Oyo-Buturi International

Interview

Dr Toshimitsu Musha has spent the last 25 years clarifying the source of 1/*f* fluctuations. One of his major contributions to science has been the discovery that biological rhythm is basically subjected to 1/*f* fluctuations with the result that visual, auditory and sensory stimuli all show 1/*f* fluctuations. Dr Toshimitsu Musha is Director of Brain Functions Laboratory Incorporated and The Institute of Fluctuation Phenomena Incorporated.

OBI: Can you briefly describe why you became interested in Johnson or 1/*f* noise? (**OBI**: "one over f ").

Dr. Musha: Well, it's a long story but as I recall, I graduated from Tokyo University in 1954 and joined the research laboratories of *Den-Den-Kou-Sha*, or ntt as it is now called, where I worked on negative resistance in gas discharges in vacuum tubes. As you may know, gas discharges are unstable and noisy. That meant that it was difficult to apply the results of this research, so I went on to look at how electromagnetic waves travel through gas a plasma. Those were the two main topics of research I studied. I left the company in 1964.

OBI: Why did you leave?

Dr. Musha: I was not satisfied with the policy towards basic research. In a major change of direction, the scale of basic research was sharply reduced. I told the laboratory director on a number of occasions that "it is easy to stop basic research but much more difficult to reactivate it". I was only in my thirty's, and there was little chance of the director's paying any attention at all to what I said.

OBI: So what did you do?

Dr. Musha: I sat and passed the Fulbright Scholarship examination for exchange scholars and decided to go to mit. I did not tell my company that I was going to sit the exam and the director reacted strongly against my action for "deciding on my own future". A very strange state of affairs! But anyway, I went to mit in August 1964 and carried out research on plasma discharges with a team that was working on nuclear fusion. I worked at The Research Laboratory for Electronics, which was housed in the only wooden building in mit. The building still stands today. The main emphasis of research in the group that I joined was on semiconductors and so I shifted research direction from gas plasmas to semiconductor plasmas. Actually, before going to mit, I was asked by a professor at The Swedish Royal Institute of Technology if I would be interested in setting up a group at his Institute. I told him that I had already decided to go to mit but that I would be glad to go to Sweden after my stay at mit. So, after staying at mit for a year I went to Sweden in 1965 for a year.

OBI: What did you do in Sweden?

Dr. Musha: I continued my work on instabilities in plasmas. During this time I was asked whether or not I would be interested in returning to Japan and work at Tokyo Institute of Technology. I thought about it and decided that it might be a good idea to return to Japan. But the problem was that the offer of a position had to be approved by a professorial committee and the results of the meeting were difficult to predict.

OBI: Yes – the offer of a possible job, but no guarantee. So how did you overcome this problem?

Dr. Musha: I wrote a letter to The Director of The rca Research Laboratories in Tokyo asking him if he would allow me to work in his Laboratories while I waited for the results of my application to tit. Thankfully, rca gave be a research position in August 1996. My post at tit post was confirmed in November of the same year.

OBI: What type research did you do at tit?

Dr. Musha: Initially I worked on semiconductors and, in particular, the helical instability of InSb in a magnetic field. That phenomena was problematic but we were able to solve it. Afterwards I again studied noise fluctuations in electrical discharges; the same theme that I had pursued at *Den-Den-Kou-Sha*.

OBI: What do you mean by noise in this context?

Dr. Musha: There are four types of noise associated with semiconductors; thermal noise, shot noise, generation-recombination noise and 1/*f* noise. The first three types of noise were well understood at the time but 1/*f* noise was still a mystery. 1/*f* noise was first observed in vacuum tubes by Johnson in 1925. He published his results in Proceedings of ire but it was not known as 1/*f* noise at the time. In fact, there was so very little known about the source of the noise that I decided to carry out research to try to find out more about these strange noise fluctuations.

OBI: Was research related to noise phenomena being carried out at tit at the time?

Dr. Musha: No, but there was one group working on the frequency stability of quartz oscillators. The results of their research showed that under extremely stable conditions, only the 1/*f* fluctuations of the frequency remained. We also observed a correlation between temperature and frequency fluctuations and how the spectrum of the frequency fluctuations depends on temperature stability. We found that when the temperature is extremely stable, then the fluctuations are independent of the temperature and only the 1/*f* spectrum remains. This is the case for atomic clocks. Being interested in the field, I attended the annual International Frequency Standard Conference held in America. There were many interesting presentations such as observations of $1/f$ noise in transistors; $1/f$ fluctuations in the terminal voltages across a resistor when a current is passes through it; $1/f$ fluctuations in atomic clocks; $1/f$ fluctuations in the earth's rotation and so on.

I suggested to the organisers of the conference that an interdisciplinary approach would be required to solve the problems of $1/f$ fluctuations and that it would be a good idea to organise an international conference on the subject.

OBI: What was the response to your proposal?

Dr. Musha: Many participants agreed with my proposal but volunteered to be an organiser. So I decided to organise the first such interdisciplinary international symposium.

OBI: When was that symposium held?

Dr. Musha: In 1977. Being interdisciplinary, there were people from various backgrounds, including, electronics, physics, biology and astronomy. There was a very interesting paper presented by F. Voss of ibm Watson Labs. He found that acoustic frequency fluctuations of most pieces of music contain $1/f$ fluctuations. I was really intrigued...The conference was then held every two years changing locations between Japan and usa.

OBI: Why did you decide to look at $1/f$ fluctuations in living cells and, more particularly, human beings?

Dr. Musha: That was pure coincidence. In 1976 I moved labs from the tit Ookayama campus in Tokyo to the newly built Nagatsuda campus in Yokohama. Now, the Nagatsuda campus is on the Den-En-Toshi line and, on the same line, is the large the Showa University Medical Hospital, near Fujigaoka Station.

My associate professor at the time used that line daily, as did a doctor working at the Showa Hospital. They happened one day to sit next to each other and, after introductions the doctor explained that he had a problem in diagnosing heart problems. Although the doctor wanted to make a detailed study of the potential distribution in the region around the heart for diagnosing patients with heart trouble, there was no apparatus available for the purpose.

OBI: And did you collaborate in finding a solution?

Dr. Musha: Yes. We adapted our technology for mapping semiconductor equipotentials to make measurements in the human body. I think that our results helped to make a significant scientific contribution to society.

We analysed many ecg results and, to our surprise, we found clear evidence of $1/f$ fluctuations in the ecg spectra. That was 1982 and the first time that $1/f$ fluctuations were observed in the "rhythm" of living organisms. I wanted to carry out further experiments on heartbeats, and by looking at large neurons from "African snails", I was able to confirm that the pulse trains from neurons do indeed show 1/f fluctuations.

OBI: Did you investigate why they were $1/f$ fluctuations?

Dr. Musha: We found by using computer simulations where living cells were modelled mathematically with the inside being negative and outside positive that the ion current slowly leaks away until there is a sudden release of current, after which the process starts once again. From such simulations we were able to confirm that the discharge interval showed $1/f$ fluctuations provided that a leaking ionic current is subject to $1/f$ fluctuations just as that in semiconductors. So the discharge process was one source of the $1/f$ fluctuations.

OBI: Do your results explain some of the observations about $1/f$ fluctuations in classical music?

Dr. Musha: What I found was a close relationship between the acoustic frequency fluctuation of music and that of biological rhythm fluctuations. External stimulation evokes a comfortable sensation in the body when it has the same fluctuation as the biological rhythm fluctuation. It seems that music that we consider to be good and enjoyable to listen to has $1/f$ fluctuations in it. There are exceptions in very modern music.

OBI: What other aspects of $1/f$ fluctuations have you studied?

Dr. Musha: We have also investigated visual $1/f$ fluctuations. We have found that humans find patterns that have a $1/f$ fluctuation to be more comfortable and relaxing. The design of offices, streets, cars and so on, can all be made more appealing by using the results of our work on $1/f$ fluctuations. Our results even show that traditional Japanese houses, with tatami, shoji, and the use of wooden pillars, are built with $1/f$ fluctuations. That is why they are more comfortable than the modern mass produced housing units.

OBI: Are there any other examples of the application of $1/f$ fluctuations to making life more comfortable?

Dr. Musha: A few years ago I was approached by miti and asked how to reduce helicopter noise in order to encourage more people to commute by helicopters. Apparently, the noise from the rotors is the main reason why helicopters are not a popular as a means of transport.

I said that reducing noise would require using more insulation which would make helicopters heavier and difficult to fly. So my proposal was not to reduce the noise but to make the rotors turn with $1/f$ fluctuations; to turn the helicopter into a "musical instrument". The idea of changing the rotor frequency or doing anything at all to the rotor was rejected out of hand by all the helicopter manufacturers. However, there is a way of realising this idea by hydrodynamic control without changing the mechanical rotation. The mystery of the $1/f$ fluctuation has not been resolved for the last 70 years and it will not be solved as long as we stick to an "ensemble treatment" in statistical physics. We need to introduce new ideas and mathematical tools into statistical physics in order to clarify the situation. It is an exciting theme in both physics and biology.

OBI: Can we change the subject now to the main reasons for the increase in the number of young children who lose interest in science and technology while still at school?

Dr. Musha: Children should be taught the interesting aspects of science at school, before they go to university. One idea would be for university academics to teach science at local schools on a voluntary basis. I have heard that this has been tried in Tsukuba City; more use should be made of retired academics as well. They could teach in schools and show young children how much fun science can be. It's important to do it at an early age when the experience will have most impact on the children.

The problem now is that children are too busy studying for *juken* (obi: school entrance exams). They need to play more; science is a form of play from which new ideas are born. They need the time and freedom to think about more than just tests and exams. Society has become too efficient with the loss of simple everyday comfort and the time just to think.

OBI: What kind of person do you think has most affected the 20th century?

Dr. Musha: I think that many physicists fit that category of person, particularly those who developed ideas in relativity and quantum mechanics. They speculated about things that could not physically be seen; it was a special form of imagination that led to many major proposals and discoveries.

OBI: What about the 21st century? What kinds of science and technology await us in take next 100 years?

Dr. Musha: It has been said that the last ten years of this century have been the "decade of the brain". I agree with this. But the first ten years of the 21st century will no doubt be "the decade of the mind". The functions of the brain are medical issues, but the mind and heart are areas in which the general public have a deep interest.

OBI: Do you have any comments to make about the recent experiments on cloning?

Dr. Musha: I think that our ideas related to *rinri* or ethics need to be reviewed. You cannot make laws and rules that say "You must not do this or that," because ultimately it will be our sense of ethical responsibility that will determine the future of any new idea. The effective use of cloning technology is the issue; you cannot stop human interest in the subject.

I have my reservations about the objectives of medicine. Should life be prolonged at whatever cost? Or is it better to let terminal illness take its natural course? The ethics of modern medicine are still based on ideas that are outdated; the ethics of medicine and medical care require reviewing.

OBI: You have worked with many people from many different backgrounds and, in some cases, different nationalities. How have you managed to maintain such a wide network of people to collaborate with? Also, you seem to have changed your career path almost every ten years. What reference do you use for making such decisions?

Dr. Musha: Physics is natural philosophy and a basis for interpreting what is happening around us. I think that you should try to listen to others from your own perspective even when they are from different fields from your own. This is a way of increasing your human network. Moreover, I think that one of the most important traits of a researcher is *shakousei* or sociability. When you want to know something new, it is much more efficient, at least for me, to call a friend instead of rushing to a library. Also, if you know what you want to do and can maintain the desire to do it, you will no doubt have the chance to try out your ideas during your lifetime. My research may seem to have made turns several times but the whole stream is connected by a causality chain inside. But meeting people has triggered many new ideas.

As far as making decisions is concerned, I am an optimist and once I have started on a project I do my best to realise the aims. I don't really read a lot of books, but I enjoy talking; I get a lot of ideas when I'm talking with people.

OBI: Have you reached a final conclusion about the ubiquitousness of $1/f$ fluctuations?

Dr. Musha: Yes I have. Energy partition in a complex system in almost thermal equilibrium must have $1/f$ fluctuations. This is the origin of many observations of $1/f$ fluctuations. True thermal equilibrium does not exist in a classical sense of the meaning. We have some experimental evidence to prove this but it is not easy to explain this idea mathematically. This is the present status of our understanding of $1/f$ fluctuations.

OBI: Do you have any time for hobbies?

Dr. Musha: I don't really have any hobbies-I don't play golf or mahjong! I enjoy travelling, though, particularly by car or train, but going to places by air does not appeal to me.

OBI: And the future?

Dr. Musha: I have established two venture laboratories and I want to combine them to establish a small international research centre. This will be possible when the present venture laboratories become profitable and I have enough finance to support my idea; it has already been partly realised.

Interview by Adarsh Sandhu

Further information

- `http://home.ksp.or.jp/bfl/index.html`
- *Journal of Multidisciplinary Research* Vol. 11, No. 1, p. 892, April 1998

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Review: International Patent Systems

A two part series of articles reviewing the history of the modern international patent system based on a review by Mr Fumio Sato, an international patent attorney.

The original Japanese text was translated into English by Dr. F.M. Saba, Toshiba R&D Centre.

The present status

The move to a common international set of procedures has progressed to such an extent that there is usually little need to worry about the differences. However, differences remain which can cause problems at times and even though the legal wording may appear to be the same, the actual interpretation may differ according to local traditions.

The Japanese Patents Office produces a list of the differences between the patent laws of about 160 nations and regions. (See `http://www.jpo-miti.go.jp/index.htm` for more details).

The Rise of Early Capitalism and the Birth of Patent Systems

A patent system is said to have existed in the Athenian colony of Sybaris, which was situated somewhere around the tip of the Italian peninsula until about 500 B.C. Sybaris prospered greatly on account of a favourable climate and rich soils, but in the battle with Crotona (the site of Pythagoras' activities) it was totally annihilated, so that its exact location remains unknown to this day, though its echoes remain in the word "sybarite". The next time a patent system appeared was in Venice with the enactment of patent laws, in 1474 A.D. The fine details of these systems have been lost in antiquity, but there are features common to the background of both cases. These include the development of a market based on trade, particularly the move towards the use of gold currency, the rise of capitalism through the accumulation of wealth, the flowering of the arts and sciences (as shown by the arts and sciences in Ancient Greece, and likewise in Venice of the Renaissance (14th to early 16th centuries)), and the development of economies and scholarship based on freedom of thought. In Athens, against the doubts expressed by the elders whether the new spirit of profit-making brought in by foreign merchants had to be accepted to such a degree that the old traditions of respect for the collection of city states, order, rectitude, and simplicity should be sacrificed, the Sophists declared their approval of a break with the past and are said to have extolled the beauty of the motivation of individuals brought about by the pursuit of personal wealth.

(In the legal world it had been held that the law represented the will of the gods, which was received and exercised by the rulers of nations, but the Sophists put forward the idea of "the rights of the mighty" and that the law be the subject of debates.)

Patents systems thus appeared together with the rise of capitalism as economies developed and the formation of markets reached a certain level.

Confrontation between Trade Capital and Industrial Capital

There are records that letters of patent had been granted in England from about the 14th century. At the time, England was a developing nation and its capacity to produce gun powder was limited by the amount of saltpetre which the King of Spain authorised to be exported there. However, by bringing in craftsmen from abroad, England succeeded in producing its own source of this strategic mineral. England was also able to replace its bronze canons with iron ones by using foreign craftsmen. It was to guarantee the freedom of these craftsmen from the guild system that was the original purpose of these letters of patent.

However, technological and economic progress changed the situation. For example, as a result of the establishment of a sea-route to India by Vasco da Gama, the price of spices fell drastically.

(The price of pepper, which was purchased in East India at 2.5 to 3 ducats per 100 pounds in weight and sold in Lisbon for 40 ducats, fell to 20 ducats. Trade is based on the principle of buying commodities where the price is low and selling them where high prices can be obtained, but if the capability for transporting goods increases, the price differential will drop. The main reason behind this increase in transport capability came from advances in seafaring, which came about through progresses in shipbuilding technology together with the development of Newtonian mechanics, astronomy, and high precision chronometers).

The King of Spain imposed penalties on selling at low prices, but the advances in transportation methods diminished the profits of the merchants. The finances of the rulers were being squeezed with increases in military spending, which were necessitated by the introduction of canons, and the move to a currency-based economy, which replaced taxes in kind with the payment of taxes with currency. The desire by merchants to secure profits through monopolies and the desire by the rulers to prop up their finances resulted in the use of letters of patent changing to become instruments for granting monopolies. For this reason, it is said that the situation in England became such that apart from the air and flour everything had a patent, and the resulting high prices bred discontent amongst the masses.

With the influx of gold and silver from the New World and the thriving textile industry at its core, industrial capital strengthened its move out of the control of trade capital, and the pattern of confrontation between the ruling classes together with trade capital arraigned against industrial capital and the masses was formed. What is said to be the first patent law, the Statute of Monopolies of 1623 A.D., was in fact brought in to remove all of these monopolistic privileges apart from the letters of patent granted for inventions.

The French Revolution likewise saw the abolition of monopolies, except for the privilege granted to industrial capital through the letters of patent for inventions.

The Industrial Revolution and Patents

The Industrial Revolution began in Britain, running from 1769 to about 1830. Britain became the factory of the world, but it implemented a strict policy not to allow its colonies to manufacture.

However, as the free movement of products became necessary, free trade was called for, and seeing the patents system as an obstacle to this, a movement arose to abolish it. Actually, in Holland, a trade capital nations, the patents system was abolished (July, 1869, to 1912). After a delayed start, European and American nations each succeeded in carrying out their own industrial revolutions. In 1857, after the first economic crash in Europe and America, each country brought in protective tariffs to safeguard their industries, and simultaneously the opposition to the patents system melted away.

With this background and the problem of protecting exhibits to the Austrian World Exposition, the Paris agreement came into being on 20th March, 1883. The signatories promised the same degree of protection to the citizens of each of the other signing nations as afforded to their own citizens.

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