



## **Nobel Voices Video History Project 2000-2001**

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**Interviewee:** Klaus Von Klitzing  
**Interviewer:** Neil Hollander  
**Date:** June 27, 2000  
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HOLLANDER:

Tell us who you are and what it is you do.

VON KLITZING:

My name is Klaus von Klitzing. I got the Nobel Prize, like many of the participants, in '85, in physics, for the discovery of something called quantum Hall effect. At present I am director of a research center in Germany, the Max-Planck-Institute, which are doing basic research, and I'm working in semiconductor physics, a new generation of faster devices, for example, this is my idea, to learn something about electronic devices.

HOLLANDER:

Why did you get the Prize? What is it you did?

VON KLITZING:

I was interested already a long time ago in semiconductor physics when I started my study. Semiconductor was the most important device in real life, and I wanted to improve semiconductor devices, to understand how electrons are flowing in a semiconductor device, how to get faster devices, and to understand microscopic properties. In order to understand it, you have to know how they're moving, how fast electrons are moving in electronic devices. You have to know how many electrons are participating in an electrical current, and in this way you are doing standard experiments called also Hall effort, which is used to define the number of electrons in a device.

In these experiments I was doing this for more than ten years, I discovered something which was unexpected, which looked strange, and I didn't say, "Okay, I don't like it." I want to know what the origin is. So I looked at an experimental [unclear] and found it was produced for different devices, devices from the United States, from England, from Germany. Then I get the idea, perhaps there's something fundamental behind this.

So this was really by accident. I was using the so-called Hall effect to know something about the number of electrons, but in the Hall effect itself, I saw something unexpected. In the night of the fifth of February 1980, I saw this and decided, okay, to understand it. Within some hours, I found that there was something very fundamental behind it, and this

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was the discovery of the quantum Hall effect. So I was doing something for industry, more or less, to understand the function of a Field effect transistor, and then suddenly I saw something unexpected, and I was free to look, to understand this new phenomenon, and change my direction of research, and in this way I discovered something qualitatively new, the quantum Hall effect, which is finally a new type of electrical resistance. Normally, everyone learns at school electrical resistance can be any variable, depends on lengths of wire, the cross-section of the wires, material, and the final result of my discovery was suddenly the electrical resistance, which has always the same value, which has always 25,812.807 ohms, within two or three years all national laboratories which are responsible for the kilograms, the amperes, the volt, and so on, they repeated this experiment and found everywhere in the world the same value. Then from this, the unclear was developed, which is this fundamental value of 25,812.807 ohms.

HOLLANDER:

How does this help us? Can you draw a line between that and what we do every day?

VON KLITZING:

In real life, you have to know what is kilogram. If you buy something, you rely that it's really a kilogram. Okay. In real life, you don't see the difference between this which is accurate to three decimals or with higher accuracy. But in order to have international trade, you need some units. Everyone in the world, you're using the international system of units, but up to this time, until my discovery, the ohms, the electrical resistance in the United States was different from the ohm in Germany and in Japan. And you cannot have international trade if everyone is using a different unit. It's not so strange like the last Mars mission, which failed because they used different units like an inch and the centimeter, but you know it's very important to have the same units to do measurements.

This is the main contribution for us, that my discovery made it possible to have everywhere in the world the same unit, because it's based on a fundamental constant. The fundamental constant are everywhere in the world the same. This is a nice thing, the fundamental constants. They are independent of everything. So this is from these so-called metrology aspects that we have the basis for doing accurate measurements.

But the other thing is to understand the microscopic picture of electric conductivity or electrical properties. There are now several books, each 500 pages, just called quantum Hall effect, and you may know that in '98, the fractional quantum Hall effect, also something connected to this phenomenon, got the Nobel Prize again. This is very fundamental to understand the microscopic properties of electric conductivity. So that electrons are like waves, and the reflection of waves has something to do with resistance and the transmission of light goes through a window, this is transmission and some reflection. You can transfer this idea also to electrical properties, and resistance transmission is a current. So there's quite new ideas in understanding in a microscopic way, quantum mechanical way, microscopic properties of devices also.

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A lot of new devices are based on quantum phenomenon because this quantum Hall effect has to do with quantum mechanics, that electrons are not just small balls. They have wave nature. The quantum mechanics comes in. A lot of new electronic devices which are very, very small, are based on quantum phenomenon. So this is a whole direction of so-called low dimensional electron system, where electrons are moving in very small structures, and this is important to new devices also. So, the quantum Hall effect has something to do with new semiconductor devices in very small structures.

HOLLANDER:

How or when or where did you decide to be a physicist?

VON KLITZING:

I was always interested in mathematics, because mathematics is a very clean science. I had problems and I knew in principle it should be possible to solve this problem, and I tried to solve it from different directions. When I got the Nobel Prize, one of my teachers sent me some exercises I had done on Christmas night, so the 24<sup>th</sup> of December I had done some exercises—I don't remember this—to solve some mathematical problems.

This was my interest at school. We had not too much physics, only one hour per week, and I started at the university to do mathematics. But then I discovered that you can apply mathematics in physics in a very nice way because you have to do experiments to understand nature, and then to apply mathematics. So in this way I went into physics via the way of mathematics, and at this time when I started to do my studies, semiconductors was the most interesting one, so in this way I entered the field of material research.

HOLLANDER:

[inaudible]. Where do you think this inquisitive nature came from?

VON KLITZING:

My father was walking in the forest, for example, and I had a lot of connection to nature, to understand nature, to look at nature, and to understand the reason. That's science, to understand nature. This was always my feeling, that I took behind what happens in our world.

HOLLANDER:

Where do you think you got this from?

VON KLITZING:

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Living in nature. I was always outside the house and to look at nature, to understand what happens, what is the reason of something. This was the drive. I don't know. It's a gene somewhere.

HOLLANDER:

Has the Nobel Prize changed your life?

VON KLITZING:

I think everyone who got the Nobel Prize feels some change, because mainly from outside everyone believes that you behave differently now, because you know everything and you should have an answer to all questions. A lot of people believe that you should be different from other persons. So if you're going shopping, they say, "You cannot do this." Or cut the grass in the garden, a Nobel Prize winner should not do this. My first reaction was, when I got the Nobel Prize, just behave like before, in the same way. You are not different due to the Nobel Prize.

The main pressure comes from outside. But it's changing a little bit, because everyone feels that your opinion is more valuable than the opinion of other people, and this may be true, because as a Nobel Prize winner, you got everything, you cannot lose too much, and you can just say what you believe. Therefore, your words are more important than other words, because other scientists perhaps have more personal interest in something to manipulate.

As a scientist, especially a politician asks you, they believe what the Nobel Prize winner is saying may be more true than the opinion of other people. Therefore, one has a certain power and in this way one should be also more careful what one is saying. This is one of my problems. I saw everything what I believe, and this way it's careful, and talk shows and television are always dangerous, because you have not a fixed opinion. As a scientist, you are always in doubt whether you have the right opinion. You learn all the time something new.

But I hope that Nobel Prize winners are more reliable in their opinion and they are really saying what they believe is the truth.

HOLLANDER:

Where do you think we're going as a society in the world of science? What is the future?

VON KLITZING:

What is the future? Everyone speaks about the number of students in science is going down, and the number of lawyers and other, from my opinion, not so productive people for the society is going. So I worry a little bit about the creativity, about the input of new

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ideas in the future. Perhaps we do not take enough attention to science at present. I always say we need this. If somebody is productive for the future, if you create some [unclear], you need scientists, because this is the basis for everything which is new in the world.

So I'm fighting for science, for the support of science, to the understanding of science, so I am going to schools, to the public, to get the feeling about how important is science, and that science has always more positive aspects than negative aspects, which is too dominant in the public at present.

HOLLANDER:

Do you think you're winning this fight, or losing it?

VON KLITZING:

At schools I have the feeling I'm winning it, but in the political area, I'm not so optimistic.

HOLLANDER:

Have you ever been wrong?

VON KLITZING:

Oh yes. Sure. And every time you are just sitting on your desk and have some idea what will be the [unclear] of experiments. This will never work. I have always the success just in the interaction between experimental [unclear] and the understanding of the experimental [unclear]. So, always fighting about what I think and what nature is giving me. Normally if I've just developed something on the paper, to 99.9 percent I'm wrong. I always recommend to the students, also, just to look at the nature as it resides, and if you don't understand something, then you ask the question to nature, and then you think about an experiment to verify the theory, which you have to explain [unclear].

Ninety percent of your [unclear], yes, but you need an explanation what you are seeing. This is very important, this interaction. Therefore, I'm an experimentalist. I am doing experimental [unclear] and the experimental effects. This is the truth for me, and I have to understand it. But ninety percent of the theory is incorrect, what I'm developing, but this is an interactive way to understand nature.

HOLLANDER:

What about humor? What's your favorite science joke?

VON KLITZING:

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All kinds of things. When I made my discovery, it was in the night on the fifth of February 1980. Afterwards, there was a lot of publication in *Astrology* that everything was given already by the moon, by the sun, and I made jokes about this more or less to say this is not the truth. But jokes are very important also in lectures. I think this is part of my life.

HOLLANDER:

What's your favorite one?

VON KLITZING:

Oh, there's so many different.

HOLLANDER:

The first one that comes to mind.

VON KLITZING:

This is difficult now. There's not so many jokes. I'm not better prepared.

HOLLANDER:

[inaudible]

VON KLITZING:

What do you mean, is funny? Something about myself?

HOLLANDER:

What do you find amusing in life?

VON KLITZING:

Amusing in life. That is difficult.

HOLLANDER:

I'm asking difficult questions.

VON KLITZING:

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Yes, but I have to think about this.

HOLLANDER:

What do you like most in life, outside of science?

VON KLITZING:

This is one of the problems. Every scientist feels his main hobby is science, yes? But I told you that I have a special connection with nature, so walking and to have some freedom in the nature, this is my hobby. But I am spending too much time for science. If you ask my family, they will have the same feeling.

HOLLANDER:

Do you read books outside of science?

VON KLITZING:

Not enough. If you read newspapers, you have to read at least three or four different ones to get some truth out of this. Then you spent that time already to see what is happening at present. So I'm not reading enough literature outside of the scientific literature.

HOLLANDER:

Film?

VON KLITZING:

To the theater, yes. Films, to small theaters, small groups, unorthodox groups, yes, I like most, which discuss problems which are modern problems. Operas, I didn't go for one year to opera, for example, but to small theater groups.

HOLLANDER:

What do you think is the single most problem facing us today?

VON KLITZING:

Yes, what is the single most, perhaps religion. Perhaps confrontation between different religious groups. This is one confrontation we will have in the future. We see the problems involved in wars. A lot of them, the origin is deep in the religious behavior of different groups, and maybe we will have some problems. We have to solve the problems between different Christian groups, Islamic groups, this different understanding, to find some common basis for our future life, to have some ethics or

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some general rules which are accepted by everyone. Maybe the United Nations, they have some duties to bring together these different groups to find a common basis.

HOLLANDER:

Are you optimistic or pessimistic about the future?

VON KLITZING:

As a scientist, you are more optimistic. You know about probabilities, about positive developments. I am always optimistic, because if you see real problems, I think then we should be able to solve the problems. But very often the public doesn't see the real problems.

HOLLANDER:

What are your metaphysics?

VON KLITZING:

Metaphysics is for me something which you cannot do an experiment, and for me, the experiment is the truth. Therefore, I want to have real facts. Sometimes in metaphysics you can have different opinions. You cannot solve or give a solution who is right.

HOLLANDER:

Don't you have a certain metaphysical perspective [unclear]?

VON KLITZING:

No.

HOLLANDER:

All right.

VON KLITZING:

[Laughs] You want to have long discussion on this, yes?

HOLLANDER:

I did, but we're obviously not going to. [Von Klitzing laughs.] We'll go back to physics. If I were to come to you as a student and I were to say to you, "I want to study science. I want to go into science. I don't know what to do. What do you think I should do? Give

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me the name of a book you think I should read. Which way do you think I should go?" what would you say? In all seriousness, I'm asking for specific advice, not for someone to say to me, "Follow your interest." "Where do you think I should go?"

VON KLITZING:

Okay, but first of all, I always say you must be interested. You must be enthusiastic about something, and you have to do it in a relatively short time. So this is the most important part. All scientists, they are enthusiastic about their work and their life, like a hobby. But then we often are told in biology we have a situation like eighty years ago in physics. You know that the last century, the 20<sup>th</sup> century, was essentially of physics, and so I think in biology we have so many open questions, we can do a lot of new things in this year that for a long time I recommended this. But one should be careful that one should be not directing everything in one direction. This was my feeling already ten years ago, when I was a [unclear] and the future was the next century.

My daughter is doing biotechnology because I believe this is an interesting subject, but physics is always an excellent basis for all science, and I'm quite sure that in the future you will not distinguish on a microscopic level between chemistry and physics and biology. You have to understand nature really at the bottom, to have some solution to all kind of problems.

So, I recommend, yes, to go to understand nature really from the smallest particle and to build up on this to understand more complex. The problem is, in real life you have very often very complex systems which we are not able to solve, and for me, I am trying to solve problems really from the pieces and to build up from this piece to understand everything, and then develop to more complex systems.

HOLLANDER:

[inaudible]

VON KLITZING:

Physics is very important to understand something about probabilities, because a lot of people, the public, they are very afraid about science because they have no feeling about positive and negative aspects and about probabilities. If something is the probability of ten to the minus 20, it's unimportant. Even if it may be one single event which is unhappy, makes you unhappy, yes, but to understand a little bit about these probabilities makes the scientist much more optimistic for the future than most of the other people.

HOLLANDER:

I mean in terms of your social relations with people, [inaudible]?

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VON KLITZING:

Not too much, because a lot of people, they say, “Okay, scientists is something very, very great and very important, but I don’t understand anything about science,” and that normally opens the gap between really highly educated people when you say you are a scientist. So I think it’s much easier to be a painter, to have a better social life than a physicist. Therefore, we have to do more, perhaps, in the public. It’s one of the problems. I have a feeling in different groups, as a scientist you are treated like an outsider, and a lot of other people are happy that they don’t understand anything about science. Especially perhaps in Germany, science is not—okay, it’s the culture, but literature is more important than the importance of an electron or so, and if you speak to people, they are happy to say they have never heard something about an electron, what is the property of an electron. But if you say this about Goethe or so, you should not do it in the public.

Therefore, I feel one has to do much more to promote science and to distribute the information about science in the public.

HOLLANDER:

[inaudible]

VON KLITZING:

Oh, no, fifty different teams are here, I think, from newspapers and from television stations, so there are a lot of teams here. I don’t know the whole week is this conference running. Okay, at present there’s nothing in the television, but that’s not so important, I think. [Laughs]

HOLLANDER:

What are some things you personally dislike?

VON KLITZING:

What I dislike? Normally if a journalist wanted to know everything about me outside of science, about details of the family or private things, I think I dislike this very much, and I decided when I got the Nobel Prize the journalists can ask me everything but nothing about the family and details of the family.

HOLLANDER:

Anything else you dislike? What about in your students?

VON KLITZING:

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I dislike it if a student is predicting something and looking for a result only in a certain direction, without asking questions in between, so to develop by computer programming already the program such a way that only one result is picked out of a large number of experimental results. So I dislike a critical reflection of your results.

HOLLANDER:

[inaudible]

VON KLITZING:

I like it very much if they are independent, if they have crazy new ideas, if they have done something in addition just to physics, if they are engaged in social activities, and they have to interact with other people. This is very important for me.

HOLLANDER:

[inaudible]

VON KLITZING:

A crazy new idea is if you personally don't believe it will work, but if he is enthusiastic about it, I say you should give him a chance, yes? And very often it doesn't work exactly in this direction, but they found always a side away that was successful finally. So to have the feeling you have an idea, and "I believe in this and I will fight for this." So this is for me everything that I don't believe, I call it first crazy, because what is crazy otherwise, yes? And to give them a chance to demonstrate that something will come out.

HOLLANDER:

[inaudible]

VON KLITZING:

Oh, I'm fighting very often with my students. I always—negative. I say, "Okay. What do you think? No, it will never work.?" And I hope that he would say, "Okay. Now, I believe it will work." And to have this fighting, this is the most interesting part. And then always to critical analyze what he is saying, and say, "This point, you are wrong." But then he has to find, "Okay, but if I do it this way, I might, yes." And this fighting, this is very fruitful.

HOLLANDER:

[inaudible]

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VON KLITZING:

Ah! So many. [Laughs]

HOLLANDER:

What didn't I ask?

VON KLITZING:

No, it's fine. It's fine.

[End of interview]