UK HEP Forum 2023: Completing the Higgs-saw puzzle Setting the scene Rodrigo Alonso urham University

The assignment: "unboxing" and spreading the pieces on the table?





Some pieces are blurry or partially in the dark

Experiments and their challenges LHC, HL-LHC, Future Colliders Gravitational Waves, LISA



We need standard pieces to compare with and make sense of the puzzle

> SM predictions; amplitudes, PDFs, Parton shower BSM guidance, couplings deviations EFT

Are we missing pieces?

Does the Higgs complete a puzzle or leads to another?

The Large Hadron Collider

A great flashlight

Overcame (ing) pile-up, e-cloud, tear&wear



So that what was conceived as a discovery machine





And has painted a 10% precise picture of a massive unstable scalar with linear couplings



Flavour structure Double H production % level couplings...

[Lucchessi talk]



Muon collider

Parts unknown

Cosmology and the EW phase transition



will LISA, BBO, ... shine on electroweak Physics?



Did a phase transition occur?

Is our universe in a metastable state?

What does the world look like outside our neighbourhood?

[Gauld talk] [Rajantie talk] [West talk]

Standard pieces to compare with

In order to interpret results we need a model of the world

The Standard Model is the most economical framework and provides predictions (not fits!)



SM says: EW symmetry is broken by a fundamental scalar

Higgs scalar is evidence for the dynamics of EWSB

Predictions with no free parameters in pple but of a finite precision



Amplitudes with twistors, generalised Polylogarithms, finite field, ... [Jones, Stone, Sreepathi talks]



and a distance away from experiment that we bridge





We need not be Standard in our framework while keeping assumptions to a minimum

Effective Field Theories

Same spectrum, new interactions



Fig. 13: 95% CL individual limits from electroweak measurements.

[Mimasu, Beltran, Thomas, Loisa, Naskar talks]



SMEFT Non-Linear Theory Space = HEFT/SMEFT

HEF

Exploit separation of scales

"Revival" of EFT lead to new TH results

 $\mathcal{A} = \mathcal{A}_{SM} + \mathcal{L}_{EFT} + \mathcal{O}/\underline{E^{\prime\prime}}$

Helicity Amplitudes, Soft theorems, Geometry for Field theory, Operator counting, functional methods...



*

Inflation, strong CP, flavour

What do these other pieces have to do with the Higgs? QFT: any two magnitudes for the same phenomenon 'mix' unless there's a good (symmetry) reason for it

Effective field theory suggests naturalness itself

 $A = A_{QCO} + C_{EFT} \left(\frac{E^2}{\Lambda^2}\right) \qquad m_{H}^2 = O(\Lambda^2) + \cdots$ This are guiding principles that have been proven Unight out in

Lightest in QCD spectrum

Separation of scales and EFT ubiquitous in Physics

SUSY, COMPOSITE, EXTRA-DIMENSIONS

Maybe the Higgs is different from everything else we've seen?

Higgs mass is not fundamental, but theTheory ground shiftoutcome of peculiar dynamicsImage: Comparison of the state of the



Relaxion Dvali, Vilenkin, Graham, Kaplan, Rajendran... Axion, inflation and The multiverse

Tangarife, Tobioka, Ubaldi, Volansky

It could be the EFT picture does not hold beyond the EW scale

EFT not valid in Quantum GR -> Cohen, Kaplan Nelson 19' Abel, Dienes 21'

Not look at QGR sideways Swampland ... Even no news is news

Close the feedback loop working out The new signals of the physics behind EWSB



Leave no stone unturned, 4t, longitudinal boson scattering

Rejoice in the uncertainty!