Hadron Jets and Confinement Using Abelian Higgs Model

We investigate the production of hadron jets and confinement from the final state of high energy e^-e^+ annihilation using abelian Higgs model. The model produces *scalar QED* at high energies (UV regime) when e^-e^+ annihilate. This process is represented by a complex scalar field $|\phi|$ and at low energies the virtual photon γ produced in the process transform into *glueball field* η coupled to high energy complex fields represented by $|\tilde{\phi}|$ (identified as (anti)quark fields) after *spontaneous symmetry breaking* (SSB). The glueball fields produce *color confinement* with a *glueball mass* m_η in the IR regime, calculated phenomenologically. The glueball field leads to gluon condensate resulting into effective masses (glueball and gluon masses) and monopole condensate as a by-products of confinement. The jets are formed through vacuum excitations of the glueballs by decay of the glueball fields, temperature fluctuations or long distance separation of (anti)quarks. The energetic fields $|\tilde{\phi}|$ represents the behaviour of the color particles (massless quarks) at short distances (UV regime), usually refered to as partons. The glueball vacuum $\langle \eta^2 m_\eta^2 F^{\mu\nu} F_{\mu\nu} \rangle$, confining potential $V_c(r)$, string tension σ, penetration depth λ and the effective masses (m_η^{*2} and m_A^{*2}) were studied at a finite temperature T as well. We introduce a color dielectric function $G(|\phi|)$ coupled with gauge field which is well defined to produce confinement. After SSB we identify the color dielectric function $G(\eta)$ with the strong 'running' coupling α_s and subsequently the QCD β-function. Finally, we use our model to investigate the inflationary regime of the early universe.

We demonstrate the high energy annihilation through scalar QED and followed by spontaneous symmetry breaking of the $SU(2) \times U(1)$ symmetry to an energy regime suitable for describing the expected final hadron state of the process i.e. $e^+e^- \to \gamma \to q\bar{q}g \to 3-\text{jets}$. Because the running coupling, $\alpha_s(Q^2)$, of the strong interaction decreases with momentum increase (short distances) so, it has been argued that the final state of e^-e^+ annihilation can be calculated from perturbation theory for the production of quarks and gluons in the UV regime. *That notwithstanding, the experimental result of the final state of this process is hadrons and not quarks and gluons.* This is the main motivation for this work. We are able to systematically trace the final process of e^-e^+ annihilation by combining phenomenological and effective field theories making approach curious with very interesting results.

I. BIOGRAPHY

I am Adamu Issifu, currently a PhD student in Federal University of Paraíba, (UFPB), Brazil. My current area of concentration is **Nuclear Physics** specifically, studying different forms of confinement of quarks and gluons in hadrons using an Abelian Higgs model similar to QED. I had my masters degree in Federal University of Campina Grande (UFCG), Brazil, with a dissertation in *Confinement in Tachyon matter*. My degree was obtain in University of Cape Coast, (UCC), Ghana, with a project work in *Electronic Structure of Silicon*. I have done many presentation (both oral and poster presentations) in my young carrier as a physicist. Finally, I have one publication and a paper in the press both papers are tractable on-line with s with several in the pipeline.

[1] S. Marzani, G. Soyez and M. Spannowsky, *Looking inside jets: an introduction to jet substructure and boosted-object phenomenology* Lect. Nots. in Phys. **958** (2019), [arXiv:1901.10342 [hep-ph]].

[2] B. Gripaios, *Lectures on Physics Beyond the Standard Model*, [arXiv:1503.02636 [hep-ph]], (2015).

[3] M. Laine and A. Vuorinen, *Basics of thermal field theory - a tutorial on perturbation computations*, Lect. Notes Phys. **925** 1 281 (2016), [arXiv:1701.01554 [hep-ph]], Doi: 10.1007/978-3-319-31933-9.

[4] ATLAS Collab. (G. Aad et al.), *Observation of a new particle in the search for the Standard Model Higgs boson with the ATLAS detector at the LHC*, Phys. Lett. **B 716**, 1 (2012).

[5] C. Louis Basham, L. S. Brown, S. D. Ellis and S. T. Love, *Energy Correlations in electron - Positron Annihilation: Testing QCD*, Phys. Rev. Lett. **41** 1585 (1978), 10.1103/PhysRevLett.41.1585.