Igor Suslov and the beta function of the scalar field

Research Blogging

I think that blogs are a very good vehicle for a scientist to let his/her work widely known and can be really helpful also for colleagues doing research in the same field. This is the case of Igor Suslov at Kapitza Institute in Moscow. Igor is doing groundbreaking research in quantum field theory and, particularly, his main aim is to obtain the beta function of the scalar field in the limit of a very large coupling. This means that the field of research of Igor largely overlaps mine. Indeed, I have had some e-mail exchange with him and we cited our works each other. Our conclusions agree perfectly and he was able to obtain the general result that, for very large bare coupling λ one has

$$\beta(\lambda) = d\lambda$$

where d is the number of dimensions. This means that for d=4 Igor recovers my result. More important is the fact that from this result one can draw the conclusion that the scalar theory is indeed trivial in four dimensions, a long sought result. This should give an idea of the great quality of the work of this author.

On the same track, today on arxiv Igor posted another important paper (see here). The aim of this paper is to get higher order corrections to the aforementioned result. So, he gives a sound initial explanation on why one could meaningfully take the bare coupling running from 0 to infinity and then, using a lattice formulation of the n components scalar field theory, he performs a high temperature expansion. He is able to reach the thirteenth order correction! This is an expansion of $\beta(\lambda)/\lambda$ in powers of $\lambda^{-\frac{2}{d}}$ and so, for d=4, one gets an expansion in $1/\sqrt{\lambda}$. Again, this Igor's result is in agreement with mine in a very beautiful manner. As my readers could know, I have been able to go to higher orders with my expansion technique in the large coupling limit (see here and here). This means that my findings and this result of Igor must agree. This is exactly what happens! I was able to get the next to leading order correction for the two-point function and, from this, with the Callan-Symanzik equation, I can derive the next to leading order correction for $\beta(\lambda)/\lambda$ that goes like $1/\sqrt{\lambda}$ with an opposite sign with respect to the previous one. This is Igor's table with the coefficients of the expansion:

N	$\beta(g)/g$
0	4.0000000000000
1	−26.127890589687
2	106.66666666666
3	−557.39499924665
4	3214.2222222221
5	−16396.702894504
6	67356.444444432
7	−139720.34647768
8	−717634.37037244
9	9878174.8209247
10	−59767955.489704
11	186179701.36334
12	355069103.58896
13	−8851453360.7421

So, from my point of view, Igor's computations are fundamental for all the understanding of infrared physics that I have developed so far. It would be interesting if he could verify the mapping with Yang-Mills theory obtaining the beta function also for this case. He did some previous attempt on this direction but now, with such important conclusions reached, it would be absolutely interesting to see some deepening. Thank you for this wonderful work, Igor!

I. M. Suslov (2011). Renormalization Group Functions of \phi^4 Theory from High-Temperature Expansions *J.Exp.Theor.Phys., v.112, p.274 (2011); Zh.Eksp.Teor.Fiz., v.139, p.319 (2011)* arXiv: 1102.3906v1

Marco Frasca (2008). Infrared behavior of the running coupling in scalar field theory *arxiv* arXiv: 0802.1183v4

Marco Frasca (2010). Mapping theorem and Green functions in Yang-Mills theory *arxiv* arXiv: 1011.3643v2

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