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PIERRE VAN MOERBEKE: THE FIRST 60 YEARS

The university of Poitiers organized a conference on integrable systems in June 2004 to honor Pierre at the occasion of his sixtiest birthday. Among the participants, there was an overall consensus that the conference was a great success, due to the high scientific content of the lectures, delivered by the very best people in the field.

Secondly, the year-long help and support of my colleagues and co-organizers Hervé Sabourin and Rupert Yu, of our directors (chairmen) Abderrazak Bouaziz and Patrice Tauvel, and -last, but not least- of our secretaries Brigitte Brault and Valérie Chauchet, also contributed to the success of the conference and led to a climax during that week. Finally, this event would not have taken place without the financial help from the following sources:

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1. The early years

Pierre was born on October 1st, 1944 in Leuven (Louvain), an old university town in the heart of Belgium, near Brussels. At that time the city was liberated by British soldiers, who were patrolling the city for German snipers and strongholds. Medieval Leuven had already suffered from the successive bombings; then a new string of V2-attacks came in the early spring 1945 and destroyed other parts of the city. Post-war Belgium was politically agitated, but nevertheless the country's reconstruction started and the economy started flourishing and marked a new era for Belgium.

It is in this turbulent period that Pierre grew up, in a bilingual family, as the youngest of a family of five. The most interesting stories of what Pierre did during his infancy cannot be told here. What can be said will not come to a surprise to those who know Pierre: already at a very young age he had a strong curiosity in a wide range of scientific fields, he also loved the outdoors (sailing, hiking, skiing,...) and inherited from his parents a taste for fine arts, including music, theatre and visual arts. But it was his interest in applied sciences that attracted him to become an engineering student in his home town university, still a bilingual university in the 60's. Like many of us, who started out in a slightly different direction, he got along the way seduced by the beauty of mathematics, and finally got a degree in mathematics, in 1966. A research grant from the Belgian government gave him the possibility to prepare a PhD, first in Leuven, and later, starting in 1969, he became a graduate student at Rockefeller University (New York).

During those years, the late 60's, most European universities underwent major transformations; the old "Université Catholique de Louvain", founded in 1425 by Pope Martin V, was no exception! Additional political pressures led to a split of the bilingual university into a Flemish and a French part; the former stayed in the Flemish city of Leuven, while the latter settled on rolling hills, mostly wheat and sugar beet fields, some twenty kilometers from Leuven, and of course at the other side of the newly established linguistic frontier. A new city, *Louvain-la-Neuve*, was born!

2. From Brownian into soliton motion

In New York, Mark Kac and Henry McKean had a very profound influence on Pierre's mathematical career; Henry McKean became his advisor. Pierre's thesis dealt with the *rational pricing of stock warrants*, a problem initiated by Nobel laureate Paul Samuelson and put on a solid mathematical basis by Henry McKean in a widely noticed appendix to Samuelson's paper. A warrant is a contract conferring the right to purchase a common stock at a fixed unit price at any time prior to some expiration date. Taking the logarithmic Brownian motion as model for the stock prices, the optimal strategy is to buy the stock as soon as the current price exceeds a certain time dependent curve; the question is ultimately transformed into a *free boundary problem* for the heat equation and led to Pierre's first paper, which appeared in the Swedish Acta Mathematica.

A 1971 lecture by Ludwig Faddeev at Rockefeller University on the transformation of the Schrödinger equation to scattering data arose Pierre's interest in the Korteweg-de Vries equation. The Feynman-Kac formula for Brownian motion, which he learned from Mark Kac, in the context of the stochastic optimization problems, ought to be a generating function for the KdV invariants: that was Pierre's first paper in that new field, and some jointly with Mark Kac. Then together with Henry McKean, he linearized the periodic KdV equation in terms of Hill's equation, $\partial^2/\partial x^2 + q(x)$ on the circle, and hyperelliptic theta functions; geometrically speaking, KdV is a linear flow on Jacobians of hyperelliptic curves, whose branch points are the Floquet spectrum of Hill's equation. This is now known as the finite gap integration for the Korteweg-de Vries equation and was carried out almost at the same time by two other groups, in Leningrad (Its and Matveev) and Moscow (Dubrovin and Novikov).

Thus new objects as algebraic curves, Abelian varieties and theta functions appeared in the context of the Schrödinger operator and the Korteweg-de Vries equation. A very fruitful era of integrability emerged!

3. Classical mechanics and algebraic integrability

After having completed his thesis on optimization and in the middle of solving problems connected to the Korteweg-de Vries and Toda lattice equations, Pierre returned to Belgium, where he accepted in 1972 a professorship at the *Center for Operations Research and Econometrics (CORE)* of the University of Louvain. But restless as he was, his return was short, but just long enough to steal the heart of Bernadette Van der Schueren, whom he married in 1977, and to take her to Berkeley. Indeed, in the years after his thesis he occupied several positions, ranging from short term to permanent positions in centers, such as the Institute for Advanced Study (Princeton), Stanford University, Paris XI (Orsay) and the University of California (Berkeley).

During this period another interesting shift took place in Pierre's research. Since the Korteweg-de Vries equation has, on the one hand, all formal properties of a finite-dimensional integrable system, in the tradition of Euler, Jacobi, Hamilton, Liouville, Lagrange and Kowalevski, and, on the other hand, allows algebraic geometric solutions, which are obtained by the finite gap integration method, one naturally wonders whether this method could be applied to a finite-dimensional context. In a series of papers by himself and jointly with Mark Kac, he did this for the Toda lattice and related lattices; the latter is a finite-dimensional discretization of the Korteweg-de Vries equation. The deep connection between integrability and algebraic geometry, appearing at the horizon, gets a further boost when David Mumford and Pierre study, in a systematic way, the isospectral deformations of band matrices, generalizing the standard Toda lattice for tridiagonal matrices. They show how to linearize Lax equations with a spectral parameter on the Jacobian of the spectral curve.

Andrew Lenart and Franco Magri's discovery that the KdV equation has two compatible symplectic structures and Pierre's formulation of the symplectic structure for Toda led Mark Adler to show a deep and striking connection between Lie algebra splittings and integrability, a result which is now cristallized under the name of the Adler-Kostant-Symes Theorem; it applies to finite-dimensional and infinite-dimensional systems.

In the summer of 1978, Mark Adler and Pierre meet at Berkeley and exchange ideas while hiking in the Sierra; this was the beginning of a long-lasting scientific collaboration. Soon after their first encounter, they give birth to a twin paper, one of the most cited papers in the subject, where they introduce Kac-Moody Lie algebras into mechanics and explain their integrability, in terms of algebraic geometry, through Lax equations (with a spectral parameter). Almost all integrable examples from classical mechanics fit into this mold. Their results get amplified soon afterwards, when they reveal the geometric contents of Kowalevski's method, and introduce the notion of algebraic integrability; this sets the stage for a rich interaction between algebraic integrability, geometry and Lie theory. At the 1982 Warszaw International Congress of Mathematicians, postponed at the last minute to 1983, Pierre gives a lecture on integrability in the Lie algebra section. In 1988, he gets the Francqui prize, the highest scientific distinction in Belgium, from King Beaudouin. When Brandeis University came up with the idea of offering a part time position, besides his duties at Louvain-la-Neuve, Pierre chooses for this linear interpolation between his family life, teaching and research, with one foot in each continent.

4. Matrix integrals, the string equation, combinatorics and integrable lattices

An MIT lecture by Edward Witten in the early 90's on the connection between the topology of moduli space of curves and the KdV equation again stimulated Pierre's interest. The precise conjecture was established by Maxim Kontsevich and led to the famous Kontsevich integral, a matrix integral with a matrix Airy integrand. This conjecture states that the common solution to the Korteweg-de Vries equation and the string equation contains topological information on the moduli space $\mathcal{M}_{g,d}$ of genus g Riemann surfaces, with d marked points. The work of Kontsevich and Witten and much earlier work by Bessis, Itzykson and Zuber was the starting point for a new research direction on matrix models, orthogonal polynomials and integrable equations. Soon later, around 1994, an Oberwolfach lecture on random matrices by Craig Tracy again led to new horizons; Mark Adler and Pierre wrote a series of papers -some with Takahiro Shiota and some with Emil Horozov- on random matrices and the new underlying integrable lattices. Their approach, based on integrable equations and Virasoro constraints yielded PDE's for the distribution of the spectrum of the random matrices for various ensembles; it also led to PDE's for the transition probabilities of stochastic processes arising in the context of Dyson's Brownian motion, a dynamic version of random matrix theory, when the matrices get very large.

5. A personal note

I was introduced to Pierre in 1987 when I was a first year graduate student in the Flemish part of the "Université Catholique de Louvain". He walked in my office, gave me a three hour lecture on algebraic integrability and presented me with a list of interesting problems, some of which are still unsolved. Starting from that very first day he became a friend and felt like a collaborator, more than a supervisor. He engaged me in the most beautiful mathematics, gently slowing down to my pace, which made him stroll, while I still had to run. But mathematics is not the only thing I learned from Pierre, quite on the contrary. Between two spoons of mathematics he taught me human values, he shared with me his love and passion for the outdoors and fine arts, he was there when I needed any kind of help, throwing a flashlight to get me out of the dark. Happy 60th birthday Pierre and thanks, in the name of all your students, collaborators and friends for what you have given us.

October 1st, 2004

Pol Vanhaecke