Laudatio for Herbert Spohn

Laureate of the Henri Poincaré Prize 2015

It is a great pleasure and honour to give the laudatio for Herbert Spohn on his winning the Henri Poincaré prize "for his seminal contributions to the theory of transitions from microscopic to macroscopic physics, including his derivation of kinetic and diffusive behaviour from classical and quantum systems, and his work on the fluctuation behaviour of surface growth models."

Let me first start with a few short biographical notes on Herbert's career. He obtained his PhD in 1975 at LMU Munich under the direction of Süssmann. After this, he moved to Yeshiva University in New York as a postdoctoral researcher under the supervision of Joel Lebowitz. This was the beginning not only of a very successful and long-lived scientific collaboration, but also of a deep friendship. Two years later, Herbert moved to Princeton, but since Joel moved to Rutgers at about the same time, he would actually spend much of his time there, before moving back to Munich in 1978. There, he rose through the academic ranks, holding an associate professor position at LMU from 1982 and then being appointed to the Chair of Mathematical Physics at TU Munich in 1998.

The award of the Henri Poincaré prize is the latest in a string of honours which include an honorary degree from Paris Dauphine, a 1993 Max-Planck Research Award, the 2011 Leonard Eisenbud Prize for Mathematics and Physics, the 2011 Dannie Heineman Prize for Mathematical Physics, the 2011 Premio Caterina Tomassoni e Felice Pietro Chisesi Prize, as well as the 2014 Cantor Medal, the highest honour awarded by the German mathematical society. These biographical notes wouldn't be complete without mentioning another important encounter in Herbert's life which took place in 1971, when he met his wife Sian. Through her effervescent personality and warmth, Sian has since very much become part of the mathematical physics community.

One overarching theme of Herbert's research is the study of non-equilibrium statistical mechanics, where his contributions range from addressing fundamental questions like the derivation of macroscopic laws from microscopic dynamic all the way through to the precise study of some specific interesting models. This is an area where general principles are still quite few and far between, but in a joint work with Lebowitz, he obtained a rigorous mathematical justification, within a certain context, for the Gallavotti-Cohen fluctuation theorem, one of the very few general such principles. Another large body of work deals with the derivation of "hydrodynamic limits", where one seeks to derive laws for the macroscopic behaviour of systems from their microscopic description, often as a collection of interacting particles. In quite a different direction, Herbert has pioneered the derivation of kinetic limits from a "first principles" description of a particle either via a Hamiltonian system or by the Schrödinger equation, with its interaction with the surroundings modelled either by a random noise term or by a nonlinearity. Some of his early work in this area was nicely summarised in his influential 1980 review article, but this has remained an active line of research. For example, his recent contributions include an impressive work with Lukkarinen where they link a discretised version of the nonlinear Schrödinger equation to a linearised kinetic equation.

In recent years, a large fraction of Herbert's research has been dedicated to the study of interface fluctuation models, with some of his most spectacular results obtained in the realm of $1+1$-dimensional (1 space dimension and 1 time dimension) interface growth models. Instead of making a futile attempt to give an exhaustive overview of Herbert's many contributions to the field, let me now focus on one specific result which is emblematic of the body of work being distinguished with the Henri Poincaré prize. In a 2002 article, joint with Michael Prähofer, Herbert investigated the large-scale behaviour of the polynuclear growth model, one very specific interface growth model. This model can most concisely be described as follows: consider a Poisson point process μ on $\mathbf{R}^2$ with intensity twice Lebesgue measure and define a function $h\colon \mathbf{R}_+ \times \mathbf{R} \to \mathbf{N}$ by letting $h(t,x)$ be the largest number of events of μ that can be collected by a piecewise linear path connecting $(0,0)$ to (t,x) having all of its slopes in $[-1,1]$. (One could set $h(t,x) = 0$ for $|x| > t$ since these points cannot be reached by such a path.) A moment's thought shows that this indeed has some of the features one would expect from an interface growth model: it is increasing in t

In their beautiful article, Prähofer and Spohn show that if one defines $A_t(x)$ by

$$A_t(x) = t^{-1/3} h(t, xt^{2/3}) - 2t^{2/3} + x^2 \;,$$

then there exists a limiting stochastic process A_∞ as $t \to \infty$, which they call the Airy process. The Airy process is stationary, non-Gaussian, and has a description of its finite-dimensional marginals in terms of Fredholm determinants of some explicit integral operators. In particular, its fixed-time marginals are given by the Tracy-Widom distribution χ_2 governing the fluctuations of the largest eigenvalue of a GUE random matrix.

The importance of this result is that the Airy process is conjectured to be *universal*, namely it is expected to describe the large-scale fluctuations of *any* stochastic interface growth model, provided that the interface in question is curved. This was demonstrated in quite a spectacular fashion in recent experimental work by Takeuchi, Sano, Sasamoto and Spohn, where they measured the fluctuations of the interface between two turbulent states of a thin layer of liquid crystal. These were shown to be in perfect agreement not only with the $t^{1/3}$ fluctuations predicted by the above scaling, but also with the Tracy-Widom GUE distribution. It very rarely happens that such universal processes can be described explicitly: the most prominent example is of course Brownian motion, but there are very few non-Gaussian examples. (One notable exception is that of $2D$ models of statistical mechanics that exhibit conformal invariance in the scaling limit, but this is of course not the case here.) More recently, the appearance of the Airy process (and the construction of related processes corresponding to different initial conditions) was confirmed in a whole family of interface growth models exhibiting some form of integrability.

It is a pleasure to see that this area of mathematics is thriving and I am looking forward to many more new insights by Herbert. In the meantime however, I would like to offer him again my warmest congratulations for the 2015 Henri Poincaré Prize.

Martin Hairer, August 2015