The IAMP Early Career Award 2021
Amol Aggarwal (Columbia University)

Laudatio

Delivered by Fabio Toninelli (TU Wien), at the ICMP 2021 (Geneva), August 2nd, 2021

It is a pleasure and a honor to introduce to you Amol Aggarwal, who receives today the 2021 IAMP Early Career Award. This prize was attributed to him *"for fundamental contributions to the asymptotic analysis of two-dimensional lattice models, including proving the universality of local correlations for dimer models, characterizing Gibbs measures and their current fluctuations for the stochastic six vertex model, and providing a rigorous framework for the tangent method of finding boundaries of frozen regions in planar ice models"*.

Amol Aggarwal's (born 1993) CV in a few lines:

- undergraduate studies at MIT
- In 2016, *AMS Morgan prize for Outstanding Research by an Undergraduate Student.* Even before starting his Phd thesis, Amol already had 4 articles published in leading combinatorics journals!
- Amol received his PhD in 2020 from Harvard University, where he was advised by Alexei Borodin (MIT).
- Just after that, in July 2020, he was appointed as a Clay Research Fellow for a term of five years and he is presently Assistant Professor at Columbia.

Amol's research lies largely in the area between probability theory and combinatorics known as "integrable probability", with strong connections with mathematical physics, in particular integrable systems and out-of-equilibrium statistical mechanics (interacting particle systems and stochastic growth processes).

Let me say a few words about just a few among his (numerous) ground-breaking achievements.

1. **Universality for lozenge tiling local statistics (2019).** This is perhaps my favorite among Amol's results, and it is very easy *to formulate*. The story starts with dimer models, or random tilings, in 2 dimensions. As was observed by Cohn, Larsen and Propp in '98, typical random tilings of large planar domains show phase separation between "frozen" and "rough" regions, separated by so-called frozen curves, or phase separation lines. Cohn-Kenyon-Propp in 2001 formulated the natural conjecture that the local behavior of such tiling models is always governed by translation invariant Gibbs measures. Over the years, partial progress was achieved via heavy analytic tools (orthogonal polynomials, asymptotics of Kasteleyn matrix) but only for very special domains (polygons of a certain type). In a real tour de force, Amol proves the conjecture for dimers on the hexagonal lattice *in arbitrary domains*. The proof of this claim is extremely multifaceted. It relies on deep results in the "exactly solvable" realm (integrable probability), borrows some general intuition from Erdös-Schlein-Yau-et al's approach to universality in random matrices and develops new regularity results in elliptic PDEs. From a personal perspective, I was also thrilled to see that methods I had previously developed with B. Laslier to study mixing properties of Glauber dynamics of tiling models played a role in this fascinating story!
2. **Arctic Boundaries of the Ice Model on Three-Bundle Domains (2018)** For the dimer model mentioned above, phase separation can be exhibited explicitly: frozen curves/limit shapes can be computed exactly because the model is determinantal and the surface tension is explicitly computed. Things become much more challenging as soon as models are not determinantal and

maybe the most well-known example is the so-called "six vertex model". For a square domain with domain wall boundary conditions, phase separation for this model at the "ice point" was predicted long ago by numerical simulations. A few years ago, physicists Colomo and Sportiello derived an equation for the frozen curve (which they predicted to be the union of explicit algebraic curves), using a non-rigorous approach they called the "tangent method". Amol was the first person to make the tangent method rigorous, for the square ice model in a family of domains that included the square with domain-wall boundary. Amol's idea was to apply a formalism of Gibbs line ensembles, developed previously in the context of random matrices and random growth models, to prove certain stochastic monotonicity for lattice paths arising in square ice.

3. Another amazing work is **Current Fluctuations of the Stationary ASEP and Six-Vertex Model (2016)** The Asymmetric Simple Exclusion Process (ASEP) in one dimension is a prototypical interacting particle system that has been studied in the last decades in hundreds of papers, both by physicists and by mathematicians. One of the key questions is its space-time fluctuation behavior at stationarity. In 1985, van Beijern, Kutner and Spohn predicted anomalous behavior of the stationary ASEP along its characteristic lines. They predicted the height function's fluctuation exponent, and a later work of Ferrari-Spohn in 2006 on a simpler model (known as TASEP) in the same KPZ universality class predicted the asymptotic (large-time) distribution. It is that distribution that Amol proved for the ASEP. He also proved a similar result for certain translation invariant Gibbs measures of the six vertex model – again one of the very few rigorous results known about fluctuations in this fundamental lattice model of Statistical Physics.

4. I'll also mention the work **Large Genus Asymptotics for Volumes of Strata of Abelian Differentials (2018)**. This is *very* far from my area of expertise, but what I gathered from experts is that Amol's proof of a conjecture of Eskin and Zorich, describing large genus asymptotics of the Masur-Veech volumes and the Siegel-Veech constants, is a major advance in geometric topology/dynamical systems.

Summarizing: just 5 years after *starting* his PhD thesis, Amol Aggarwal already emerges as one of the most promising mathematical physicists of his generation. He has single-handedly (all works mentioned above are authored by him alone!) solved several important conjectures in mathematical physics, integrable probability, combinatorics, and well beyond. I am simply amazed.

Congratulations Amol, and best wishes for a brilliant mathematical career!