November 9 , 2023

Recollections from the

Orange preprints era

Apologies *for speaking mo*

Edouard Brézin
member of SPhT 1963-1986

- I joined the Service de physique théorique in October 1963; it was still located in the main Saclay centre.

- It had existed for already several years (under a different name)

- The group was young! led by Claude Bloch
  Balian, Bessis, Bros, des Cloizeaux, De Dominicis, Froissart, Gaudin. Gillet, Itzykson, Jacob, Mehta,Morel, Pham, Raynal, Ripka, Stora

- Most of us had been given a permanent position with just an undergraduate education, plus sometimes one year of master courses, a completely unreasonable system!

- although charged with creating new knowledge, we were only students

- Strong feeling of illegitimacy

- We were engineers : no need for a PhD

A glance at the landscape

Landau's *diktat* (1960):

The Hamiltonian method [i.e.quantum field theory] *for strong interactions is dead and must be buried, although of course with all deserved honours. The brevity of life does not allow us the luxury of spending time on problems which will lead to no new results.*

- Bloch and De Dominicis Work in Nuclear Physics and Quantum Statistical Physics (soon with Balian)

- Froissart *Should one keep teaching field theory, now that QED is understood ?*
  was working on an S-matrix approach to QED

- Stora Remained faithful to QFT

- Jacob Phenomenology, Current algebra, Regge poles

I'll spare you the account of my personal work during those first years (on Faddeev equations with Balian, on a solvable N-body problem with Zinn-Justin) ⋯

$Claude \quad Itzykson$

Question raised to us by a laser physicist: Is Schwinger's result on pair creation by a constant electric field in vacuum, applicable to the field created by a laser?

Is it a non-perturbative tunneling or a perturbative multi-photon effect?

- If the frequency is negligible (Schwinger case)
  pair creation probability $\sim e^{-m^2c^3/eE}$

- or is it a multi-photon ionization of the vacuum?
  pair creation probability $\sim \alpha^{2mc^2/\hbar\omega}$

Pair production in vacuum by an alternating field
(EB and C.Itzykson, Phys.Letters 1970)

The dielectric breakdown of the vacuum has not yet been observed.

However recent experiments on Dirac electrons in graphene report the observation of this Schwinger effect.

Mesoscopic Klein-Schwinger effect in graphene

A. Schmitt, B. Plaçais et al. (ENS)

Nature Physics 2023

In 1971-72 I was working at Princeton U. Ken Wilson, a guest of the IAS, was invited (by David Gross) to give a talk at the University on his recent work
Renormalization group and critical phenomena. I. Renormalization group and the Kadanoff scaling picture
(Phys Rev B 1971)
I had read with interest Kadanoff 1966 article which introduced block spins and coupling constant flow. I had tried to see whether I could reproduce Onsager 2D results, I did not succeed and I gave up.
Wilson had been more insightful! His answer to David was that he could not explain his work in one talk, but Gross invited him to talk as much as he wanted. He ended up giving 15 talks!
Wilson-Kogut *The renormalization group and the ϵ-expansion*
(1974)

After an initial phase of skepticism I ended up working with David Wallace and Ken Wilson : Universal equation of state using the ϵ-expansion.

Back in Saclay, during the fall of 1972 I was asked to lecture about the new approach to renormalization group and critical phenomena. I was uncomfortable because, if I knew how to use it with tools such as the ϵ or $1/N$ expansions, I was far from understanding how to make Wilson's approach systematic.

Fortunately Jean Zinn-Justin was also back from his stay in Stony Brook where, with Ben Lee, they had given a beautiful proof of the renormalizability of Yang-Mills theories.

We were aware of the recent field theory approach independently by C.Callan and K.Symanzik. For instance
Broken scale invariance in scalar field theory by C.Callan (1970).
Note added in manuscript: For another, not dissimilar, approach to these questions, the reader should consult a, recent paper by K. Wilson, this issue, Phys. Rev. D 2, 147 (1970).
We realized with Jean Zinn-Justin and Jean-Claude Le Guillou, that the scaling limit of critical behavior

$$distances \gg spacing, \quad \xi = m^{-1} \gg spacing, \quad distances/\xi \;\; finite$$

was precisely the renormalized theory. This made a lot of calculations easier and feasible.

Interaction with the Russian school

A.Migdal reported at the Statphys conference in Budapest 1975 his improvement over Kadanoff block spin idea. He alluded to an unpublished result by Polyakov *near two dimensions* using non-linear interactions of Goldstone bosons. With Jean we understood the renormalization of the non-linear sigma models in 2d and the expansion in powers of $d-2$ based upon it.

Renormalization of the nonlinear σ Model in two dimensions, Application to the Heisenberg ferromagnets
with J.Zinn-Justin PRL 1976

but before it was published we had received Polyakov's article
Interaction of Goldstone Particles in Two-Dimensions. Applications to Ferromagnets and Massive Yang-Mills Fields
Phys.Lett.B 59 (1975)

Large orders of perturbation theory.

We had learnt from the two Sasha's that Lipatov had developed a semi-classical method for estimating the nth coefficient of the 4D beta-function of $(\phi^4)_4$ for large n.

We understood that an instanton method indeed provided the required large order information

Perturbation theory at large order.

EB with JC Le Guillou, J Zinn-Justin - Phys. Rev. D, 1977

Then JC and Jean went on and applied it in various clever ways to get the most precise results (at the time) on critical exponents, based on various expansion schemes such as the ϵ expansion.

In 1978 I gave a talk in Rome at a *triangular meeting* (Paris, Rome, Utrecht). Gerard 't Hooft at the end of my talk pointed out that, in dimension four, one single Feynman diagram of order n could grow like $n!$, casting doubt on the instanton method for the ϵ-expansion for instance. Nowadays it is called *renormalons*.

After wondering for decades on instantons versus renormalons I have returned to this question this year
Should we worry about renormalons in the epsilon-expansion?
arXiv:2301.01174
I claim that the answer is NO.

Some other memorable visitors to Saclay in that period

1977-1978 Giorgio Parisi

Many discussions on large orders, planar diagrams...

Our ambition was to find a large N solution in arbitrary dimension but we succeeded only in dimensions zero and one.

Planar diagrams

Comm. Math.Phys. with Claude, Giorgio, Jean-Bernard in 1978.

In the summer of 1978 in Cargése, Giorgio told me about his attempts to solve the Sherrington-Kirpatrick problem with a replica symmetry-breaking scheme ... and I didn't like the idea of breaking $\mathcal{S}_n$ for $n \to 0$.

1982-1983 Bert Halperin

We worked on the *wetting transition*

Critical wetting in three dimensions

with BI Halperin and S Leibler , PRL 1983

David Gross

With David he had solved the external field problem $\int dU e^{N \mathrm{Tr}(UA^\dagger + U^\dagger A)}$ in the large N limit in 1980 (while I visited the ITP). David was in Paris in 1984 and we used SUSY and its characteristic dimensional reduction to compute the

Density of states in the presence of a strong magnetic field and random impurities

with DJ Gross and C Itzykson - Nucl. Phys.1984

By the time I left Saclay (fall of 1986) the SPhT had re-cruited many bright new people, whose names I shall not try to list. Many of them are in this room now, wondering when I am going to stop talking.

MANY THANKS TO THE SPhT FOR ITS SUPPORT AND INTELLECTUAL ATMOSPHERE THROUGH THOSE EXCITING YEARS

and

Thank you for your patience