Remembering Dr. Ohkawa Ming-Sheng Chu

It was so sad for me to learn that our respected and beloved teacher and leader passed away.

I came to know Dr. Ohkawa when we were both “young”. I was a fresh and inexperienced Ph. D. postdoc right out of graduate school. Dr. Ohkawa was a young and rising leader in the burgeoning world of nuclear fusion. He just dispelled the curse of “Bohm Diffusion” in plasma confinement and proved the existence of “Neoclassical Difussion” in the Octopole(1). It was right after the Soviets have demonstrated the equilibrium and stability of the Tokamak and its ability to break through the ionization barrier. The gospel of tokamak was being preached all over the world. Fusion laboratories competed in converting their devices to tokamaks. It was quite clear that nature has left us much more work to do: to improve the tokamak. A first step in this direction has already been hinted by Dr. Ohkawa in his table top doublet (2). Also, nature showed us that it did not shut the door to fusion on earth completely. There might be other devices out there that could be just as or even more promising than the tokamak. We should work hard to find out what they are. Dr. Ohkawa had many, many ideas: pinches, mirrors, tokamaks, stellerators, multipoles, picket fences, plasma focus, reversed field pinches, field reversed devices, … , and combined confinement concepts. It was during this period I first came into contact with him. Many of us, yes specially me, had much to learn – this meant learning while doing the work. It was much more interesting and mentally challenging than learning at school. Luckily he still had a little time to teach: sometimes even came to our offices and sat down with us to talk about details of the task.

During the early 70's, after the decade of post sputnik of the 60's, which exhausted the burst of aura of defense research during the war as a savior to humanity. Scientific research fell from the radar screen to the demands of the great society. We felt lucky to be able to continue working in science and understood that we need to dedicate our work only to the immediate needs of our projects at hand. Competition for research funding was fierce. Experimental colleges would take all day until 5:00PM to prepare their machine, do exploratory shots. At 5:00PM and after a full day of meeting in his office, Dr. Ohkawa would go down to the laboratory and direct the experimentalists to try this and try that, and yes: try the more "daring" and "difficult" cases. It would usually last until after 7:00PM. We would think that every one would be exhausted for the next say. But next morning, we could still see Dr. Ohkawa drove in on time in his MGB, with the same bounce in his steps up the stairs from the parking lot, and started his whole routine of meeting in his office and came in to talk to us about theory and then to the laboratory at 5:00PM. Despite the excellent hard word of the group, it remained small.

But situation changed shortly. The OPEC oil crisis of 1973 served as a rude awakening to the US administration and congress on its long-term energy policy. Long-term energy sources are needed; multi-prong development paths are also encouraged. AEC and later ERDA (and DOE) openly solicited ideas for new and improved devices. At that time, GA is a very small group in comparison to other national laboratories. But this "once in a blue moon" opportunity is only there for the ready. If it were only scientific ideas, Dr. Ohkawa probably was ready more than a hundred times over (3). But, I understood that ERDA needed to assess all the other capabilities of the "organization": staffing, engineering, environment, company support, …. Dr. Ohkawa was there and assembled a capable

team around him and passed all these hurdles one by one. We started the design of Double III. Countless trips were made to ERDA and other related organizations for reports, reviews and ...

Then overnight, we saw the parking lot was expanded and there appeared trailer offices in it. And more trailers appeared. New faces appeared in offices. The new dedicated physics team, the engineering team, the theory and computation team, and reactor design team were formed. Then a new big machine building complex is built in Sorrento Valley "down the hill" from GA main campus. A bustling of construction activities: new motor generators, designated power lines, cranes, concretes, coils, laboratories, machining facilities... There are even bus to take people up and down the hill. We noticed that streams of people constantly went in and came out of Dr. Ohkawa's office. And the General Atomics fusion facility was constructed. I witnessed first hand vicariously how a vision was turned into the reality. Dr. Ohkawa was truly a "builder."

An ancillary effect of the oil crisis was that the energy industry also realized the importance of long term research. There was again an open call for research proposal, this time within the private oil companies. Opportunity appeared again for GA fusion and Dr. Ohkawa was ready. He proposed the idea of OHTE. Judging from hindsight, this was an obvious missing closed confinement system from those which already proved their viability and which we were all familiar with. We had the low current systems of the tokamak and the stellerators, with circular and helical cross sections. We also had the high current system but only the reversed field pinch with circular cross section. It should have been obvious that the high current helical cross section system was missing and should also be a

viable system. A panel of international experts was assembled to review the concept. Just as in the case of Doublet III, although on a smaller scale, the OHTE device went into design, construction, and then operation. Although due to reasons beyond our control in the corporate world of the oil industries, the device did not get its chance to scale up. But it finished its proof of concept experiments. This is one of the rare examples of a fusion device supported by private industry, came into full operation and fulfilled its original design mission. Dr. Ohkawa was forever an innovator and some of his innovations were so "obvious" and powerful.

Dr. Ohkawa recognized that importance of building a device right. During the Doublet III (Later DIII-D) design phase, he would push for exploration of parameter space that could allow it's most flexibility and the achievement of the highest performance. He was also very meticulous in the review of the design. I could almost still hear him say to someone, " I am going to begin to pour concrete and cut metal. I need an answer to this question. " or " This is the parameter, you need to make sure you can achieve it" or " That's the tolerance, I want you to make sure that's the maximum give allowed." On the other hand, he was also very protective of the engineers and the construction crew. He understood the importance to keep the schedule and the budget. After the design was frozen, he would always tell us "You can keep on working on improving the design for future reference, but the design is frozen." I never learned how many detailed milestones there were on the constructions, or how many times unforeseen events caused the critical construction path to be changed. But it seemed to me that the construction projects were always on schedule and within budget. One very important decision made by Dr. Ohkawa was that he would never skim on the construction budget. He wanted a good machine. This decision

bore fruit when the machine stood the test of time and remained in operation even today. Dr. Ohkawa was a good engineering manager.

Dr. Ohkawa used to joke with us saying that experimentalists and theorists are the same. It depends on how you obtain your scientific results. He wrote many theoretical papers mostly to bring out his innovative ideas. He did not have time to do any lengthy calculations. By using just a few pages, he can capture all the essence of the physics and bring out the most far-reaching inferences. Notable amongst these are the theory on the octopole; the doublet – a noncircular tokamak; the OHTE – a new strong current driven confinement system; neutral beam current drive; RF current drive; impurity confinement; … Because he was also an experimentalist, he appreciated fully the implication of theoretical idealization. He would advise us never to carry the theoretical idealization too far. It would be a waste of effort to get bogged down on theoretical details that had the root of its complexity in the idealization of the model. He would say "that can never be observed." He was also ready to share credits and would always invite people as his co-authors or co-inventors. He was a brilliant, generous and prolific theorist.

The decade of 1970 was the expansion decade of GA's effort in fusion. We were experimentalists, theorists, and engineers. Dr. Ohkawa's criterion for hiring new employees was not based on what you already know, but on what you are capable to know and do. We were constantly under the pressure of not able to measure up to the new hires. Most of the new staff came with a varied physics or engineer background but not plasma confinement physics. Dr. Ohkawa used to tell ERDA (later DOE), " We will educate a new generation of fusion physicists for you". Yes, he instituted a lecture series to teach us on

plasma confinement physics. He also taught us how to do physics: to keep a scientific diary. An Awakho (Ohkawa spelled backwards) award was once instituted to award whoever can keep a most creative scientific diary. I doubted many people did keep up. Lunch at the cafeteria became a time to bounce off whatever ideas that did not get aired at regular meeting hours. There was always a crowd around Dr. Ohkawa. He was a fast eater and quick responder. His answers were usually short and fast. We usually had to keep these answers and go back to the office to chew and work on them to finish the lunch. To help make his communication precise, he also always wrote down clearly his thoughts: in memos, in notes, in papers. We were very happy to receive them. We could usually get a glimpse on what were the hot topics in plasma physics from these. This was the case even in later years, after Dr. Ohkawa moved to start the research institute at the GA headquarters and stopped being responsible for the daily work of fusion. We could still learn how to do new and basic physics in new areas. There were so many of them. I could not but wonder what if everyone of us were just one tenth as productive and as disciplined as him. Dr. Ohkawa was a great hands- on teacher. He practiced what he preached. A whole generation of fusion scientists grew up under his tutelage.

An incident left a deep impression on us about Dr. Ohkawa. In the early days, GA fusion inherited some surplus batteries as power source for the experiments. These batteries are installed in an open airy area. Some of the insulations gradually broke down. One night it caught fire and caused some damage. The implication was that because GA is close to the popular La Jolla resort, it could seriously threaten the future of the experimental devices. I was not aware of the fire, which broke out at night. We only noticed that the next morning, having been up at night to direct the fire fighting effort, many of the

responsible experimental colleagues came in late. We learned later Dr. Ohkawa did not blame anyone on the incident. Not a single person lost his job. Only new safety procedures were established for the batteries. We understood that he had to stand in front of a lot of people "higher up" in and out of the company explaining about the situation. Somehow, aside from the new safety procedure, the fire did not cause a serious damage to GA's experimental program. This incident showed us Dr. Ohkawa's leadership quality. Like everyone else, the "good lord" did not spare him his share of unexpected difficulties and failures. He took the responsibility to solve the problems and was forever steady and ready to stand up again and continue on ward.

I joined the fusion group when it was still small. Dr. Ohkawa (and Mrs. Ohkawa) paid attention to our life outside of the office. I still remember the occasion when he told me I should buy a house. At that time, we could still get a reasonable house in San Diego for $30,000. What a good (and free) financial planning advice! Mrs. Ohkawa also introduced my wife to the wives of other fusion colleagues. We even attended quite a few parties at their house on the hill up in La Jolla. Later, the organization grew bigger. These functions can only be held by separate groups at different locations.

Looking back, I found I was never formally his student, yet I regarded him as one of most respected teachers. I never directly reported to him, but I treated him as my boss. I never directly received my paycheck from him, but I knew he was responsible for my salary for a long time. I worked closely off and on for Dr. Ohkawa for about a decade. I really learned a lot and enjoyed a lot. One of his most important abilities was able to find the "best" people to work for him. I was glad that after

the first decade, I did not work so close with him anymore. I was truly afraid that I did not serve him well. I was also glad to see that he was surrounded by people who are much more capable and suitable than me. I kept on reading his writings and kept on finding out about him Although I did not accompany him from place to place, from one scientific area to another, I counted myself as one of his "followers". I know that what I shared here is but a very small part of Dr. Ohkawa's life. But it represented such an important part of my life. An important reason that I was able to "enjoy" physics throughout my humble career is due to him. What a fascinating person! I am truly fortunate to have known him.

References:

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(2) Ohkawa T. and Voorhies H.G. Phys. Rev. Lett., 22 p 1275 (1969)
(3) Ohkawa T. and Jensen T.H. Plasma Physics 12 p 789 (1970)