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Quantum Collider probes of the fermionic Higgs Portal

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Solutions to the dark matter puzzle and the hierarchy problem can include a BSM fermion ψ that is a SM singlet and couples to the visible sector via a Higgs portal interaction: $\mathcal{L}_{H\psi} = c_\psi/f\ |H|^2\bar{\psi}\psi$. Despite its potential of solving these tensions with the SM being well-established, the study of $\mathcal{L}_{H\psi}$ at hadron colliders remains challenging as the Higgs boson is the only portal between the ψ-particles and the SM sector. We study the interaction $\mathcal{L}_{H\psi}$ with several off-shell Higgs probes, namely the contribution of ψ to the Higgs self-energy in $pp \to ZZ \to 4\ell$ production, Di-Higgs production, and the direct production of ψ-pairs in off-shell Higgs decays. Finally, we present the combination of these three analyses providing complementary results and give an outlook on the collider reach of HL-LHC and other beyond-LHC pp-colliders in constraining the $\mathcal{L}_{H\psi}$ interaction.

Primary author: SCHMID, Konstantin (University and INFN Padova)

Presenter: SCHMID, Konstantin (University and INFN Padova)

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