

## Stories about Friedhelm Waldhausen

by members of the algebraic topology community

Friedhelm Waldhausen passed away on November 21, 2024. The following are thoughts and stories about Waldhausen that were shared by members of the alg-top email list.

### **Stefan Schwede, 11.29.24, 7:00am CST**

Dear all,

As Stefan Bauer already mentioned, Friedhelm Waldhausen passed away on November 21; I would like to share some memories about him. I will not go into his ground breaking mathematical contributions to 3-manifold topology and algebraic  $K$ -theory, but rather stay more on the personal side.

I was Waldhausen's student during the first half of the 1990s, and he supervised both my diploma and PhD thesis. In those days, Bielefeld University had an amazing student-to-faculty ratio; in particular, advanced classes were intimate and intense. I attended all of Waldhausen's topology classes, from pointset topology to spectra. After each term, some students dropped out, and in the final class, there were only two of us left. As long as we students were OK with it, Waldhausen ignored holidays and breaks between terms, and continued to teach regardless. And only when the other student quit, there would not be any further classes. During the 1990s, Bielefeld hosted the SFB 343 "Discrete structures in mathematics", a large collaborative grant funded by the DFG (German science foundation). Waldhausen was the center of the topology part of it, and many prominent topologists visited Bielefeld.

Most who knew Friedhelm Waldhausen will probably agree that he was a character. Here are some anecdotes as illustration; I'd be happy to see others contribute more. From the 1990s until he left his Bielefeld house earlier this year, his answering machine would simply say "Dies ist der Anschluss der soeben von ihnen gewählten Nummer." (roughly: "This is the number you have just dialed.") Whenever we had a speaker from outside Germany in the topology seminar, Waldhausen would open the talk by him cleaning the blackboard the proper German way, with sponge and squeegee. The squeegees were just a bit too short to completely wipe away the water in three turns, so he would use four turns, explicitly advising the speaker to do likewise and "not to try to be clever". Almost inevitably, the speaker would be sloppy and only give it three turns, leaving water drops behind. Then Waldhausen would comment, with some satisfaction: "I told you not to try to be clever."

Waldhausen was opposed to any kind of personality cult. When Rainer Vogt and I organized a workshop in Bielefeld in February 1999 on the occasion of Waldhausen's 60th birthday, we were obliged not to mention the occasion in the communication; speakers were forbidden to pay homage to him.

Waldhausen was one of the first people who already in the 1980s strongly advocated what we now call "higher algebra", i.e., algebra over ring spectra; he introduced the term "brave new algebra", emphasizing that it references Shakespeare's, not Huxley's, "brave new world". There were no infinity categories back then, but he and others rigorously dealt with these objects already half a century ago.

Friedhelm Waldhausen was always very supportive of me, an inspiring teacher, and a very hospitable person. I have fond memories of many social evenings that he and his wife Traute hosted at Poetenweg 66, with open fire barbecues and exquisite red wine from his cellar.

**Tom Goodwillie, 11.29.24, 10:19am CST**

Dear all,

Like Stefan Schwede, I would like to share some personal memories of Waldhausen. I, too, am very grateful to have had him in my life. His generosity as a mentor was all of a piece with his generosity as a host.

As a student, around 1978, I had heard about his early work on algebraic  $K$ -theory, and I had also heard a few stories about him as a person. I had the good fortune to meet him in the summer of 1981, at an algebraic topology conference at the University of Western Ontario. I believe that even in those days he did not travel much, so this was very lucky for me. It was also my first international conference.

Kiyoshi Igusa introduced me to Friedhelm. He took an interest in my work (I was having early glimmerings of some kind of functor calculus that summer) and invited me, before the week was over, to attend an upcoming Oberwolfach week and to go on from there to Bielefeld for a visit. That was to be the first of a number of visits to Bielefeld, mostly in the 1980's.

It was the first of two times when I stayed in the Gartenhaus at 66 Poetenweg. This was a little building with two tiny rooms, basically a storage shed. One room was filled with junk, and the other held a small deliciously soft bed as well as some further junk. In those days it served as a bedroom for visiting mathematicians. I understood from Kiyoshi that he himself had lived in the garden house one summer, as had Dan Grayson before him — I don't know who else. I felt that I had become a part of a distinguished lineage.

One slept in the Gartenhaus and spent one's days in the house or at the university. I have happy memories of mathematical conversations, but also of meals with the family, and spending evenings (in the summer of 1982, it must have been) watching World Cup games on TV while drinking red wine from Yugoslavia.

I once witnessed a heated dispute between Friedhelm and Traute about methods of driving moisture out of the Gartenhaus. His argument was based on the laws of thermodynamics, and hers was based on common sense.

I first learned of Friedhelm's devotion to garlic during that week in London, Ontario. As I recall, a bunch of us wandered into town one day when there were no talks. When we stopped for a quick lunch, Waldhausen asked for garlic pizza. They said that that was not on the menu, but he was ready; he had bought some garlic at a farmer's market along the way, and he pulled it out of his pocket and handed it across the counter to put on his pie. I later learned that in Bielefeld, in his favorite restaurant, if he wanted extra garlic in a dish, he had only to say "mit Verstaerkung" ("with reinforcement") with a knowing look, and they would get the message.

I want to mention his serious relationship with music, too. He used to play the piano every day, and he regretted that he had not learned to play as a child. At first there was an upright piano, and later a grand that he adored. Eventually during one of my visits he discovered that I enjoyed singing, and that I was able to read both German and musical notation just well enough to hack my way through some of his favorite Schubert songs. That was a lot of fun.

Getting back to his qualities as a mentor, I want to share a memory from when I first met Stefan

Schwede, some time in the 1990's. We were at Oberwolfach, and Stefan gave a beautifully clear talk about some research he had done as a student. When it was over Friedhelm turned to me, beaming with pride, ready for me to share in his admiration (which I was).

I would like to say one more thing about his relationship with chalkboards. Besides his insistence on the squeegee method, I recall that when one was talking with him in his office one was generally encouraged not to use the chalkboard at all. That was partly in order to cut down on the amount of chalk dust in the room, but it was also in order to encourage economy of thought: try not to get bogged down in notation. Keep the ideas simple if you can.

### **Ralph Cohen, 11.29.24, 2:44pm CST**

I was very saddened to hear of Friedhelm Waldhausen's passing. Of course Waldhausen's influence on Algebraic and Low Dimensional Topology was huge. Others will probably talk about that. But I would like to share a memory of how Waldhausen's intuition went beyond mathematics.

In 1989 there was an emphasis year in Algebraic Topology at MSRI. The organizers all very much wanted Waldhausen to participate by coming to Berkeley for an extended stay. We contacted him, and at first he was hesitant because he was concerned that he would not be able to practice piano during his stay. The director of MSRI at the time, Irving Kaplansky, who was also a pianist, assured us that there would be a piano for Waldhausen to play. When we told Waldhausen this, he was quite thankful, but then said he had a fear of earthquakes, and was worried about the possibility of one happening during his visit. We told him that of course we couldn't guarantee there would not be an earthquake, but we said that the probability of that happening was quite small. Nonetheless, Waldhausen politely turned down our invitation, and did not come to MSRI for the program that year.

Well, Waldhausen's intuition was correct! In October of 1989, the San Francisco Bay Area suffered its worst earthquake in more than 80 years! While MSRI was not damaged, The San Francisco -Oakland Bay Bridge, which one can see from the common room window at MSRI, collapsed. We should have never questioned Waldhausen's intuition!

### **John Klein, 11.29.24, 2:44pm CST**

Waldhausen had a lasting impact on me—both personally and professionally.

I first met him at Oberwolfach in 1985 at a meeting on Cyclic Homology (it was a new subject then) when I was a graduate student. Waldhausen and I ended up as partners in a Doppelkopf game. The other team consisted of my advisor, Kiyoshi Igusa, and Tom Goodwillie. However, I don't think Friedhelm took much, if any, notice of me except when I played the wrong card.

I subsequently moved to Germany in 1990 as an assistant of Ulrich Koschorke at the University of Siegen. It did not go well in Siegen for a variety of reasons.

In the Spring of '91 I was awarded a Humboldt Fellowship which in theory would allow me to go elsewhere. In the Summer of '91, Igusa was visiting Waldhausen in Bielefeld and my name was mentioned. Waldhausen invited me to give a talk in August. I asked Kiyoshi what to expect—He said that

Waldhausen did not tolerate fools well and he did not shake hands.

That caused quite a bit of anxiety.

I made the trip to Bielefeld, and I recall having to find Poetenweg 66 by traipsing through the woods as it was getting dark. All sweaty, I finally found the house. I heard scales on a piano being played from inside. I rang the bell. Waldhausen came to the door and I introduced myself.

He motioned me in and offered me red wine. He said that he could regrettably not join me at the moment since he had two hobbies:

- (i) piano playing, and
- (ii) red wine drinking.

He maintained that the order of performing these hobbies mattered greatly.

I slept in the Gartenhaus (as many others, more illustrious than I, have done). I woke up smelling of burnt wood.

I gave my talk the next day and immediately afterwards he offered to have me come to Bielefeld in January 1992. I moved into the basement apartment at his house. When my Humboldt Fellowship ended in May 1993, he provided me with a postdoctoral (C1 position) which I held until 1998.

I learned a great deal about mathematics from Friedhelm and even though I was out of touch with him for quite a while, I have thought of him often.

### **Henning Krause, 11.29.24, 6:25pm CST**

Dear topologists,

Let me add a few words as an algebraist, who got as a postdoc in Bielefeld at some stage interested in homotopy theory. It was in the 1990s when one went to the library to learn a new subject. So I did this, but often finding out that the books I was interested in were taken out by Waldhausen. This meant there were at his home (not his office!) and I needed to contact him. That was my first interaction with him, and he was always friendly. In fact, he was then happy to answer my naive questions and patiently listened to my ideas, sitting in his office with eyes closed, so blackboard or paper were not accepted. At that time I learned a lot from him and the group of people around him (like Stefan and John who wrote already before), in particular through memorable working seminars. I am not sure how much Waldhausen's daughter Maja learned from sitting in my representation theory course, though I do remember her whisky expertise. Over the last years, Waldhausen came rarely to the department. The last time I met Waldhausen was already a somewhat sad occasion. Shortly before Andrew Ranicki passed away, he visited Bielefeld and his intention was to see Waldhausen one last time. So we went together to his house and Andrew was happy to enjoy the particular hospitality at Poetenweg 66.

**Teimuraz Pirashvili, 11.30.24, 6:51am CST**

Dear All,

It is very difficult for me to talk about Friedhelm in the past tense. Altogether, the time I spent in Bielefeld adds up to a few years. That period was the most productive in my career as a mathematician.

It all began in 1989, when I sent him one of my papers that had been published in Georgia, together with a translation. I was very surprised when I received an official invitation to the University of Bielefeld one month later. At that time, my eldest was one year old and I was awaiting the birth of my second child. Thus, my visit to Germany was postponed for a year and I first visited Bielefeld in September 1990 for a period of three months.

Waldhausen met me at the train station in Bielefeld by my request, and helped me to settle in. When he found out that I only had 20DM, he lent me money.

The visit turned out to be a success: our joint paper was written at that time. During that period, Georgia was trying to leave the Soviet Union and I was eager to return home. So I was a little surprised when Friedhelm began talking about a subsequent visit when the time for my departure arrived. I said no. He gave me an official invite to take with me and told me that if I changed my mind I could use it to get a visa from the German embassy. In fact, a civil war broke out in Georgia in 1991 and the invite turned out to be very urgently needed.

Over the years, he and Traute cared for me and my family, which is something we will always be grateful for.

Once I got to know him better, I realised that my family was by no means an exception. Many people have received his help (often financial as well). His help was always accompanied by such warmth that one never felt awkward accepting it.

**Oliver Roendigs, 11.30.24, 8:40am CST**

Dear all,

Like Stefan Schwede, I had the honour of being supervised by Friedhelm Waldhausen through Diplom and Promotion. He did not travel anymore, so Traute and their daughter Maja had to drive to the Erlanger Schloss in 2004, to pick up Waldhausen's von Staudt prize on his behalf. Waldhausen accepted the honorary doctorate from Osnabrueck University only under the condition that he would not have to leave his house for the proceedings, and Rainer Vogt managed to hold the Festakt at this location. Waldhausen's lecture notes on analysis, topology, and the "simpliziale Gehirnwaesche" were excellent, written with clarity, precision, and wit. His praise for authors (Frank Adams, Ernest Hemingway, John Milnor, and Dan Quillen) helped in my education as well. I am very grateful for his support.

**Jack Morava, 11.30.24, 11:22am CST**

IIRC Friedhelm Waldhausen contacted me out of the blue in late April of 1986 and invited me to Bielefeld for a visit. I was a clumsy guest who had a wonderful time; I got lost in the woods, FW

tried to show me a video game about an Aztec temple treasure and I had to be taught to click on things.

A main feature of the trip was conversations with FW and Marcel Bökstedt (simultaneously visiting who I'd also never met) about the then recent calculation of the topological Hochschild homology of  $\mathbb{Z}$ ; the other was the directly upwind Chernobyl meltdown. It took me a little short of 30 years to understand things he tried then to tell me. The exuberance of the Bielefeld seminars was really remarkable...

### **Bjørn Dundas, 12.1.24, 2:52pm CST**

Waldhausen had a lasting impression on many of us, both through his mathematics and as a person. Early in my career I had the great fortune of visiting Bielefeld regularly.

Only later did I understand why I always was there in late fall - the SFB 343 “Discrete structures in mathematics” grant invited a series of important mathematicians, but as the year neared its end there must have been some money left. Once I had a flight home from Hannover rather early on a Sunday, and someone (I think it was you John ;-)) had assured me that the yellow poster at the railway station claimed that there actually was a convenient train. Turned out that that it didn't go on Sundays so all of a sudden the envelope with cash (that's how the per diem was handled) I felt I hadn't earned came to good use, and SFB unwittingly financed a taxi from Bielefeld to Hannover.

Visiting was an adventure, with not only Waldhausen, but also the group in Bielefeld and Osnabrueck. Waldhausen was always very supportive, although occasionally it felt like being with a tiger who at any point could just devour you, but so far strangely had only shown kindness. He will be sorely missed. Whenever 1126 turns up I think of him.

### **Thomas Huettmann, 12.1.24, 7:20pm CST**

I had the privilege of being Waldhausen's student, for both my Diplom and doctoral thesis. Before committing to Bielefeld as an undergraduate student, I visited for a couple of days and attended one of his algebraic topology lectures. I immediately liked his relaxed but very informative teaching style. As I was to find out in the coming years, Waldhausen was a very patient and generous teacher. His views of and approach to mathematics, concentrating on concepts rather than technical details, have strongly influenced my own thinking. Two particular pieces of his advice remain present in my mind at all times: never write words like “easy” or “obvious” in a maths paper, and always read a maths book backwards, starting at the interesting result. Trivial as they may seem, they helped me a lot at the time - and I'm happy to pass them on to my own students who face similar challenges. Though we've been out of touch for a long time, I think back to my time as Waldhausen's student very often. He will be missed greatly, as a mathematician and as a person.

### **Manos Lydakis, 12.2.24, 7:53am CST**

I too would like to share a few memories about Friedhelm Waldhausen.

I went to Bielefeld a few days after I got my Ph.D. He picked me up from the train station (he recognized me from the “yellow book” he suggested I was holding), took me grocery shopping, and then to the apartment I was to stay for the next few months. After that they had to pick up some sacks of

concrete for an extension of the stable (Traute had some donkeys as pets), I offered to help, and after that was done we went to this italian ice cream place in a small town (Werther) nearby. There was this loft apartment in the house next to his (but still some distance away, as Poetenweg is appropriately poetic, being in the middle of the Teutoburg forest) which he had reserved for visitors. I stayed there for six years and two (of my four) kids were born there. I spent quite a few evenings at his place, sometimes at big gatherings, sometimes just me and my wife (he and Traute were also at our place quite a few times), more often with the topology group around Waldhausen enriched by the many shorter-term visitors.

He was a noble generous supportive person. It was my good fortune to have met him.

### **John Klein, 12.3.24, 9:09am CST**

Incidentally,

A short history of SFB 343 can be found here:

<https://www.math.uni-bielefeld.de/ringel/sfb/sfb.html>

There are very few existent images of Waldhausen on the internet. A rare picture of Waldhausen, as he looked back then, appears on this page.

### **Andy Baker, 12.3.24, 10:13am CST**

There is an interesting picture of FW along with many other well known topologists attached, it can be found in the gallery at [warwick.ac.uk/fac/sci/mathsgallery/](http://warwick.ac.uk/fac/sci/mathsgallery/) and it shows participants in the Institute the year before the University opened (I believe).



**Michael Weiss, 12.4.24, 10:27am CST**

To me, FW always seemed like an incredibly robust person, almost immortal, so I was surprised and saddened to hear of his death. But there were earlier reports and rumours that after the death of his wife Traute, he had lost the zest for life.

My second postdoc position (1983-1986) was at Bielefeld, though I spent the middle year of the three at Edinburgh. At the start of this I still saw myself as a specialist in algebraic L-theory, but I fell in naturally with the Waldhausen group. Other members of this were Marcel Boekstedt (who had earned the respect of FW to the extent that he was allowed to say “Du” and “Friedhelm” to him) and Wolrad Vogell. We ran a joint seminar with the Osnabrueck topologists, mainly Rainer Vogt and Roland Schwaenzl. Ross Staffeldt and Thomas Gunnarsson often came to visit for longer spells. It was something of a paradise for topologists. If I remember correctly, seminars could and did sometimes take place in the garden surrounding the Waldhausen home (essentially a small piece of forest), only a small distance from the legendary chicken shed. (Forgive me if I am repeating what others have already written. There is so much to read there, it is like an online Quaker meeting.)

As John Klein points out, FW was not always ready to talk about mathematics when we others thought he should be. Among the distractions, piano-playing and red wine have been mentioned, but he also had a passion for action films. I remember watching “Capricorn One” in his house, with many detailed explanations and alerts from him which I undoubtedly needed. Almost certainly this was an afternoon when I came to his house with a wish to talk about mathematics.

Although my memory is very unreliable, I do remember a particular train journey from Bielefeld to Oberwolfach, with Waldhausen and maybe with Marcel Boekstedt. “Logical” arguments suggest that this took place in 1984. (Some people who know me well maintain that my life is organized around fateful train journeys, although I am not one of those nerds who memorize train timetables for an entire country.) In a momentary impulse of faithlessness towards algebraic L-theory, chain complexes with quadratic forms and all that, I asked Waldhausen whether he could suggest a good \*geometric\* problem for me to work on. Perhaps not a very grown-up question, but he answered kindly. “There are elements of order 691 in the algebraic  $K$ -theory group  $nr\ 22$  of the integers. There are also elements of order 691 in the group of oriented smooth homotopy spheres (up to oriented diffeomorphism) of dimension 23. Is it pure coincidence or can this be explained ...”

This has guided me for the rest of my mathematical life. Unsurprisingly 691 became my favorite prime. (It is an irregular prime.) Never mind that I have not been able to answer the question to this day. It made me interested in connections between algebraic L-theory and algebraic  $K$ -theory, and when I returned to Bielefeld from Edinburgh I teamed up with Bruce Williams, who I knew was also passionately interested in this theme. Our joint work on this is still going on. Now it is nearly 30 years behind schedule, and sadly Bruce Williams died in 2018. The orthogonal calculus is also an outgrowth of that. In OC there is a “speculative reduction” of the 691 question to a more conceptual question. A lot of progress on this has been made recently, arXiv:2109.03500. But this is rational progress and so does not do full justice to the prime 691.

My CV claims that in the early 90s I returned to Bielefeld for a short spell, 8 months. This is true. I got to know John Klein there. John Klein came from a postdoc position at Siegen university and had/has never-ending stories about all that befell him there! So that Bielefeld was, also for him, a refuge and possibly a paradise. I am sure that FW was glad to have a lively character like John Klein in the group. Stefan Schwede must have been a “Diplom” student at Bielefeld at the time (I consulted



his CV). FW was the supervisor of his Diploma thesis (like a Master diss.) and he did not make a secret out of his respect for Schwede.

**Lars Hesselholt, 12.4.24, 7:34pm CST**

During my time as a student in Aarhus, I had the great privilege to be invited to visit Bielefeld and to stay with in the famous Garten House. My first visit, which had been arranged by Michael Weiss, was in November of 1992. As I remember it, there was not a single moment during the three weeks of my visit that it did not rain. The first night in the Garten House was freezing cold. The bed has damp and the stove, which I had lit before going to sleep, burned out in the middle of the night, leaving me to ponder whether I would survive the visit or not. The next morning Waldhausen asked me how I had slept, to which I answered that I had been very cold. He asked me I had been cold from below or from above, to which I answered "both." He managed to find a dry comforter, which made the subsequent nights much warmer, and relighting the stove in the middle of the night also helped. But staying with the Waldhausens was a wonderful experience. From the first moment, I was treated as a member of the family, as opposed to a visitor, and included in the daily life, including trips to Jacques' Wein-Depot and the nearby Greek restaurant, which Waldhausen liked. There were also plenty of opportunities to talk about mathematics, typically while eating something out the refrigerator in the kitchen. On one of these occasions, Waldhausen said that Goodwillie had wanted to know that stable TC is THH, which I managed to prove to during my stay. On my last night, Waldhausen suggested that I choose a movie to watch together. He recommended that I choose Rambo II, and so it was.

My subsequent visits were during the spring and summer, when the weather in Bielefeld was more welcoming. One day, on my second visit, a storm knocked over the tallest tree in the garden during the night, but luckily the tree fell in the unique direction, where there was nothing for it to hit. The tree's roots, however, uplifted the walls in the house, where Traute kept her donkeys, so the next few days were spent moving the donkeys to a neighbor's barn and knocking down the walls in the now-decrepit donkey house. I was also assigned the task of teaching Waldhausen's student Schwede how to use spectral sequences. Waldhausen himself had no interest in spectral sequences that did not collapse, but he nevertheless thought that it would be good for his student to know.

Waldhausen advocated the philosophy that (higher) algebra over the sphere spectrum should simultaneously be easier and contain more information than (ordinary) algebra over the integers, and he famously employed this philosophy in the case of algebraic  $K$ -theory. (The introduction to his paper "Algebraic  $K$ -theory of generalized free products" gives a beautiful explanation of how he was led to these ideas.) The spectacular vindication in recent years of his philosophy must have pleased him.

**Nick Kuhn, 12.5.24, 10:44am CST**

Not mentioned in the amusing recollections of Waldhausen's 'guesthouse' was that one needed to dash into the main house to use the bathroom upstairs there. He was also a native plant enthusiast ahead of his time: one did not step on the dandelions growing around the stepstones leading into the house.

**John Rognes, 12.5.24, 11:08am CST**

Some more memories of Friedhelm Waldhausen:

He once told me of some days in the U.S. (I think at UIUC in the 1960s) when he and someone else (I think Wolfgang Haken) were both thinking about the Poincaré conjecture. One day he saw the other person in the distance, apparently bouncing with joy. The other one was sure he had a proof. Some days later he saw the same person in the distance, clearly sad and in despair. Later on I think Waldhausen had a kind of classification of faulty proofs of that conjecture.

Another time he told me how he got involved in algebraic  $K$ -theory. He had proven that for sufficiently large 3-manifolds, homotopy equivalence implies homeomorphism. Only later did he become aware that, due to the role of Whitehead torsion, only simple-homotopy equivalence has a chance to imply homeomorphism. He mentioned a poem, which I believe must be “Der Reiter und der Bodensee” by Gustav Schwab, where a horseman riding in winter longs to reach the large Lake Constance. Only after the fact does he realize that he has crossed it, without the ice breaking under him. The horseman dies from the shock. Fortunately, Waldhausen instead was able to prove that for the fundamental groups that arise for sufficiently large 3-manifolds, the Whitehead group is trivial, so homotopy equivalence is the same as simple-homotopy equivalence.

Apparently, when Waldhausen was hired at Bielefeld University, he insisted on a clause in his employment contract saying that he could take library books home, which was otherwise not permitted.

In the 1980s, Friedhelm and Traute bought a cast-iron stove made by a Norwegian producer, I believe Jøtul. The assembly instructions were in Norwegian, but Traute knew Plattdeutsch, and all North Sea dialects have some words in common, so they were able to decipher most of the instructions. There was, however, one word they were not sure about, which came up often. Marcel Bökstedt was able to clarify: the word was “ikke”, which means “not” in Norwegian.

The Bielefeld Sonderforschungsbereich (SFB 343) was titled “Discrete structures in mathematics”. The subprogram representing Waldhausen’s work held the wider title: “Discrete and indiscrete structures in mathematics”.

I spent time with Waldhausen’s “Algebraic  $K$ -theory of spaces” when I was a PhD student. It was nicely typed up, but at some point it was recognized that a third axiom in the definition of a cylinder functor was not needed, and instead of retyping, Waldhausen’s inserted some bars from “Alborada del gracioso” by Ravel, sometimes translated as “Morning song of the clown” or “Fool’s morning song”. Later the paper was accepted by a well-known journal, but the publisher did not want to include the musical score. Waldhausen then withdrew the paper. Andrew Ranicki was visiting Bielefeld on that day, and in the process of editing proceedings from a conference at Rutgers, which I believe Waldhausen did not attend. Waldhausen then offered his paper for these proceedings, the Springer LNM 1126, preserving the bar of notes, of course.

I believe the  $A$  in  $A(X)$  is for “algebraic”, or possibly “abstract”. Waldhausen never referred to it as “ $A$ -theory”.

He also disliked the use of the word “clearly”. I see that it somehow snuck in three times in our book with Bjørn Jahren.

After finishing my PhD in the U.S., I spent a year doing military service in Norway. In April 1991 I had some leave, and went to visit Bielefeld and Aarhus, staying in the Gartenhaus. At the time Friedhelm and Traute had used it to smoke fish, but not while I was sleeping there. Waldhausen learned that I could leave military service up to a month earlier than usual, if some pressing engagement were waiting, so he wrote a letter to my superior officer explaining that there was some “very urgent work in algebraic  $K$ -theory” that I needed to do. I am sorry not to have a copy of the letter, but I was let off early.

With me being a student of Gunnar Carlsson, Waldhausen proposed that I look into a possible Segal conjecture for an equivariant algebraic  $K$ -theory of spaces, containing the now-classical one as a retract. Using Goodwillie derivatives I found that this did not work, at least in the most naive way, but much later Mona Merling, Cary Malkiewich, Tom Goodwillie and Kiyoshi Igusa have made good progress along that route.

My memory of the origin of “brave new rings” is that it was indeed a reference to Huxley’s “Brave New World”, which I think was closer to Waldhausen’s reading interests than Shakespeare, but that someone else thereafter told him how this title in turn references a quote by Miranda in Shakespeare’s “The Tempest”. This came up in the summer of 1991 in the context of some NeXT computers (by Steve Jobs) that the Bielefeld department had acquired, and which had Shakespeare’s collected works on disk. This is not quite how Stefan Schwede remembers the story, so I may have misunderstood.

I believe “brave new algebra” is a kind of portmanteau due to Peter May, reflecting the generalization from rings to modules and algebras.

I rented the basement apartment in Poetenweg 66 that summer of 1991. There was no kitchen, yet, since the demand for new kitchen furnishings had skyrocketed after the reunification of Germany.

I was allergic to some plant in Waldhausen’s living room, with the grand piano. Nonetheless I was able to attend a concert there by Bjørn Jahren, playing the famously difficult “Gaspard de la nuit” by Ravel, without me sneezing or coughing.

Waldhausen held high standards, also when refereeing. One paper had a flaw that should “make it unacceptable to some journals” – he left it open for the editors of the famous journal in question whether that made it unacceptable for them.

A chain of events involving (what we at the time thought of as) the end of the Cold War led him to offer me in 2001 or 2002 to assemble his notes on the parametrized stable  $h$ -cobordism theorem for publication (to appear since 1979, eventually appearing in 2013, i.e., after 34 years). I was happily allowed to include Bjørn Jahren in the project, since he had been a kind of intermediary between us.

One February morning in 2008 I received an email from Waldhausen sent at 06:30, and commented “Good morning (we’re both up early!)”. That afternoon he replied “Your conclusion is not the only possible one.” I assume piano practice and red wine were involved.

I am happy and honored to have known him.

**John Klein, 12.5.24, 12:25pm CST**

The story about Waldhausen, Haken, the PC, and UIUC has a longer version which I find extremely comical.

As I remember it from Waldhausen's telling:

Waldhausen and Haken had two different approaches to the PC. Waldhausen's involved checking many cases, something like 27. Haken's was different (I don't remember how). They were both competing in real time. Waldhausen thought his approach was better, since it supposedly would establish a much stronger result.

Being an honest fellow, Waldhausen decided to check the "hardest" of the 27 cases first. By the end of the work week, he had established all but 24 of them. However, on Friday, Haken claimed to have resolved the PC.

Waldhausen went home, and over the weekend, decided to persevere anyway. He discovered that one of the three remaining "easy" cases fell through, and for this reason his program fell apart.

He was depressed, so he decided to take a walk towards the football stadium.

In the distance, he saw a figure on a bicycle coming towards him. He eventually recognized that figure as Haken. As Haken drew nearer, Waldhausen observed a dejected look on Haken's face. Waldhausen then realized that Haken's program was also busted.

Waldhausen then felt a bit less depressed.

**Dan Isaksen, 12.5.24, 12:51pm CST**

My first job after graduate school was at Bielefeld in 1999-2000. I owe Brooke Shipley and Stefan Schwede for connecting me with the position. At the time, the SFB was winding down, and Waldhausen was in the process of retiring. There was a lively group of topologists, including Stefan Schwede, Morten Brun, Iver Ottosen, Oliver Röndigs, and Thomas Hüttemann. Dan Christensen visited, and we started a collaboration that stretched for several manuscripts over several years. I also vaguely recall meeting Manos Lydakis and Dan Grayson during that year.

I was particularly struck by the descriptions of Waldhausen's reliance on a verbal mathematical process. That's very different from the way that I operate. Our opinions about spectral sequences didn't diverge until later; at the time, I was studying model categories. Perhaps because of our incompatible approaches, I was unfortunate that I did not get to know Waldhausen well. I do have first-hand memories of Poetenweg 66, although I never slept there!

**Wolfgang Lück, 12.6.24, 4:24am CST**

I am not as close to Waldhausen as people which have written their PhD under Waldhausen's supervision or spent some time at Bielefeld. Nevertheless, I would like to share some Waldhausen-moments.

I was invited to a conference, probably Topology in September 1987 or 1988, where Waldhausen was also present. I had written one of my first papers where I had characterised the functor sending a finitely dominated CW-complex to the projective class group of its fundamental groupoid together with the assignment given by Wall's finiteness obstruction as a functorial additive invariant and also given a, easy purely geometric description of it. I had an illuminating conversation with Waldhausen, where he explained his point of view that spaces are points in  $A(X)$  and that linearization on the  $\pi_0$ -level is Wall's finiteness obstruction.

Here is a typical Waldhausen moment at that conference. He gave an extra informal talk late in the evening. He wrote down on the blackboard the word "Theorem". Then we went to the window and looked out of it which was a little bit strange since it was already dark. After two minutes (of silence from him and the audience) he went back to the blackboard and added the number 90. Then after another pause he wrote down the theorem. He outlined the proof. Then someone dared to ask whether the 90 stands for 1990 in the sense that Waldhausen hopes that it may be published in 1990. Waldhausen replied: Oh No. I stands for 90 procent, I am only sure for 90 procent that the theorem is true.

I think that Waldhausen's wife was by far the most important person to him. I never had personal conversations with Waldhausen but indeed with his wife. In 1994 or so I was invited to a colloquium in Bielefeld and we met at his house in the evening. At that time one of my daughters had recovered from a life threatening disease and, I do not know why, I was talking about it and about the meaning of family in general with Waldhausen's wife. Waldhausen was standing close to us, saying no word, but following very closely.

I can very well imagine that Waldhausen's life and the desire to live changed after the death of his wife.

I want to emphasize that he was also a leading figure in the theory of 3-manifolds before he turned to algebraic  $K$ -theory. His results on the topological rigidity of 3-manifolds were a real breakthrough and some of the deepest results in that theory before Thurston entered the stage. As already described in another email, his transition to algebraic  $K$ -theory was motivated by the fact that an explanation of consequence of his work on 3-manifolds is the vanishing of the Whitehead group of compact 3-manifolds with torsionfree fundamenal groups. In dimension 3 there is the prime decomposition, the Jaco-Shalen-Johannsen splitting and the Fibration Conjecture of Thurston, meanwhile proved by Agol. They triggered the question how Whitehead group behave under amalgamated products and HNN-extensions. This led to the corresponding Annals papers of Waldhausen and finally to the development of  $A$ -theory. For me it is extremely impressive, that Waldhausen made such important contribution to very different areas which require a very different way of thinking and solving problems.

I think that, at least in Germany, Waldhausen was underestimated for a long time. One reason may be that he did not fulfill the expectations of a German professor which I found very refreshing and interesting. At least Waldhausen obtained the von Staudt-Prize in 2004. It is typical for him that he did not appear to the ceremony himself but sent his wife instead, although he was in good health.

**Doug Ravenel, 12.6.24, 5:44am CST**

Regrettably, I can only recall one conversation with Waldhausen.

It took place at a conference at Northwestern (one of many) in the 80s. I told him I knew of an action

of the  $n$ th Morava stabilizer group  $\mathbb{G}_n$  on the  $n$ th Johnson-Wilson spectrum  $E(n)$ , but I could only define it up to homotopy. His reaction to my admission was “This is very bad.” This did not surprise me because I had suspected as much myself.

That was before Goerss, Hopkins and Miller figured out how to define such an action pointwise on Morava’s souped up version of  $E(n)$ , or at least it was before I knew about it. Waldhausen would surely have been happy to hear about this development. He probably did hear about it, but I do not recall seeing him after that.

I can see now that he understood these subtleties far better than I did. He was a deep thinker and a visionary.

My hat is off to him.

### **Tom Goodwille, 12.6.24, 8:07am CST**

Let me add to Wolfgang’s funny story about “Theorem 90”. The way I remember it, there is more. After explaining that he was calling it ”Theorem 90” because he was 90% sure of it, he corrected himself, saying that he was 60% sure of it, and that he had explained the proof to Boekstedt, and Boekstedt was 30% sure of it.

### **Jim Davis, 12.6.24, 9:37am CST**

Every though I never spoke with Waldhausen, I do have a story, told to me by Sylvain Cappell. In between Waldhausen’s 1968 Annals paper “On irreducible 3-manifolds which are sufficiently large” and his 4 part 1978 Annals papers “Algebraic K-theory of generalized free products I, II, III, IV”, Waldhausen wrote a 1969 paper “Whitehead groups of generalized free products”.

<https://www.maths.ed.ac.uk/~v1ranick/cat>

This link is supplied by Andrew Ranicki.

Some time later Sylvain met Friedhelm, and pointed out the main theorem of the paper (the Sum Theorem on page 21) must be incorrect - the point being that  $Wh(D)/Wh(A,B:C)$  must fit into a Mayer-Vietoris exact sequence, and shouldn’t be a sum. (Sylvain knew this because he was thinking about the corresponding case in algebraic L-theory - which is even more important in manifold theory!) Friedhelm immediately agreed that there must be a mistake, and took the only typed copy of the manuscript from the trunk of his car and placed it in a nearby garbage can. Sylvain said no, no, no, and took the manuscript and placed it back in the trunk of Waldhausen’s car.

Waldhausen later published a corrected version of the paper in Springer Lecture Notes 342: I am sure that the retrieved paper was useful for producing the corrected version. (I also think there are some interesting results in the flawed version which never appeared in print.)

I have suggested the following (doable) project to several younger mathematicians: give an explicit counterexample to his stated Sum theorem. (I even have some candidate groups. . . )

**Johannes Huebschmann, 12.6.24, 12:07pm CST**

Waldhausen's work on 3-manifolds exploits earlier results of W. Haken.

After his phd in 1954 at Kiel U Haken worked with the Siemens company. He pursued pure maths for leisure and composed papers which later became fundamental. In view of his results, he eventually obtained a position at UIUC.

Haken belongs to the generation of the Seifert students Dold, Puppe, and Schubert. Seifert, Dold and Puppe spent most of their academic career at Heidelberg, Schubert at Kiel.

In 1978 (or somewhat later) Haken delivered a talk on the four colour problem at Heidelberg, but in the dept of applied math rather than in the topology Oberseminar.

At Seifert's 75th anniversary (1982), I had the chance to talk to Schubert. At that occasion, he referred to some (or perhaps all?) of Haken's work as being "trivial". Schubert himself had reworked a construction of Haken's, however. Perhaps someone on the list knows more details about the relationship between Haken, Schubert and Waldhausen, beyond what has already been related. Waldhausen mentions Schubert's paper in his Annals 1968 paper and thanks Schubert for discussion.

I remember a talk with Waldhausen among the audience giving a hard time to the speaker. Also once I attended a talk by Waldhausen where he noted "Someone proved ...", and the someone was in the audience.

For those interested in history:

Seifert was an opponent of the NAZI regime and therefore became full professor (in Heidelberg) only after WWII.

Some of the ideas for the solution of the four colour problem are due to Heinrich Heesch but, from my memory (I remember a conversation I had a long time ago with a colleague from Hannover), Heesch preferred not to be coauthor despite Haken's offer. Heesch was also an opponent of the NAZI regime and therefore worked as a "private scholar" at that time. He obtained a professorship at Hannover after WWII.

Waldhausen obtained a permanent position at Bochum and thereafter Bielefeld at a time when there were quite a few openings in Germany. Apparently Bielefeld was a paradise for math students.

**Gregory Arone, 12.7.24, 7:03am CST**

A few more Waldhausen memories.

I spent my second postdoc year in Bielefeld, on an Alexander von Humboldt fellowship. Sometime during that time (it must have been summer or fall of 1994) Jaques Chirac announced that France would resume nuclear testing in the Pacific. There were some protest actions by Greenpeace. Waldhausen was opposed to the nuclear testing, and was often making disparaging comments about Chirac in those days.

At the same time, Wu-Chung Hsiang was visiting Bielefeld and giving some lectures. So, he drew a manifold on the board, which was decomposed in two pieces, drawn in red and green chalk. He was calling them the red piece and the green piece (which sounded like Greenpeace), and he was performing some constructions on the green piece.

At some point Waldhausen interrupted: “how about that red piece, are you going to use it for anything”?

Hsiang: er, no, I am not using the red piece.

Waldhausen, in perfect deadpan: I propose that you call this piece Chirac.

One time several of us were in Waldhausen’s office, trying to print out a manuscript that someone got by email. It was early days of the internet, we were having technical difficulties. The computer was giving error messages, that either the computer or the printer in Waldhausen’s office was not supporting some fonts that were used in the file. Waldhausen commented: “The mathematics in this paper is so new, that it requires a completely new set of fonts”.

I remember one time he was teaching his wife how she could participate more in conversations of mathematicians. If someone says something, you can say “what happens at odd primes?”, or “can you do it equivariantly?”

I never saw a movie with Waldhausen, but once I spent a Saturday afternoon in his house watching a Formula 1 race. It was the first (and close to last) time I watched one. I had absolutely no idea what was going on, and he was quite eager to explain the fine points in the strategies of various drivers.

I seem to remember that the race had to be aborted because of a bad accident, involving many of the cars. Waldhausen was quite upset. I think he was criticising the organisers for not enforcing safety protocols.

Unfortunately I did not get to talk much about mathematics with him. He did tell me a couple of times about his ideas about applying algebraic topology to number theory. Sadly, it was way above my pay grade then. I wish I could listen again to what he was saying. Maybe now I would get more out of it. Or maybe not.

Even though there was not much mathematical interaction, he was always kind to me on personal level, just as he was to everyone who visited. He took me several times on weekend trips in nearby area, along with other visitors. Of course his wife always participated. Like everyone who spent time in Bielefeld, I attended many dinners in his house, and generally felt welcome to just come over when I felt like it. Waldhausen had a formidable personality, but his house was a welcoming and open place to an unusual extent.

### **Danny Ruberman, 12.9.24, 7:50pm CST**

To my regret (especially after reading all of these stories) I never met Waldhausen. But I have a variation of Jim Davis’ story, also told to me by Sylvain Cappell when I was a postdoc in the early 1980s at Courant. I have to apologize in advance for the likely inaccuracy of my recollection of this



from 40 or more years ago, and hope that perhaps someone can supply a more correct version.

As Sylvain related, he was at a conference and Waldhausen, preparing to speak about his work in K-theory, was quite agitated. Sylvain asked what was wrong and was told “one of the arrows goes the wrong way, and the whole argument collapses”. Sylvain then suggested to work this through in the case of Whitehead groups of amalgamated free products, and sure enough everything worked out perfectly, with all arrows pointing in the right directions. Waldhausen then exclaimed to Sylvain that this is wonderful and asked if he (Cappell) had written it up. Sylvain replied that no, this was exactly the argument of Waldhausen’s 1969 paper (that appeared in Jim’s story).

I always loved the story, and would be happy if anyone could confirm or correct it.

**John Klein, 12.9.24, 8:14pm CST**

Hi Danny,

Sylvain once told me this story in some detail. Here is what I remember:

The event occurred at IHES during a period when both of them had spent some time there (I’m guessing the early 1970s). The matter had something to do with an arrow in an elaborate diagram which went in the “wrong” direction (the diagram covered several sheets of paper). He told Sylvain that the arrow going the wrong way caused the “whole picture” to collapse.

They both retreated to Waldhausen’s room to study the matter. Sylvain, having suggested that Friedhelm pass back to the original geometric structure on which the algebraic structure was based. After some time, they discovered that the arrow really went in the opposite direction.

The “whole picture” was thus repaired.

**Danny Ruberman, 12.10.24, 8:59am CST**

Hi John,

Yes, that matches my recollection; the moral of the story was supposed to be that geometry saved the day. Sylvain’s splitting theorem paper was largely written at IHES in the year 1972-73 and that certainly fits as well.