Resurgence at Kavli IPMU

12-16 December 2016, Lecture hall, Kavli IPMU

Monday, 12/Dec/2016

9:30-10:15 Yuya TANIZAKI (RIKEN BNL Research Center, BNL)

Title: Applications of Lefschetz thimbles to fermionic sign problem
Abstract: Recently, path integral on Lefschetz thimbles has been developing to treat the sign problem of lattice quantum field theories. In the original expression of the path integral, the Boltzmann weight takes complex values in many interesting applications, which forbids us to use the powerful Monte Carlo technique.

By deforming the integration region into steepest descent manifolds called Lefschetz thimbles, we can reduce the difficulty as much as possible so long as using the same path-integral expression. I would like to talk about applications of this technique to several strongly coupled quantum field theories.

10:45-11:30 Ovidiu COSTIN (The Ohio State University)
Title: New resummation techniques for resurgent series
Abstract: I will discuss recent techniques of resumming Ecalle resurgent series, with physical applications in mind. I will discuss Borel and Ecalle-Borel summation and practical ways to use it in numerically obtained series; I will also discuss "dyadic factorial expansions", which, for functions with one array of singularities converge geometrically and uniformly in C without a cut (in correspondingly smaller sectors otherwise). They are suitable for exploring the Stokes phenomenon, and also for analyzing "small coupling to large coupling" connections. Finally, I will mention new developments in Berry's hyperasymptotics.

Based on collaborative research with M V Berry, R D Costin, G Dunne and C Howls.

14:15-15:00 Ricardo SCHIAPPA (Universidade de Lisboa)
Title: Resurgence, Large N Duality, and the Phases of Spacetime
Abstract:

16:00-16:45 Aleksey CHERMAN (University of Washington)

Title: Constructing expansion parameters for QCD-type theories

Abstract: To apply resurgence theory to the study of the long-distance behavior of theories like QCD, one must first answer an obvious but difficult question: what can one use as the expansion parameter appearing in the transseries? I will give an overview of the program of adiabatic compactification of confining quantum field theories, the goal of which is precisely to construct and use such expansion parameters. I will explain recent work which showed how this program works for confining theories with continuous chiral symmetry breaking, like QCD, which opens the door to resurgence-theory studies of interesting observables.

18:00- Welcome Reception @Cafeteria on campus

Tuesday, 13/Dec/2016

9:30-10:15 Thomas SCHAEFER (North Carolina State University)

Title: Exact Saddle Points in Complexified Path Integrals

Abstract: We provide examples of exact saddle point solutions of complexified path integrals in quantum mechanics. These solutions correspond to instanton molecular contributions. We show that the molecular amplitudes can also be computed using complexfied collective coordinate integrals, which is a strategy that is easier to implement in quantum field theory.

10:45-11:30 Erich POPPITZ (University of Toronto)

Title: When instantons do “nothing”: the curious case of extended supersymmetry

Abstract: In semiclassically calculable QFTs, non-BPS field configurations — for example, various instanton-antiinstanton “molecules” — are responsible for determining the vacuum structure: the mass gap, confinement, and the realization of global symmetries. This observation alone should ignite one’s desire to better understand the proper ways to do higher-order semiclassical calculations; further motivation stems from the observed resurgent relations between perturbative and nonperturbative contributions to physical quantities. I will begin with a review of the QFT puzzles that led to the present study. Then, to benefit from a case where some exact results are known, I will focus on extended supersymmetric quantum mechanics. I will show that—when not using localization and supersymmetry—integration over complex paths in field space is required. This is seen to produce remarkable and intricate cancellations, without which no agreement of higher-order semiclassics with supersymmetry can ever occur. I will end by mentioning issues that are not well understood, intending to provoke a discussion of what, from my perspective, is the main question: can the quantum mechanics results, beautiful as they are, be bootstrapped to QFT?

Wednesday, 14/Dec/2016

9:30-10:15 Gerald DUNNE (University of Connecticut)

Title: On Perturbative/Non-perturbative Relations
Abstract: Resurgent analysis of various quantum mechanical systems has revealed a wide variety of relations between perturbative and non-perturbative sectors, even when there is supersymmetry. I present a unified geometric formulation of these relations, one class of which exhibits a close connection to aspects of number theory.

10:45-11:30 Gabriele Spada (International School for Advanced Studies (SISSA) in Trieste)

Title: Instantons from perturbation theory
Abstract: Using a geometrical approach based on Lefschetz thimbles I will show that the asymptotic series associated to a regular thimble is Borel resummable to the full result. Exploiting this property, one can define a perturbative series in quantum mechanics that leads to exact results without the need of non-perturbative effects.

I will show this explicitly in a number of examples which are known to contain contributions from instantons.

14:15-15:00 David SAUZIN (Pisa Scuola Normale Superiore/IMCCE-UMR 8028 du CNRS, Observatoire de Paris)

Title: On resurgence, normal forms and mould calculus
Abstract: Resurgent power series naturally appear when trying to normalize such an elementary differential equation as $x^2\,dy = (x+y)\,dx$, which is the simplest example of saddle-node singularity. I will discuss the formal classification of saddle-node singularities and illustrate on that case the use of Ecalle's resurgence theory and mould calculus. The latter is a powerful combinatorial tool which allows to deal with more complicated normal form problems.

16:00-16:45 Gökçe BAŞAR (University of Maryland)

Title: Going with the flow: a solution to your sign problems
Abstract: I will discuss a novel solution the sign problem which prevents first principle Monte-Carlo computations of quantum field theories at finite density as well as real time quantities such as transport coefficients. The solution is based on deforming the region of integration in the path integral into a complex manifold where the sign problem can be mitigated substantially. I will explain the new Monte-Carlo algorithm based on this idea and give examples of interacting quantum field theories (bosonic and fermionic) with nonzero chemical potential as well as real time dynamics where this method successfully solves the sign problem. This approach generalizes the "Lefschetz thimble" method that received much attention lately.

Thursday, 15/Dec/2016

9:30-10:15 Takashi AOKI (Kindai University)

Title: The Gauss hypergeometric function, the Kummer confluent hypergeometric function and WKB solutions

Abstract: The Gauss hypergeometric function ${}_2F_1$ (a, b, c; z) and the Kummer confluent hypergeometric function ${}_1F_1(a, c; z)$ are well known classical special functions. They are solutions of the Gauss hypergeometric differential equation and the Kummer confluent hypergeometric equation, respectively. We introduce a large parameter in the parameters contained in these equations as linear forms of the large parameter. Then we can construct exact WKB solutions of the equations. Taking the Borel sums of them, we obtain analytic solutions of the Gauss equation and the Kummer equation. Then the following natural question arises: What are the relations between those special functions and the Borel resummed WKB solutions? We will give an answer to this question.

10:45-11:30 Marco GUALTIERI (University of Toronto)

Title: Abelianization and Exact WKB

Abstract: I will describe a new way of understanding the key insight of the spectral networks programme, Abelianization, and how it relates to the approach of exact WKB analysis.

14:15-15:00 Pavel PUTROV (Institute for Advanced Study, Princeton)

Title: Resurgence in Chern-Simons theory

Abstract: In my talk I will consider resurgence properties of Chern-Simons theory on compact 3-manifolds. I will also describe what role resurgence plays in the problem of categorification of Chern-Simons theory, that is the problem of generalizing Khovanov homology of knots to compact 3-manifolds.

16:00-16:45 Tin SULEJMANPASIC (Philippe Meyer Institute, Ecole Normale Supérieure)

Title: A twist on quantum field theories: Global symmetries, volume independence and continuity

Abstract: I will discuss how twisted boundary conditions, i.e. boundary conditions which are perodic up to a twist by a global symmetry, can be used to better study the ground state properties of a theory. By special kind of twists the various members of the symmetry multiplets interfere with each other and cancel in the partition function and observables, leaving relevant only a limited subspace of the Hilbert space. For symmetry groups such as SU(N) and O(N), when the large N limit is taken, all excitations associated with the symmetry can be eliminated. I will explicitly demonstrate how this works for the CP(N-1) model. This realizes rigorously a version of the Eguchi-Kawai reduction. Further I will show that the 1+1D CP(N-1) model realizes continuity and smoothness for all sizes of the compact direction.

Friday, 16/Dec/2016

9:30-10:15 Takahiro Kawai and Yoshitsugu Takei (RIMS, Kyoto University)

Title: On virtual turning points--- an important ingredient of the WKB theory of higher order ODEs

Abstract :A virtual turning point is a point where two different singularities (precisely speaking, their projection to the base space) of the Boreltransform of a WKB solution collide, and it plays an essentiallyimportant role in the exact WKB analysis of higher order ordinarydifferential equations as well as of holonomic systems of differentialequations. It was first defined by Aoki-Kawai-Takei [1] (where a different terminology "new turning point" was used instead of "virtual turning point") to understand a new Stokes curve introduced by Berk-Nevins-Roberts [2] as a Stokes curve emanating from a virtual turning point. In this talk we discuss several topics related to recent developments of the theory of virtual turning points. The topics include a relationship between virtual turning points and the theory of simple singularities, parametric Stokes phenomena of WKB solutions associated with the Stokes tree type degeneration of the Stokes geometry, and so on.

References

[1] T. Aoki, T. Kawai and Y. Takei: New turning points in the exact WKB analysis for higher order ordinary differential equations, Analyse algebrique des perturbations singulieres. I, Hermann, 1994, pp.69-84.

[2] H.L, Berk, W.M. Nevins and K.V. Roberts: New Stokes' line in WKB theory, J. Math. Phys., 23(1982), 988-1002.

[3] N. Honda, T. Kawai and Y. Takei: Virtual Turning Points, SpringerBriefs in Mathematical Physics, Vol. 4, Springer-Verlag, 2015.

10:45-11:30 Tatsuhiro MISUMI (Akita University)

Title: Manifest Resurgence Structure in CPN models

Abstract:

We elucidate the full resurgence structure in CP^N-1 quantum mechanics reduced from 2D CP^N-1 sigma model. For our purpose, we complexify the variables and consider the trans-series composed of a perturbative series and non-perturbative contributions from real and complex solutions. The perturbative series of the ground state energy is calculated by use of Bender-Wu recursion relation and the associated Borel resummation is derived. The non-perturbative contribution is derived via Lefschetz thimble integrals associated with all the real and complex bion saddle points including multi-bion solutions. We first show that the imaginary ambiguities arising from these contributions cancel out. We then find out that the exact ground state energy calculated from the Schroedinger equation precisely agrees with the full trans-series composed of the perturbative and non-perturbative contributions. This is the first result in which the full resurgence structure in the trans-series including contributions of complexified saddle points is clarified at the quantum mechanical level.

14:15-15:00 Alexander Getmanenko (Universidad de los Andes)

Title: Microlocal properties of sheaves and complex WKB

Abstract: In a joint work with Tamarkin (published in Asterisque in 2013) we apply microlocal theory of sheaves in the style of Kashiwara and Schapira to prove analytic continuation of solutions of the Laplace-transformed Schrodinger equation.