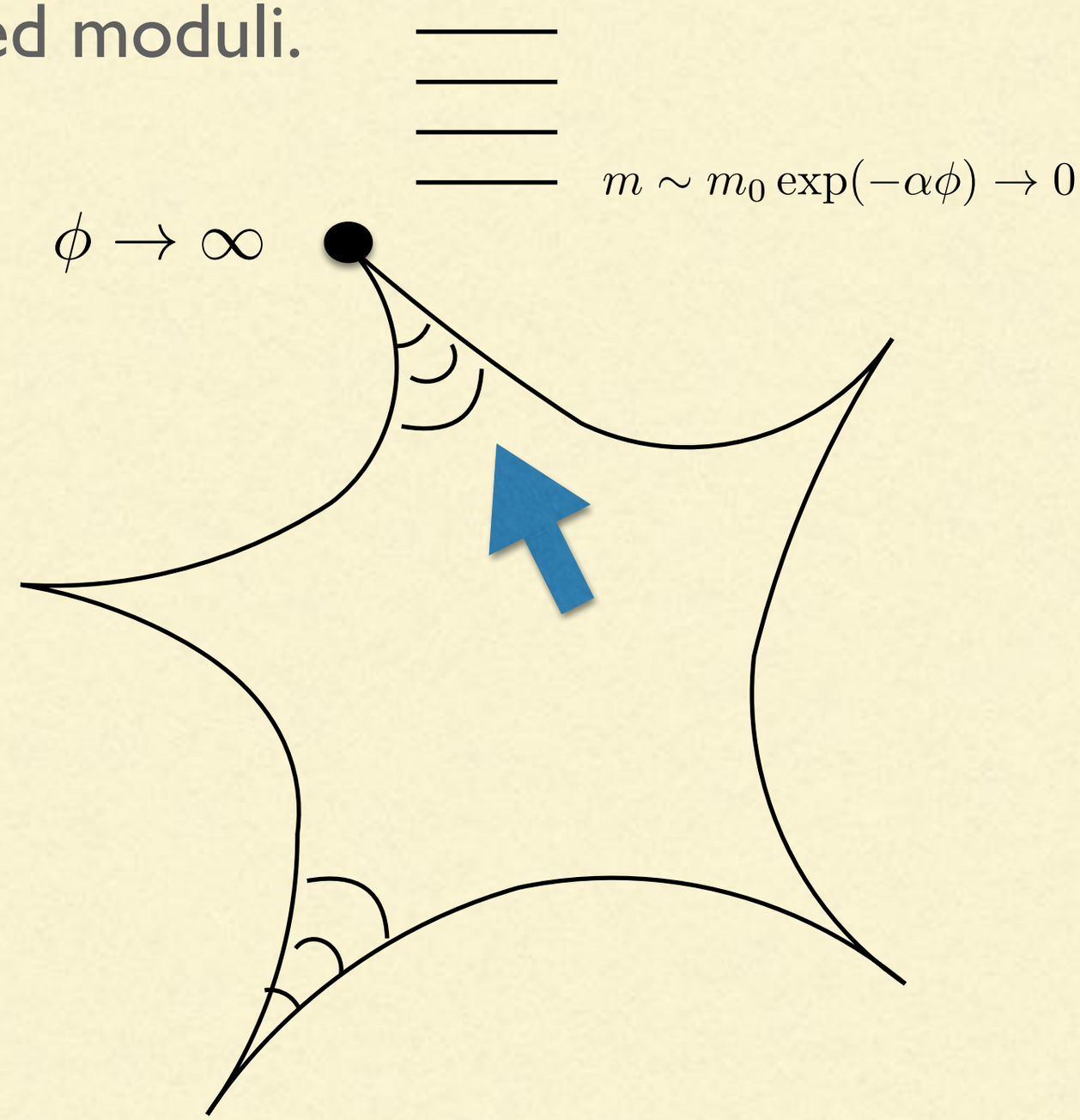

They control the couplings of the theory.

Empirical ST observation: As a scalar gets a very large vev, many states become light with respect to Planck mass and EFT breaks down

Distance Conjecture: These towers of states are **always** there at infinite distance limits

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In every infinite distance limit, some gauge coupling goes to zero.

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In all examples, this tower is either a a **KK tower** or a **fundamental string**

(emergent string conjecture [Lee-Weigand-Lerche '19])

The Distance Conjecture is important for cosmology:

$$m(P) \sim m(Q)e^{-\alpha\Delta\phi} \longrightarrow \Delta\phi \lesssim \frac{1}{\alpha}\log\left(\frac{M_p}{\Lambda}\right)$$

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$$\alpha \geq \frac{1}{\sqrt{6}} \text{ for } \mathrm{CY}_3$$

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And it may be relevant today; a KK tower of states with

$$m_{KK} \sim (5\,\mu m)^{-1}$$

is compatible with observations & suggested by Swampland

[MM, Vafa, Valenzuela '22]

There is much more to the Swampland than the ideas sketched here.

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You can also join our biweekly online seminar series:

https://sites.google.com/view/swamplandseminars

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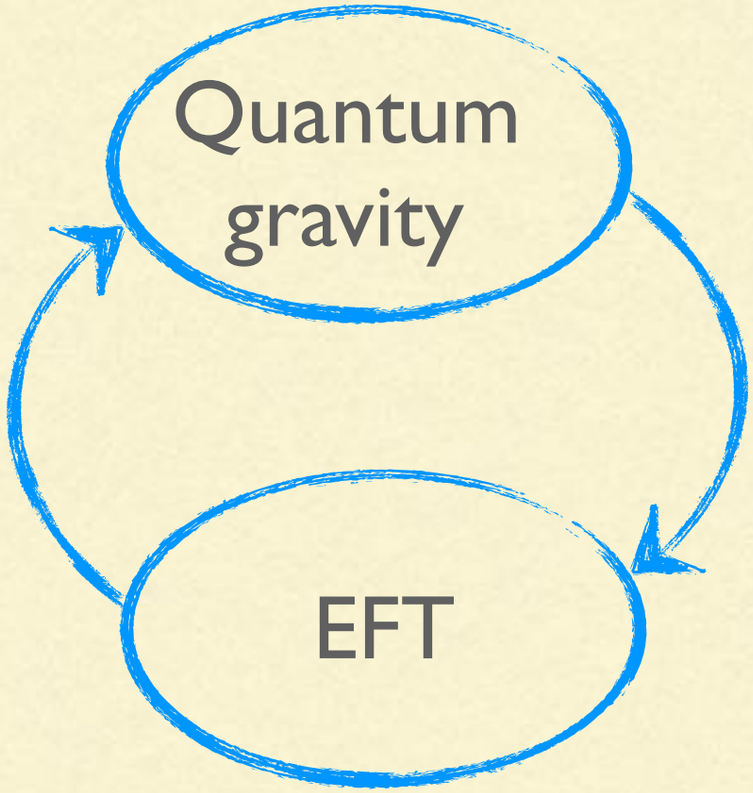
which is why I am excited to find out what we will **discover** together this week!

HOPE YOU ENJOYED THE HIKE!