Laudatio for Cedric Villani

It is a great pleasure to participate in this ceremony honoring some of our distinguished colleagues, both young and mature. The fact that these honorees are also good friends, indeed the mature ones very dear old friends, only adds to the pleasure of my task to give the laudatio for Cedric Villani. Cedric is not only young and brilliant he is also a prime example of the type of mathematician we want to join our fraternity of mathematical physicists. Here is an abbreviated c.v. taken from his web page.

Born October 5, 1973 in Brive-la-Gaillarde (France)
PhD Thesis (1998; advisor P.-L. Lions); Habilitation dissertation (2000)
Louis Armand Prize of the Academy of Sciences (2001)
Peccot-Vimont Prize and Cours Peccot of the Collège de France (2003)
Jacques Herbrand Prize of the Academy of Sciences (2007)
Prize of the European Mathematical Society (2008)
Director Institut Henri Poincaré, July 1, 2009
hobbies: walking, music (piano)

Cedric started his research with studies of the Boltzmann equation (BE), an equation first "derived" by Ludwig Boltzmann in 1873. More precisely, instead of derived I should say that it was "based" on a combination of deep physical insight and mathematical bravado. The equation describes the deterministic evolution of the smoothed or coarse grained empirical density in the six-dimensional space of position and velocity of an isolated, dilute, gas of particles. The dynamics are Newtonian with interactions idealized as succession of instantaneous binary collisions. It was and remains a paradigm of what mathematical-physics, at its best, can and should be. It is beautiful, challenging and it works. Cedric's devotion to the study of the solution of the BE and more recently to that of the related Landau/Vlasov equation are therefore in the best tradition of mathematical physics.

Examination of implications of the BE started with Boltzmann who first thought that his H-theorem provided a microscopic derivation of the second law of thermodynamics – at least for gases. Of course this roused a veritable storm of objections by those who noted that, if the equation is taken literally to apply to every initial microscopic configuration of an isolated system, it violated the fundamental reversible nature of Newtonian mechanics (and for that matter of quantum mechanics). Furthermore, if assumed to hold for all times, it also violates, for finite systems, the Poincare recurrence theorem. This led Boltzmann to clarify the meaning of his equation, as well as that of the second law, so that they are not only compatible with reversible microscopic laws but in fact can be expected to follow from them for "typical", macroscopic initial states. This is however not the aspect of the BE on which Cedric has worked so far. What he has done is followed in the traditions of Hilbert, Chapman Enskog, Grad, Cercignani, Di Perna Lions, and others and looked for solutions of the equation. He has significantly advanced this line of research by proving theorems giving precise quantitative estimates on solutions, particularly concerning the rate of approach to equilibrium: a difficult problem, especially when one deals with spatially inhomogeneous systems.

Rather, than trying to give a summary of Cedric's results which would go beyond my competence and time limits, I will quote from his own description of his work:
My research activity lies between analysis, probability theory, statistical physics and more recently

differential geometry, Here are some results:

- the first explicit estimates for convergence to equilibrium for very smooth solutions of the Boltzmann equation, without any a priori assumption of smallness of linearization.
- the discovery of tight links between certain concentration inequalities due to Talagrand, logarithmic Sobolev inequalities and the study of diffusion equations (in collaboration with Felix Otto).
- a synthetic definition of Ricci curvature lower bounds in measured metric spaces, the proof of stability of this definition, and its use to generalize to this setting various theorems of Riemannian geometry, thereby solving some open problems formulated by Gromov (works in collaboration with John Lott; closely related results have been independently obtained by Karl-Theodor Sturm).
- the discovery of a new geometric property of the tangent cut locus in Riemannian geometry: if the Ma–Trudinger–Wang curvature tensor is strictly positive, and in the absence of focalization, this cut locus is the boundary of a convex region. An outcome of this work was the proof that an almost round metric on the n-dimensional sphere has uniformly convex injectivity domains. This is part of a series of works by Alessio Figalli, Grégoire Loeper, Ludovic Rifford and myself.
- the first mathematical treatment of Landau damping in the nonlinear régime (with Clément Mouhot).

Let me conclude by noting the feat of Cedric's writing several books. One of them 1,000 pages long.

- A Review of Mathematical Topics in Collisional Kinetic Theory (230 pages)
- Topics in Optimal Transportation (360 pages)
- Optimal transport, old and new (1,000 pages)

This is amazing for a very young, very active scientist.

Congratulations Cedric and Bon Chance