

## CED : « Engineering Sciences and Techniques »

# THESIS DEFENSE

## «HAMZA ABOUABID»

CANDIDATE FOR DOCTOR IN ENGINEERING SCIENCES AND  
TECHNIQUES

« Contribution to the Study of the Radiative Corrections  
in the Inert Higgs Doublet Model »

<b>Date :</b>	<b>Saturday 17 june 2023</b>
<b>Time :</b>	<b>11 am</b>
<b>Location :</b>	<b>Amphitheater 5, Mathematics Department, FST - Tangier</b>

### Committe Members

Pr. Mustapha DIANI	FST - Tangier	Chair
Pr. Mohamed CHABAB	FS - Marrakech	Reviewer
Pr. Driss BENCHEKROUN	FS - Casablanca	Reviewer
Pr. Yassine HASSOUNI	FS - Rabat	Reviewer
Pr. Farida FASSI	FS - Rabat	Examiner
Pr. Thomas HAHN	MPI - Germany	Examiner
Pr. Abdesslam ARHRIB	FST - Tangier	Thesis Director



## ABSTRACT

With the discovery of a spin-0 scalar particle, identified as the long-sought Higgs boson, by the ATLAS and CMS experiments at the Large Hadron Collider (LHC), the Standard Model (SM) was completed, providing a coherent description of the fundamental particles and forces, including electroweak interactions. However, despite its numerous successes, the SM still leaves many questions unanswered, such as the origin of neutrino masses, the hierarchy problem related to the Higgs boson mass, and the nature of dark matter and dark energy, among others. These unresolved issues suggest that the SM may serve as an effective theory, which describes fundamental processes governing the universe up to a certain energy scale, but falls short in providing a complete explanation for all phenomena.

To address these challenges, researchers are exploring new theoretical frameworks that go beyond the scope of the Standard Model, such as extending the Higgs sector by considering models like the Inert Higgs Doublet Model (IHDM) and the Two-Higgs Doublet Model (2HDM). These models introduce additional Higgs bosons or doublets, potentially providing explanations for some of the phenomena that the Standard Model cannot account for, and offering a promising avenue for further research and experimental investigation.

We start this thesis by providing a thorough introduction to the Standard Model, discussing its limitations and the motivation behind exploring extended Higgs sectors. Subsequently, we explain various renormalization techniques, including momentum cut-off regularization, Pauli-Villars regularization, and dimensional regularization. We then employ the on-shell renormalization scheme throughout our analysis.

Within the framework of IHDM, we investigate the one-loop radiative corrections to processes such as  $e^+e^- \rightarrow Zh^0$ ,  $H^0A^0$  and charged scalar pair production  $e^+e^- \rightarrow H^+H^-$ . Using advanced computational methods, we calculate the one-loop virtual corrections and real emission, while considering the parameter space of IHDM in light of theoretical constraints, collider experimental bounds, and dark matter search limits.

Our results show that the radiative corrections in IHDM can be sizable and detectable by futur



electron-positron colliders, such as the CEPC/CLIC/FCC-ee/ILC and LHC. Additionally, we propose benchmark points that could serve as physics targets for these colliders. Moreover, we explore the implications of the recent CDF measurement of the  $W$  boson mass in 2HDM. We demonstrate that the 2HDM parameter space can accommodate a significant correction, aligning the predicted  $W$  mass with the new CDF  $M^W$  measurement. We also discuss the phenomenological implications of the charged Higgs and CP-odd Higgs boson decays in 2HDM type-I and type-X.

The thesis features detailed appendices covering Passarino-Veltman Functions, Feynman Rules in IHDM, charge and wave function renormalization, and treatment of divergences in calculations. Our work contributes to a deeper understanding of these extended Higgs sectors and their potential role in addressing some of the limitations of Standard Model.