

# CP-violating top-Higgs coupling in gauge theories

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Theoretical particle physics

## Abstract

Phenomenological consequences of CP-violating (CPV) top-Higgs coupling at a future muon collider process, a top pair associated production with Higgs particle and missing neutrinos has been studied. We found sharp increase of the production rate with energy and identified its origin as the gauge non-invariance of the traditional CPV interactions. We proposed a gauge invariant SMEFT framework for the study and obtained consistent theoretical predictions. In addition, novel unitarity bound on the coefficient of SMEFT operator is obtained by studying the 2 to 2 and 2 to 3 cross sections in the  $J=0$  channel.

## Research background:

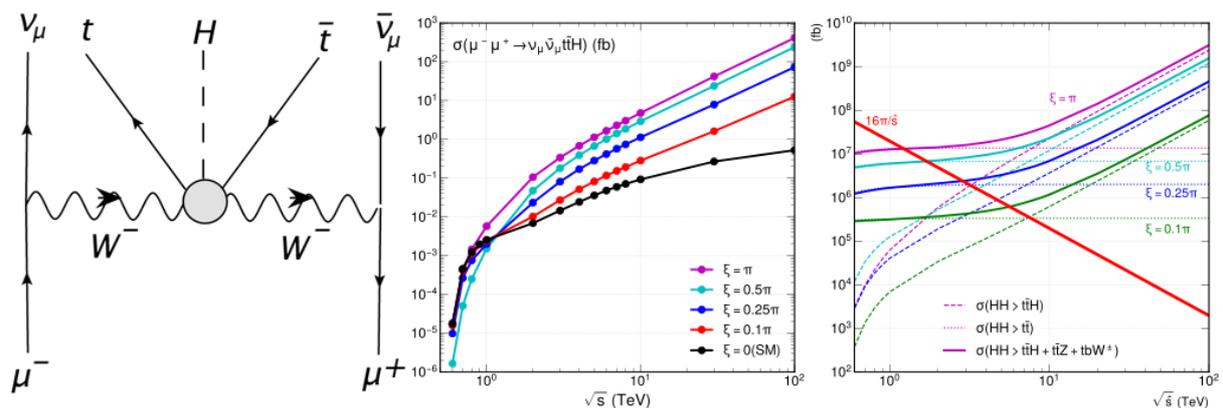
The particle physics standard model (SM) as an effective field theory (EFT) has been successful in interpreting all high energy experimental data, but the matter-antimatter asymmetry of our universe tells that there should be new CP-violating (CPV) interactions. One promising possibility is the CPV top-Higgs coupling, which is the strongest coupling of the Higgs particle. Phenomenological consequences of CPV top-Higgs couplings has been studied at various hadron collider and electron-positron collider processes. A future muon circular collider is supposed to reach very high center-of-mass energies beyond 10 TeV and provides a new realm for the CPV study.

## Research contents:

We study consequences of the CPV top-Higgs interactions through a muon collider process: a top pair associated production with Higgs particle and missing neutrinos.

## Research achievements:

Abnormal growth of the cross section at high energies is found when the CPV phase is nonzero and its cause is identified as a violation of gauge invariance in the sub-amplitudes of the left figure. We propose a gauge invariant description in the SMEFT framework, and obtain the first consistent predictions of the middle figure. Since rising cross section with energies leads to unitarity violation, we obtain the upper bound on the coefficient of the SMEFT operator by using a novel method of calculating all 2 to 2 and 2 to 3 cross sections, as shown in the right figure.



### Future plan:

I would like to explore the possibility of observing new CP violation phenomena in the top-Higgs interactions at all present and future collides and uncover the origin of the matter-antimatter asymmetry of our universe.

### Published paper:

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### Scientific Terms

- **CPV:** Violation of the CP symmetry, or the symmetry between matter and antimatter, is a necessary condition to explain the observed matter dominated universe.
- **SMEFT:** Effective Field Theory (EFT) which respects the gauge symmetries of the Standard Model (SM) of particle physics
- **Gauge invariance:** Invariance under the gauge symmetries allows the SM to have predictions, which should be confronted against experimental data.
- **Unitarity:** Conservation of probability is an essential principle of all physical theories, which is expressed as the unitarity of scattering amplitudes in the quantum field theory.

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