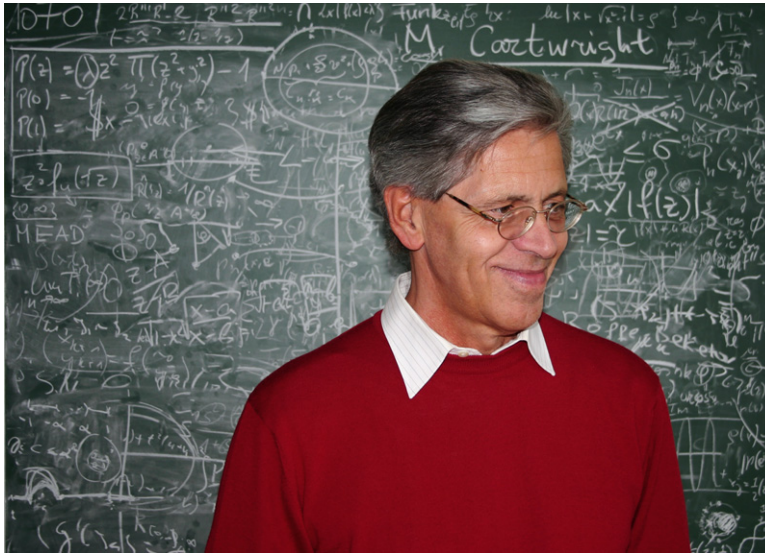


In memoriam

Franz Peherstorfer July 26, 1950–November 27, 2009



Franz Peherstorfer was born in Zwettl an der Rodl, a village near Linz, the provincial capital of Upper Austria.

After attending elementary and secondary schools in and around Linz, he matriculated in the newly founded Johannes Kepler Universität Linz<sup>1</sup> in 1970 where he obtained his university degrees, Masters (1975) and Ph.D.<sup>2</sup> (1977), both with *summa cum laude*. He was appointed as *Assistent* there in 1976. In 1982, Franz received his Habilitation; for his dissertation he was awarded a special prize of the Austrian Mathematical Society. Franz remained at Johannes Kepler University and served as Head of the Group for Dynamical Systems and Approximation Theory until his untimely death. During his tenure there, Franz had 6 Ph.D. students. He had a profound influence on their professional carriers; their reminiscences, see below, provide a vivid testimony of this. Franz was a kind and gentle man, his modesty and reserved manners kept him from

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<sup>1</sup> Until 1975, it was called “Hochschule für Sozial- und Wirtschaftswissenschaften”.

<sup>2</sup> His Ph.D. advisor was Paul Otto Runck.

the spotlight in the early years of his professional life, but soon his peers learned to appreciate and admire his powerful and deep understanding of orthogonal polynomials (OPs), numerical integration, and extremal problems of best approximation. Franz spent 8 months in 1986 at Texas A&M University in College Station, Texas, and 3 months in 1987 at Alfréd Rényi Institute of Mathematics<sup>3</sup> in Budapest, Hungary. He served as Associate Editor of *Journal of Approximation Theory*, *Computational Methods and Function Theory*, and *Kragujevac Journal of Mathematics*. Franz wrote more than 100 research papers, many of which became seminal. He was extremely active and prolific until his last days. The topics of his papers cover a number of immensely popular subjects, such as the general theory of OPs, interpolation theory, polynomial inequalities, trigonometric approximation, rational approximation, extremal polynomials in  $L^p$  spaces and their zeros, Gaussian and related quadrature formulas and their characterizations, Chebyshev polynomials and OPs on several intervals, linear combinations and perturbation theory of OPs, OPs on the unit circle and on arcs of the unit circle, OPs with respect to asymptotically periodic recursion coefficients, spectral theory of Jacobi matrices, complex dynamics, Toda lattices and integrable systems.

Franz died of lung cancer during chemotherapy in a hospital near Linz.

Franz is survived by his wife Heidi, who was his true companion of many years and whose love and support certainly contributed to Franz's brilliant professional carrier.

We hope that the following reminiscences, written by a few of his friends, colleagues, and former and present students will shed light to the true spirit and quality of this outstanding mathematician.<sup>4</sup>

### **Reminiscences of Franz Peherstorfer**

**Clemens Inninger** (*Kommunalkredit Austria AG, Vienna, Austria*)

I joined the team of Franz Peherstorfer as a student researcher and became one of his Ph.D. students later. I would like to say that working together with Franz Peherstorfer was a pleasure! He was very visionary and had an admirable intuition about unknown facts and connections between topics which had not been considered together before. He had a very broad knowledge of different fields of mathematics; he was always at hand with new points of view and tips for useful literature. Last but not least, Franz Peherstorfer was full of integrity, honesty, and correctness. He gave opportunities to us, his pupils, and was pleased with our progress and achievements. It was a deep pain for me to hear about his passing. Franz Peherstorfer was a great mathematician and a very likeable man.

**András Kroó** (*Alfréd Rényi Institute of Mathematics, Hungarian Academy of Sciences and Budapest University of Technology and Economics, Hungary*)

My last conversation with Franz Peherstorfer. . .

It has been 25 years since we met in College Station, Texas, both of us young visitors at the Center of Approximation Theory there. Kind intelligent eyes, mild reserved and slightly conservative manners, a characteristic ironic smile, and a shared passion for mathematics, these were my first impressions of you. . . And from the first days we were pretty much inseparable. Working together on campus during the day, playing tennis in the evening. I am still amazed that being an accomplished tennis player, you took up the burden of teaching the game to me, a total beginner at that time. Typical Franz, kind and patient. And after the tennis game we would sit

<sup>3</sup> At that time, it was called the Mathematical Institute of the Hungarian Academy of Sciences.

<sup>4</sup> This biographical sketch is based on information provided by James B. Cooper, Gerhard Larcher, and Peter Yuditskii.

down by the pool in the stuffy heat of the Texas night, have a few beers together, discuss politics and mathematics. This is how our first joint paper was conceived. (We proved that the roots of the  $L^p$  Chebyshev polynomials are interlaced between the roots of Chebyshev polynomials of the first and the second kind [14], and also conjectured the stronger strictly monotone nature of these roots. Later, we frequently returned to discussing this problem as it remained one of our favorites.) One night after you badly beat me again on the tennis court I asked you: Franz, how long will it take until I can win a tennis game against you? You answered, smiling: it might happen, András, when we both are in our eighties. And now even though I am still proud that I won my first set of tennis against you several years later while you visited Budapest, I wish your prediction had been correct, as I would much rather have waited until you were 80. . .

We stayed in touch ever since Texas, after all it's only 4 hours drive between Linz and Budapest. So more tennis games and new joint papers followed, it was so great to have you as a friend! I knew that whenever I headed west from Budapest, I had a place to stay in Linz, with warm hospitality and delicious dinners cooked by your lovely wife Heidi. . . I also always loved those hikes in the Alps that we took together; you were so fond of your mountains. . .

And even though with time our meetings became less frequent, I always knew that I had a friend in Linz. Do you remember years later we spoke once on the phone and I mentioned that I was going through difficult times? You came to see me in Budapest within a week. . . I still have very fond memories of this weekend together, your wise advice, warm support, and more joint papers followed as a result of this visit. On the last day, when I was taking you to the train station, you asked me to stop at a supermarket and show you the best Hungarian red wines. So we walked along the aisles and I picked out for you the best wine that Hungary has to offer. Then you paid and handed the whole sack to me, nice trick, Franz!

I still remember all too well that e-mail several months ago, it was purely professional business, but at the end you wrote that a private letter would follow soon. It sounded strange, I had a bad feeling about it. . . And next day I got the bad news about your illness. What a horrible shock. . . I felt like talking to you right away, but on the other hand I was also dreading this phone call. Then I called, my voice shaking, and I was astonished how calm and well balanced you were. . . I was trying to be upbeat, say something optimistic, but you replied: András, we are mathematicians, we are used to dealing with facts. . . I know that working was your real comfort and it was amazing how productive you were to the last day. . . Later we talked again, but I really wanted to see you. . . You said: wait until I feel better and get out of the hospital, but you never did. . . So no chance to see you for the last time, no more tennis, or math, or beers together. But I do feel very privileged that I had you for a friend for 25 years, for all those good times together, for having a chance to work together with you. Farewell, my friend. . .

### **Francisco (Paco) Marcellán** (*Universidad Carlos III de Madrid, Leganés, Spain*)

People in the orthogonal polynomial community were deeply shocked when they learned that our friend Franz Peherstorfer died after a short illness. I remember my last meeting with Franz in Leuven in July 2009 at the conference Orthogonal Polynomials, Special Functions, and Applications. Franz attended almost all editions of this event where we not only shared mathematics but many other wonderful moments around a table with food, wine, and beer. Franz was a gourmet and I liked to talk with him about new wines from Spain which he appreciated very much. In Leuven, according to Flemish traditions, we tasted very good beer with several of our old friends.

Before personally meeting him for the first time, I had already known Franz's work on numerical integration published in the eighties concerning not only Gaussian, but also

Gaussian–Kronrod quadrature and Stieltjes polynomials. He published 16 papers in this field, which attracted his attention throughout his scientific career.

First I met Franz in Granada in September of 1991<sup>5</sup> at the Seventh Spanish Symposium on Orthogonal Polynomials and Applications. There I mentioned him a problem suggested by J. Dehesa, A. Ronveaux, and myself concerning finite perturbations of orthogonal polynomials with respect to measures supported on the real line. He wrote a nice paper in *Journal of Computational and Applied Mathematics* in 1993 in which he answered our questions giving, under some constraints, the explicit expression of the measures associated with such perturbations. This approach is related to spectral rational transformations of Stieltjes functions which has attracted the interest of many people who based their works on this result by Franz.

Franz and Robert Steinbauer were invited to Universidad Carlos III de Madrid in June 1994 as speakers on a workshop on orthogonal polynomials on the unit circle together with Leonid Golinskii, who had been a co-worker of Franz for some time. We were impressed by the results of Franz and Robert on the analytic properties of orthogonal polynomials on the unit circle with asymptotically periodic reflection coefficients and on the spectral analysis of them. This was the subject of the doctoral dissertation of Robert and the starting point for the research group around Franz for a systematic study of orthogonal polynomials on the unit circle that has been highly recognized by our community. We started a very fruitful cooperation in the framework of a Joint Spanish–Austrian Bilateral Grant in the period 1994–1996 focusing our attention on orthogonality properties of linear combinations of orthogonal polynomials on the unit circle. I shared with Robert Steinbauer and Klaus Schiefermayr, Ph.D. students of Franz, nice moments in Linz and we even were able to find time to run with Robert through the wonderful pedestrian walks near the Donau river.

My visits in Linz allowed me to get to know more closely Franz and his wife Heidi. They opened their house for delicious dinners during which we often discussed holiday travels—one of their passions. I visited with them some nice places in Austria in their BMW car and, as a consequence, in 1996 I spent my summer holidays with my family in the western part of this country, as a complement to the visits in the East provided by Franz and Heidi. I convinced them to travel to the Canary Islands with beautiful landscape and wild nature to have a nice relaxed period and sunny weather. They visited some of the islands and appreciated to be in a quiet place without a lot of tourists.

My Ph.D. student Ana Foulquié and some Spanish colleagues spent some time in Linz enjoying the friendly atmosphere created by Franz in his research team, his excellent mathematical background and his Austrian–German approach to do mathematics. As a result they published joint papers with him.

Later I met Franz on several International Symposia on Orthogonal Polynomials and Special Functions as well as on other scientific events related to our field. In particular, I remember a meeting held in June of 2008 at Campos do Jordão, Brazil, organized by D.K. Dimitrov and A. Sri Ranga. This city has a German reminiscence and the hotel was a Bavarian style building where we spent five wonderful days. Heidi and Franz enjoyed very much this time despite the fact that the hotel was far from the city in a hilly area with no good transportation. Even though the scientific program was very intensive, we had time to visit some interesting places like the State Governor's house and a brewery where we tasted a delicious Brazilian beer brewed with a German flavor.

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<sup>5</sup> Unknown to Paco, they already met in June of 1989 in Columbus (added by the editors).

Franz published 100+ papers with more than 370 citations according to MathSciNet and 560+ citations in the Web of Science. His most cited manuscript is one of my favorites. It was published in *Constructive Approximation* in 1996 and deals with some special classes of orthogonal polynomials on the unit circle whose Carathéodory functions are related via a spectral rational transformation. This subject has been one of the focuses of my scientific interest during the last five years and this paper of Franz was used by two of my Ph.D. students as the starting point for their doctoral dissertations.

The mathematical heritage of Franz is very impressive. I learned a lot from him not only by reading his papers but also by listening to his precise presentations in meetings and seminars. We lost a good friend, but his mathematical work and his extraordinary humanity will remain with all of us.

**Ionela Moale** (*Johannes Kepler University, Linz, Austria*)

I met Franz Peherstorfer four years ago when I came to Linz to start my Ph.D. studies under his supervision. When he proposed the subject, approximation theory in several variables, he told me he had not worked before in several dimensions, but that it seemed very interesting and that we would learn about it together. It turned out to be a wonderful choice.

Franz Peherstorfer was a very good-hearted person, a talented mathematician, a gifted teacher, and an extremely responsible advisor, even during the time of the dreadful illness which took him away so soon. I feel privileged to have had him as an advisor and I am deeply grateful for the chance he gave me to work with him, for his constant guidance and support, for the enormous influence he has had on my life. He will always have a big place in my heart and I will cherish his memory forever.

**Paul Nevai** (*The Ohio State University, Columbus, Ohio, USA*)

Usually, I have a clear picture carved into my brain as to under what circumstances I met a person the first time, especially if this person eventually becomes a quintessential component of my existence. However, exceptions exist, and Franz is one of them.

No matter how hard I try, I can't recall when we first met but it is a fact that when he came to Columbus in June of 1989 for our NATO ASI,<sup>6</sup> then we have already known each other quite well. This was before the electronic age, so neither e-mail nor the web existed yet,<sup>7</sup> at least not for ordinary mortals with less than minimal new-age skills (I am referring to Franz here), so clearly we couldn't have been in frequent touch then. Nevertheless, we hugged each other as old friends, and the friendship lasted for several days until Vilmos Totik and Franz teamed up and creamed Tamás Erdélyi and me in a couple of tennis matches.

Eventually, I learned to deal with the fact that Franz was a superior tennis player (and so were Tamás and Vilmos as well), that is, I quit tennis for good, and from then on our friendship blossomed until September 16, 2009, when the very last e-mail came from Franz and after which he was no longer able to continue the vibrant life he and his wife, Heidi, have pursued together for so many<sup>8</sup> but not enough years.

I believe I first paid attention to Franz when he published a paper on positive quadratures [4],<sup>9</sup> although 2 years prior to that he had already a paper in JAT [2].

<sup>6</sup> NATO Advanced Study Institute on Orthogonal Polynomials and Their Applications.

<sup>7</sup> Alphonse Magnus and I exchanged e-mails and chatted through the ethernetless ether already back in the middle 1980s.

<sup>8</sup> 30+ years.

<sup>9</sup> The numbers in the brackets refer to Franz's publication list.

In [4] Franz characterized all quadrature formulas based on  $n$  nodes that have positive weights and are exact for polynomials of degree at most  $2n - 1 - m$ , where  $0 \leq m \leq n$ ; a wonderful result. Such quadrature formulas exist if and only if there is a polynomial with certain properties that involve both the quadrature points and the orthogonal polynomials associated with the quadrature formula; cf. [Theorem 2, p. 938].

Based on this paper, with the wisdom of hindsight, one could have easily predicted Franz's future. Let me summarize it. Franz is one of the most original, one of the deepest, one of the widest,<sup>10</sup> one of the least appreciated, one of the most isolated, one of the least understood, and one of the least recognized approximators of the last 30 years.

Please allow me not to make my point by comparing Franz to other approximators; this is an obituary after all. Instead, let me refer to Franz's tendencies to write things in a rather complicated way that made it difficult for other people to understand his ideas. In addition, Franz's English, both spoken and written, was somewhat user unfriendly. Case in point: "Since the  $qf$  is a positive  $(2n - 1 - m, n, w)$   $qf$ " [4, p. 936, line 1].

Other approximators of Franz's caliber were constantly on the move: plenary speakers here, principal lecturers there, distinguished visitors over there, editors of and credit takers for conference proceedings, and so forth. Although Franz's CV refers to 9 plenary talks and lectures at international conferences and workshops, I don't recall any occasion when he was the celebrated center of attention and attraction which he would have undoubtedly deserved.<sup>11</sup>

I usually think of myself as having excellent intuition in orthogonal polynomials. As I recall, it happened only twice that my intuition led me astray. One of them happened with a marvellous<sup>12</sup> series of papers by Franz and Robert Steinbauer where they studied orthogonal polynomials on several arcs arising from polynomial mappings; see [43, 44, 46, 50, 61].<sup>13</sup> Franz and Robert claimed that some asymptotics took place when a certain sequence was of bounded variation, see [61, formula (1.5), p. 97], whereas I insisted that additional conditions are required involving the imaginary parts. The more they claimed they were right, the less I believed them. In the end, natürlich, they turned out to be correct and I was the one left with a red face.

The last time I met Franz<sup>14</sup> was in the Brazilian city of Varna,<sup>15</sup> aka Campos do Jordão, in June of 2008. Franz and Heidi provided plenty of entertainment for the rest of us since they forgot to pay attention to a minor detail, namely, that *this* Varna is located in the Southern Hemisphere, and, therefore, what seems to be Summer, is, in fact, Winter. Hence, to our never ending amusement, they both were constantly complaining about the cold. For the record, those of us who came fully prepared for Winter weather, were equally freezing because the Brazilians are not familiar with the concept of closed doors and windows, and that of heated indoor facilities during daytime.

Franz and I sat next to each other during most of the talks; see Fig. 1. We happened to sit right under a large air conditioner unit that made Franz even less comfortable and he kept whining even though it was not turned on, and even after we found out that, in fact, it *was* a (non-functioning) heat pump.

<sup>10</sup> I am referring to his mathematical breadth and not his waist.

<sup>11</sup> Private conversation with some of the biggest stars in approximation theory confirm my assessment.

<sup>12</sup> Following Mourad Ismail's footsteps, I borrow Dick Askey's favorite expression here that he plagiarized from Billy Crystal.

<sup>13</sup> The other failure I am referring to involved heated arguments with Jeff Geronimo in 1976–1977 that lasted over a year. In the end, Jeff won by invoking Gelfand's theorem on Banach algebras.

<sup>14</sup> Ditto about Borislav Bojanov who died at the age of 64 in his sleep on April 8, 2009.

<sup>15</sup> It was Dimitar Dimitrov who accomplished this seemingly impossible geographic magic.





Fig. 1. Brrr....

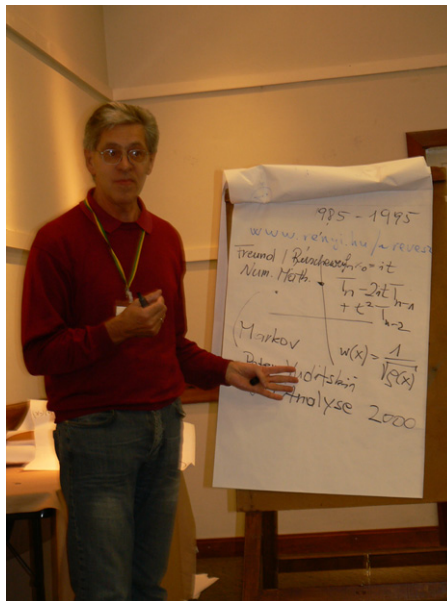


Fig. 2. Zolotarev....

I will never forget Franz’s spontaneous lecture at the informal problem session about extremal properties of polynomials; see Fig. 2. With no substantial preparation whatsoever, he lucidly explained to the audience, consisting of both regular college students and established researchers, what the Zolotarev problem is, and what issues are worth studying.

I must admit I made fun of Franz on several occasions. As I pointed out in my BAMS review of Barry Simon’s OPUC, Franz’s webpage, still operational as of February 24, 2010, [www.dynamics-approx.jku.at/peherstorfer/](http://www.dynamics-approx.jku.at/peherstorfer/)<sup>16</sup> lists *wine* as his *hobby*. We also learn from this

<sup>16</sup> Download its snapshot from <http://math.nevai.us/AT/2.pdf>.

webpage, that his full title was *A. Univ.-Prof. Dipl.-Ing. Dr.* which is a little more complicated than the usual titles we have here in North America, that is,  $\emptyset$ . If one knows the Austrian academic system, which is almost identical to the German one, then one understands that even his own university did not elevate Franz to the professorial rank that he so richly would have deserved.<sup>17</sup>

I frequently helped out Franz with English. In return, he always sprinkled his e-mails with German expressions so that I would get a chance to learn a few of them such as *Ich wünsche dir*<sup>18</sup> *ein schönes Wochenende* that I regularly use in e-mails with our German approximators many of whom might get shocked that I address them with *Dir* (thee) as opposed to *Sie* (you).

Franz knew how to relax. For instance, under normal circumstances, he read no e-mail on weekends and never during his regular yearly vacations when Heidi and he used to disappear from public view. This was probably the secret to his seemingly unlimited energy and his extraordinarily disciplined working habits. He practiced what most of the rest of us only preach but never actually put into action.

One spectacular (and heartbreaking) example of how Franz operated happened just about a month and a half before the beginning of the end, late July and early August of 2009. My dear friend Sergey Khrushchev wrote a paper for JAT's Lorentz volumes<sup>19</sup> that had connections to [46] and [64] by Franz and Robert. To make the long story short, on the one hand, it was crucial to explain to the readers what the connections were, but on the other hand we weren't sure what was the most efficient way to proceed. In the end, Sergey and I decided that the best way to handle the situation was to toss the ball to Franz and ask him to compare the papers. Sergey even suggested that Franz write a survey paper on the subject. As it happened, Franz was busy with exams. Nevertheless, he readily agreed to the former even though he knew he had less than 10 days to accomplish to job. Indeed, within days, Franz e-mailed me the initial draft on August 6, and then by August 14, revision #4 was ready for acceptance; it appeared together with Sergey's paper; see [101]. Next day, on August 15, Franz wrote me *I missed your last two e-mails from yesterday, because yesterday late afternoon we went for one day to the countryside. I was really exhausted. The last two weeks I was working 12 to 14 hours daily, studying Sergey's paper, reading the papers of Robert and mine, writing the note, . . . and holding examinations. It is too much at my age!* In retrospect, we know what was going on inside Franz's body.

On September 16, 2009, Franz wrote me about his inoperable lung cancer. He added, *Doctors say that the time when I can do mathematics will be very limited, weekly as well as concerns the future. (Nevertheless my wish is to finish several papers which are almost ready — 85%. We will see).*

As it turned out, time was running out fast and Franz was no longer able to do math anymore. The subsequent intensive chemotherapy sucked away all his energies, and it was up to his student Ionela Moale and his colleague, collaborator, and friend, Peter Yuditskii to finish some of his manuscripts.

Coming back to Franz's e-mail, he finished with *es grüßt Dich ganz herzlich a very depressed Franz.*

I immediately responded by telling Franz a lot of things that normally are left untold and suppressed. . . *I will tell you now a fact that I never mentioned to you since I didn't want to*

<sup>17</sup> *A. Univ.-Prof.* means *Außerordentlicher Universitätsprofessor* ( $\approx$  Associate Professor). In order to really understand what this means, I recommend to copy/paste the appropriate paragraph at <http://de.wikipedia.org/wiki/Professur#Au.C3.9Ferdentliche.Universit.C3.A4tsprofessoren> to, say, <http://translate.google.com>.

<sup>18</sup> I always wondered if “dir” should be capitalized.

<sup>19</sup> *Rational compacts and exposed quadratic irrationalities*, JAT **159** (2009), 243–289.



embarrass you by praising you in front of your eyes. I told several times to my colleagues that you are the most underrated OPs guy on Earth. You are of the very same class as X, Y, Z, and W. I consider the five of you to be way above the rest of us. Your depth and your breadth are astonishing. . . I have no idea why the international OPs community has not recognized you as much as the other 4. Maybe because your English is not as good. Maybe because you are too deep and use a lot of stuff that are not standard in OPs (e.g., elliptic functions). . . With you, I knew you were a genius around 1995, but, initially, I failed to promote you as much as X/Y/Z. However, in the past 5 years or so I very explicitly put you in this top group.

The same day, in a follow-up e-mail, Franz's last words to me were *Mein lieber Freund Paul, thanks for all written at 12:56:48 GMT on Wednesday, September 16, 2009.*

Let me turn it back to you, mein lieber Freund Franz, ich danke Dir für alles.

**Klaus Schiefermayr** (*School of Engineering and Environmental Sciences, Upper Austria University of Applied Sciences, Wels, Austria*) and **Robert Steinbauer** (*Consulting and Innovations Management, CYBERhouse GmbH, Austria*)

It is with great sorrow that we mark the passing of our doctoral advisor, a great scientist, and certainly one of the best mathematicians that the Johannes Kepler University Linz has ever produced, Franz Peherstorfer, who passed away on November 27, 2009. Although our doctoral degrees and collaborations with Franz ended some time ago, it was a huge shock for all of us to learn of his severe illness followed shortly thereafter by his death. Stunned, we stood by the coffin of our great teacher, who introduced us to the theories of classical approximation theory, complex function theory, orthogonal polynomials, dynamical systems and chaos theory. For his broad understanding of mathematics, his consolidated knowledge above and beyond his area of specialization, his tenacious sense of accuracy – often felt by his Ph.D. students – and his flair for mathematical correlations, for all of this he will always be remembered. Franz Peherstorfer was a man who exemplified mathematical research and his enthusiasm for the discovery of new principles and correlations he kept right up until the end. “Mathematics was his life” — rarely has this sentence applied to anyone as much as to Franz Peherstorfer. Everybody who knew him felt the enthusiasm he shared for mathematics. He was fascinated by the wondrous and elegant correlations between different mathematical fields. Franz was always on the hunt for the toughest mathematical problems to crack. And once he had really sunk his teeth into a challenge, there was no way back for him. With admirable persistence, combined with his extraordinary intuition and vast experience, he would not give up until the problem had been solved. Franz was a great visionary who was always committed to passing his inspirational work and mathematical perspective on to his students and colleagues. His irrepressible drive for research and discovery is something from which his co-workers benefited immensely, and despite his enormous workload, he was always accessible for his colleagues and always had an open ear for their problems. In Franz, we have lost not only a great mathematician, but also an extremely valuable and endearing person.

**Barry Simon** (*California Institute of Technology, Pasadena, California, USA*)

While spectral theorists and workers in OPs have long been studying the same objects, there was little contact between the communities until the early years of this century. One of my personal pleasures of the first blooming of this contact was my learning of the work of some of the major figures of OPs. It was in connection with my books on OPUC that I discovered and came to admire the work of Franz Peherstorfer.

The main goal of my OPUC books was to carry over the ideas of spectral theory to that arena. I quickly realized that some of the major spectral theory tools, most notably coefficient stripping,

had been already discovered and profoundly understood by Franz. It was in the study of the periodic case that Franz's contributions really shone. I learned an enormous amount from trying to cope with his papers written from what was for me a fresh and sometimes difficult point of view.

By focusing on the OPUC case, it took longer for me to appreciate what is Franz's most beautiful work that was on aspects of OPRL. There is a basic paper with Yuditskii on Szegő asymptotics with only a Blaschke condition that overlapped my work with Killip. It was an important element of the follow-up that Zlatoš, Damanik, and I did on this subject. Most importantly, there was Franz's work with Yuditskii on Fuchsian groups and OPs for finite gap sets. I regard these papers and the earlier motivating papers of Sodin–Yuditskii as among the deepest and most significant papers in orthogonal polynomials in the past twenty-five years.

My interactions with Franz were invariably pleasant and he was always exceedingly polite. He was a great mathematician and a wonderful person. I shall miss him.

**Christoph Stroh** (*Magna Powertrain, Engineering Center Steyr, Austria*)

I got to know Franz Peherstorfer right from the beginning of my studies of Technical Mathematics at the Johannes Kepler University in Linz. He gave the main Calculus lectures in the first two semesters, and it was a clear and interesting lecture. A year later he asked me if I could write a script for him, which I did, so we kept in contact. Not long after that he asked me if I would like to join his department as a student researcher (student assistant). What an honor! But since I wanted to have enough time to finish my regular studies in time, I shared this student researcher position with my colleague, Clemens Inninger. The interesting point, however, was that our studies were not in Franz's main fields of research (approximation theory, orthogonal polynomials, etc.), but in a field which was also new to him. We investigated chaos, fractals, and dynamics. In particular we investigated the complex iteration theory, i.e., Julia and Mandelbrot sets. It was a very nice time at his department, Franz was always available for discussions and helped if we needed help. Also the warm atmosphere at the department gave a solid base for research work with high motivation. Working together with Franz, Clemens, Robert, and Klaus was very enjoyable. This research work led to my diploma thesis "Julia Sets of Complex Polynomials and Their Implementation on the Computer", which was finished in 1997. For me it was clear that I wanted to go for a Ph.D. Although I had a job offer from another institute, I decided to stay at Franz's department. We managed to acquire two research projects funded by the Austrian Science Fund (FWF). So in the next three years we took a much closer look at the complex iteration theory, and in particular we extended our research from polynomials to general rational functions. Franz also managed to establish a link to Chebyshev polynomials, leading to interesting investigations of Mandelbrot-like sets of Chebyshev families. We could also establish various criteria regarding the connectedness of Julia sets of rational functions. All this led to papers and to my Ph.D. thesis which I could finish in 2000.

Although I left university in late 2000, I met Franz several times, and I enjoyed every meeting with him. It was a shock to me when I heard the sad news about his passing. A brilliant researcher and in particular a valuable human left us.

**Vilmos Totik** (*University of Szeged, Szeged, Hungary, and University of South Florida, Tampa, Florida, USA*)

Around 1998 Franz Peherstorfer asked me a question that profoundly influenced my mathematical interest during the following decade. Franz was interested in sets

$$E = \bigcup_{j=1}^k [a_{2j-1}, a_{2j}] \quad (1)$$

consisting of finitely many disjoint closed intervals with the following special property: there is a polynomial (called  $T$ -polynomial)  $T_n(x) = x^n + \dots$  of some degree  $n$  such that there are  $n + 2k$  points  $y \in E$  (called extremal points) with the property  $|T_n(y)| = \|T_n\|_E$  (call such sets  $T$ -sets). Then it automatically follows that all endpoints are extremal points, furthermore  $T_n$  has an  $n + 1$ -point alternation set on  $E$ , and hence it is the  $n$ th Chebyshev polynomial of  $E$ . His interest in these sets originated from the fact that such sets share many properties of intervals. He proved that if  $n$  is the smallest degree for which such a  $T_n$  exists, then all other  $N$ 's for which such a  $T_N$  exists are of the form  $N = kn, k = 1, 2, \dots$  and  $T_N = c_N T_k(d_N T_n)$  with some appropriate constants  $c_N, d_N$ , where  $T_k$  is the classical Chebyshev polynomial (on  $[-1, 1]$ ) of degree  $k$ . A set (1) is a  $T$ -set precisely if  $E$  is the inverse image of  $[-1, 1]$  under a polynomial, i.e. if and only if there is a polynomial  $P$  such that  $E = \{x : P(x) \in [-1, 1]\}$ . With  $H(x) = \prod_{j=1}^{2k} (x - a_k)$  another characterization is that the Pell-type equation

$$P_n^2(x) - H(x)Q_{n-k}^2(x) = \text{const} \neq 0$$

is solvable in polynomials  $P_n$  and  $Q_{n-k}$ . Another characterization is that the equilibrium measure of  $E$  has a rational mass on every interval  $[a_{2j-1}, a_{2j}]$ . Furthermore, if these rational numbers are of the form  $b_j/n$ , then for this particular  $n$  there is a  $T$ -polynomial  $T_n$  of degree  $n$  such that  $T_n$  has  $b_j + 1$  extremal points on  $[a_{2j-1}, a_{2j}]$ .

Franz had many papers on  $T$ -sets<sup>20</sup> and developed the theory of orthogonal polynomials on them (on these sets there are measures for which the orthogonal polynomials have periodic recurrence coefficients; and for many other measures the recurrence coefficients are almost periodic). His question to me was if  $T$ -sets are dense among sets consisting of finitely many intervals, i.e. if for an arbitrary  $E$  in (1) and for arbitrary  $\varepsilon > 0$  there is a  $T$ -set  $E'$  consisting of the same number of intervals such that  $|a_j - a'_j| < \varepsilon$ . I solved this problem via an analysis of the equilibrium measure; simultaneously Franz also solved it using a continuous variation technique, and the same density result was proved at the same time by A. B. Bogatyrev using function theory. Eventually, from this density theorem a powerful technique emerged: go from an interval to finitely many intervals (more precisely, to a  $T$ -set) by a polynomial-inverse map, then approximate sets consisting of finitely many intervals by  $T$ -sets and finally approximate arbitrary compact subsets of  $\mathbb{R}$  by sets consisting of finitely many intervals. This polynomial-inverse image method has worked in various situations and it is the only general technique that allows proving interval results for more general sets (more precisely, it transforms them from an interval to general sets). In a way, Franz' problem led me and others to this technique and to several of its consequences.

Franz's work was very deep and pioneering, he should have received much more recognition for his accomplishments. His standards were high, he was extremely well informed about his research area. I often consulted with him about various ideas and results and, as editors, we frequently discussed papers submitted for publications. I loved his reserved personality and always enjoyed his company. His premature departure is a big loss for all of us.

**Peter Yuditskii** (*Johannes Kepler University, Linz, Austria*)

If you can imagine a modem with the capacity of 13 bits per second, you would understand that my family phone back in Ukraine then was busy for about two hours receiving an invitation from the Austrian professor Franz Peherstorfer to join his research project in 1998. By that time, his close collaborator Robert Steinbauer had left to work in the Czech Republic, and a substitute

<sup>20</sup> For a good account, see [68] in his publication list.

was required urgently (as far as I know, Franz knew of our joint “report” with Misha Sodin in St. Petersburg Mathematical Journal, 1993). Naturally, it took more than half a year to get Austrian visas in Ukraine for my family and myself, but, finally, in March 1999, we arrived in Linz. Our collaboration during that year was quite successful, and we published two papers: Asymptotics of orthonormal polynomials in the presence of a denumerable set of mass points and Asymptotic behavior of polynomials orthonormal on a homogeneous set (the latter was honored by AMS Featured Review). We must have liked Franz, his nice town and its vicinity (Salzkammergut) so much that after 3 years of work at Michigan State University (where we were staying by invitation of Sasha Volberg), we decided to go back to Franz, to wait there for the offer from Israel. Franz was extremely kind to me and my family, so that when we eventually left Israel for family reasons he again gave us place and bread. He also put an immense amount of effort into helping me get Austrian citizenship, for which I am very thankful.

Franz taught me how to put references in the right order so that our proposal would go to the right referee, and his report would allow me to obtain the Marie Curie fellowship in which he was the Scientist-in-charge (the project had several components related to asymptotics of orthogonal polynomials, iteration theory, integrable systems, at all of which Franz was a highly recognized expert). We repeated this in a few subsequent FWF research projects.

I apologize for my seemingly light-hearted tone... On the one hand, Franz was a very easy-going person. On the other hand, we find ourselves so dejected by the loss that it is in any case impossible to find the right words to describe our feelings. Any words seem too light-hearted, anyway. Franz was an extremely hard worker. In the last year of his life, even while he was combating his illness, he wrote an impressive amount of research papers. His determination to get results is a great example to us all.

In his last call, he was worried about citizenship for my wife...

Franz was much more to me than a fellow mathematician. For years, he was my only friend in Austria. He did not only offer his friendship to me and kindness and attention to my family, but also helped us to obtain a second home, our home country.

Franz will stay in the memory of me and my family forever. It is with great sorrow that we mourn his passing.

### List of Ph.D. students of Franz Peherstorfer

1. *Clemens Inninger*
2. *Ionela Moale*
3. *Klaus Schiefermayr*
4. *Werner Schwyhla*
5. *Robert Steinbauer*
6. *Christoph Stroh*

### List of Publications of Franz Peherstorfer

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