Editorial

In Memoriam, Floris Takens 1940–2010

Many people will remember Takens for his 1971 paper *On the Nature of Turbulence*, jointly written with David Ruelle, which amongst other things introduced the term ‘strange attractor’. For others, Takens will always be associated with his work on time series initiated in his 1980 paper *Detecting strange attractors in turbulence*. Both of these results were hugely influential and had an impact far beyond mathematics, with over 1000 citations each. Colleagues, students and friends will remember his technical skill, his remarkable ingenuity and a truly impressive human being.

Floris Takens was born on the 12th November 1940 in Zaandam, 20 km north of Amsterdam. As a child he built radios and model airplanes, started playing the flute and also became interested in science. From his early years he developed a strong work ethic, focus and meticulous attention to detail. In 1959 he went to the University of Amsterdam, but after one year was drafted for 18 months into the compulsory military service. In later life Floris often remarked that ‘many would have benefited from a period in the army’, but also related many funny stories from this time. Soon after returning to his studies he finished his undergraduate degree and, in 1969, he completed his Ph.D. under the supervision of Nico Kuiper. His thesis *The minimal number of critical points of a function on a compact manifold and the Lusternik–Schnirelman category* was unusually short, was published in Inventiones Mathematicae even before his thesis defence, and – remarkably – cited regularly to this day.

Following his doctoral studies, Floris spent a year as guest researcher at the Institut des Hautes Études Scientifiques in Bures-sur-Évette near Paris (1969–1970). Here he met and was influenced by both René Thom and David Ruelle. It is also here that he met his contemporary, Jacob Palis, who obtained his Berkeley doctorate from Smale in 1968 and with whom he would develop a long-standing and extraordinarily successful collaboration. With Ruelle he wrote the paper *On the Nature of Turbulence*, published in 1971, in the journal Communications in Mathematical Physics [6]. This was a groundbreaking paper, in which they proposed an alternative to the established paradigm about the onset of turbulence in fluid motion. The classical theory, as developed by the leading physicists Landau and Lifschitz and the eminent mathematician Hopf, suggested that as fluid flows faster, it develops more and more ‘Fourier modes’. Contrary to this, Ruelle and Takens suggested that turbulence was fundamentally a low dimensional phenomenon, associated to what they called a ‘strange attractor’. This notion was later incorporated into the theory of chaos.

See also the article in “Nieuw Archief voor Wiskunde” [1] for some additional bibliographical background.

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In 1972, aged 31, Floris Takens became a full professor of mathematics at Groningen University. Takens’ chair was in the field of ‘Differential Topology, in particular Dynamical Systems’. The title of his chair is interesting in that the field ‘Dynamical Systems’ was described as a subfield of Topology and Geometry rather than as a branch of Analysis. Although Takens was an excellent analyst, his particular strength was his geometric intuition and a solid grounding in differential topology. Geometrical ideas had been introduced into Dynamical Systems research by the pioneering work of Poincaré, in particular in relation to celestial mechanics. In the 1960s and 1970s an enormous impetus was given in this direction by the input of the Fields medal winners Stephen Smale (University of California Berkeley) and René Thom (IHES) and their schools. Both had become famous through their work in differential topology. Smale and Thom shared an research programme to describe ‘typical systems’ rather than analyse solutions of specific equations. Their idea was that within the physical constraints of the system (e.g. conservation of energy), nature should be expected to evolve following ‘generic’ rules rather than according to some simple equations. This way of considering dynamical questions in geometric terms suited Floris extremely well.

Indeed, Floris’ work until the early 80s was focused around the themes of ‘structural stability, bifurcations and moduli’. The approach in this work is the setting of (almost) hyperbolic systems and bifurcations from simple to complex behaviour. One of his earlier papers during this period relates to a bifurcation analysis of two-parameter two-dimensional vector field, often now referred to as the ‘Bogdanov–Takens bifurcation’. In the mid 1970’s his collaboration with Jacob Palis began in earnest and Floris started becoming a guest researcher for several months each year at the beautifully situated Instituto de Matemática Pura e Aplicada in Rio de Janeiro (IMPA). Floris loved these visits and, having taken Portuguese lessons, became proficient in the language. Mathematicians at IMPA, local Ph.D. students and others who visited IMPA benefited hugely from his visits. Many of the papers he published during this period were jointly with Jacob Palis. In spite of the complicated technicalities of the papers, the underlying questions were simple: how can a system with simple dynamics evolve to one with complicated dynamics when one changes a parameter. Some of this work is described in the monograph [5] which he wrote jointly with Palis. Together with his work in time-series, Takens considered this monograph as his most important scientific contribution. The ideas he developed during this time is still at the heart of much current work, a great deal of which is presently undertaken under the heading of the ‘Palis conjecture’.
Around 1980 Floris Takens initiated a new direction. This work was triggered by a challenge by a famous British mathematician working in fluid mechanics, who suggested to him that his work with Ruelle had no empirical foundation. Of course this criticism was reasonable, as there were no experiments which could establish whether the Landau–Lifschitz–Hopf or the Ruelle–Takens explanation for turbulence was the correct one. True to style, Floris felt that he had to tackle this challenge head-on. Based on a classical theorem in Differential Topology, he proved a theorem and developed a methodology \cite{7} in which information can be obtained regarding characteristics of the dynamics, such as dimensions of attractors, entropy, Lyapounov exponents and so on. This information is extracted from observed time series in which the only underlying assumption is that it is generated by a stationary deterministic system, without requiring knowledge about the equations of motion. Experiments seem to vindicate the Ruelle–Takens explanation for turbulence. Since then many non-mathematicians\footnote{Google scholar indicates there are over 5000 citations to this work.} have applied and adapted what is currently known as the ‘Takens Reconstruction Theory’. His contributions to chemical process technology earned him an honorary doctorate at Delft University of Technology, an award in which he took considerable and justified pride.

Later on, towards the end of his life, Floris again became increasingly interested in Differential Topology and also in Classical Mechanics, rereading the Feynman lectures on physics. Specifically, one of his interests in the last decade of his life consisted of the geometry of torus bundles as these occur in integrable and nearly integrable Hamiltonian systems. This is an interesting area of research related to earlier work by Hans Duistermaat and Richard Cushman, having both classical and quantum-mechanical applications, among other things in theoretical chemistry. Here he could whole heartedly give free rein to his old passions for Differential Geometry and Algebraic Topology. A sketch of a Morse Theory of monodromy and Chern classes forms the basis of ongoing work. Also, together with Henk Broer, he wrote the advanced textbooks *Dynamical Systems and Chaos* and also the *Handbook of Dynamical Systems* vol. 3, see [3,2].
Floris Takens wrote over hundred papers, many of which remain influential to this day. His papers have been cited over 3000 times, not only by mathematicians and physicists but also by researchers from such wide ranging fields as chemistry, physiology and economics. His international reputation was phenomenal. He was a speaker at the International Congress of Mathematics in Berkeley in 1986. In 1991, he became a member of the Royal Netherlands Academy of Arts and Sciences (KNAW), while much earlier he had been made a member of the Brazilian Academy. In 2005, he was made a Ridder in de Orde van de Nederlandse Leeuw (Knight in the Order of the Netherlands Lion) by her Majesty Queen Beatrix of the Netherlands for his important contributions to the scientific life of the Netherlands and beyond. Floris’ reputation also resulted in him becoming editor of the Springer Lecture Notes in Mathematics in 1989, an honorable task which he continued to perform for a further decade after his retirement in 1999.

Floris attracted many Ph.D. students to Groningen, including Albert Hummel (1979), Henk Broer (1979), Gert Vegter (1983), Fopke Klok (1983), Jan Barkmeijer (1988), Cars Hommes (1991), Ale Jan Homburg (1993), Bernd Krauskopf (1995), Florian Wagener (1998) and Evgeny Verbitskiy (2000). Moreover he was co-advisor of Svetlana Borovkova (1998), Renato Vitolo (2003) and Olga Lukina (2008). Floris also supervised several Ph.D. students from other universities, including Freddy Dumortier (Limburgs Universitair Centrum, Belgium, 1973), Bert Jongen (Universiteit Twente, 1977) and Sebastian van Strien (Utrecht, 1982). His work on time-series analysis was highly influential and resulted in him co-supervising several Ph.D. students, namely Jan-Pieter Pijn, Pieter Been, Cees Diks and Marcel van der Heijden. Several of his former Ph.D. students in turn have created their own research groups.

Floris was a conscientious lecturer. He felt strongly that the department should offer a full range of courses. Often this resulted in him having an unusually large teaching load. One of the courses he introduced was the compulsory course Differentiaalrekening in $\mathbb{R}^n$. For many this course was demanding, and somewhat dreaded. However, he produced excellent notes and most students passed this course despite its challenges. Floris Takens regularly taught a large range of master’s courses, including Analysis on Manifolds, Differential Geometry, Differential and Algebraic Topology, and he held weekly seminars in his office. These dealt mostly with Dynamical Systems, but occasionally also Riemann Surfaces, Sheaf Theory, and many other subjects.

Although Floris certainly did not enjoy taking on administrative tasks and was no politician, he dutifully performed his share. From around 1990 he served for several years as chairman of the Maths Department. Also he served a term as chairman of the national Mathematics Research Institute, a research collaboration of the mathematic departments of the Universities of Nijmegen, Twente and Utrecht. Floris was one of the founders of the Dutch FOM/SWON programme Mathematical Physics and also acted as chairman for a period. Within the KNAW he was also involved in administration, including chair of the Mathematics Section. Floris Takens never shirked the demanding tasks that came his way. An example is the inter-university Teaching Assessment that took place in 2008 in both the Netherlands and Flanders. When the acting chairman Jacques van Lint suddenly passed away in medias res, he took over this responsibility.

For Floris Takens the discipline of mathematics was one organic entity, including its applications. This fitted well with his own career, in which both the ‘pure’ Differential Topology and the ‘applied’ Time Series Analysis coexisted in a brotherly fashion. In his papers, among other things, Analysis, Geometry (in many manifestations) and Measure Theory take their natural place. Furthermore he wrote code himself in computer languages such as Matlab and C++ when...
the need arose. For Floris, pure and applied mathematics could and should go hand in hand. Quoting from his interview with Bernd Krauskopf [4]:

In the beginning [of the field of dynamical systems] applications did not play a role at all. For example, Smale’s programme concerning structural stability was very much pure mathematics, as it was inspired by the wish to ‘classify’ all generic dynamical systems. Today the situation is very different with many areas of application. One reason for this development is that dynamical systems theory does give insight. But the real change came with the availability of numerical simulations. Without them there would be no, or only minimal, connections between dynamical systems theory and applications. In the analysis of concrete models theory plays a role, but the key is the close contact between theory and practical questions.

For him there was no pure or applied mathematics, just good mathematics. Without theoretical understanding there is no point of working on applications, but without applications pure mathematics could become too self-serving.

Floris also always fiercely resisted the constant threat of fragmentation of the mathematics curriculum. One of his ideals was that all professors would be able to teach all courses in the first three years of the curriculum (corresponding to the Bachelor curriculum). This never came to pass in Groningen, but certainly he taught a wide range of courses including Differential Topology, Dynamical Systems, Singularities of Functions, Riemann Surfaces, Classical Mechanics, Differential Geometry, Algebraic Topology, Characteristic Classes.

Unfortunately Floris was witness to the undeniable decline of scientific culture over the past 40 years, as demonstrated by the decline in educational standards. He became increasingly irritated by the overly strict attention to market principles in research and education rather than guidance by scientific quality. He felt that the university had become ‘a Ph.D. thesis factory’, often at the expense of scientific depth. Scientific curiosity became replaced by a search for funding in the name of science. These developments surely contributed to the fact that Floris Takens took early retirement at the age of 59. A fitting anecdote in this regard is Floris’s farewell lecture, where he discussed a report on the Monty Hall problem featured in the NRC newspaper some years previously. A series of articles and letters on the subject had been summarized by a journalist with the words: ‘Stop, stop, stop sending letters. The misunderstanding between common sense and the mathematicians is clearly unbridgeable’. Floris observed this contempt for mathematics as part of a broader trend, also within science. This tendency seems only to have grown stronger with time, and Floris acquiesced with a certain nostalgia.

Floris had a reputation for being a meticulous man with a strong sense of duty and consistently high standards. Although he was world-famous, he never acted as a prima donna. His sense of duty applied both to his daily practice of the flute, starting 7.00 am on the dot, as well as his precision in all matters at the department or elsewhere. He used to arrive at work with a Spartan punctuality every morning, whether or not he had partied long and hard the previous night. His attitude was a bit soldierly, stoically accepting one’s responsibilities and doing one’s duty without complaint. In return he could not bear tardiness in others. For example, advanced courses were often taught in his office, by students giving lectures on chapters of the material. Students who did not prepare well for this were made to suffer, usually in unorthodox ways: he and also some of the older students would start citing from the bible or from Tolkien or ‘grumble’ in the background. By nature he was not very patient, but he was willing to discuss mathematical problems for hours. Sometimes he lectured to very small groups of students, and provided they worked hard he did not seem to mind or worry that he was wasting his time.
It must be said that Floris was not always an easygoing person, for himself or for others. Floris was no politician or tactician and had strong beliefs and principles. At departmental meetings he would not try to form coalitions or do ‘deals’ and as a result he was not always effective. Although he liked tradition, he also was a non-conformist. He would wear jeans and sandals with socks throughout the year, sometimes even at formal occasions. During his earlier years at Groningen he was also incredibly proud to be often confused with the students.

Floris had an incredible sense of fun. You could hear him often laughing from the other end of a building. At night he would regularly go for dinner with a few friends. His sense of fun came to light in particular during conferences. Many of us remember numerous joyful open-air sessions in Rio de Janeiro and in Trieste, with a view on the Atlantico or the Adriatico and a table filled with empty bottles: eat, drink and be merry, while talking about life itself. By nature he was competitive, and during his earlier years had a reputation for being able to outdrink almost anybody.

In some senses Floris was very shy and small talk did not come easily to him. But in the evening, over dinner, his warm and generous personality would shine through. He would go out of his way to meet up with his friends and Ph.D. students. In order to attend Sebastian van Strien’s wedding Floris made an arduous journey by boat, changing train three times to arrive in a small village in a remote part of England. Going to a museum or on a walk in the mountains near Rio de Janeiro with him was also a real pleasure.

Over the last twenty years, Floris increasingly mellowed. This also had to do with the change in his personal circumstances, finding himself in calmer waters after his move to the village of Bedum. During this time, he also became increasingly close to his daughter Els.

For Floris, mathematics was embedded in a much larger scientific culture, in which Minnaert’s De Natuurkunde van ’t Vrije Veld, the Feynman Lectures on Physics, as well as Gravitation by Misner, Thorne and Wheeler, were never far from his desk. Apart from this, he was also very interested in painting and music. He owned a large collection of paintings and regularly visited museums and exhibitions. For music he could be seen cycling through all weathers around the province of Groningen to performances in Leens, Feerwerd, Thesinge or in the Groningen Oosterpoort.

He was also actively involved in performing music. Often he and Henk Broer would practise and perform flute sonatas by Händel and Bach, now and then relaxing with Mozart’s Andante for Flute in C or Gluck’s Dance of the Blessed Spirits, Floris playing the traverso and Henk accompanying him on a virginal. An integral part of these evenings were the conversations afterwards, obviously with a good glass of wine. Apart from small talk and (local) politics, he would get around to matters of philosophy and theology. Floris had a clear affinity with the ideas of Spinoza and he was somewhat inclined to a form of pantheism. His long bicycle trips through the flat countryside around Groningen with the far horizons and wonderful cloud formations and the amazing scenery in Rio clearly meant a lot to him.

Floris was diagnosed with cancer in 2009, decided how he wanted to spend his remaining days and died piecefully in 2010.

References

Henk Broer
Sebastian van Strien