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# In Memoriam

Our statistical mechanics community suffered a great loss with the death of Piet Kasteleyn. Piet was a product and outstanding member of the Dutch school of statistical mechanics. He made many beautiful contributions to our subject—some of which are briefly summarized in the obituary by Frank den Hollander, his last student. Frank also captures there a bit of Piet's personality—polite, cheerful, and solid as a rock. Every meeting I had with Piet was made highly pleasureable by his elegance and sincerity. There was never any posturing or concealment. When Piet said something, be it scientific or general, one could fully rely on it. His physical statements could be taken as essentially mathematical theorems and his mathematical theorems always had deep physical content.

While I never got to know Piet well, I always thought of him as one of the solid pillars of our community: setting an admirable example for all to emulate. We shall miss him greatly.

Joel L. Lebowitz
Editor



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# Pieter Willem Kasteleyn

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Piet Kasteleyn was born in Leiden and lived there all his life. Leiden houses the oldest Dutch university and is a small, picturesque town full of historic traditions to which Piet gave his heart.

After finishing high school in 1942, Piet briefly studied chemistry in Amsterdam. Leiden University had been closed down by the Germans after the famous Cleveringa protest on November 26, 1940. But in wartime Amsterdam there was little opportunity for organized study. Like many Dutch students, Piet refused to sign loyalty to the Germans. Three months later he switched to the school for chemical analysts in Leiden, where he got his diploma in 1944. After the war Leiden University reopened and he undertook the study of physics.

Piet soon came under the influence of H. A. Kramers, who tutored him and took him along to attend the first postwar IUPAP meeting in Florence in 1949. This event made a lasting impression on him. Piet graduated in 1951 and was employed by the Royal Shell Laboratories in Amsterdam, a position secured for him by Kramers. In 1952 he married Laantje Boer, whom he had met in 1943.

Shell allowed Piet to pursue his Ph.D. studies under Kramers. He worked on lattice models of ferro- and antiferromagnetism, partly in collaboration with J. van Kranendonk. After Kramers' death in 1952 he was supervised by L. J. Oosterhof and later by S. R. de Groot, under whom he defended his thesis in 1956.

After his Ph.D. studies, Piet continued his position as a research physicist with Shell in Amsterdam. He often said that these were interesting years; he had a lot of freedom to do theoretical work and at the same time enjoy the many facets of a large industrial company. Among the skills he developed at Shell were computer programming and public speaking. (Piet was to be an excellent lecturer throughout his life.)

While at Shell, Piet did his first major piece of research: he computed the entropy of a full covering of a two-dimensional planar lattice with *dimers*, i.e., diatomic molecules absorbed onto a crystal surface with close packing. The ingenious combinatorial method developed by him to tackle this problem, based on Pfaffians and discovered independently by Fisher and Temperley, forever bears his name. He was able to show how this method led to a solution of the nearest neighbor Ising model on the quadratic lattice that was an alternative to those of Onsager (1944), Kaufman (1949), and Kac and Ward (1952). In addition, he showed how Pfaffians can be used to count *self-avoiding walks* on the quadratic lattice with the so-called "Manhattan orientation." Both are outstanding contributions to the area of statistical mechanics and phase transitions. They stood at the beginning of a very fertile period in exactly solvable models, embodied by the work of Lieb, Baxter, Yang, and others.

In 1963 Piet was nominated Full Professor at the Lorentz Institute of Theoretical Physics in Leiden. His nomination was supported by several distinguished scientists, among whom was Elliott Montroll, with whom he shared a lifelong friendship and extensive correspondence.

The mid-1960s were a quiet period for Piet and he was able to devote himself completely to teaching, research, and the many activities Leiden University had to offer. During this period he developed his ideas about the relation between phase transitions in different models, which culminated in a series of papers with C. M. Fortuin in 1969–1972 introducing the *random-cluster model.*

The random-cluster model is a percolation model where each configuration is weighted with a factor $p^O(1-p)^V q^C$. Here, $O$ is the number of occupied sites, $V$ the number of vacant sites, $C$ the number of occupied clusters, while $p \in (0, 1)$ and $q \in (0, \infty)$ are parameters. For $q = 1$ the model is ordinary site percolation [with $p$ the density of occupied sites]. For $q = 2$ it is equivalent to the Ising model and for $q = 3, 4,...$ to the $q$-state Potts model [with $p = 1 - \exp(-2\beta J)$, where $\beta$ is the inverse temperature and $J$ is the pair potential]. This unified representation of different models—now known as the Fortuin–Kasteleyn representation—shows that the occurrence of spontaneous magnetization in the Ising and Potts models below a critical temperature is mathematically completely equivalent to the occurrence of percolation above a critical occupation density. Many other quantities have a similar translation, e.g., spin-correlation functions, susceptibility, etc.

This was a beautiful moment in the mathematical modeling of phase transitions. In recent years the Fortuin–Kasteleyn representation has turned out to be pivotal in the rigorous analysis of a number of interesting phenomena occurring in the Ising and Potts models. Examples are the Wulff shape of a large droplet of one phase inside another, discontinuity of the spontaneous magnetization at the critical temperature for one-dimensional long-range potentials, tunneling between phases under Glauber spin-flip dynamics, and Swendsen–Wang algorithms for simulating Gibbs states. The percolation language is a very powerful route for tackling these problems, and it allows a cross-fertilization between the different models.

The research on the random-cluster model led to a seminal paper with C. M. Fortuin and J. Ginibre in 1971, proving what is now called the *FKG inequality*. This is a correlation inequality for averages of monotone functions on certain partially ordered sets (like the set of spin configurations) under certain convex probability measures (such as Gibbs states with a ferromagnetic potential). The FKG inequality has become a standard tool for the mathematical physicist and has led to many extensions and complementary inequalities, notably the van den Berg–Kesten inequality in

1985. An American colleague was so pleased when he saw the FKG paper that he sent Piet a box with six bottles of champagne!

The year 1969 was full of university reforms. Piet spent months debating with students, colleagues and university officials, and fought hard to preserve the quality of education and research. He was not attracted by these administrative duties, but, being an efficient and organized person, he was often asked to lead the sessions. The mid-1970s brought more reforms and the weight on him increased.

From 1969 to 1973 Piet worked on the critical behavior of *extremely anisotropic Ising models* with C. A. W. Citteur. The aim of this work was to try and link the two-dimensional Ising model to the three-dimensional one when the interaction in the third direction is extremely weak. Unfortunately, this research had only limited success. Higher dimensional Ising models are still unsolved. From 1974 to 1978 he worked with R. J. Boel and J. Groeneveld on *spin correlation identities and inequalities* for Ising models on general graphs. This gave a deep analysis of higher order spin correlations and their mutual relations, later further explored by McCoy, Wu, Perk, and others.

Throughout the 1970s Piet studied various graph-theoretic problems and had an active correspondence with W. Tutte. He tried for many years to solve the four-color problem, to find himself and others outdone by the computer. But along the way he published a paper on *chromatic polynomials* with L. B. Richmond.

In 1979 Piet was elected a member of the Royal Netherlands Academy of Arts and Sciences. From 1981 to 1985 he acted as secretary of the Physics Section of the Academy. From 1978 to 1984 he was chairman of the Commission for Theoretical Physics of the Dutch National Physics Foundation. This he combined with several local duties at Leiden University, which absorbed much of his energy.

From 1980 to 1985 Piet worked on *random walks* with the undersigned. He raised the question: "How does a random walk see and encounter random inhomogeneities in a lattice?" This work has close connections with Mark Kac's theorem on the mean recurrence time in stationary stochastic processes and with the beautiful random walk models studied by Elliott Montroll. Some problems were directly inspired by an application to photosynthesis and the trapping of light excitations by chlorophyl reaction centers. Piet greatly enjoyed seeing some of the theoretical results corroborated by experiments carried out in the Leiden biophysics group.

In 1985 Piet took early retirement. But he continued to be an active member of the scientific community and a regular visitor of national seminars. It was now, however, that he found more time to devote himself to his hobbies: long walks, trips with his motor boat, bird-watching, and occasionally ice-skating. He also became an elder in the religious community, a facet of his life he rarely spoke about with colleagues.

When thinking of Piet one sees a Dutch version of an English gentleman: tall, sturdy pace, cap on his head, a bit formal, but always polite and cheerful. In research he was modest: "not the plenty is good, but the good is plenty." He was convinced that in the end only quality survives. A person of absolute integrity, he was always able to see the quality in other people's research and give them full support, no matter how tight the competition. He loved to show guests around the country. He was very sensitive to tradition and liked to tell about the history of the Lorentz Institute and the Kamerlingh Onnes Laboratory in Leiden. At all times he carried with him a little green booklet in which he had written down dates of important local events, for instance, a list of all the eminent physicists who held the yearly Lorentz Chair since 1954.

Piet was an impeccable speaker with a passion to reach out to his audience and give them a crystal clear exposition of what he wanted to explain. His love for elegance and detail was not a mere attitude, it was the very essence of his character. He was an inspiring teacher for his students. Being tutored by him meant having the good fortune of spending an apprenticeship full of enthusiasm and love for physics and mathematics. Writing a paper with him meant being subjected to an intellectual inquisition and seeing your self-created flower being unfolded, petal by petal, until you finally got to see what was inside. Hours were spent on polishing, but what a joy it was!

Piet died after an unexpected and short illness. Even in the face of death he was stronger than everyone around him and he tried to console his family and closest friends. Piet leaves behind his wife Laantje, their three sons, and their two grandchildren. For them he was the perfect companion. All who knew him will miss him dearly. With Piet a chapter of Dutch physics has closed. But his memory will continue to inspire us.

Frank den Hollander