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Title: Theory and phenomenology of two-Higgs-doublet models

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Abstract: We discuss theoretical and phenomenological aspects of two-Higgs-doublet extensions of the Standard Model. In general, these extensions have scalar mediated flavour changing neutral currents which are strongly constrained by experiment. Various strategies are discussed to control these flavour changing scalar currents and their phenomenological consequences are analysed. In particular, scenarios with natural flavour conservation are investigated, including the so-called type I and type II models as well as lepton-specific and inert models. Type III models are then discussed, where scalar flavour changing neutral currents are present at tree level, but are suppressed by either a specific ansatz for the Yukawa couplings or by the introduction of family symmetries leading to a natural suppression mechanism. We also consider the phenomenology of charged scalars in these models. Next we turn to the role of symmetries in the scalar sector. We discuss the six symmetry-constrained scalar potentials and their extension into the fermion sector. The vacuum structure of the scalar potential is analysed, including a study of the vacuum stability conditions on the potential and the renormalization-group improvement of these conditions is also presented. The stability of the tree level minimum of the scalar potential in connection with electric charge conservation and its behaviour under CP is analysed. The question of CP violation is addressed in detail, including the cases of explicit CP violation and spontaneous CP violation. We present a detailed study of weak basis invariants which are odd under CP. These invariants allow for the possibility of studying the CP properties of any two-Higgs-doublet model in an arbitrary Higgs basis. A careful study of spontaneous CP violation is presented, including an analysis of the conditions which have to be satisfied in order for a vacuum to violate CP. We present minimal models of CP violation where the vacuum phase is sufficient to generate a complex CKM matrix, which is at present a requirement for any realistic model of spontaneous CP violation. (C) 2012 Elsevier B.V. All rights reserved.

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