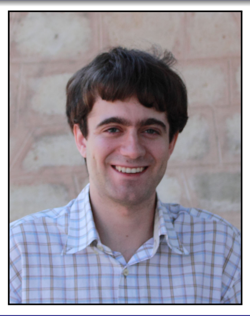
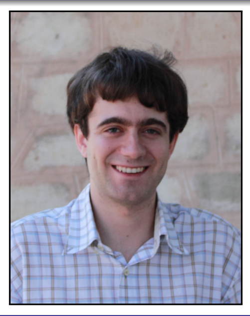
One-loop computations from the Electroweak Chiral Lagrangian with a light Higgs



Rafael L. Delgado, Antonio Dobado and Felipe J. Llanes-Estrada

Universidad Complutense de Madrid

XIth Quark Confinement and the Hadron Spectrum 2014, Saint-Petersburg State University (Russia)



Motivation

The SM Higgs boson would make the SM unitary. However, there are more general low-energy dynamics for the minimal Electroweak Symmetry Breaking Sector with three Goldstone bosons and one light scalar. So, by using a more general low energy effective Lagrangian, different processes at one-loop precision are studied. Our aim is both making phenomenological predictions which can be tested at LHC run II and discussing the limitations of the one-loop computations.

Effective Lagrangian

$$\mathcal{L} = \frac{1}{2}\left(1 + 2a\frac{\varphi}{v} + b\left(\frac{\varphi}{v}\right)^2\right)\partial_\mu\omega^a\partial^\mu\omega^b\left(\delta_{ab} + \frac{\omega^a\omega^b}{v^2}\right) + \frac{1}{2}\partial_\mu\varphi\partial^\mu\varphi$$
$$+ \frac{4a_4}{v^4}\partial_\mu\omega^a\partial_\nu\omega^a\partial^\mu\omega^b\partial^\nu\omega^b + \frac{4a_5}{v^4}\partial_\mu\omega^a\partial^\mu\omega^a\partial_\nu\omega^b\partial^\nu\omega^b + \frac{\gamma}{v^4}(\partial_\mu\varphi\partial^\mu\varphi)^2$$
$$+ \frac{2\delta}{v^4}\partial_\mu\varphi\partial^\mu\varphi\partial_\nu\omega^a\partial^\nu\omega^a + \frac{2\eta}{v^4}\partial_\mu\varphi\partial^\nu\varphi\partial_\nu\omega^a\partial^\mu\omega^a$$

Direct experimental bounds

No 2–Higgs final state at the LHC $\Rightarrow$ no relevant (order O(1)) constraint on b.

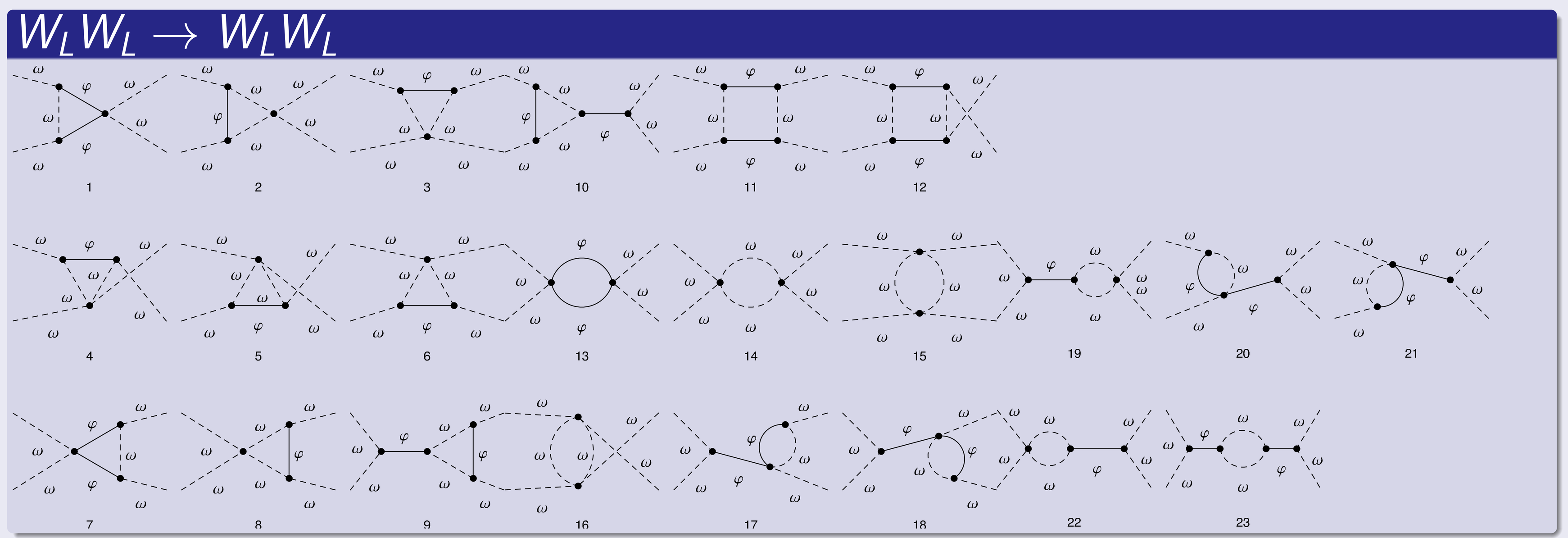
$$a \in (225, 350)\mathrm{GeV} \quad \text{or} \quad a \in (0.70, 1.1) \quad (\mathrm{CMS})$$
$$a \in (185, 285)\mathrm{GeV} \quad \text{or} \quad a \in (0.87, 1.3) \quad (\mathrm{ATLAS})$$

Unitarization methods

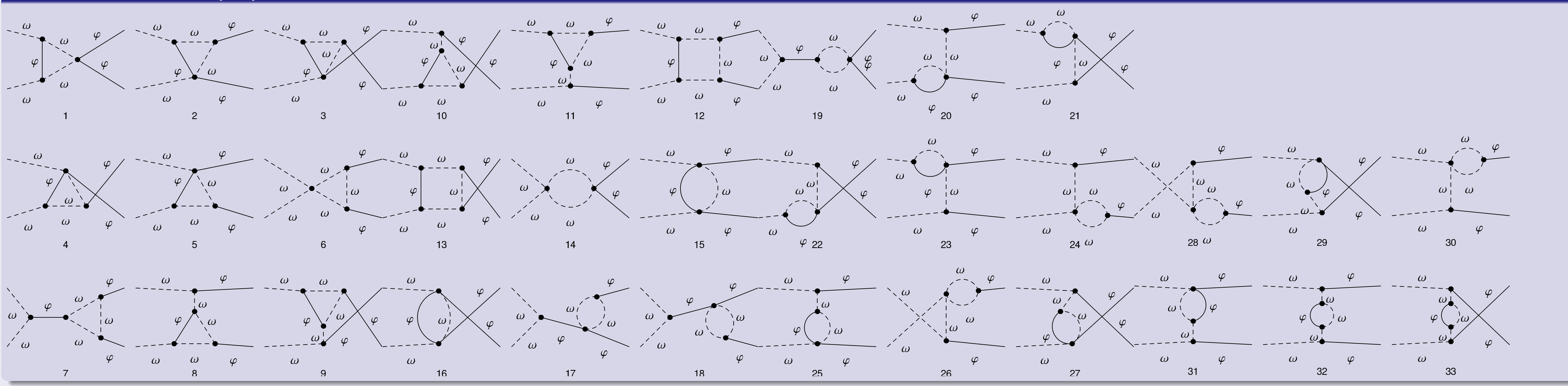
To extend the validity range of the one-loop amplitudes, we use the so–called *unitarization methods* (in particular, the *Inverse Amplitud Method*) over a partial wave decomposition of those amplitudes. These methods rely on the analytical properties of the scattering amplitudes considered as complex variable functions.

1-loop Feynman Diagrams

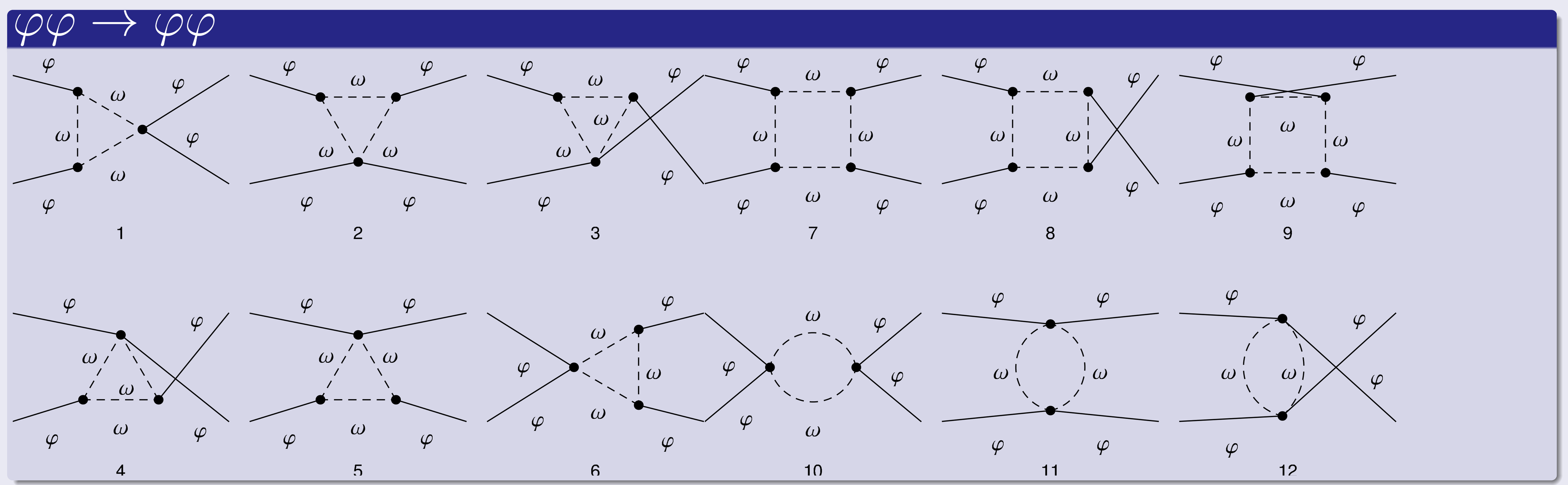
$W_LW_L \to W_LW_L$



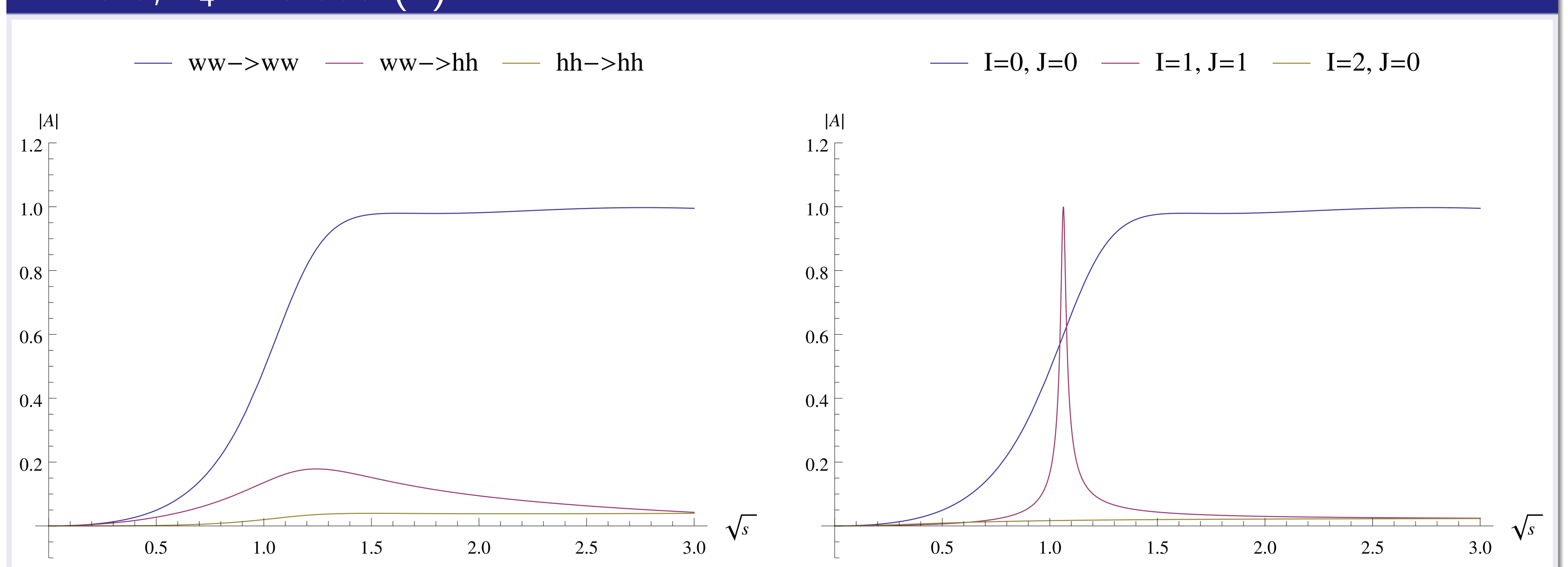
$W_LW_L \to \varphi\varphi$



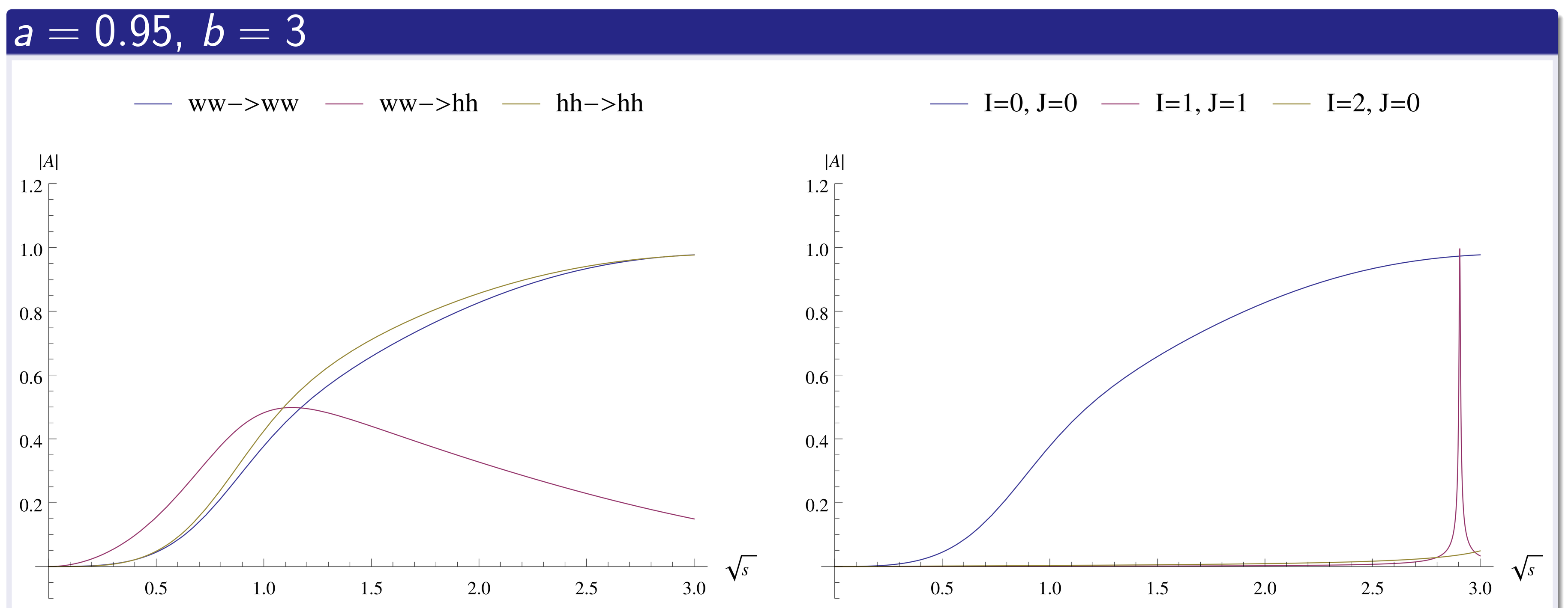
$\varphi\varphi \to \varphi\varphi$



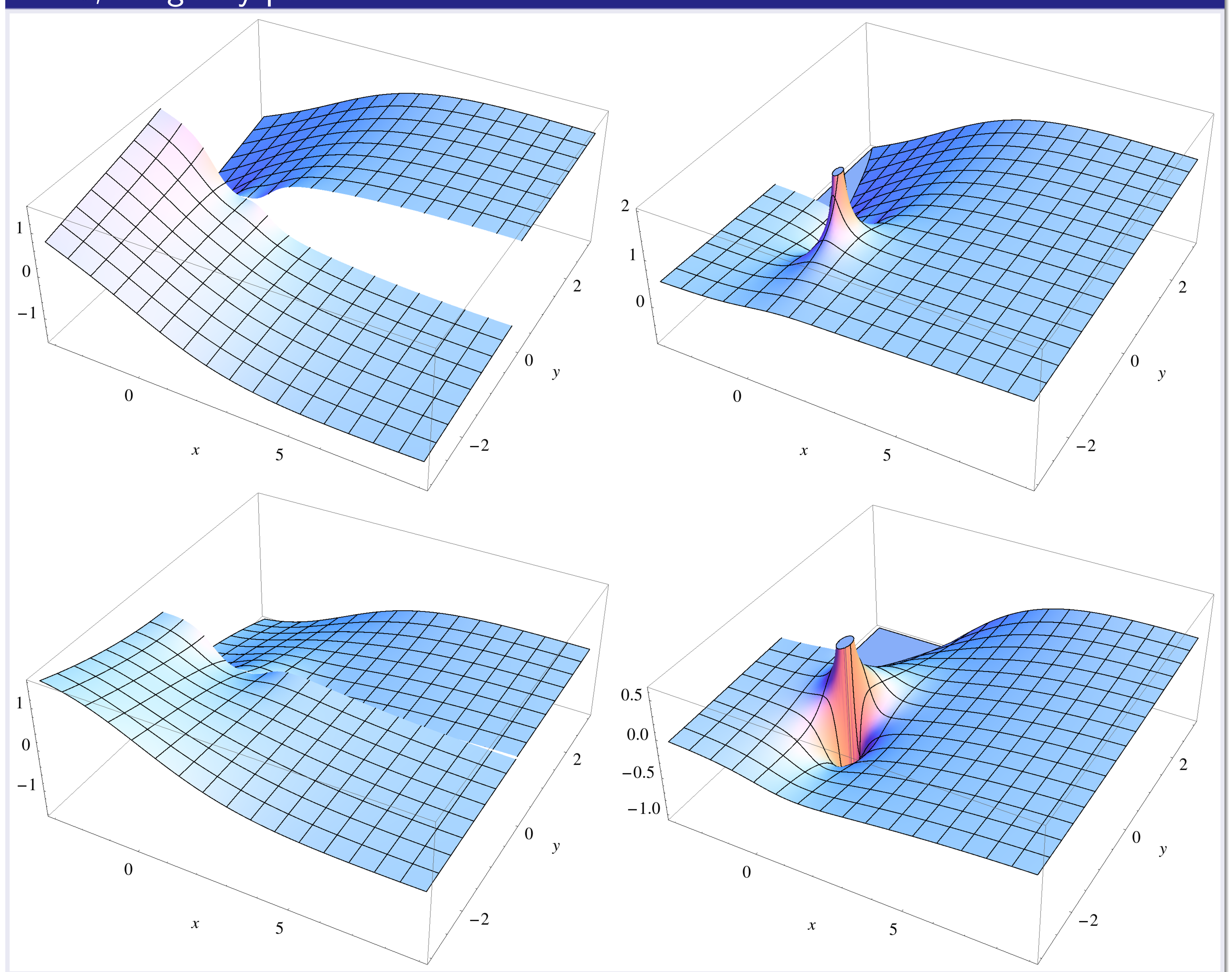
$a = 0.8$, $a_4 = 0.005$ (*)



$a = 0.95$, $b = 3$

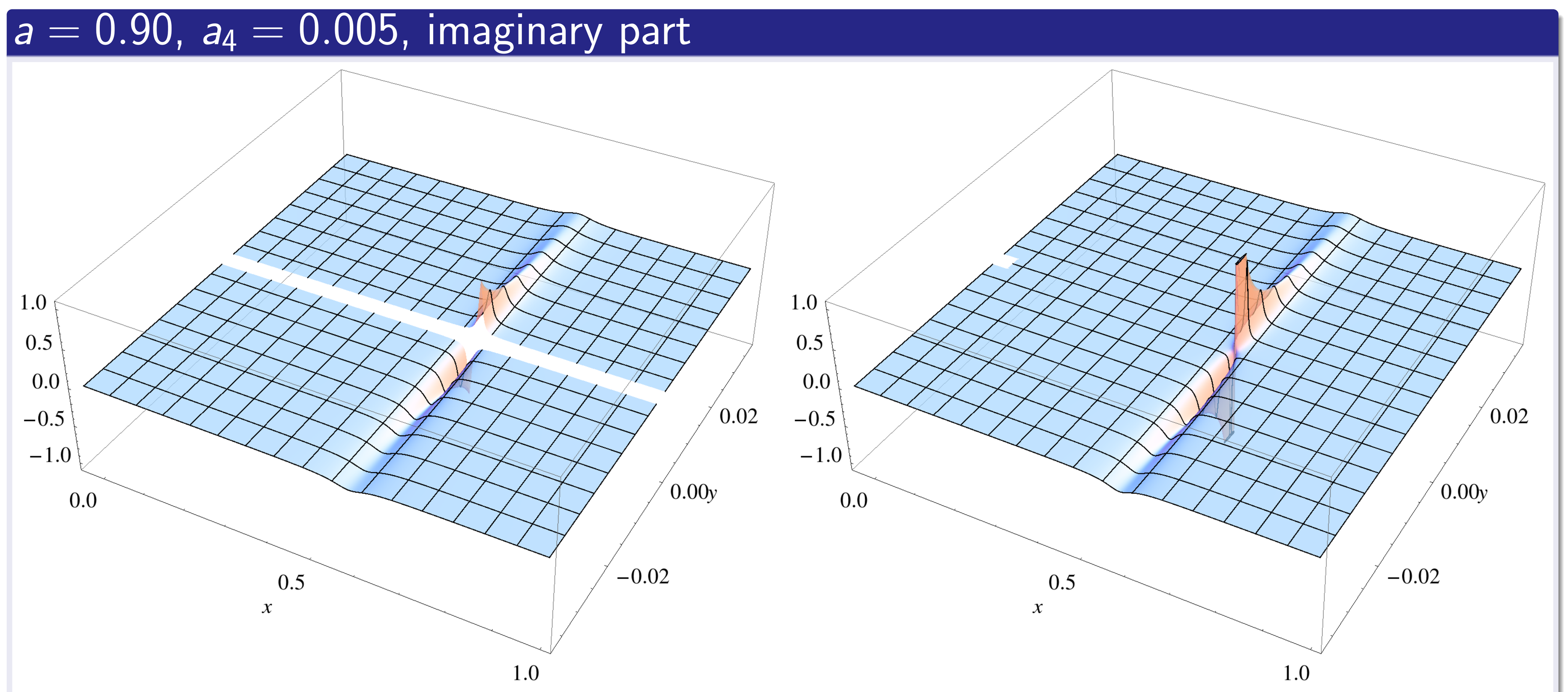


$b = 3$, imaginary part



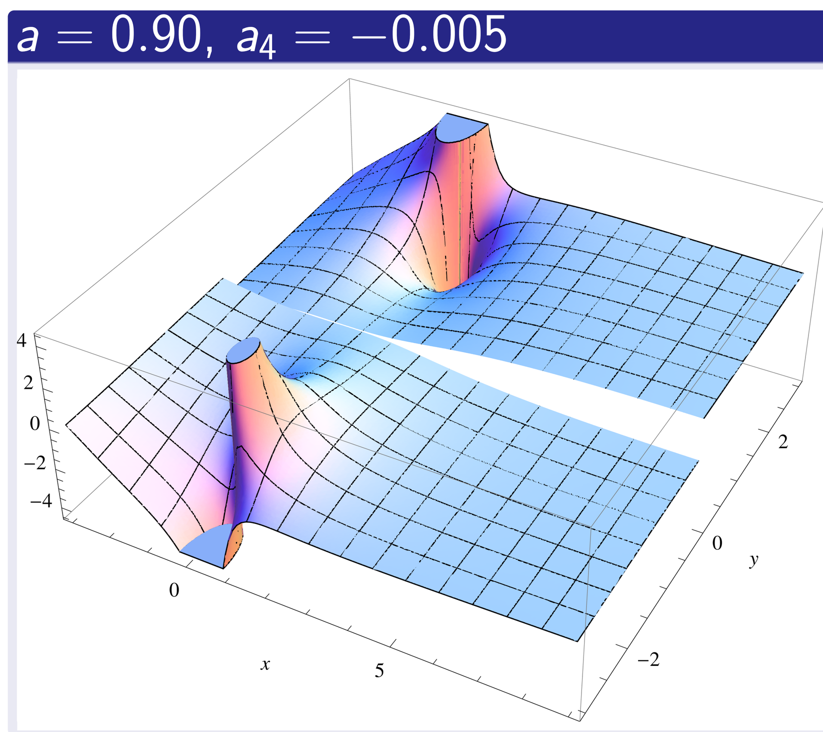
Imaginary part of the first (left) and second (right) Riemann sheets of the scattering amplitude of the isoscalar channels ($I = J = 0$) for both the $W_LW_L \to W_LW_L$ (up) and $W_LW_L \to \varphi\varphi$ (down) processes.

$a = 0.90$, $a_4 = 0.005$, imaginary part



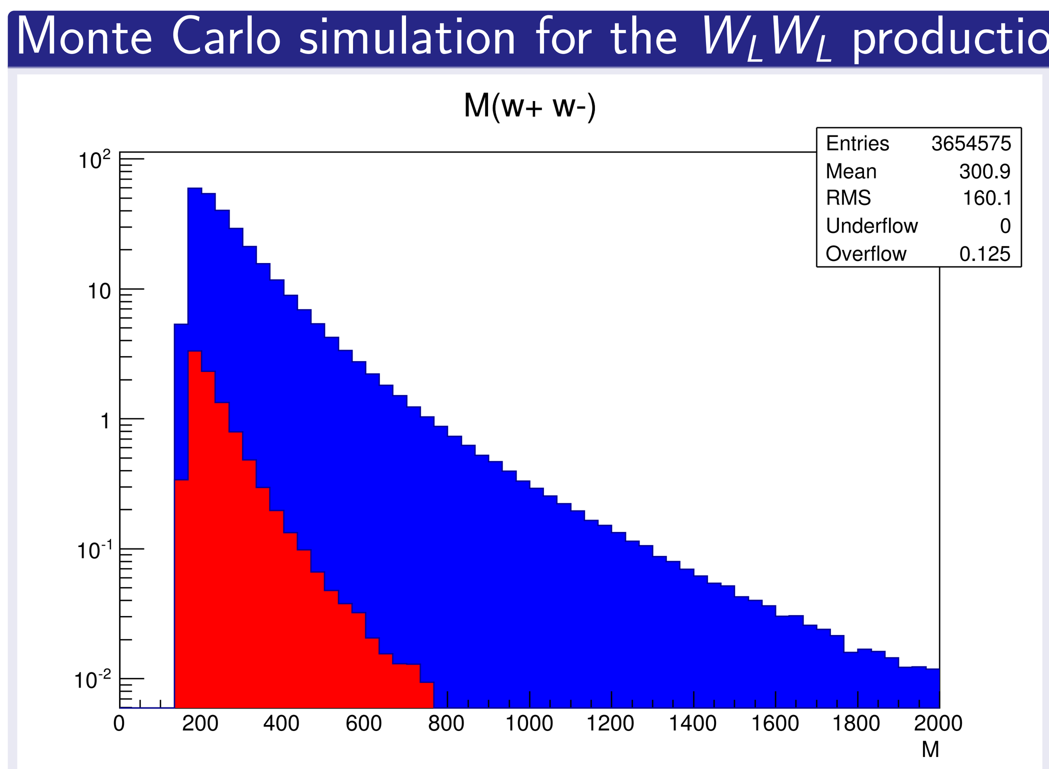
Imaginary part of the first (left) and second (right) Riemann sheets of the scattering amplitude of the isovector channel ($I = 1$, $J = 0$) for the $W_LW_L \to W_LW_L$ processes.

$a = 0.90$, $a_4 = -0.005$



Pole in the 1st Riemann sheet. Isotensor channel ($I = 2$, $J = 0$), and $W_LW_L \to W_LW_L$ process. This breaks analiticity and, therefore, the IAM unitarization method is nonvalid for those parameters.

Monte Carlo simulation for the W_LW_L production in the SM



$\sqrt{s} = 13\,\mathrm{TeV}$, $L = 10\,\mathrm{fb}^{-1}$. Production of W^+W^- (blue) vs. $W_L^+W_L^-$ (red). x–axis in GeV. y–axis in events / 33.3 GeV.

MadGraph5_aMC@NLO used. We acknowledge the computer resources, technical expertise, and assistance provided by the BCS and the Tirant supercomputer staff at Valencia.

(*) About the graphs

Unless otherwise stated, $a = b = 1$, $a_4 = a_5 = \delta = \eta = \nu = 0$. The plots which represent the amplitudes $W_LW_L \to W_LW_L$, $W_LW_L \to \varphi\varphi$ and $\varphi\varphi \to \varphi\varphi$ (i.e., WW->WW, WW->hh and hh->hh) are given for the isoscalar $I = J = 0$ channel.