Laudation for Percy Deift for his Henri Poincaré Prize 2018

It is an honor and great pleasure for me to say a few words about Percy Deift's work on this occasion of his richly deserved Henri-Poincare Prize in Mathematical Physics.

After receiving his PHD in Applied Mathematics from Princeton University, Percy took a position at the Courant Institute, which except for a short period at the University of Pennsylvania, has been his professional home and where he is the Silver Professor of Mathematics.

I first met Percy in 1980 when he gave a colloquium at Stanford where I was a graduate student. He heard that I was from South Africa and he sought me out, and we (and later our families) have been close friends since. Percy did his undergraduate and Masters degrees at the University of Natal in Durban South Africa majoring in Mathematics, Physics and Chemical Engineering. I have no doubt that this early training had a very strong and positive influence on Percy's spectacular research. His work in Mathematical Physics offers rigorous proofs of fundamental phenomenon. It introduces novel mathematical tools and these have also led to major advances in Mathematical Analysis and in Probability theory. I believe that Percy's care for detail, precision, and the search for clarity has its roots in his exposure to engineering.

Rather than listing Percy's many striking accomplishments, let me concentrate on some of his most influential breakthroughs, ones that I have had the good fortune of witnessing as they unfolded.

1. Manakov, Its and others used the tool of factorization in Riemann-Hilbert type problems to address asymptotic analysis in inverse scattering and related nonlinear integrable pde's such as KDV. Inspired by this approach, Percy who had been working in the late 70's and 80's with great success on inverse scattering and KDV, was led with X. Zhou to develop a complete and rigorous mathematical theory via steepest descent to treat the asymptotics for oscillatory Riemann Hilbert problems. Their 1992 Annals paper developed novel techniques, removed various anzatses, and turned an art into a science (a user friendly one at that). Among the many novel ideas that they introduce is the identification of canonical deformations of the contours into a small list of critical configurations which yield model problems and which govern the asymptotics of the solutions. They proceed with a complete study of these model cases and expose the intrinsic integrable structures that are carried by various leading terms.

   The method of stationary phase and the complex analytic method of steepest descent were the main tools for asymptotic analysis that were developed in the 19^{th} century. For many purposes, especially early ones in mathematical physics, these culminated in the Wiener Hopf method which was decisive in many problems (there are nice anecdotes, best left for another venue, about Lev Landau and Onsager marveling at the power of this method). The Deift -Zhou "end of the 20^{th} century and now a 25 year old classic" matrix version of Wiener-Hopf steepest descent, has proven itself to be just as potent. It has led to the resolution of many long standing conjectures and not surprisingly Percy has been involved in many of these striking applications (all of which require further novel ideas).

2. Together with J. Baik and K. Johansson, they resolved the fluctuation exponent and scaling distribution of the longest increasing sub-sequence of a random permutation on n letters (as n going to infinity). The problem was raised by Ulam and the expected mean being asymptotic to $2\sqrt{n}$ was resolved by Vershik and Kerov after works of many people. The question of the variance (even the exponent) and corresponding fluctuation law proved to be much more difficult. B-D-J determine the variance exponent and corresponding distribution law which quite unexpectedly is the Tracy-Widom Law from Random Matrix Theory. Their breakthrough is one of the cornerstone theorems in the theory of random permutations.

3. Together with T. Kriecherbauer, K. McLaughlin and S. Venakedis, Deift exploits the observation (Fokas-Its -Kitaev) that one can formulate questions in asymptotics of orthogonal polynomials with respect to various weights on the line, in terms of solutions to oscillatory Riemann Hilbert problems and with the new technology this allowed them to resolve a number of central problems in the theory of orthogonal polynomials. Specifically uniform Plancherel-Rotach asymptotics as well local densities for the n-th polynomial (as n goes to infinity). The answers involve special functions on Riemann surfaces that naturally emerge from the Deift-Zhou method and their appearance indicates that their technique is probably indispensable (or at least intrinsic) for this study.

4. The results in (3) led to complete proofs of the Universality Conjectures of Mehta and Dyson for the 10 fold symmetry types of non-compact random matrix ensembles. That is for the local spacing distributions of the eigenvalues of matrices in ensembles which are invariant by the orthogonal group in the real symmetric case, and similarly for the other symmetry types.

5. The Szego limit theorems in the theory of Toeplitz matrices, and especially the strong Szego Limit theorem had a big impact in Mathematical Physics (for example in the work of Kaufmann and Onsager on critical phenomenon in the Ising problem). Versions of this theorem for symbols which have discontinuities in the study of Toeplitz and Hankel determinants have also proven to be of fundamental importance (Fisher-Hartwick singularities). There were many partial and even quite comprehensive results by H. Widom and T. Ehrhardt for example. In a major breakthrough A. Its, I. Krasovsky, and Deift give a complete treatment of this second limit theorem in full generality. Various other problems involving asymptotics of such determinants are also resolved in this paper. Suffice it to say that the Deift/Zhang method is one of the key ingredients in the analysis.

Deift has built fundamental theories and developed novel tools that he and his collaborators, as well others, have used to resolve many long standing conjectures. Coupled with his many other outstanding contributions to mathematics and physics, he is a most worthy winner of the Poincare Prize.

Peter Sarnak, July 2018