Models inspired by Gürsey Model and their RG analysis

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Purpose

- To obtain nontrivial field theoretical models out of toy models that are classically equivalent to Gürsey model by using perturbative and nonperturbative techniques. [1], [2], [3], [4], [5].

Gürsey Model

- Scalar form of the Model

$$L = i\bar{\psi}\partial\!\!\!/\psi + g'(\bar{\psi}\psi)^{4/3}. \quad (1)$$

- Vectoral form of the Model

$$\begin{aligned} L &= \bar{\psi}\left(i\partial\!\!\!/ - ig\partial\!\!\!/ g^{-1} - m\right)\psi \\ &+ \alpha\left[(\bar{\psi}\gamma_\mu\psi)(\bar{\psi}\gamma^\mu\psi)\right]^{2/3}. \end{aligned} \quad (2)$$

1. Conformal invariant in 4-dim. [6]
2. Instantonic and meronic solutions.[7],[8]
3. Non linear but quantized [9],[10].

Toy Models for Scalar version

eS

$$L = i\bar{\psi}\partial\!\!\!/\psi + g\bar{\psi}\psi\phi + \xi(g\bar{\psi}\psi - a\phi^3). \quad (3)$$

eAgS

$$\begin{aligned} L &= i\bar{\psi}D\!\!\!\!/\psi + g\bar{\psi}\psi\phi + \xi(g\bar{\psi}\psi - a\phi^3) \\ &-\frac{1}{4}F_{\mu\nu}F^{\mu\nu}. \end{aligned} \quad (4)$$

eNAgS

$$\begin{aligned} L &= \sum_{i=1}^{N_f} i\bar{\psi}_i D\!\!\!\!/\psi_i + g\sum_{i=1}^{N_f}\bar{\psi}_i\psi_i\phi \\ &+\xi\left(g\sum_{i=1}^{N_f}\bar{\psi}_i\psi_i - a\phi^3\right) \\ &-\frac{1}{4}Tr[F_{\mu\nu}F^{\mu\nu}]. \end{aligned} \quad (5)$$

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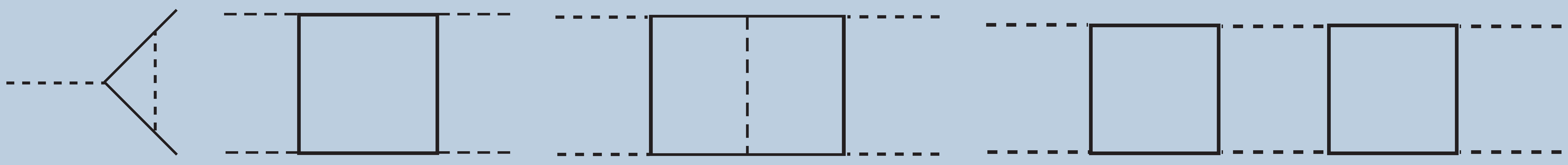
Equivalent Model to the Scalar Gürsey Model(eS)

We use path integral method. The fermion propagator is usual Dirac Propagtor in lowest order.

- Infinite part of Scalar inverse progator is derived by using dimensional regularization method.

$$\inf\left[\frac{ig^2}{(2\pi)^4}\int\frac{d^4p}{p\!\!\!/(p\!\!\!/ + q\!\!\!/)}\right] = \frac{g^2q^2}{4\pi\epsilon}. \quad (6)$$

- We studied Dyson-Schwinger equation for fermion propagator and verified that there is no dynamical mass generation.
- We find that Yukawa type vertex does not need infinite regularization.
- We see that the only infinite renormalization is needed for the four composite scalar scattering.
- We studied the higher orders and all diverges at worst $1/\epsilon$.



Conclusion: Only composite scalars take place in physical processes as incoming and outgoing particles, whereas constituent fermions only act as intermediary particles. [1]

Abelian(eAgS) and NonAbelian(eNAgS) Gauged Scalar G.M.

- **eAgS**
  - We find a model that is mimicking gauged Higgs Yukawa model.
  - Many features of (eS) model has changed, spinors can take place in physical processes.
  - First order renormalization group equations,

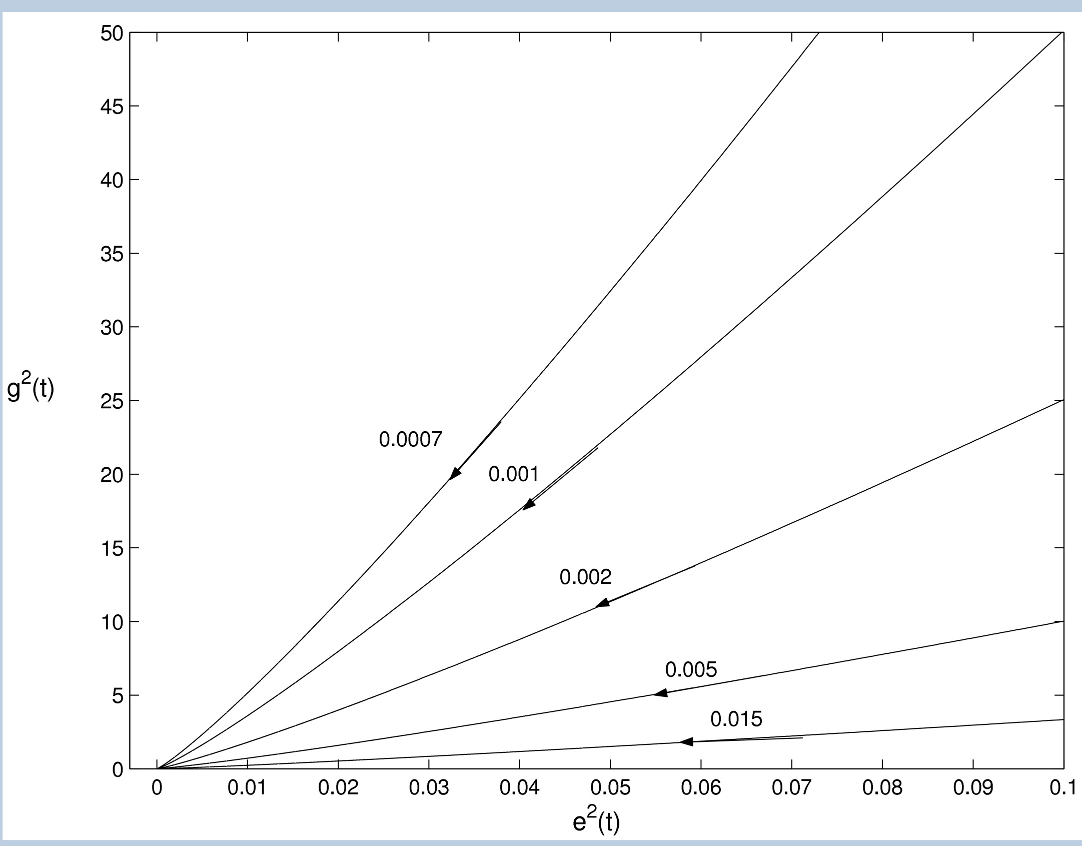
$$16\pi^2\mu\frac{de}{d\mu} = be^3, \quad (7)$$
$$16\pi^2\mu\frac{dg}{d\mu} = -cge^2, \quad (8)$$
$$16\pi^2\mu\frac{da}{d\mu} = -dg^4. \quad (9)$$

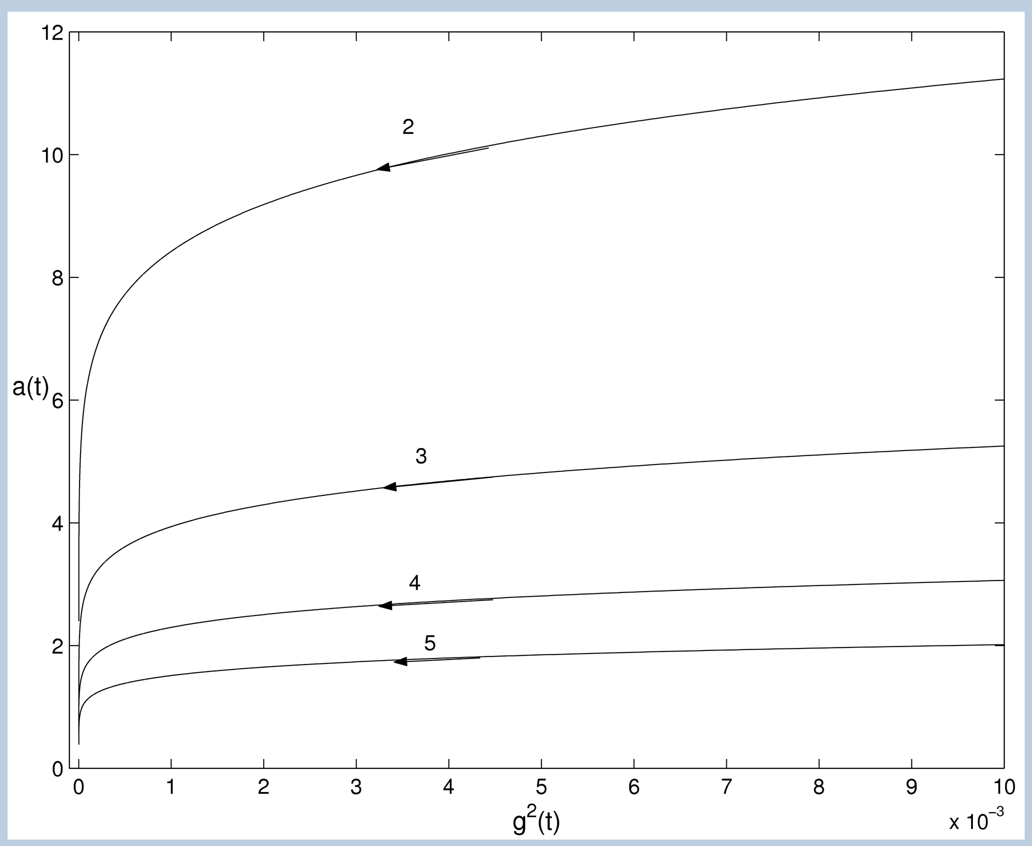
Conclusion: We encounter LANDAU POLE that means at a finite energy, the coupling constant of the vector fields diverges. **TRIVIAL MODEL.**[3]

- **eNAgS**
  - $SU(N)$ gauge field is coupled, instead $U(1)$.
  - We solve the renormalization group equations in the one loop approximation, like Harada *et al.*[11]

$$16\pi^2\frac{d}{dt}e(t) = -be^3(t), \quad (10)$$
$$16\pi^2\frac{d}{dt}g(t) = -cg(t)e^2(t), \quad (11)$$
$$16\pi^2\frac{d}{dt}a(t) = -ug^4(t). \quad (12)$$

Here b, c, d and u are positive constants.





Conclusion: Analytically, we find that this model is a **NON-TRIVIAL MODEL.**[4]