

ESF Exploratory Workshop

Random Matrix Theory:

From fundamental physics to applications

2-6 May 2007, Krakow, Poland



Convened by:

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Executive Summary

The ESF Exploratory Workshop Random Matrix Theory: From fundamental physics to applications took place from the 2nd to the 6th of May 2007 in Krakow, in the Bobrzynski Conference Room in the Collegium Maius (<http://www3.uj.edu.pl/Muzeum/>), which is the oldest building of the Jagellonian University and its historical museum, located in the historical part of the city. The participants were accommodated in the Stanislaw Pigon Visiting Professors House (http://www.adm.uj.edu.pl/dg/bursa/index_en.htm) in a walking distance from the conference center. We used the opportunity that the conference was held in the historical building of the University to organize a special guided tour of our University Museum for the workshop participants.

The workshop hosted altogether 29 participants from 11 European countries. The participants took active part in presentations and discussions. There were 25 short talks followed by short discussions after each presentation. Half an hour was reserved for each talk including discussion but the discussions were continued during the coffee and lunch breaks and after the sessions as well as at the dinners. All the meals were held together. Every day we reserved 45 min slots for round-table discussions at the afternoon coffee break.

The scientific part of the meeting was preceded by a very informative presentation by Dr. Thibaut Lery, the European Science Foundation representative, who gave us a clear account of potential follow-up programs and activities organized and supported by the ESF. Dr. Lery took actively part in co-moderating the round table discussions. He was patiently and thoroughly answering all questions of the participants concerning the possible future activities.

There was one replacement in the program. Prof. Stefan Thurner could not come and in his place we invited his co-worker Dr. Christoly Biely who presented their common work. Dr. Giulio Biroli cancelled his participation. The final program is presented below.

The idea behind organizing the workshop is to encourage informal discussions and the exchange of expertise between scientists using random matrix theory in various areas of research ranging from fundamental physics: string theory, gravity, quantum chaos, information theory, complexity theory, combinatorics, to applied research: biophysics, econophysics, quantitative finance and telecommunication and to make a first step towards creating a common European environment for researchers using this powerful theory. We believe that this main goal of the meeting was achieved. Indeed already during the workshop there were many scientific discussions in smaller groups which either strengthened some older links, or more importantly, also those which aroused as completely new collaborations, some of which have already resulted in common publications (as for instance: arXiv:0706.3776 by Yan Fyodorov and Jean-Philippe Bouchaud), but also the round table discussions showed that the community is very much interested in constructing in the future a sort of common platform which would allow an intensive exchange of ideas in this important research field.

Scientific content of the event

The ESF exploratory workshop “Random matrix theory- from fundamental physics to applications” brought together a gathering of leading researchers in the field of random matrix models. The field is extremely varied due to the ubiquitous appearance of random matrices as a mathematical tool of modeling complex systems. The randomness in that description serves to represent on the one hand our incomplete knowledge of some dynamical system, on the other hand some inherent noise present in some other applications. The size of the matrix typically represents the complexity of the system and is taken to be very large. The mathematical theory of random matrices then serves to uncover universal phenomena in the behavior of the complex system, which do not depend on the very specific fine details of the complex system in question, universal phenomena, which would be extremely difficult to guess a-priori.

Because of the above-mentioned properties of the field, the varied structure of the domain is quite apparent. On the one hand there is a central core of mathematical theory of random matrices, which aims to provide calculational tools for studying various aspects of the behavior of random matrix ensembles. On the other hand there are various domains of applications, which use the mathematical techniques of the random matrix theory in the analysis of diverse physical systems, and the specific applications serve to define new physically interesting random matrix observable for which new calculational techniques have to be developed.

For the above reasons we have aimed, in organizing the meeting, to bring together leading researchers in the pure theory of random matrices as well as practitioners in various domains of applications. It must be mentioned that

such a distinction is quite fluid and many of the lecturers have moved back and forth between more theoretical and more applied research. The aim was to provide a stimulating opportunity for cross-fertilization of ideas between different domains, which could result in new collaborations or scientific projects.

Among the more theoretical topics present in the workshop were free random variables, a noncommutative version of probability theory which found application in nonhermitian models in the guise of a very effective quaternion formalism, communication theory, superbosonisation, Riemann-Hilbert methods for studying critical phenomena. A number of topics dealt with random matrix ensembles with power-law tails, the theory of which is especially interesting in view of applications to real life systems. Theoretical studies of constrained random matrix ensembles were also presented.

Among applications discussed during the workshop there were the more theoretical ones as the modeling of 2+1 dimensional quantum gravity, and explaining certain features of noncritical string theory using its matrix model formulation. There were also presentations of application of random matrix models to the study of chiral properties of quantum chromodynamics (QCD) which are interesting in view of lattice QCD calculations. Other discussed topics involved econophysics, communication theory and signal to noise optimization, spin glass motivated phenomena such as replica symmetry breaking, modeling of disordered bosons and finally models associated with random RNA folding problems in biophysics.

Assessment of the results, contribution to the future direction of the field, outcome

We believe that the wide range of topics covered in the course of the workshop together with the fact that the common thread of random matrix model theory connected all of them, produced a stimulating atmosphere for scientific exchanges between the participants. The workshop resulted in strengthening of old collaborations and in arising of new ones, so the idea of bringing together a broad spectrum of researchers using random matrix theory in different areas of research turned out to be very good. As we mentioned, during the conference some new scientific projects were initiated and they already resulted in common publication. Further papers will be presented in workshop proceedings which will be published as a special volume of Acta Physica Polonica B towards the end of the year.

In addition to mutual interactions, we had an intense discussion about a common strategy for the field. The round table discussions at the meeting, especially that one held at the last coffee break clearly showed the intention of the workshop participants to create a European platform of researchers which could serve as a forum for a further exchange of ideas and could facilitate intensification of contacts and building collaborations between researchers in this field. There were many visions of such a collaboration discussed at the workshop, including the idea of applying in the forthcoming call for proposals for the ESF Research Networking Program.

Final programme

May, the 2nd: Registration

May, the 3rd:

09.00-09.15 Opening

I. Session **chair: Jerzy Jurkiewicz**

09.15-09.45 **Thibaut Lery**

ESF-Representative

09.45-10.15 **Zdzislaw Burda**

From Wigner Matrices to Free Random Variables

10.15-10.45 **Oriol Bohigas**

Long tailed distributions and random matrices

10.45-11.15 **Coffee**

II. Session **chair: Oriol Bohigas**

11.15-11.45 **Jerzy Jurkiewicz**

Two-matrix ABAB model and 2+1 Lorentzian quantum gravity

11.45-12.15 **Gernot Akemann**

New Chiral Two-Matrix Model and its Solution

12.15-12.45 **Jan Ambjorn**

Matrix model D-branes

12.45-15.00 **Lunch**

III. Session **chair: Jan Ambjorn**

15.00-15.30 **Francois David**

Matrix-like field theories for random-RNA folding problems

15.30-16.00 **Hans-Jürgen Sommers**

Superbosonization

16.00-16.30 [Martin Zirnbauer](#)
Energy correlations of a random matrix model of disordered bosons

16.30-17.15 [Coffee + Discussion](#)

19.00 [Dinner](#)

May, the 4th:

I. Session [chair: Jean-Philippe Bouchaud](#)

09.00-09.30 [Stanislaw Drozd](#)
Empirics vs RMT in financial cross-correlations

09.30-10.00 [Fabrizio Lillo](#)
Hierarchically nested factor models

10.00-10.30 [Christoly Biely](#)
Random matrix ensembles of time lagged correlation matrices

10.30-11.00 [Coffee](#)

II. Session [chair: Yan Fyodorov](#)

11.00-11.30 [Hans Weidenmüller](#)
Constrained Gaussian Random-Matrix Ensembles

11.30-12.00 [Jac Verbaarschot](#)
Triage of the Sign Problem

12.00-12.30 [Boris Khoruzhenko](#)
Schur function expansions and matrix integrals

12.30-15.00 [Lunch](#)

III. Session **chair: Hans-Jürgen Sommers**

15.00-15.30 **Joshua Feinberg**

Generalized Calogero Models and their Collective Field Formulation

15.30-16.00 **Yan Fyodorov**

Replica Symmetry Breaking Condition Exposed by a Random Matrix Calculation (1)

16.00-16.30 **Ian Williams**

Replica Symmetry Breaking Condition Exposed by a Random Matrix Calculation (2)

16.30-17.15 **Coffee + Discussion**

19.00- **Dinner**

May, the 5th:

I. Session **chair: Hans Weidenmüller**

09.00-09.30 **Arno Kuijlaars**

Painleve equations and critical phenomena in unitary random matrix ensembles

09.30-10.00 **Satya Majumdar**

Large deviations of the maximum eigenvalue of a random matrix

10.00-10.30 **Pierpaolo Vivo**

Wishart Random Matrices: large deviations of the top eigenvalue

10.30-11.00 **Coffee**

II. Session chair: Jac Verbaarschot

11.00-11.30 Ralf Müller

Quadratic non-convex programming: A replica analysis

11.30-12.00 Maciej A. Nowak

Quaternion Green's functions for non-hermitian matrix models

12.00-12.30 Karol Zyczkowski

Random quantum states and quantum maps

12.30-15.00 Lunch

III. Session chair: Maciej A. Nowak

15.00-15.30 Jean-Philippe Bouchaud

On the top eigenvalue of heavy-tailed random matrices,
and related problems

15.30-16.00 Gabor Papp

Two-level system perturbed by noise: a Random Matrix Theory
Approach

16.00-16.45 Coffee + Discussion + Concluding remarks

19.00- Dinner

May, the 6th: Departure

Final list of participants

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Statistical information on participants

Sex:

Male	29
Female	0

Age (estimated):

20-30	4
30-40	5
40-50	10
50-60	7
60-70	3

Country:

Austria	1
Belgium	1
Denmark	2
France	6
Germany	4
Hungary	1
Israel	1
Italy	1
Norway	1
Poland	6
UK	5