Review Form 1.6

Journal Name:	**Asian Journal of Research and Reviews in Physics**
Manuscript Number:	**Ms_AJR2P_85588**
Title of the Manuscript:	**A Phenomenological Approach to Multi-Higgs Production at High Energy**
Type of the Article	**Original Research Article**

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This journal's peer review policy states that **NO** manuscript should be rejected only on the basis of '**lack of Novelty'**, provided the manuscript is scientifically robust and technically sound.
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PART 1: Review Comments

	Reviewer's comment	**Author's comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)*
Compulsory REVISION comments	The topic dealt with in this work is very topical and currently in the literature various approaches have been proposed, as an alternative to that of "Higgsplosion". Although the topic is quite specialized, there are several points involved in this topic. Here I shall limit myself to just mentioning a few to stimulate the author's reflection. The following tips are intended to highlight the immediate reaction that, in my opinion, the author's work will have on the specialist who is working on this topic. **CRc1)** Eq. (1.1) provides the cross-section after integrating over the phase space. This expression behaves as $\sigma_n \sim Exp(n\log(\lambda n))$. Please, define the physical meaning of λ. **CRc2)** According to the *Higgsplosion formula*, the 1→n cross-section can be written in exponential form: $\sigma(E,n) \sim \exp(1/\lambda F(\lambda n,\varepsilon))$. For small $\lambda n \ll 1$ and small energies of the final particles $\varepsilon \ll 1$, the exponent of the cross-section reads $F(\lambda n,\varepsilon) = \lambda n \ln(\lambda n/16) - \lambda n + 3/2\ln(\varepsilon/3\pi+1) - 25/12\ \lambda n\varepsilon + 2B\lambda^2 n^2 + O(\lambda^3 n^3) + O(\lambda^2 n^2 \varepsilon) + O(\lambda n \varepsilon^2)$. Therefore, the author's expression (1.1) and *Higgsplosion formula* coincide only if we consider the first contribution of the expansion of $F(\lambda n,\varepsilon)$. We may object that in the authors conclusions are valid only in the limit $\lambda n \to 0$ (and not in the range $\lambda n \ll 1$). The author is asked to dissipate this possible objection. **CRc3)** As known, the gluon fusion multi-Higgs production at large *n* leads to two main problems: **CRc3-a)** 1-loop polygons with up to *n*-2 edges. This increases technical complexities due to numerical computations in the high-energy limit where E>> all kin scales; **CRc3-b)** 1→ *n*x*h* tree levels and loop corrected. Consequently, the Higgs branching grow as *n*! The full gluon fusion process is expressed as the sum of these two contributions. CRc3-b) has been discussed. Please discuss the difficulties induced by the issue CRc3-a). **CRc4)** According to the current interpretation, Higgsplosion issue may be solved by exploring the following directions: **a)** New theoretical approaches together with computational techniques are needed to go beyond perturbation theory. **b)** New physics beyond the Standard Model has to set in before the cross-sections become large. However, according to the author's conclusions, the Higgs sector at high energies should remain under control and well-described by the SM predictions, without having to resort that a new physics. Concerning point **a)**, there is a convergence of opinions. More precisely, it is (quite) commonly accepted that: **a1)** the formula for "Higgsplosion" has a limited applicability and inconsistent with unitarity of the Standard Model; **a2)** the perturbation theory is no longer be valid when $n\lambda \to \infty$. However, there is a discrepancy for point **b)**. Indeed, according to the author EW corrections will become more important as the energy scale of colliders increases, especially for the 100-TeV FCC while it is (almost) commonly accepted that a new physics beyond the Standard Model should be set up as early as at ~50 TeV. The author is asked to clarify this aspect.	Revised
Minor REVISION comments	**MRc1)** In scientific papers it is customary to specify the acronyms and variables/parameters when they appear for the first time in text (even when they are well-known in the literature). To facilitate the reading of the paper, please ensure that all the acronyms, variables and parameters that appear in the manuscript are well specified and/or defined. **MRc2)** The author explains well the problem: at high energies perturbative Standard Model exhibits a formal breakdown. Perturbative unitarity is broken. The main author's conclusion is "*at high energies (multiplicities) the Standard Model is fundamentally non-perturbative*". However, he does not compare his approach (and his vision of the phenomenon) with other approaches currently considered in the literature. **MRc3)** The scale of energies where it is believed that the Standard model exhibits at formal breakdown should also be better identified. **MRc4)** For clarity, **t**he main problems related to the Feynman diagrams for gluon fusion multi-Higgs production at large *n* have, in the reviewer opinion, to be shown and	Noted

	briefly commented.	
Optional/General comments	Recent calculations of the multi-Higgs boson production in scalar theories with spontaneous symmetry breaking has demonstrated the fast growth of the cross section with the Higgs multiplicity at sufficiently large energies, referred to as "*Higgsplosion*". The author's paper is framed within a series of works aiming to solve the issue of multi-Higgs production at high energy. However, he introduced a phenomenological approach which differs from the currently considered *Higgsplosion proposal*. The author proposal is interesting even if, in the reviewer opinion, he does not compare in a sufficiently deep way his results with other solutions that are recently appeared in the literature. For the sake of completeness, the author is therefore encouraged to insert a supplementary introductory Section where the various approaches are illustrated, perhaps helping the reader by introducing some relevant Feynman diagrams (see the above Sections "*Compulsory Revision comments*" and Sections "*Minor Revision comments*"). Anyhow, the above suggestions are only intended to help the author to attract the interest of the specialized reader more.	

PART 2:

	Reviewer's comment	**Author's comment** *(if agreed with reviewer, correct the manuscript and highlight that part in the manuscript. It is mandatory that authors should write his/her feedback here)*
Are there ethical issues in this manuscript?	*(If yes, Kindly please write down the ethical issues here in details)*	