



FACULTAD DE FÍSICA
PONTIFICIA UNIVERSIDAD
CATÓLICA DE CHILE

2ND LAWEMQCD FLASH TALKS

Effect of Magnetic Fluctuations on the Renormalons of a Self- Interacting Scalar Theory

JULIÁN TOVAR
jtovar@uc.cl |

Co-Authors: Dr. Enrique Muñoz, Dr. Marcelo Loewe

Instituto de Física. Pontificia Universidad Católica de Chile, Santiago, Chile

(November 25th, 2025)

What are Renormalons?

- Renormalons are a type of divergence that arises from the multiplicity of diagrams that contribute to a physical process [2].
- In a specific set of diagrams, the contribution can come from the IR or UV region when integrating in momenta space.

$$D[x] = \sum_k a_k x^k, \quad a_k \propto k!$$

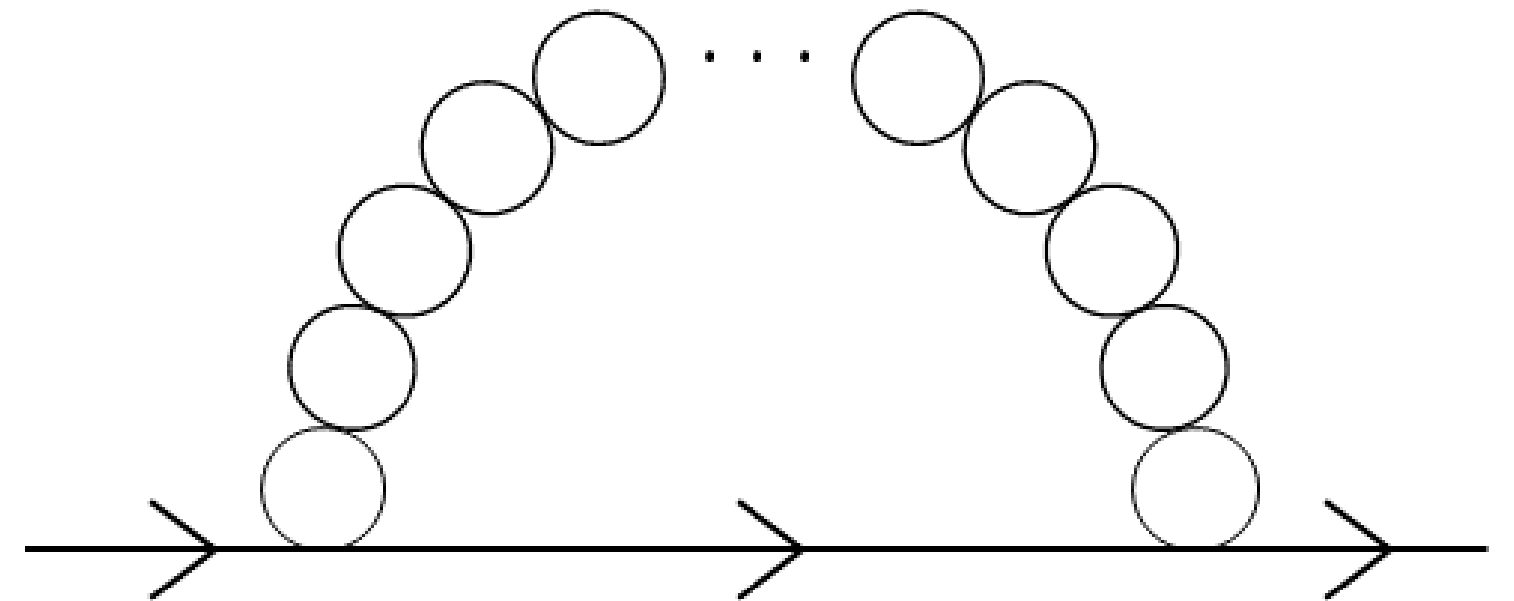


Figure 2: Diagram of the Renormalon-type correction to the propagator in the $\lambda\phi^4$ theory.

Borel Transform Method

(very briefly)

Considering a Divergent expansion:

$$D[a] = \sum_{n=1}^{\infty} D_n a^n$$

Defining the Borel transform as:

$$B[b] = \sum_{n=0}^{\infty} D_{n+1} \frac{b^n}{n!}$$

The Inverse Transform is given by:

$$D[a] = \int_0^{\infty} db e^{-b/a} B[b]$$

Sometimes $B[b]$ has poles in the positive real axis, spoiling the technique altogether...

In the literature...

- Renormalons in the vacuum and with a constant magnetic field background have been studied...
- They found positive real poles in the Borel plane

$$b_n = n \cdot 32\pi^2, \quad n \in \mathbb{N}$$

- Let us implement magnetic noise!

Magnetic noise as White noise

- A new term is added to the gauge field!

$$A^\mu(x) \rightarrow A^\mu(x) + \delta A^\mu(x)$$

- Modeled as static white noise following the theory from [5].

$$\langle \delta A^\mu(x) \delta A^\nu(x') \rangle = \Delta_B \delta^{\mu\nu} \delta^{(4)}(x - x')$$

$$\langle \delta A^\mu(x) \rangle = 0$$

Fluctuations are random. The probability distribution is given by Gaussian white noise.

$$dP[\delta A^\mu] = \mathcal{N} e^{-\int d^4x \frac{[\delta A^\mu(x)]^2}{2\Delta_B}} \mathcal{D}[\delta A^\mu(x)].$$

FMF Renormalon

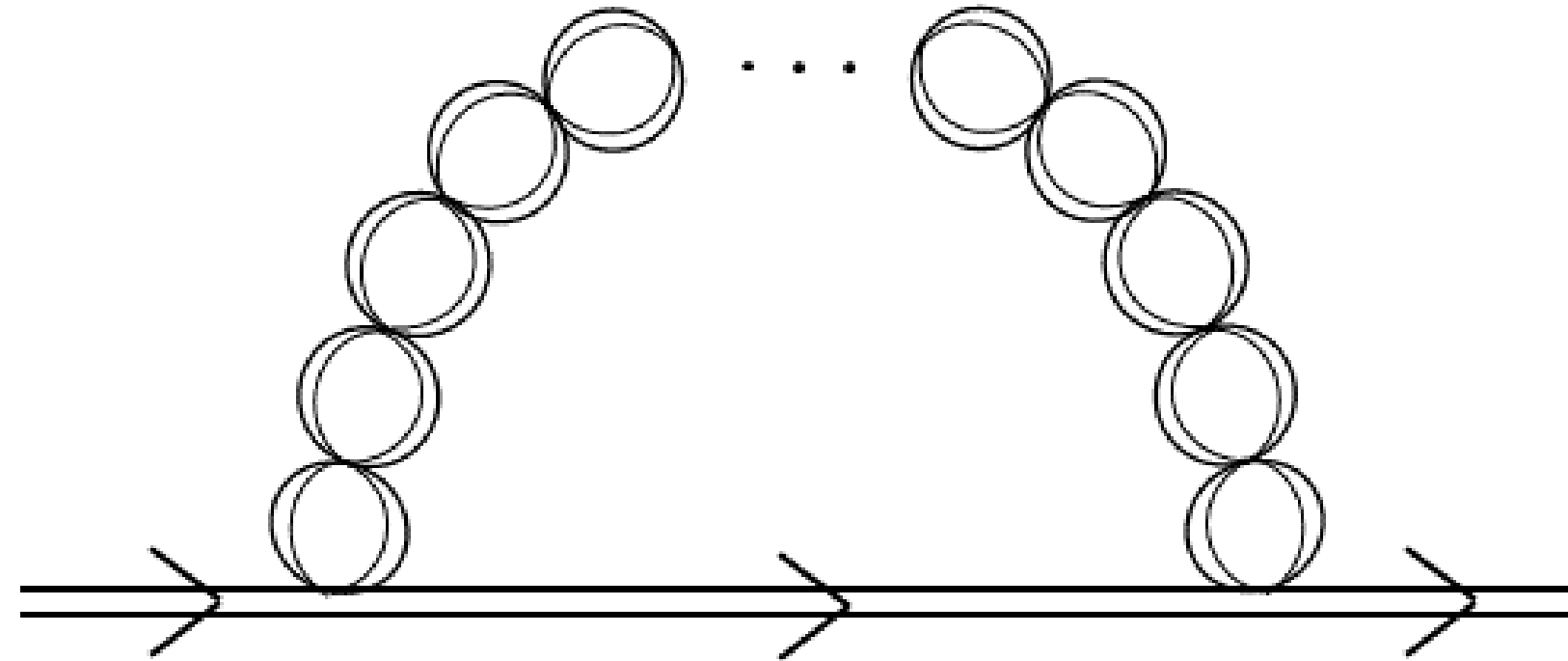


Figure 10: Fluctuating magnetic field dressed k-bubble chain diagram.

$$R_{\Delta,k}(p) = \frac{1}{(-i\lambda)^{k-2}} \int \frac{d^4q}{(2\pi)^4} iD_{\Delta}(p+q) [B_{\Delta}(q)]^{k-1}$$

FMF Renormalon

- Once again we have the same behavior for the poles reported by [2] with a couple of differences...

$$b_n = n \cdot 32\pi^2, \quad n \in \mathbb{N}$$

$$B[b] = -2i \sum_{j=1}^{\infty} \frac{g_j(\mu, eB, \Delta_B)}{j \cdot 32\pi^2 - b} + \frac{h_j(\mu, eB, \Delta_B)}{(j \cdot 32\pi^2 - b)^2}$$

I would like to acknowledge
FONDECYT Proyect 1230440
for their support and funding
throughout this work.

Thank You!

REFERENCES

- [1]: F. J. Dyson, "Divergence of perturbation theory in quantum electrodynamics," *Physical Review*, vol. 85, no. 4, p. 631, 1952.
- [2]: M. Correa, M. Loewe, D. Valenzuela, and R. Zamora, "Magnetic renormalons in a scalar self-interacting $\lambda\phi^4$ theory," *Physical Review D*, vol. 99, no. 9, p. 096024, 2019.
- [3]: J. Schwinger, "On gauge invariance and vacuum polarization," *Physical Review*, vol. 82, no. 5, p. 664, 1951.
- [4]: A. Ayala, A. Sánchez, G. Piccinelli, and S. Sahu, "Effective potential at finite temperature in a constant magnetic field i: Ring diagrams in a scalar theory," *arXiv preprint hep-ph/0412135*, 2004.
- [5]: J. D. Castaño-Yepes, M. Loewe, E. Muñoz, J. C. Rojas, and R. Zamora, "Qed fermions in a noisy magnetic field background," *Physical Review D*, vol. 107, no. 9, p. 096014, 2023.
- [6]: M. Mézard and G. Parisi, "Replica field theory for random manifolds," *Journal de Physique I*, vol. 1, no. 6, pp. 809–836, 1991.

REFERENCES

[7]: T. -K. Chyi, et. al., Physical Review D 62, 105014, (2000)