Contribution ID: **89** Type: **not specified**

Classification of CP-violating operators in SMEFT

Tuesday 6 December 2022 17:30 (20 minutes)

In particle physics, the Standard Model makes extremely accurate predictions, but experimental and observational facts like neutrino oscillation or baryon number asymmetry suggest the existence of physics beyond the Standard Model (BSM). If the BSM exists at energy scales higher than the Standard Model, its effects can be approximately described by the Standard Model Effective Field Theory (SMEFT). However, such effects are small and difficult to observe in general. One effective way to search for BSM is to measure CP symmetry breaking. Since the degree of CP violation in the Standard Model is very small, the contribution from the BSM can be detected without being buried in the Standard Model effects. Furthermore, since the BSM is required to break CP symmetry more strongly than the Standard Model to explain the asymmetry of the baryon number in the current universe, CP violation is expected to provide a clue to the detection of the BSM. Therefore, we need to investigate CP-violating operators in the SMEFT Lagrangian.
In 2015, a method was proposed to systematically list independent SMEFT operators using the Hilbert series technique. Moreover, for theories where parity transformations (P) and charge conjugate transformations (C) can be defined, an extended method was proposed that lists the EFT operators based on P and C symmetries respectively. However, since P and C cannot be defined independently for the Standard Model, it is necessary to consider CP transformation. Therefore, we have developed a method to systematically classify SMEFT operators based on the CP symmetry. In this talk, I will explain how to apply the Hilbert series in this method. In addition, I will introduce that the charge conjugate transformation $\mathcal{C}$ has the nontrivial property as an outer automorphism of $SU(N)$:

$$\mathcal{C}^2 = \begin{cases} +1 \\ (N : \text{odd}) \\ \pm 1 \\ (N : \text{even}) \end{cases} .$$

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Session Classification: BSM physics

Track Classification: Physics beyond the Standard Model