SCIENTIFIC REPORT

Young European Probabilists meeting, School and Workshop on Random Polymers

1 Summary

The YEP meeting (8–9 January 2013) was the tenth in a series of yearly meetings organized at Eurandom, Eindhoven. This year, the meeting was followed by a School (10–12 January 2013) and a Workshop (14–18 January 2013), all on *random polymers*, forming a two-week program.

Random polymer models have attracted a lot of attention in the past two decades, especially from the mathematical point of view. They are efficient models to understand the geometric configurations adopted by biopolymers or synthetic polymers interacting with themselves and/or with their environment. An example is the (1+1)-dimensional random wetting model, which is used to study the relative position of the two strands in a DNA-molecule that are tied together by chemical bounds (*A-T* and *C-G* base pairs). These bonds have different strengths and appear more or less randomly along the DNA-molecule. Recently, major advances have been made in our understanding of this model. Among these is a deeper understanding of the influence of disorder on the location and the regularity of the denaturation transition.

The main purpose of the YEP and the School was to gather junior scientists, i.e., PhD-students and postdocs specialized in Probability Theory, Combinatorics and Statistical Physics, and allow them to meet each other and start discussions. Random polymers are particularly well suited for such a meeting, because the viewpoints and the mathematical tools used in these three disciplines are different, even though they aim to give answers to similar questions. For this reason, it is crucial for people from each field to be aware of what people from the other fields are doing. In this spirit, all participants had the opportunity to give a 30-minute talk. The average quality of the presentations was high. Moreover, 4 mini-courses were offered by senior specialists of random polymers, which allowed the PhD-students and postdocs to deepen their knowledge of the field.

The main purpose of the Workshop was to bring together leading specialists in the field and learn about the latest developments. A total of 27 specialised talks were given, attended by 45 participants.

2 Organisation

The two days of YEP were organized as follows. In the morning, a mini-course was given by A. Opoku (one and a half hour). The rest of the day consisted of 8 talks given by participants. A two-hour lunch break allowed junior researchers to discuss and work together before the afternoon session.

The three days of the School were organized as follows. Two mini-courses by S. Whittington and A. Rechnitzer were scheduled in the morning, and one mini-course by F. Caravenna in the afternoon (2 hours each).

The five days of the Workshop consisted of 27 specialized one-hour lectures about a variety of topics on random polymers.

3   Scientific content

3.1   Mini-courses

The first mini-course entitled *Entropy, Relative Entropy and more* was given by A. Opoku (Delft) and lasted for 3 hours. This mini-course was self-contained and very interesting, but was also a preparation for the second mini-course given by F. Caravenna during the School. After introducing the notions of entropy and relative entropy in the context of discrete-time random processes taking values in a countable set, the speaker stated and proved various entropic inequalities that turn out to be powerful tools to estimate the probability of certain events under Gibbsian probability laws. In the same vein, the speaker showed how the concepts of entropy and relative entropy can be used to apply large deviation theory to random sequences of words cut out from random sequences of letters according to a discrete-time renewal process. This "random word" framework recently allowed for a variational description of the free energy of random pinning and copolymer models.

The second mini-course entitled *Probabilistic aspects of polymers* was given by F. Caravenna (Milano-Bocca) and lasted for 6 hours. The aim of this course was to give an overview on random pinning and copolymer models, which have been studied intensively in the past few years. These two models are defined by perturbing the law of a simple random walk via a Hamiltonian associated with the trajectories of the random walk and with disorder attached to the polymer. For both models, the Hamiltonian is obtained by summing certain consecutive subsequences of the polymer-attached disorder, in the spirit of the "random words" scenario introduced in the first mini-course. A key feature of these models is that they undergo phase transitions: a small variation of external parameters, such as the temperature, can have a large effect on the global properties of the polymer, producing interesting localization phenomena. The speaker organized his mini-course around the "rare stretch" strategy, which consists in spotting some atypical subsequences of the polymer-attached disorder. Restricting the polymer to such atypical disorder sequences amounts to shifting the coupling parameters, and opens up new ways to study the polymer near criticality.

The third mini-course *Polymer models and self-avoiding walks* was given by S. Whittington (Toronto) and lasted for 6 hours. The speaker first showed how the different architectures adopted by bio-polymers or synthetic-polymers (linear, rings, branched) can be modeled by trajectories of random walks on regular lattices. He then focussed on self avoiding-walks and self-avoiding polygons on $\mathbb{Z}^d$, which are natural models for polymers and turn out to be very challenging to investigate. The speaker described several powerful techniques, like subadditive inequalities, unfolding operations and pattern theorems, and explained how these techniques can be applied in the context of polymer adsorption, polymers in confined geometries, and random knotting.

The fourth mini-course *Enumerative combinatorics and models of polymers* was given by Andrew Rechnitzer (British Columbia) and lasted for 6 hours. The speaker first presented

some enumerative combinatorical methods, based on generating function manipulations and Tauberian theorems, to estimate the cardinality of large sets of geometric objects. Then he applied these methods to study some homogeneous polymer models, especially adsorption, collapse and localization.

3.2 Participant talks

Short talks by the participants (15 in total) were given during the YEP meeting. The presentations fall into two subgroups: talks about polymer models themselves and talks about random walk in random environment (including random walk on random conductances).

Among the talks dedicated to polymer models, we mention the presentations given by Q. Berger (Los Angeles) and J. Poisat (Leiden) about the influence of a correlated disorder in the polymer pinning model. Their talks were linked to what F. Caravenna presented in the second mini-course, with the difference that the polymer-attached disorder had some time dependence. G.B. Nguyen (Nantes) showed how the free energy of a polymer collapse model can be expressed as a variational formula and N. Beaton (Melbourne) presented a model of polymer adsorption on a rotated honeycomb lattice.

Among the talks about random walk among random conductances, we mention the talks given by T. Wolff (Berlin), M. Salvi (Berlin) and M. Slowik (Berlin) dealing with annealed asymptotic occupation times, moments conditions for non-zero speed and invariance principle, respectively. The talks about random walk in random environment were given by L. Tournier (Paris 13) about the quenched and annealed fluctuations of such walks and by M. Ortgiese (Berlin) about intermittency in branching random walks in random environment.

Finally, A. Cipriani (Zürich) spoke about fluctuations near the limit shape of young diagrams under a conservative measure and M. Becker (Berlin) spoke about self-intersection local times of random walks.

3.3 Workshop talks

A total of 27 talks were given. Topics covered include: self-avoiding walks with self-attraction and with adsorption at an interface; DNA zipping and unzipping; knot theory; polymers with disorder; localization-delocalization transitions; random walk in dynamic random environment; random interfaces; KPZ-equation.

4 Conclusion

The YEP meeting and the School were an opportunity to bring together young researchers from all over the world, all of them at a very early stage of their career and interested and active in Statistical Mechanics. The mini-courses provided a detailed introduction into the most recent advances in the field and were an excellent preparation for the Workshop, which took place the week after at Eurandom and which many participants of the YEP meeting and the School attended. The inspiring atmosphere created by the YEP meeting and the School has stimulated interactions, not only between the young people, but also with more senior researchers. This allowed for an optimal circulation of ideas and techniques and led to new collaborations.

The Workshop brought together top specialists on random polymers to present and discuss latest developments, and offered the young researchers the opportunity to interact with them.

Organizers:

D. Erhard (Leiden), N. Pétrélis (Nantes): YEP and School.

F. den Hollander (Leiden), V. Sidoravicius (Rio de Janeiro), S. Whittington (Toronto): Workshop.