Report

# SKIN RESISTANCE vs. BODY CONDUCTIVITY: *On the Background of Electronic Measurement on Skin*

by Chang-Lin Zhang

## ABSTRACT

In this paper, we discuss several critical problems of electronic measurements on the acupuncture system, such as the size, shape, location and stability of acu-points and acu-meridians; the violent fluctuation of the measurement data; the holographic phenomena and the statistical self-similarity of measurement data; the transmission of signal along meridians and its speed; the parallel distributions between higher-conductivity points and higher sound intensity points and the mathematical background of log-normal distribution of measurement data.

A conclusion, which comes from the contradictions between the results of these experiments and the existing knowledge in modern anatomy, histology, neurology and biochemistry, is that there is an invisible dissipative structure of electromagnetic fields which are mainly composed of an interference pattern of standing waves in the resonance cavity of the human body under the condition of permanent support of energy in an open system. To some extent, the invisible structure corresponds to the mysterious acupuncture system and is closely related to many energetic medicines.

The conclusion and recognition of the existence of the invisible dissipative structure of the electromagnetic field inside a body offers not only a new understanding of the background of acupuncture and many other branches of holistic medicine, but also a scientific and quantitative way to evaluate the degree of coherence, namely harmony, of a body-mind system.

**KEYWORDS:** Acupuncture, skin resistance, electromagnetic field, standing wave, holography, dissipative structure coherence

# ELECTRONIC MEASUREMENT OF THE ACUPUNCTURE SYSTEM

Acupuncture is a living and stubborn challenge to established scientific knowledge. If acu-meridian and Qi really exist, the modern scientific views of the body-mind clearly need to be revised. Therefore, research in the mechanism of acupuncture is not only for the understanding of the old medical method, but also for the development of modern science itself.

## No Anatomic Evidence

The first dilemma is that we could not find the anatomic evidences which may prove the objective existence of acu-meridian and Qi.[1-3] However, the absence of anatomic evidence does not mean that we can deny the existence of an acupuncture system, which is not only working, but, through clinical success, is becoming more and more popular in many countries.[4-6]

## Electronic Measurement

Besides the clinic success of acupuncture, the electronic measurement on skin offers clear objective evidence which powerfully proves the existence of an acupuncture system even though we could not see it through anatomy. The electronic measurement of the acupuncture system was at first devised by German doctor Croon in 1947, then independently deviced by Japanese doctor Nakatani in 1950.[7-9] Since 1953, German Doctor Voll spent forty years developing it into a diagnostic system.[10,11] Today, the Voll-electro-acupuncture and some other similar diagnosis methods based on electronic measurement on skin have been used in many countries, including China.[4-13]

## What is Behind the Measurement?

However, the point is what is the basis for the electronic measurement.

## Querying the Terminology "Skin Resistance"

Usually, researchers call the electronic measurement of acupuncture "skin resistance measurement."[4-13] There are several reasons to use such a terminology. The first reason is that the measurement is performed on the skin of patients, the terminology objectively describes the place where we perform measurement. The second reason is that the acupuncture measurement is almost the same as the resistance measurement in electronics. Therefore, people think that what is measured on acu-point is also resistance. The third reason is that the resistance of body fluid is so small that it is completely negligible in clinical measurements. It seems that the reading of the instrument could only come from the resistance of skin, nothing else.

However, if we seriously check the terminology, we will find that there are many puzzling problems which do not fit into the existing knowledge of anatomy, histology, physiology, biochemistry and physics. Our discussion begins with a series of important experiments.

**Experiment 1: How big is the difference of "skin resistance" between acu-points and other places? And is the difference reliable?** The first question we have to answer is why the readings between acu-points and non-acu-points are so large. The ratio between acu-points and non-acu-points is usually more than ten times (see Figures 1-4). Many experiments show that this difference is almost independent of pressure (see Figures 1 and 2), voltage (see Figure 3) and frequency (see Figure 4) of measurement current as well.[3]

Then, a crucial question occurs. If the difference had come from the big difference in skin properties, shouldn't it be quite easy to find a big difference of the structures of the skin on acu-points and on non-acu-points through anatomy or histology? Unfortunately, there is no such evidence.

**Experiment 2: The shapes of acu-points and acu-meridians from the data of so-called "skin resistance" measurement.** For quite a long time, people believed that acu-meridians to be a pipeline like blood vessels or nerve fibers and acu-point was something like neuroganglion or some holes, and expected that we would find them through dissection one day.

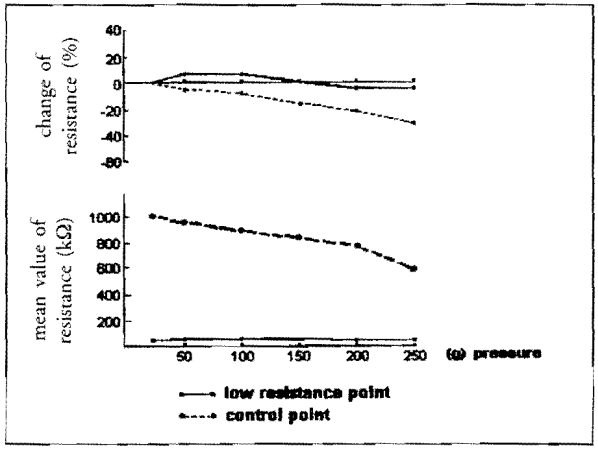


***Figure 1.*** *The relationship between "skin resistance" and pressure on electrode.*[3(p.188)]

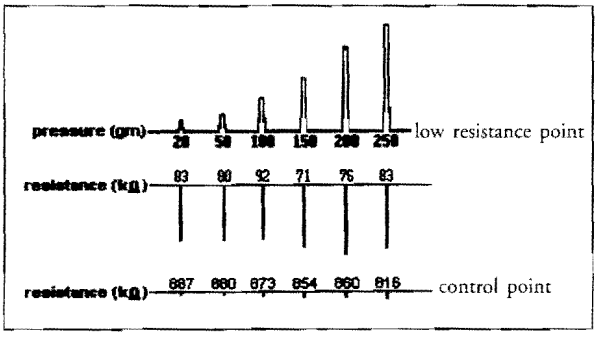


***Figure 2.*** *The relationship between "skin resistance" and pressure on electrode.*[3(p.189)]

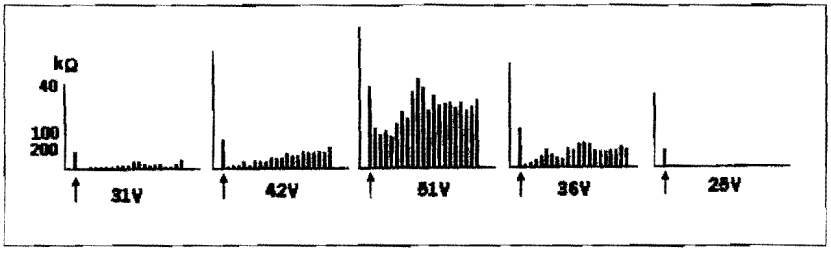


***Figure 3.*** *The relationship between "skin resistance" and measurement voltage.*[3(p.194)]

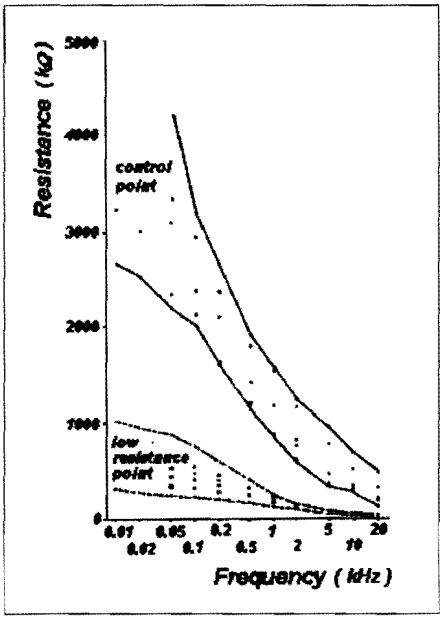


*Figure 4. The relationship between "skin resistance" and frequency of measurement current.*[8(p.26)]

Unfortunately, this belief failed to be proven through anatomy or histology in spite of half century of research. On the other hand, however, the objective existence of acu-points and acu-meridians is proven by means of electronic measurement with excellent reproducibility. Then, we have to ask what the acu-meridians and acu-points look like from the data of electronic measurement and whether they are like some invisible pipelines or knots or holes.

From Figure 5, we can see the shapes of two acu-points electronically measured by the American scientist, Dr. Becker.[12] The two pictures in Figure 6 are the results of electronic measurement along the meridian and across the meridian, respectively from American scientist R. O. Becker and Chinese scientist R. J. Zhang.[3,12,13] These results show that acu-meridian is not something like a pipeline with clear boundary, but more like small and invisible mountains without clear boundary, with several small and invisible peaks, which we call acu-points, on the small and invisible mountains.

The picture with pseudo-colors in Figure 7 shows a landscape of conductivity on the skin of a palm. At the center of the palm, we can find the point with the highest conductivity which is called acu-point "Laokung," which emits "Qi" according to the theory of acupuncture. There are other five points with higher conductivity on the centers of five fingers, which are also five important acu-points.

**Experiment 3: The movement of acu-meridian and acu-point on a large scale.** We have to point out that the landscape of conductivity on skin which has some correlation with the acupuncture system is not a fixed one, but a

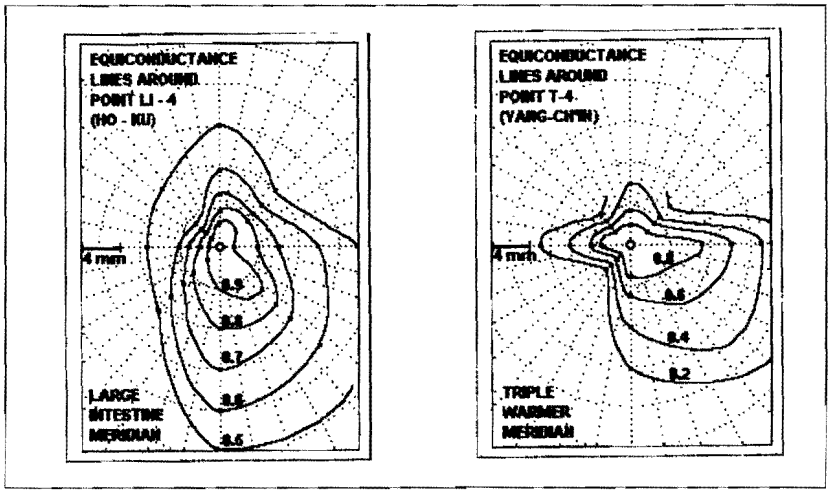


*Figure 5. The shape of acu-points.*[12(p.166)]

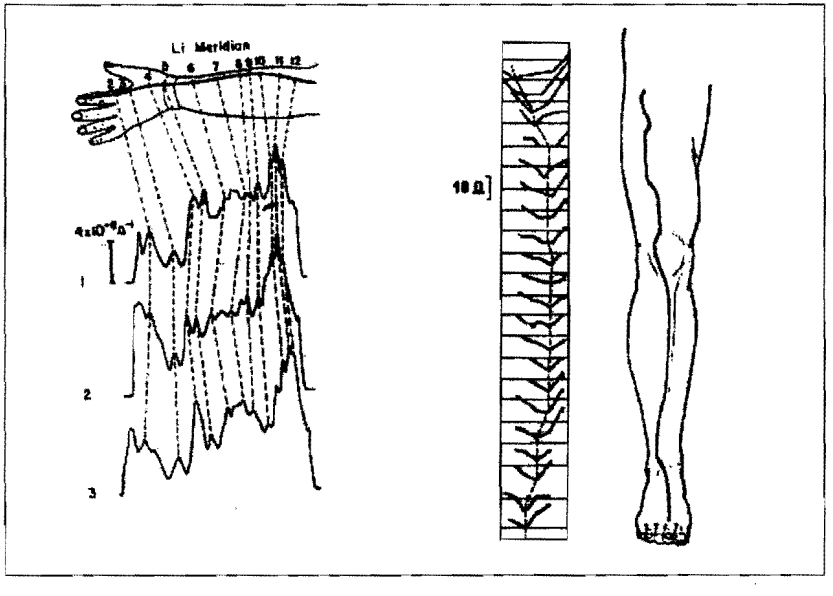


*Figure 6. The shape of acu-meridians.*[3(p.185),12(p.165)]

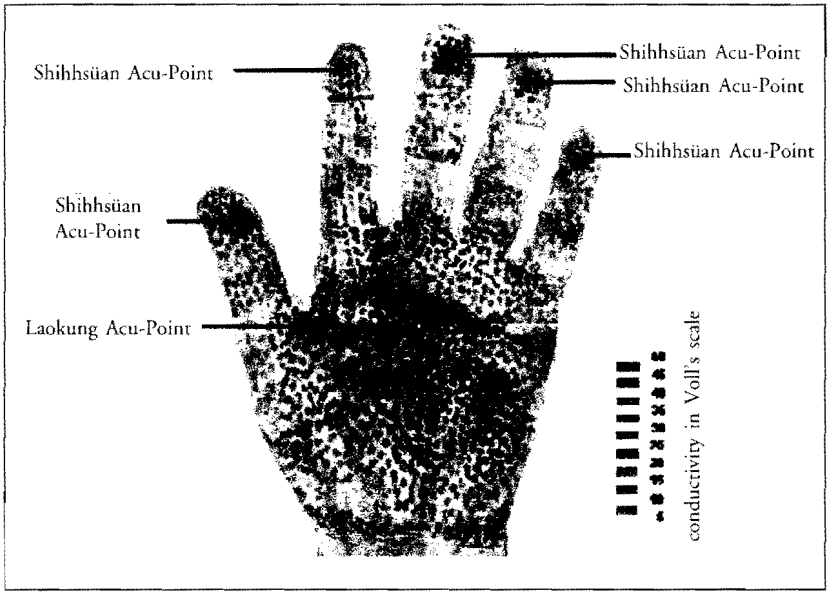


***Figure 7.*** *The distribution of conductivity on palm (from the author).*

dynamic one which greatly changes in some special pathological, physiological or psychological conditions.

The two pictures in Figure 8 were observed by the Chinese medical doctor D. Z. Li in a project for plotting sensation propagation along meridians.[14] They show that the route of "sensation propagation," which are usually coincidental to acu-meridians, can have large variations in some special pathological states.

This important phenomenon can also be objectively measured electronically. We can see a big difference in the comparison between the normal distribution of the so-called "skin resistance" in Figure 7 and the changed distributions of it in some abnormal pathological, physiological and psychological states in Figure 9.

In Figure 10, we see that the so-called "skin resistance" could have some quite fast changes during a needling operation as well. Therefore, the large scale

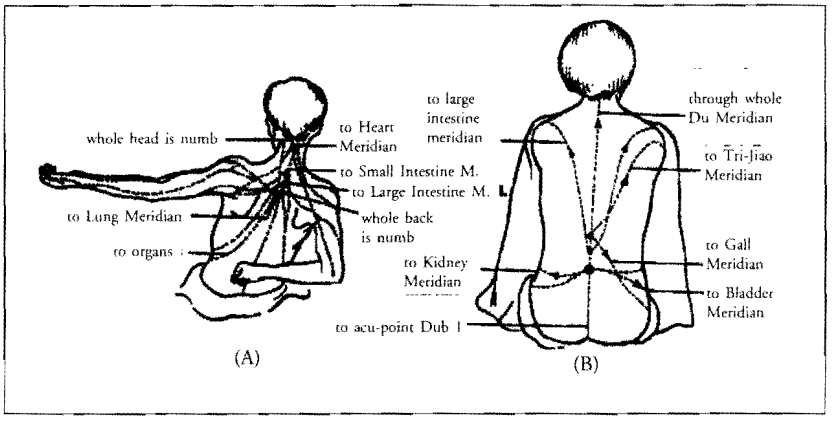


***Figure 8.*** *The big change of the routes of "sensation propagation" in some pathological states.*[14(p.209)]

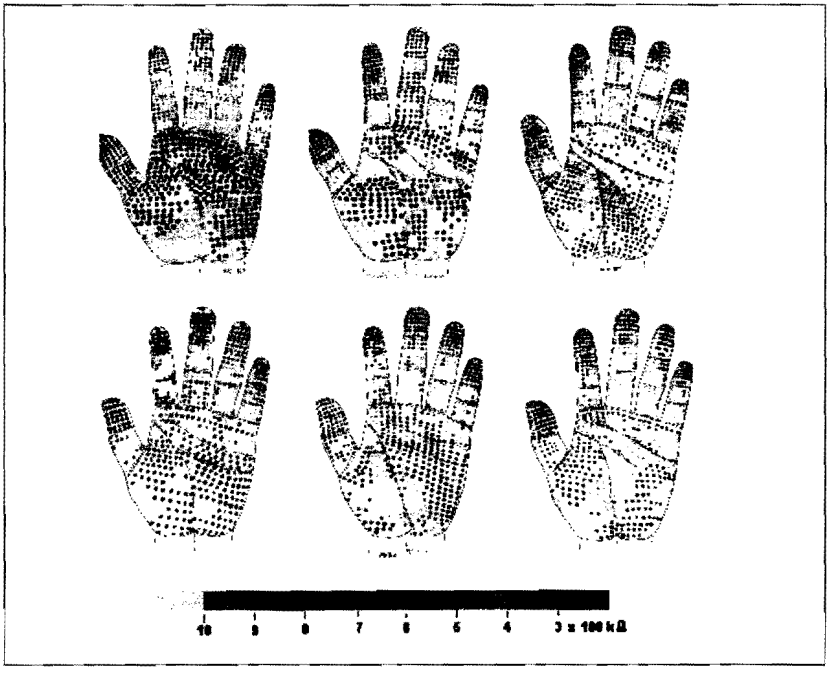


***Figure 9.*** *The big change of resistance on the skin of palms in various physiological states (from the author).*

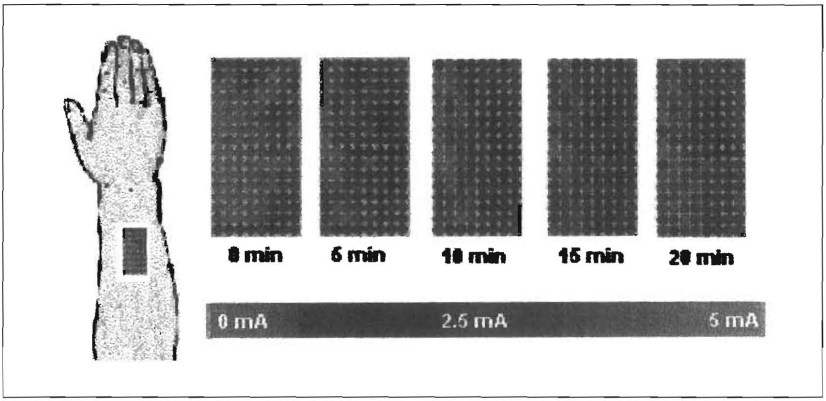


***Figure 10.*** *The instant and continuous change of resistance on the skin during needling (from the author).*

movement of acu-meridians and acu-points can be both subjectively felt in the observation of the "sensation propagation" and objectively measured with an electronic instrument.

The large scale movement of acu-meridians and acu-points tells us that the acupuncture system is not some fixed network like the blood vessel network or nerve fiber network, but something which is a dynamic structure. In the normal state of a body-mind system, the structure is relatively stable. The outline of the relatively stable structure was somehow discovered by ancient people and roughly described in the theories of acupuncture and ayurveda as an acu-meridian network and chakras.

**Experiment 4: Violent fluctuation of the so-called "skin resistance."** It is important to notice that the so-called "skin resistance" would not only have a big change in some pathological or unusual physiological states, but have fluctuations at various levels (see Figures 11 and 12), even for healthy persons.

The more precise instrument we use, the bigger fluctuation we would find in the so-called "skin resistance" measurement. If we use an instrument with very high sensitivity to measure the so-called "skin resistance" we would find that the reading of the instrument would be violently fluctuating at very high frequencies (see Figure 12). Therefore, from the viewpoint of electronics, skin

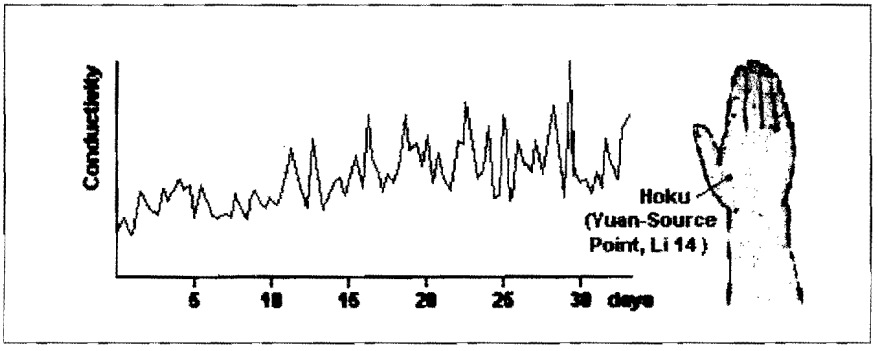


***Figure 11.*** *The large scale of wave-trains of body conductivity (from the author).*

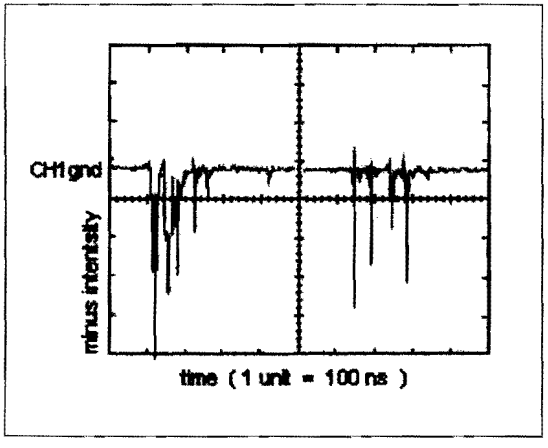


***Figure 12.*** *The small scale of wave-trains from living system.*[15]

would be a very bad and unstable resistor.

**Experiment 5: Simultaneous and holographic change of the so-called "skin resistance."** It is worth further noticing not only that the so called "skin resistance" would change in various states of a body-mind system and at various times, but also the so-called "skin resistance" on all related acu-points in a body change simultaneously.

What makes the problem even more complicated is that the synchronous change of the so-called "skin resistance," when a patent is ill, could not only be found on all main corresponding acu-points on the acu-meridian network, but also on all micro-acu-points on ear, nose, palm, foot and so on. In other words, the change of the so-called "skin resistance" is "holographic" or "fractal."

The holographic change of the so-called "skin resistance" happens not only on the level of ordinary acu-points and micro-acu-points, but also on any point

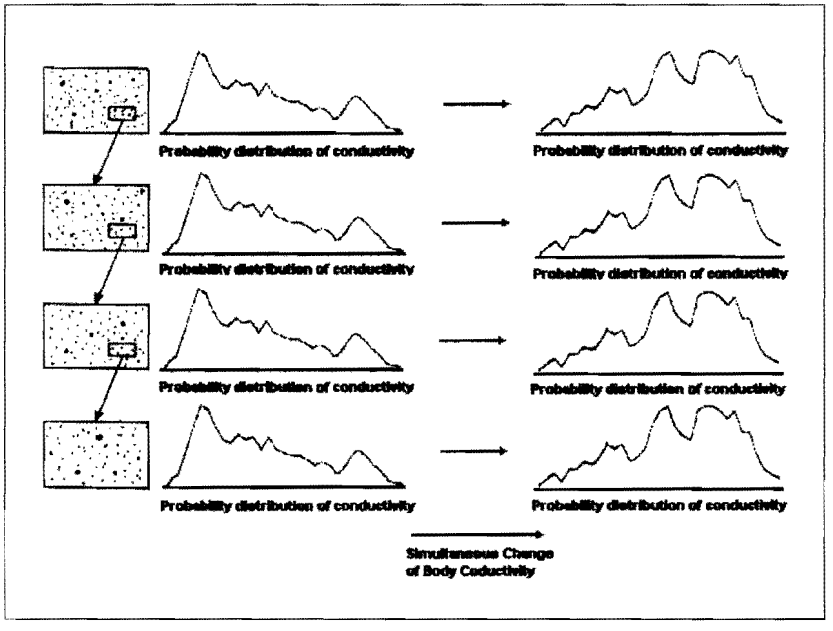


***Figure 13.*** *Simultaneous and holographic change of body conductivity.*

on skin. That is, whenever the body-mind system has some change, the shapes of probability distributions of electronic measurement data synchronously change and keep similar patterns in different places and at different levels (see Figure 13). This phenomenon is called "statistic self-similarity."

**Experiment 6: The speed of "sensation propagation" and the related change of the so-called "skin resistance."** Another very interesting and important phenomenon is that the speed (slower than 40 cm/sec) of the "sensation propagation" (see Figure 14) and the change of the pattern of the so-called "skin resistance" is much slower than the speed of signal transmission (20-120 cm/sec) in nerve fibers. Obviously, the phenomenon can not be explained by the nervous system.

**Experiment 7: Acu-meridians as channels of electromagnetic waves.** Chinese physicist B. W. Zhang found that the acu-meridian is a good channel for microwave transmission at 1359 MHz.[3,18] He not only carried out experi-

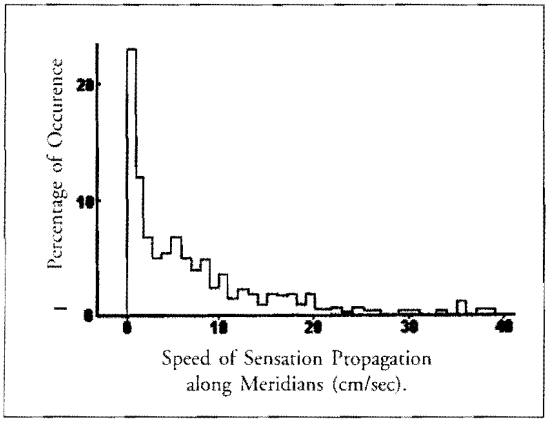


***Figure 14.*** *Speed distribution of sensation propagation.*[3(p.47)]

mental research, but also postulated that the acu-meridian is some kind of "wave guide" in which the slow speed of signal comes from the group velocity of the wave. This is the best explanation about the slow speed of signal transmitted in acu-meridian among decades of various hypotheses about the mechanism of acupuncture. It is really outstanding that B. W. Zhang had such a brilliant ideal of group velocity of the waves in the acupuncture system in 1959, long before the recognition of ideas about dissipative structure in the scientific community.

It is also well-known that many medical doctors in Western countries who performed soft-laser acupuncture also found that acu-meridian is a good channel for laser beam transmission. Therefore, acu-meridian may be a channel for electromagnetic waves.

**Experiment 8: Acu-meridians as channels of acoustic waves.** Another Chinese physicist P. S. Sun and his colleagues found a high coincidence between the higher sound intensity points and meridians of the human body (see Figure 15).[3,17] The result reveals that acu-meridian is also a good channel for acoustic wave propagation.

**Experiment 9: Lower resistance points and higher sound intensity points after amputation.** For a long time, many people wondered whether the acupuncture system exists after death. The Chinese biophysicist Z. X. Zhu observed the lower resistance points and the higher sound intensity points after amputation.[16] The result shows that the lower resistance points almost maintain their original positions even after amputation (see Figure 16).

**Experiment 10: The lower resistance points and the higher sound intensity points on the surface of plants.** Z. X. Zhu not only measured the lower

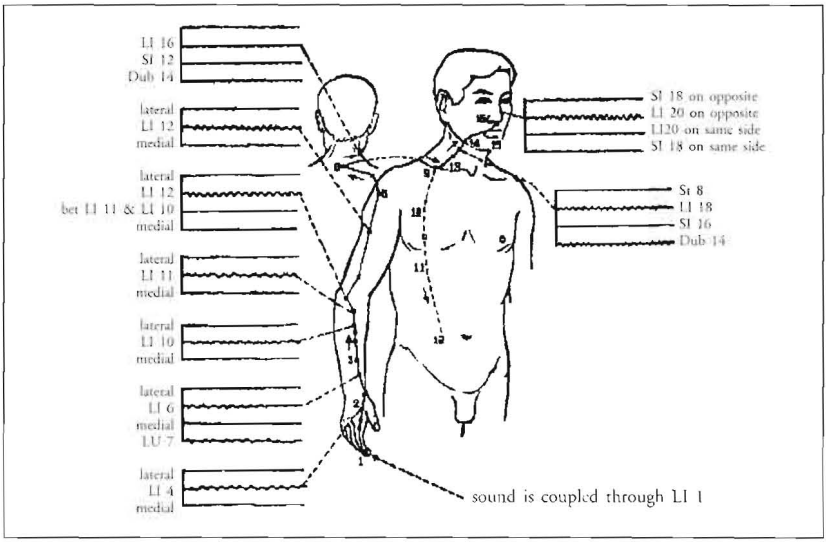


***Figure 15.*** *The acoustic measurement along an acu-meridian.*[3(p.201)]

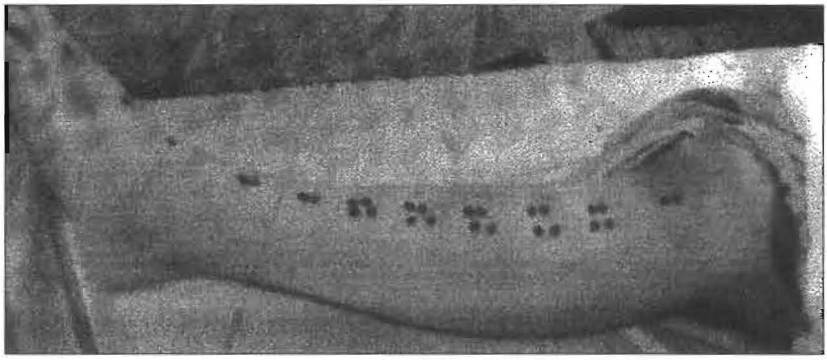

***Figure 16.*** *The lower resistance points and the higher sound intensity points on a leg after amputation.*[16(p.326)]

resistance points and the higher sound intensity points on the legs after amputation, he also made a series of measurements on the surfaces on various animals and plants.[16] The results show that the distributions of lower resistance points and the higher sound intensity points on the surfaces of animals and plants coincided (see Figures 17 and 18).

***Figure 17.*** *The lower resistance points and the higher sound intensity points on the surface of a rabbit.*[16(p.320)]

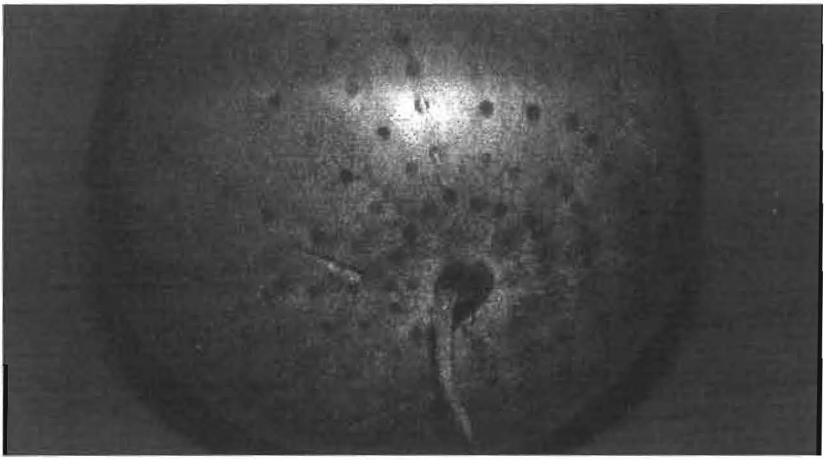

***Figure 18.*** *The lower resistance points and the higher sound intensity points on the surface of a watermelon.*[16(p.323)]

It is worth noticing that the lower resistance points and the higher sound intensity points on the surface of a watermelon, which is almost a perfect spheroid, are scattered along the lines of longitude and latitude of the spheroid. This is the phenomenon and characteristic of interference pattern in a ball-like resonance cavity.

# BEHIND THE MEASUREMENTS

The exploration of the background for the so-called "skin resistance" measurement is a big challenge to biologists and physicists. In some way, it is quite like the situation of seismologists when they explore inside the earth. Both are exploring what is inside a body, but not allowed to open it.

Of course, there is a difference. The problem for seismologists is that they are unable to open the earth in order to see what it inside; whereas the problem for biologists is that they have opened the human body and studied it thoroughly and saw nothing related to an acupuncture system, though they have electronically got some mysterious signals on the surface of the body. Therefore, both of them have to explore what is inside from careful analysis of the data which were measured on the surfaces.

## PEELING OFF THE SKIN

Japanese physiologist Y. Motoyama did such an experiment of peeling off the horny layer from skin, and found that only 30% contribution of reading of electronic measurement comes from the horny layer and 70% from somewhere beneath or behind the horny layer.[19]

Motoyama assumed that the 70% contribution comes from the polarization of the tissue beneath the skin and near the measurement electrode. However, the problem for the polarization explanation is that the change in the so-called "skin resistance" is not a local event which could be induced by a measurement electrode, but a holographic change on all points on the surface of the body.

Many other physiologists assumed that the change of the so-called "skin resistance" comes from the activity of nervous system or blood capillary. However, the problem for the explanation of the activity of nervous system or blood capillary is that both the nerve system and the blood circulation system are completely immersed in the body fluid, whose resistance is so small that the change of nervous system or blood capillary plays almost no roll in such a measurement. It seems that it is really difficult to avoid the word "skin resistance" since only the skin has high enough resistance.

## Conductivity vs. Resistance

Now, let's try to change the way we think a little in order to ask another, more fundamental question: *what is "resistance."*

Literally, the word "resistance" means something which resists measurement current. Unfortunately, it is not the real case, in the viewpoint of electrodynamics; resistance (R) is the inverse of conductivity (J) which is the ability which allows electrons to travel.[20] The conductivity is proportional to electrical field (E).

$$R = 1/J \text{ and } J = \sigma E$$

here $\sigma$ is a constant characteristic of the substance. Therefore, *what we measure on the skin of a body is actually the conductivity for the measured current, which is proportional to the electrical field inside the body.*

## Acupuncture System and Heterogeneous Distribution of the Electromagnetic Field

In order to make this statement more clear, let's measure an "ideal" human body, which is an ideal cuboid described in Figure 19. In such a situation, the two measurement electrodes can be regarded as two big flat ones which press on the ideal cuboid body from both sides.

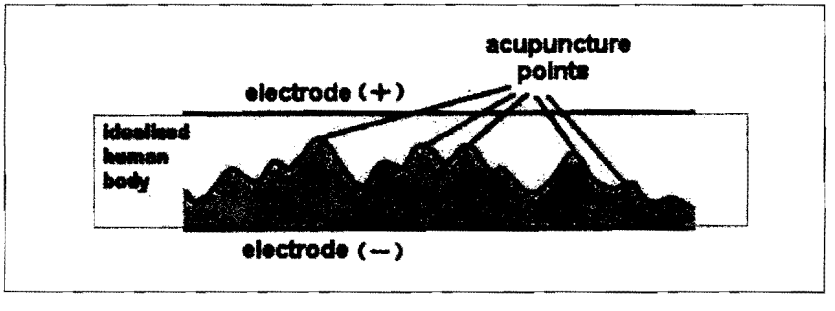


***Figure 19.*** *The background of electronic measurement.*

In such a highly simplified picture, we can see clearly that what we measure is in fact a heterogeneous distribution of the electrical field inside the body. In comparing Figure 18 to the pictures in Figures 5, 6 and 7, we can find that the acu-meridians are lines with higher electrical field strength and the acu-points are actually places with the highest electrical field strength.

From the viewpoint of Figure 19, we can find the real skin resistance on the surface of the ideal body is actually only a disturbance for such an electronic measurement. What makes it even worse is that the *real skin resistance not only disturbs the measurement results, but the wrong terminology "skin resistance measurement" misled the direction of basic research of the mechanism of acupuncture for almost half a century.*

## The Source of the Heterogeneous Distribution of the Electromagnetic Field Inside A Body

Now, we can finally ask where the heterogeneous distribution of the electromagnetic field comes from. From Figures 6, 7, and Figure 5 in particular, it is easy to see that *the heterogeneous distribution of conductivity is the image of an interference pattern.*[21,22] The interference pattern is composed of electromagnetic waves, which, even from the existing knowledge of physiology, comes from many organs, tissues and cells. The relatively stable interference pattern is mainly composed of electromagnetic standing waves in the resonance cavity of the human body, or the bodies of many other living systems.

As a matter of fact, the interference pattern of electromagnetic waves inside the human body is a dissipative structure, which is relatively stable as long as the energy supporting the body is stable. At the same time, it is a very dynamic structure. This is the reason why we observe big fluctuations in various frequencies (see Figure 11 and 12) if we use instruments with high sensitivity.

As soon as the energy support or the boundary condition of the resonance cavity changes, namely, the human body, having some pathological, physiological or psychological change, the shape of the interference pattern would also change. This is the reason why acu-points and acu-meridians would greatly change their places in some unusual physiological or psychological states (see Figures 8, 9 and 10).

It is well known that the holographic phenomenon is a basic characteristic of any interference pattern. From the viewpoint of interference patterns, the holographic phenomenon of the acupuncture system is no longer a puzzling problem, but an inherent property.

Further, it is not only the electromagnetic wave that has the ability to produce interference patterns, but acoustic waves also do so. This is quite a simple reason why there are similarities and parallels between the lower resistance points and the higher sound intensity points on the surfaces of the human body and the bodies of other living systems.

Moreover, the slow speed of the sensation propagation or the change of so-called "skin resistance" can easily be explained with the group velocity of waves in the wave guide, which is a part of interference pattern.

From the viewpoint of interference patterns, the pattern can also exist in a dead body, or any other bodies like fruits or plants as long as they are resonance cavities with constant energy manifestation (notice the measurement current itself can be a source of energy).

From this viewpoint, we would have a completely new understanding of the puzzling effect of acupuncture needling without chemical remedy involved. The metal needle is a good new boundary condition to be introduced into a body in order to change the interference pattern in it. If the metal needle is introduced in some decisive place, it would be able to change the interference pattern. The decisive place is usually on the point with the highest strength of electromagnetic field where many peaks of electromagnetic standing waves are brought together.

## The Relationship Between the Inner Electronic Field and Outside Radiation

From the viewpoint of electromagnetic fields, it is also easy to understand why there is such a high coincidence between the acu-meridian and the discharge pattern under high voltage and high frequency (see Figure 20), since the discharge pattern is closely related to the distribution of the electromagnetic field in the body.[23]

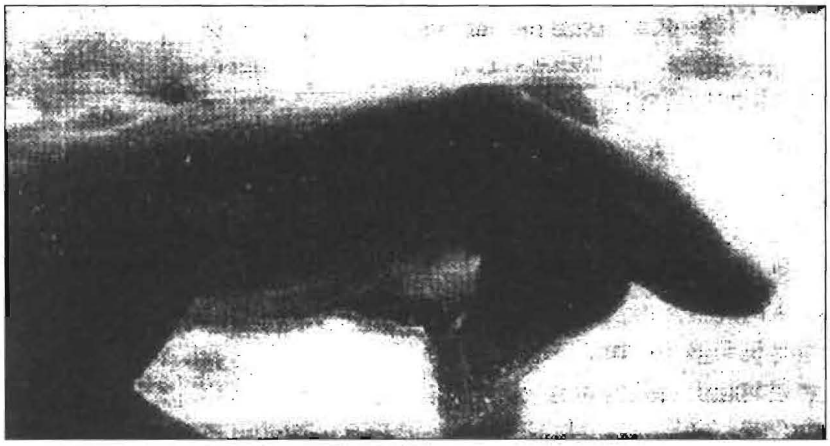

***Figure 20.*** *The discharge pattern along meridian.*[3(p.194)]

In this viewpoint, there must be some relationship between the inner electromagnetic field in living systems and the outside radiation. The mysterious aura which has been described in many religions as something which is holy, though it is not holy since every body has it and we can measure it easily with instruments today (see Figure 21).[25-28]

## Mathematical Background of the Statistical Behavior of Measurement Data

German mathematician L. Sachs found that the data from many physiological systems fit into "log-normal distribution" (see Figure 22) instead of "normal distribution" which exist widely in many non-living systems.[27] German medical doctor Rossmann found that the data of the so-called "skin resistance measurement" on acu-points also fit into "log-normal distribution," instead of "normal distribution."[28]

The author of this paper found that the data of the so-called "skin resistance" on any point of the skin of a body fit into the "log-normal distribution" as long as the tested person is in an ordinary state; the "statistical self-similarity" of measurement data on different places and various scales (see Figure 13) when

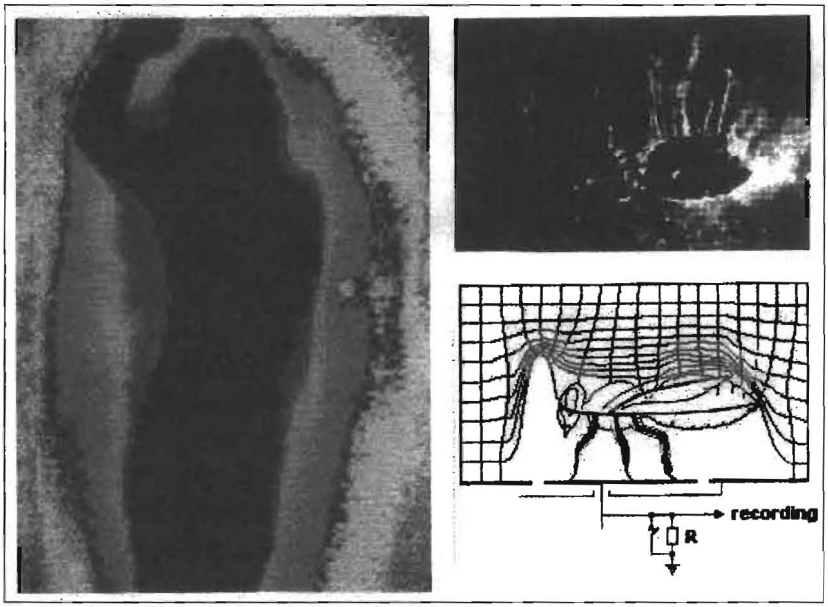


***Figure 21.*** *The thermographic image around a human body (left) and the distribution of the electrical field strength around an insect (right).*[24(p.286),26]

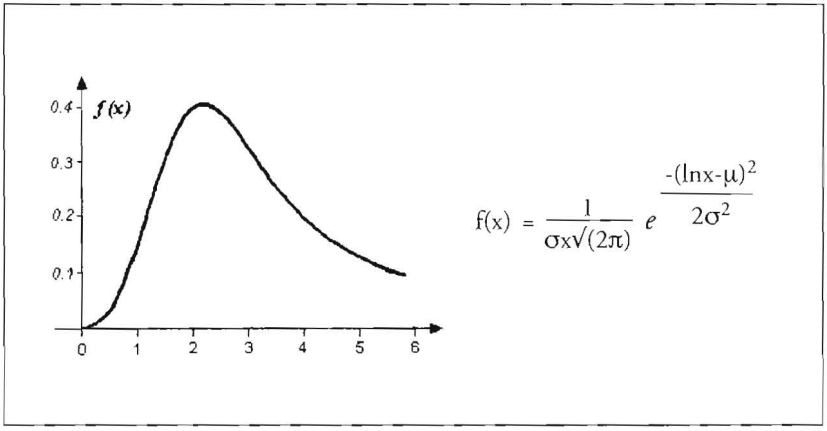


***Figure 22.*** *The shape and formula for "log-normal distribution."*

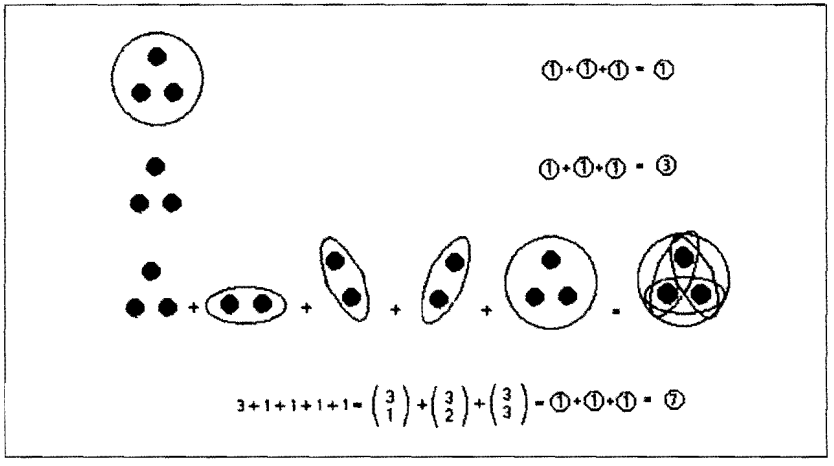


***Figure 23.*** *The backgrounds of "Delta Distribution" (upper) "Normal Distribution" (middle) and "Log-normal Distribution" (lower).*

the tested persons are in abnormal states, or in large disturbances.[21] The author also proved with combinatorial mathematics that the background of the "log-normal distribution" is that the elements in the measured system are independent of others, and at the same time there are possibilities of combination with others.[29] In other words, the data which fits into "log-normal distribution" comes from a system that is in coherence, namely, in harmony (see Figure 23).

From electrodynamics, when the data from the so-called "skin resistance measurement" fit into the "log-normal distribution," it means that the data, measured at the surface of an interference pattern, comes from the superposition of many standing waves that were emitted from those oscillators. Here, through proper coupling, every oscillator emits not only its eigen frequency, but also many beat frequencies through this coupling with other oscillators.[21,29] In such a case, the frequency spectrum would change from "white noise" to "1/f noise," in which the energy decreases from higher frequencies to lower frequencies.

The detail of the mathematical proof was published by the author in Britain in 1994.[29] As a matter of fact, the mathematical proof was very important and decisive.

## The Rough Picture of the Invisible Dissipative Structure

***Figure 24.*** *The electromagnetic field in and around the body.*[30]

Finally, let's stop our hard rational discussion using physiology, physics and mathematics to see a painting by which the American artist Alex Grey vividly described the "invisible rainbow and inaudible music" in and around a human body.[30]

In this painting, we can roughly see the outline of the dissipative structure of electromagnetic field in and around a body, which obviously includes some knowledge from acupuncture, chakras and aura which came from the experience and intuition of ancient people. Though there must be many errors in such a primitive recognition, it can still be a reference image for serious scientific researchers, who are exploring the details of the invisible and dynamic dissipative structure.

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