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WHY AND HOW PHYSICISTS ARE INTERESTED IN THE BRAIN AND THE MIND

MINORU ODA

Hitherto, brain research has been carried out with pathological, physiological and psychological approaches. Apart from the experts in neuroscience, scientists in general are now more interested in brain research, as I have emphasised here in this Academy on some occasions in the past [1, 2]. And meetings by physicists have been held.

Ever since Masao Itoh founded a Brain Research Institute in the RIKEN Institute, Japan, and gathered together there a group of (experimental and theoretical) neuroscientists, as well as scientists from a variety of disciplines, more and more physicists have become interested in the brains of humans, small animals such as cats, dogs, apes, fish, and insects such as bees and ants.

Three approaches adopted by physicists may be delineated:

1) understanding the brain as though it were a computer;

2) producing new concepts where the computer is seen as an imitator of the brain;

3) observing physical traces left on the brain caused by the activities of the brain.

If, as suggested, the traces left in the brain are observable more or less randomly and can be freely detected, then the relevant issues may be listed as follows:

The brain of the foetus: when and how does the brain of human and animal foetuses grow to be brain-like in the mother's body? What is the physical mechanism involved?

What should be said about the imprinting of the brains of chicks as discovered by K. Lorenz?

When we or animals sleep what happens to our brains?

How do tropical fish control their 'millisecond' reaction of motion?

How do the brains of adult salmon or baby eels recognise their original mother-river so that they can return to it after their long journeys in the ocean?

What controls the swift group motion of birds and fish?

The visual cognition of stellar constellations (?) as opposed to traces in the brains of migrating birds (if they exist)?

The question of auditory cognition versus traces in the brain: noisy and musical sounds; group singing (e. g. cricks, sparrows). How do the brains of spring-singing birds evolve into those of autumn-singing birds?

The human brain: are there any differences in the brain which underlie Western or Eastern languages?

The brains of musicians: how do the brains of pianists, violinists, and conductors work differently?

How do the brains of painters work? When the drawing is started and when the painting is about to be finished.

The social behaviour of groups of animals, birds, fish, and insects can be watched and followed by means of telemetry.

The relationship which exists between instincts and evolution: how does a group of animals or insects develop or acquire and fix its instinct? How do insects such as bees or ants acquire differentiation as regards soldiers, workers, and the queen? How are instincts developed and fixed?

The Observation of the Brain

Now, what could be the techniques to look into traces in the brain which have a high spatial resolution? The X-ray astronomy technique, which we may call the Fourier Transform Telescope (FTT), can be converted.

The principle of the FTT, which was conceived as a high angular-resolution telescope for the angular resolution of arc-seconds for X-ray imaging, may be understood with reference to Fig. 1. The metal grid structure shown in Fig. 2 (see p. XIII) is attached to a solid structure and fixed with a certain relative distance. Combination of the grid units with a certain spatial frequency and a unit of the same frequency, a quarter phase displaced, and with a certain angular orientation with the corresponding grid, can produce a point on the Fourier u-v plane as shown in Fig. 3. The configuration of the points on the u-v plane produces an image. The principle of the FTT can be converted to that of the Fourier Transform Microscope (FTM) to achieve high-resolution images of the traces in the brain.

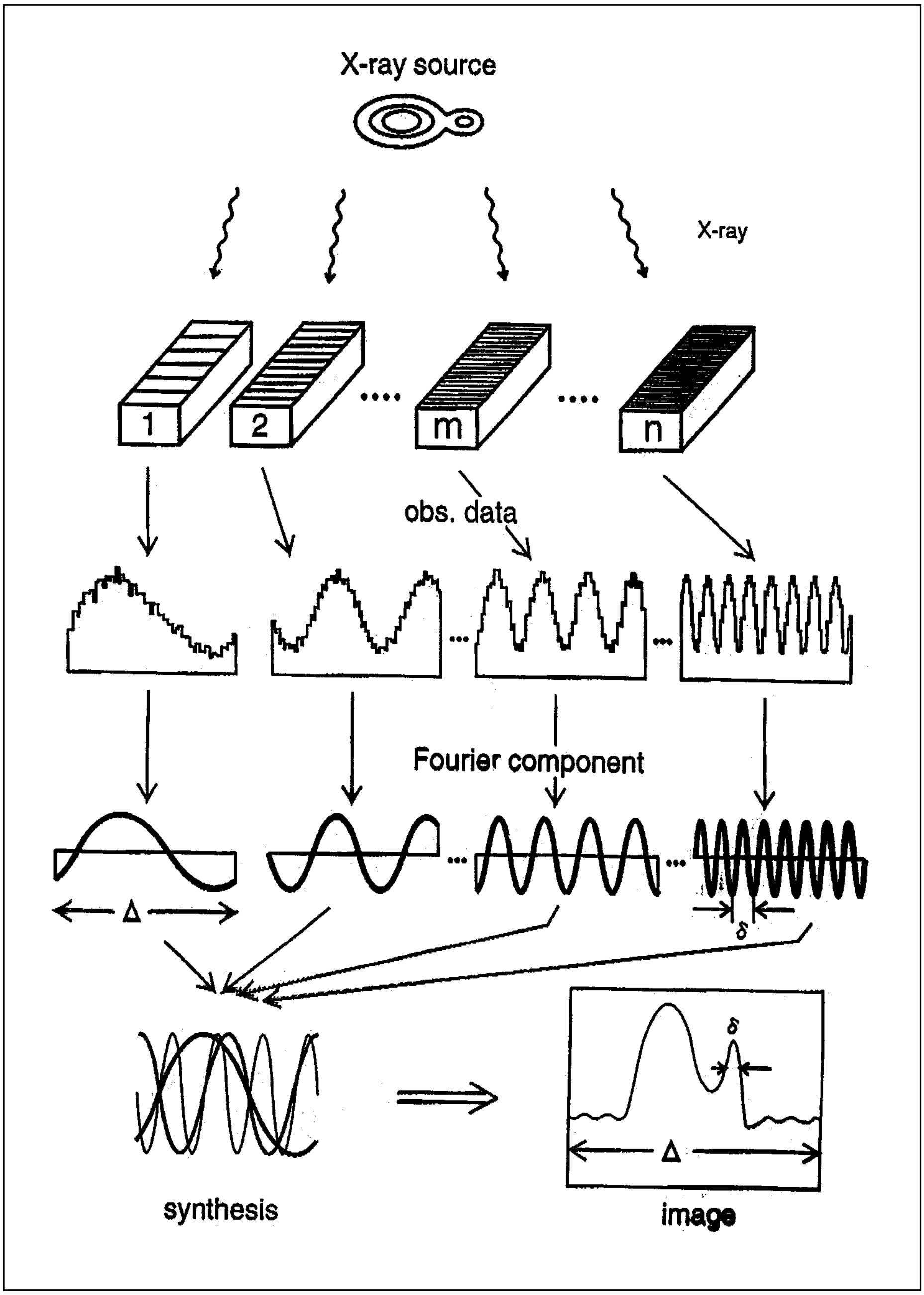
X-ray source
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Fig. 1

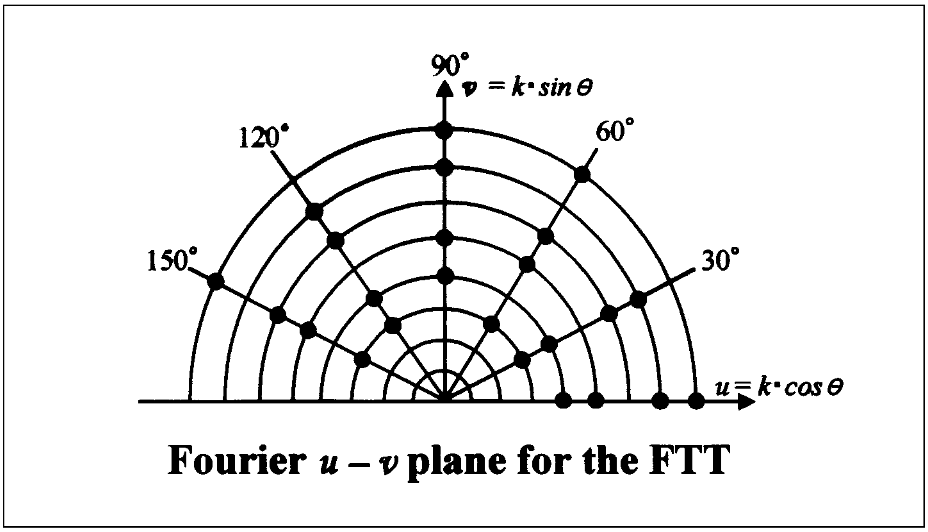


Fig. 3

Among the variety of ways by which to produce X-ray sources in the brain, Fig. 4 (see p. XIII) illustrates how a minus muon beam produced by a facility of the RIKEN/Rutherford Appleton Laboratory can irradiate targets in the brain and produce muonic atoms which in turn produce LX-rays.

Thus, images of metal concentrations in the brain, which are normally physiological or pathological, can be produced. The combination of grids at the distances corresponds to the point on the Fourier u-v plane by which the image can be reproduced with a high spatial resolution.

Group Evolution to Instinct

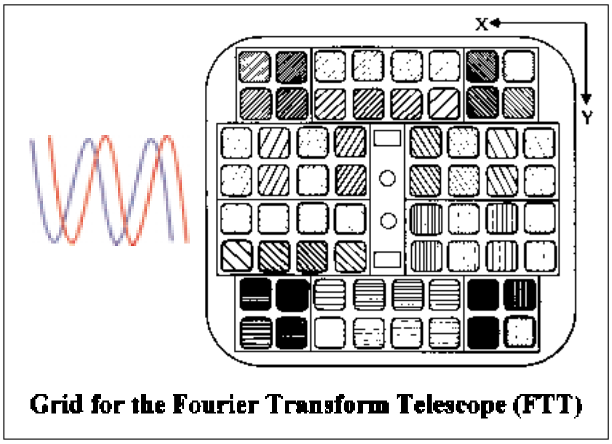
The relationships within social evolution as described by the late Dr. Motoo Kimura and by Freeman Dyson, and the development and fixing of the instinct of the group, can be experimentally understood in the case of the differentiation of soldiers, workers, and queens in the case of insects, such as bees or ants.

Such experiments on the relationship between evolution and the acquisition of instinct by insects can be attempted using the combination of techniques of FTM, telemetry, and the technique of the freezing and defrosting after some length of time of eggs and sperm, as developed in a laboratory of the RIKEN, the Yokohama Institute.

Brain science as seen from the viewpoint of experimental physicists has in this paper thus been described and discussed.

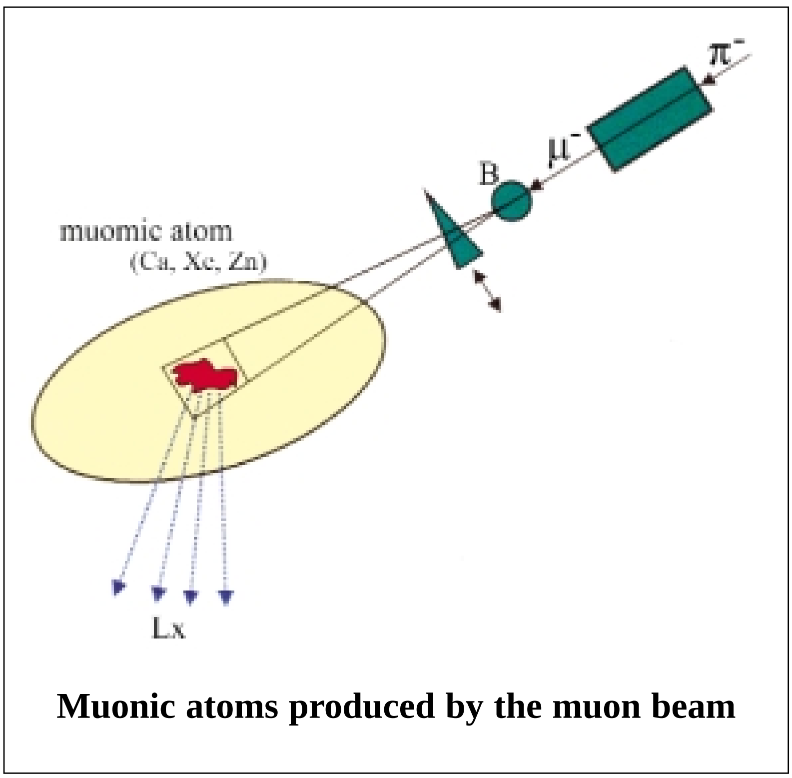
REFERENCES

[1] *Proc. Japan Acad.*, 71 (1995), pp. 1-4.
[2] A memo on this subject was circulated during the Meeting of October 1998.



Grid for the Fourier Transform Telescope (FTT)

fig. 2



Muonic atoms produced by the muon beam

Fig. 4