April 2, 2024

Entrance Ceremony (4th)

Greetings from Honorary Fellow

OISHI, Shinichi

Congratulations to everyone on your entry and advancement. Thank you for conferring on me the title of honorary fellow. I entered Waseda University's Electronics and Communications Engineering Department at the School of Science and Engineering in the spring of 1972, so it was 52 years ago. When I was a third-year doctoral student in 1980 I served as a research associate so for the past 44 years I have conducted education and research at Waseda University. To put it shortly, I've freely done my preferred research to my heart's content. I only have words of gratitude for the university.

Today, I'm going to talk about the history of my research, and I hope that it serves as a reference for your own college lives. To make it easier to understand, I will express my messages to sound like proverbs.

My first "proverb" is, "If you concentrate and study during your time in college you will get surprisingly smart." Entering my second year, in chemistry, I studied atomism based on quantum mechanics. The Iwanami Course that was published at the time was *Fundamentals of Modern Physics* (12 volumes), and from that series we read one volume *Quantum Mechanics II*. I used my summer vacation to read the book as if I were breathing it in while filling in the spaces between the lines and reproducing the calculations. It took all of summer vacation to read it, but I think I got pretty smart. If you focus on studies during your time in college you will get smart—I experienced this. So that is the first thing I'd like to tell all of you here today.

My second "proverb" is, "What you learn in the classroom is very helpful and efficient, but it is only an introduction; to study deeply it is important to learn what is not taught in class." In the 12-volume *Fundamentals of Modern Physics* series, physics professors from around Japan spoke about physics as if it were an adventure story, so it was terribly interesting and I just continued to read. In the *Classical Physics II* volume, the inverse-scattering problem of quantum mechanics was used to solve in detail nonlinear equations, a fantastic way to introduce soliton theory.

Around the end of my third year, I decided to write the graduation thesis on communication theory using solitons. Hirota equation, which expanded the nonlinear Schrödinger equation, the governing equation for non-liner optical fiber, still had not been solved, so I decided to work on it. I immediately solved it and announced the results first at an academic symposium. Entering the master's degree program, I looked into Hirota's strange bilinear soliton equation. I immediately discovered that a two-soliton solution existed in a class of bilinear equations with a certain form. When I announced this, I was ecstatically praised by Prof. Morikazu Toda, one of the developers of soliton theory. Advancing to the doctoral degree program, I announced that that class of bilinear equations had in a certain sense a general solution by applying the Fredholm determinant. I was a second year doctoral student. After that I was able to write papers once a month and eventually I put eight of the papers together and received my doctoral degree. I had studied Fredholm determinants on my own. In a mathematics class in my second year at the university, the textbook we used was *The Basics of Industrial Mathematics Volume 1* by Jiro Takeda. Since there was a Volume 1 there had to be a Volume 2, and I wondered what could be written in it, so I bought it and read it. It contained Fredholm's integral equation theory. Fredholm determinant was derived as an expansion of determinates of finite dimensions to infinite dimensions. This led to my doctoral dissertation. You don't know what's to come after learning something. I learned it's good to take an interest in things.

My third "proverb" is, "Don't go into a popular field, create a popular field." Simply said, do what the geniuses won't do.

In my third year as a doctoral student, I was often summoned by the Research Institute for Mathematical Sciences at Kyoto University and presented papers at research symposiums. I gave copies of papers I'd just written to the group led by Mikio Sato, well-known for Japan's first theory of hyperfunctions. That year, Prof. Sato showed that the totality of soliton solutions form a Grassmann manifold and that the identities on that manifold expressed in Plücker coordinates become a bilinear equation. In addition, soliton equations can be classified by using infinite dimensional Lie algebra, so what I showed was that what I did was to obtain a general solution for bilinear form associated to Lie algebra of type A. The Sato group focused on the interaction term of my solution. I derived this term using a strange determinant identity. This was an essential part in the algebraic structure of Lie algebra of type A. The algebraic structure of that mysterious soliton equation, was solved in a night by Sato theory. Prof. Sato was an incredible genius. Whether I would be able to overcome him was my next theme. Solitons was a popular field and I wanted to pioneer a new field, so I veered away soliton research. I changed my theme to exact solutions to nonlinear partial differential equations with no algebraic structure, an area Prof. Sato didn’t like. Specifically, I started researching computer-aided analysis where, using a computer, I would look for interesting approximate solutions and prove that the true solution existed close by. My method was to aim for a strict solution to a non-linear equation using numerical calculations with precision guaranteed by grasping all errors generated with a calculator, including errors from the four arithmetic operations that are rounded. I tried things in this vein and immediately came up with various results. When I tried for a strict proof of the existence of chaos in Lorenz equations, which had not been solved, I noticed the level of research on verified computation was insufficient at the time. The limit for guaranteed accuracy was solutions for simultaneous linear equations of around 80 variables. Solving this problem I made my top priority, and as I pursued it, I noticed I was able to guarantee accuracy for solutions to simultaneous linear equations with two times the effort of an approximate calculation by, like an egg of Columbus, changing the direction of the rounding the floating-point numbers per matrix. In an instant I figured out that it would be possible to solve in some cases systems of equations to around 10 million dimensions. And, I was able to show how almost all numerical calculation problems could be solved efficiently using this methodology. I had systematically developed a new field. Non-linear equations could be strictly solved using a calculator. I had succeeding in outwitting the geniuses, which want beautiful solutions.

I’ve given you my three proverbs above. Now, the Faculty of Science and Engineering is in the process of expanding its beautiful building. I would like to thank the president and everyone else who is making this possible. For everyone, it will be a more comfortable environment to study and do research.

Once again, congratulations to everyone on your entrance to the university.