Western and Eastern Approaches to Nature and Science

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Introduction

This paper or essay is what was presented at meeting of the Pontifical Academy of Sciences, Vatican Oct. 22-26, 1996, and construct the background of the High-tech Research Center of the Tokyo University of Information Sciences. The context of this article here may be simply understood by means of my first cartoon, Fig.1, which is hopefully self-explanatory to indicate the historical route of Western and Eastern culture together with the clocks of millenniums.

I) Nature for the East and the West

Until humanity all over the world of the twentieth century has been overwhelmed by recent advancement of modern science and technology, there has been a striking contrast in approaches of Eastern and Western mind to Nature. For Eastern mind, Nature is what exists by itself. It is an automation in the flow of time. Time plays a dominant role,humanity being its *outside*. Nature expresses itself by flowers, birds,trees, wind, snow, water flow, etc. as observed. In the West in contrast, fundamental element of Nature is space and humanity is to interact with Nature or something lying behind it, say, God. For Western mind, being baptized by Medieval Catholicism and Scholasticism, Nature exists on the basis of "Laws" or "Gods will".

II) Eastern Art and Western Art

The contrast is typically seen in arts. In the East, beauty or comfort resides in a break of symmetry or some kind of disorder. It is, in Japan typically, represented in the so-called tea ceremony or the Japanese garden. Both

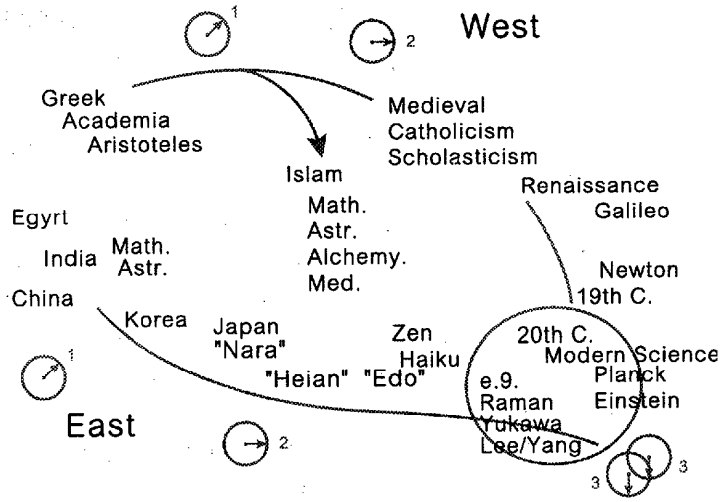

fig. 1. Historical route of Western and Eastern culture.

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the tea ceremony and the Japanese and Chinese garden are considered to be some expression of "Zen" spirit. And in paintings, calligraphy and potteries, the order underneath a mask of the disorder had appeals to the Eastern mind.

The break of symmetry, irregularity rather than regularity, non-linearity rather than linearity, some complexity rather than simplicity, turbulence rather than quiet flow, instability rather than stability are often emphasized in Ukiyo-e and other Japanese or Eastern arts, like pottery, architecture, gardening. As the West pursued Logos and God in the Medieval age, beauty of abstraction of Nature has been thoroughly pursued in the East. The Ukiyo-e has apparently stimulated also the mind of Western artists like, van Gogh, Gauguin, Monet and many others. The beauty of Japanese gardens and Buddha statues were strongly appreciated by Western thinkers like, e.g. Bruno Taut, Karl Jaspers and others. Beauty had been discovered in Eastern folk art by Bernard Leach, Souetsu Yanagi and other artists of Shirakaba school. In Noh-play and Kabuki we find another example of thorough abstraction of Nature. Though the essence of appreciation of Eastern arts is in strong contrast to the basis of Western beauty, artists nowadays including musicians,regardless of Eastern or Western, instinctively see the beauty or harmony, more or less in the break of order.

I would like to present some examples of what I mean. In fig. 2 shown is a Hokusai's Ukiyo-e. Of course, he did not know the concept of "non-linearity" and the shock wave. Besides, without a photographic

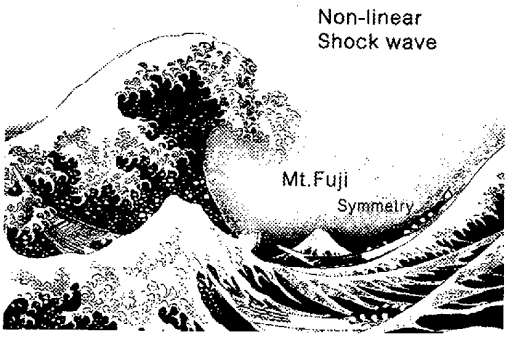


fig. 2. Ukiyo-e (Japanese painting of Edo-era) 1: Wave.

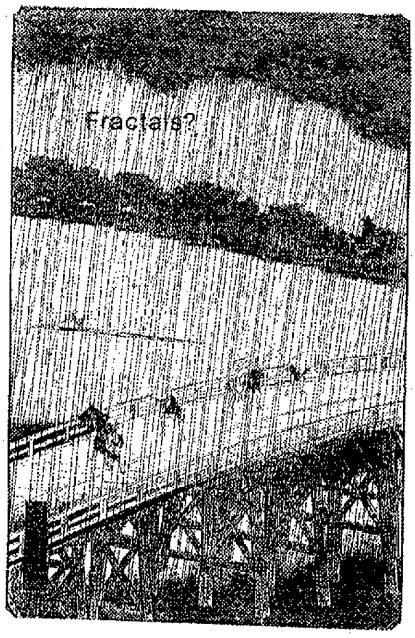


fig. 3. Ukiyo-e 2 : Rain.

camera, this can not be a realistic sketch. Yet if you analyse the shape of his wave front, it precisely exhibits the mathematical shape of the ***shock front wave***, except the details of water splashes. He must have been inspired by beauty of the contrast of this non-linearity with the symmetry of Mt. Fuji in the far view. There are many drawings of rains in Ukiyo-e and Chinese drawings as seen fig. 3. If you experiment yourself to draw random lines of rain mixed with regular lines

mathematically with a computer, you find that you may not reproduce the beauty of Hokusai's rain by mathematics.

III) From Determinism to Chaos and Human Mind

Now, let me follow the history of Western science. Here, excuse showing a series of cartoons which may be of too much over-simplification with jokes of bad taste and may be even of misleading. Yet I utilize them to show the essence in a limited length of time.

As shown in fig. 4 the basis of Western science in the 18th to 19th century is characterized by "determinism" as indicated by the cartoon of "Laplace's appointment book" as the consequence of the Newton's law and by a Japanese lottery. Entering the 20th century, the quantum mechanics (fig. 5) and the general relativity have revolutionized physics and science in general. Statistical physics use to tell us that Nature loves "disorder". Yet order or structure develops in Nature and we see often example of "spontaneous self-organization" of complex systems. Emphasis of "analysis" in science is now reversed to "synthesis": the total is not the sum of parts but is produced by the orchestration of the parts.

The former trend of science, pursuit for simplicity of basic law, i.e. reductionism, is now switched to the study of spontaneous self-organized complexity. Fundamental question now is why and how the elements which obey simple basic laws self-organize themselves to complex systems like stars, galaxies in the universe, weather, climates on the earth. Even more drastic change has been brought about during the past few decades by "chaos" and "fractal" which emerged

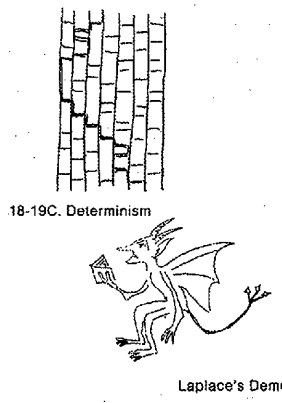


fig. 4. Determinism of 18-19th century.

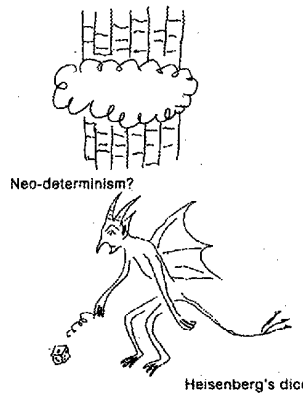


fig. 5. Probability in quantum mechanics.

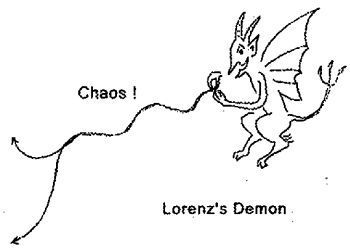


fig. 6. Discovery of chaos.

after the introduction of "non-equilibrium" physics. The concept of "chaos" was originally introduced by E. Lorenz in early 1960s unexpectedly when the computer model of weather was being pursued, and then the concept developed in various fields

of science through the 1970s. Chaos is now known as extreme sensitivity to the initial condition as shown again by the cartoon of fig. 6. Chaos is also characterized by the production of unpredictable consequences from deterministic elements. Chaos often leads to self-similar "fractal structure" and is often called "deterministic disorder". The discovery of chaos and fractal structure which appear in a variety of Nature's aspects is a great and dramatic event in science of the late 20th century.

Before then, that is, when science had been ruled by "determinism" disorder had been considered to be "unfair" , so to speak, to appear in Nature. Physics students used to be trained in their research works to acquire skill in avoiding disorder to elaborate simple and clean facts. Physics then was represented by the "elementary" particle physics. Other disciplines, chemistry of course and even biology, when molecular biology appeared, were exaggeratedly regarded as "applied" physics. A word "physics imperialism" was then often referred to.

Now that "chaos" appeared, these, say, unnecessary complications convert to something essential. This "order" which wears a cloth of "disorder" appears in spatial as well as temporal distribution in cosmology, astrophysics, geo-sciences, evolutionism, physiology, pathology and other disciplines of science. Extreme example of "non-linear" and complex system is brain and mind. Fascinating development of computer leads to possibility of handling various non-linear and complex systems. And now, brain/mind may become the subject of physical science as jokingly seen in a cartoon of fig. 7.

fig. 7. Brain and mind will become the subject of physical science.

IV) Chaos in Astrophysical Phenomena

Being an X-ray astronomer myself, from a variety of complexity I pick up some examples from astrophysics which appear chaotic or random, but appeal to me at least, since I feel " something behind". The "something" often exhibits "self-similarity" and may indicate the fractal structure.

One example is the temporal variation of the X-ray intensity of an X-ray star in Cygnus constellation, Cyg X-1, which is now considered the most likely candidate of the stellar black hole. It exhibits large intensity fluctuation on all time scales as suggested in fig. 8. As soon as the peculiar time variation of

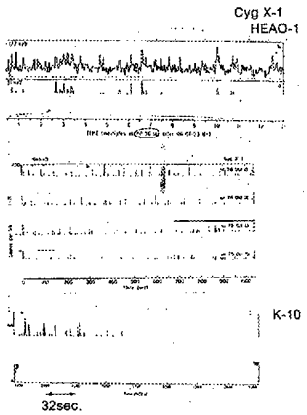


fig. 8. Examples of time variability of an X-ray star, Cyg X-1. Features of grouping are seen.

Cyg X-1 was discovered in the early period of the history of the X-ray astronomy, the chaotic but not completely random feature of its light curve was suspected to have something to do with its being a black hole. However, approaches with Fourier analysis and other analyses had been unsuccessful to reach any reasonable model of the black hole, except that the "self-similarity" was often notified as indicated in fig. 9.

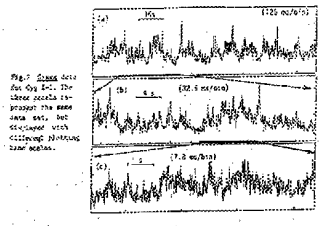
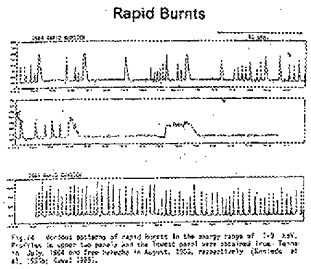


fig. 9. Fractal structure is suggested in the X-ray light curve of Cyg X-1.

In addition to this black hole candidate, there are a few other kinds of astrophysical bodies which have not yet been physically well understood, although they have been closely observed in the past decades and archives of data have been quite accumulated.

Normally X-ray stars are binary stellar systems which consist of a normal star and a neutron star to which stellar matter from the star accreted. A number of these X-ray stars exhibit a bursting feature due to the thermonuclear fusion of the accreted matter. Among these bursters there is one example known as the "rapid burster" which exhibits much more rapid bursts with repetition periods of seconds to minutes as shown in fig. 10. Fourier analysis has not led anywhere. The time sequence of the train of the bursts is typically chaotic but the origin of its behaviour within the context of the standard accretion disc picture is not clear.

Most of the bright Galactic bulge sources do not contain X-ray pulsars, but some times they exhibit a remarkable periodic behaviour which has been known as quasi-periodic oscillation (QPO) as its period is unstable as indicated in fig. 11. The power spectrum analysis of the source intensities as a function of time show, not a single sharp line spectrum indicative of a stable period, but rather a broad peak covering a range of frequencies. Physics behind this phenomenon has not yet been understood.



neutron star with a Circumstance of complex structure

fig. 10. Light curves of the rapid burster (1)

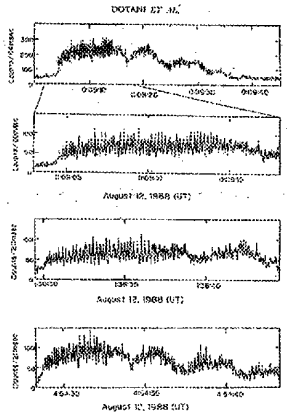


fig. 11. Light curves of the rapid burster (2). QPO feature is seen.

Perhaps the most extreme forms of energetic burst phenomena in the sky are those known as γ-ray bursts. The γ-ray bursts are rare events, no more than about 10 to 20 being observed each year. The typical burst lasts for only a few seconds. But during that time the source becomes the strongest γ-ray source in the sky. In addition, it has been shown that essentially all of the energy is emitted at γ-ray wavelengths range.

Accurate positions of the burst are not known and no optical identifications have been made to date. Thus, the distances of the source are unknown. But observations have shown that the distribution of the γ-ray bursts is remarkably uniform over the sky as exhibited by fig. 12. If this uniformity implies that the X-ray burst sources are of extra-galactic, and very distant origin,the amount of energy involved is too large to be acceptable. Physics behind the γ-ray burst is still vague

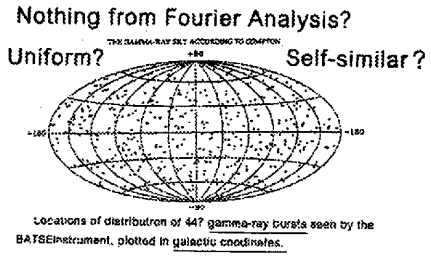


fig. 12. Celestial distribution of γ-ray bursts.

despite the decades of exhaustive observations.

These astrophysical events which appear mysterious at the moment may be, though not conclusively, understood in terms of chaos and fractals.

V) Prospect of Chaos

Chaos and fractal which our modern science has reached now as parts of fundamental features of Nature may be similar to what the East had unconsciously reached in its arts and culture centuries ago.

As a mathematical route opened by Newton led to Newton's law. that has been a basic physical law since then, mathematical formulation of "chaos" and "fractal" may provide new directions to science and technology, and may open up new applications.

Suppose we introduce fractal analysis as a new tool, instead of traditional "Fourier analysis like" mathematics, we may provide human activities with a new vision, not only for science but for sociology, economics, humanity, mind science etc. which some schools like "Santa Fe Institute" and others are actively searching for.

Great future may be extended in front of us.

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