

INFORMATION, PHILOSOPHY AND THE INVERSE PROBLEM IN OPTICAL TOMOGRAPHY – A THOUGHT-PROVOKING ESSAY ON HOW MODERN PHILOSOPHY DEALS WITH INFORMATION

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Summary. Starting from some general considerations on how information has to be valued as a third philosophical entity between subject and object, the problem on how signal transmission will be influenced by the environment is discussed. The environment with its non-predictable and unknown statistical fluctuations causes a disturbance of the information channel in use which is referred to as noise and becomes the ever important entity in questioning how we could understand our world. In this context the term “Erwartungswert, i.e. “expectation value” is introduced.

Key words: *trivalent logic, resolution criterion, expectation value, angeletics, hermeneutics, inverse problem, oxymoron, optical tomography*

The inverse problem of optical tomography [4] is predominantly a question of

- how to handle information,
- how to process information and
- the very basic understanding what information is all about.

Since ancient times the Greek philosopher Aristotle [1] has been internationally famous for his teachings, better known as Aristotelian logic. Aristotle was the first who described very clearly that all understanding of human beings of their environment is basically related to the finding of two entities, one being the subject like the human being itself, the other one the object – the material or outside world.

Coming back to Aristotle, this is what philosophers all over the world and throughout the past millennia have called the basics of bivalent logics. But in the fif-

ties and sixties of the last century, Norbert Wiener [11] and his school, and especially Gotthart Günther [4], have questioned the thousands of years old patriarchal differentiation between spiritualism and materialism in a manner unprecedented so far.

In fact, this was basically the cybernetic way of thinking which understood and emphasized that the traditional differentiation between simple subjectivism and antithetic objectivism is too general and too simple. Besides this first approach in trivalent logic, there is a sphere of phenomena which can be more precisely defined today as being neither allocated to the physical material nor to the subjective physical aspect of thinking and understanding.

This not allocable remainder is usually called information.

This term denominates not only the immediate fact of information, but also the active or communication process through which information is transferred.

The phenomenon of information and its communication, especially the phenomenon of intelligent control of and hence the influence on reality, coherences by informative data, logical structures and abstract motives had been assigned to the so-called spiritual aspect of reality.

For here the categories of inwardness became involved, such as remembrance, oblivion, spontaneity, competence, learning aptitude, intelligence, etc.

These behaviour patterns were thought to be more or less mysterious functionalities of a living inwardness referred to one's self. That a process like that of imitation does not originate from material factual conception should be known at least since Plato, but according to the "excluded third person" proposition – not all objective necessarily must be subjective, such categories and others were plainly assigned to the domain of spirituality.

This view, however, is vehemently objected to by cybernetics. It has been explained, even practically established, already that categories such as remembrance, oblivion, spontaneity, intelligence, etc must not necessarily be considered as a manifestation of intellectuality and spirituality, at any rate not to the extent to which these categories can be interpreted and repeated in a "mechanical" model.

This would be especially true for the laws of mathematics and statistics which govern the structure of both information and the intelligent communication processes. Although these laws would not be natural laws, they would be laws of the subjective intellectual life neither. Therefore, information, beyond not being just matter and energy, respectively [11], is intellect and subjectivity neither.

Starting from the bivalent logic approach, this thinking leads us to a trivalent logic systematic, where in addition to subject and object a third domain called information becomes evident and increasingly important.

Besides, the more technical phrasing of cybernetics, philosophers like Heidegger and Gadamer in the fifties and sixties of the past century have modified – in differentiation to the Aristotelian logic, the phrase of "hermeneutics" [3], which

had been defined originally by Schleiermacher and Dilthey as the art of deciphering, interpretation and understanding.

According to Gadamer [5], Hermes as an active transmitter is in charge of transferring information between an actor or author and

the listener as the subject and the object, but since Hermes delivered his messages encoded, “hermeneutics” is the technique to interpret this blurred or noisy information.

Bearing this in mind, one may reflect that we have now defined two levels of logic systems, namely the bivalent and the trivalent logics, and as a matter of consequence there must be a univalent logic too, which is evidently beyond this human and terrestrial understanding, nothing else than “god” in this philosophical discussion.

It is god, no matter in which religion or ideology, who can send unidirectional information and commandments which are just self-consistent and valued neither being good or bad, but just given.

One layer beneath there is the human thinking in a bivalent manner between you and me, between us and the non-living material world, and so forth. But nowadays we realize that any kind of recognition of the outside world to a subject is related to an exchange of information and, therefore, the trivalent logic system had to be developed. It started with the understanding of Wiener and his school and others in describing the new scientific field of cybernetics or, in philosophy, the new field of modified hermeneutics.

And it has been only recently that after the development of the internet the understanding of this new philosophical entity called information has led to another understanding which nowadays and very recently proposed by Sloterdijk

(www.petersloterdijk.net/) and Capurro (www.Capurro.de) has led us to a new field in philosophy called “angeletics”. It’s based on the Greek word “αγγελος”, which is understood as an improvement of hermeneutics, where a well-defined messenger, i. e. Hermes is sent out to transfer unidirectional but blurred sentences, whereby angeletics takes care of the fact that e.g. the internet opens up a completely new domain of philosophical understanding on how information is disseminated, either

- one to one,
- one to many or
- many to one,

and, therefore, information itself becomes even more intricately structured.

In terms of this aphoristic way of speaking and thinking, information is understood as the third value of consciousness and understanding. One may imagine this as a triangle having three edges called subject, object and information, which will help us to open our sight to reality (fig. 1).

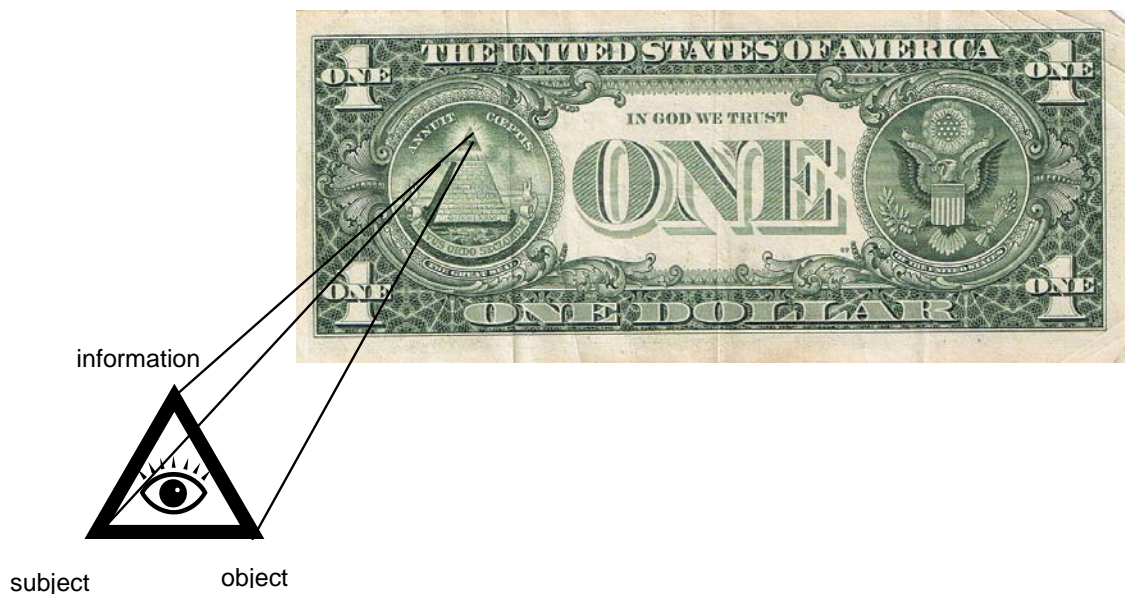


Fig. 1. Why?

Coming back to some very simple examples in everybody's daily life, we could consider numerous examples on this trivalent understanding of biological consciousness in a materialized world related to communication channels.

A very simple example of this is what happens during any lecture or verbal performance in a theatre: individual beings are sitting in the audience and listening to the actor, another human being, while they are realizing him as just an object generating sound and motion.

All what they receive are motion pictures on the background of their eye at the retina and sound modulation through their ears. Since everybody in the audience is different from one another, everybody will receive a different image of the actor on his retina and a different sound pattern through his ears. And it's only based on our common education and experience that the motion picture which is received from the stage is realized as a human being, namely the actor or lecturer, and it's again only experience and training that everybody understands the sound modulation as an information carrier referred to as language. And, of course, these two information channels can be blurred, may be through the properties of everyone's eyes and ears, which are part of the information channel, by the information channel itself, which means interference through some additional sound from the outside world, or by lightening or blurring through fog or flashlights and also e.g. by rapid movements of the actor or wearing of his optical and acoustical parameters.

Just to give an example how easily such information channel can be disturbed, one may switch over to another language like German: „*und obwohl*

der Informationsgehalt nach wie vor der gleiche ist, werden die meisten Leser Schwierigkeiten haben, diesen deutschen Text spontan zu verstehen“.

Now one may realize that just by changing the code or the modulation, information is manipulated. This is referred to by Marshal McLuhan [10] too.

In history, science including physics, chemistry and philosophy, were all the same and understood as just a homogeneous description of the outside world.

Being part of the process to understand what hermeneutics and angeletics, the philosophy of information processing, will bring us, one now can realize that modern science may be understood as the art of how to put questions to the object world and how to decipher the answers being received through our activated receptors.

What does that mean? The question of a human subject to nature one may call an experiment. And, of course, even by putting such question information techniques are used which may be referred to as tools. It may be for example one's finger to touch the object and get a tactile response.

But one will realize only what is expected. That means just by using ones own tactile response ability one only will realize from different human or animal tissues or textile fabrics what one expects to realize unless the difference exceeds a certain threshold.

This leads to the fact that another quantity in the information process has to be defined, which is called the **“expectation value”**.

This is nothing else than the well known “Erwartungswert”, as defined by quantum mechanics.

In the field of optical tomography, this has been called “the photon banana” [2] . This expression gives a good idea on how the three-dimensional shape of the photon pathways looks like.

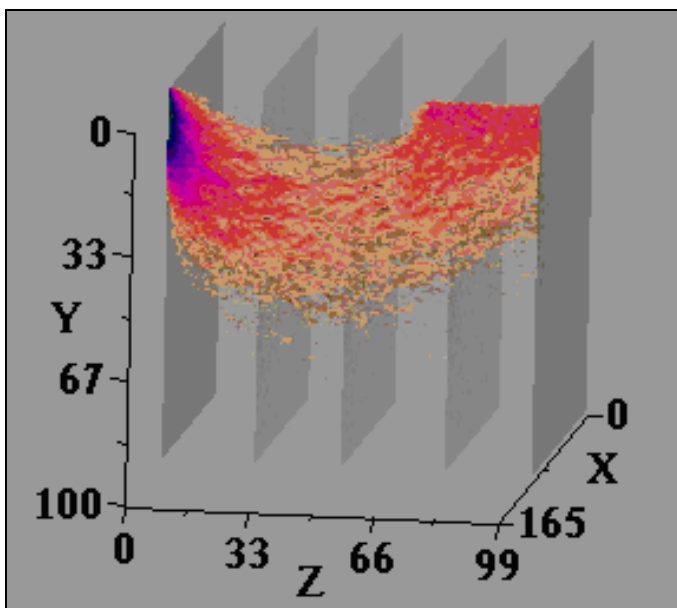


Fig. 2. Longitudinal cross-section a 1 mm irradiance spot dia. 50 μm detection spot dia. 600 μm NA=0.45.BMP [11]

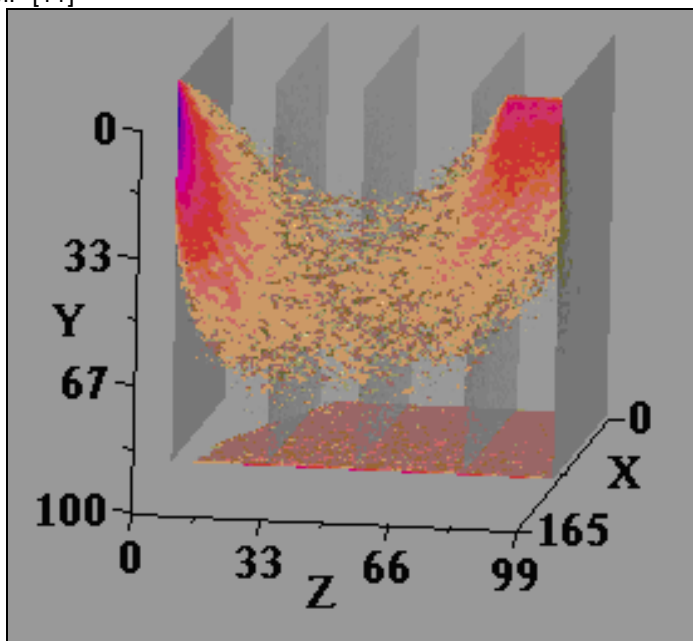


Fig. 3. Longitudinal cross-section a 2 mm irradiance spot dia. 50 μm detection spot dia. 600 μm NA=0.45.BMP [11]

Considering once again the situation of a tactile response information channel, the feedback information is predominantly influenced by what is referred to as the **expectation value**. And, of course, if one extends this model to a number of individuals, each individual will have a different approach to the same object and evidently a different expectation value.

By transferring this concept to optics or any other radiative information carrier, one immediately will understand that the expectation value is defined by the sensitivity of everyone's detector and even more important by the receiving aperture of everyone being a detector. But, of course, it will also be influenced by the sending aperture and modulation amplitude and hence determines one's individual perception.

For example, a human subject sends an optical beam to an object, may be another human being, where the beam will be reflected, transmitted, scattered, absorbed, and thus transformed.

And now one is looking for a response signal.

More precisely, one expects to receive sense and realize a response signal. But of course, any individual's expectation will be limited by his expectation horizon or, in more technical terms, by his receiving aperture. This, in turn, will be influenced by the frequency response of the individual sensors and also by the sensitivity of these sensors, i.e. the detectivity. In addition, it will be influenced by the capability of one's receiving network to interpret the modulation and hence the information content of the signal received. These findings are intimately related to the question of dosimetry of non-ionizing, i.e. non-destructive radiation [10]. Furthermore, the whole scenario leads directly to the inverse problem in optical tomography [8]. We as subjects try to communicate with an object while the object is embedded into another object which, in fact, influences the communication channels in use.

Of course, we are able to send well-defined sensing signals – in general terms: questions – such as light beams or mechanical probing like ultrasound or others or electrical probing like impedance measurement or others. But since our object of interest is embedded in a non predetermined, statistically varying other object, which we may call the information environment, we do have the situation that although we can precisely determine our probing signals being sent, and of course we can precisely measure and determine signals received from the information environment, which will contain modulated information from our object in question, this information will not be complete enough to reconstruct or to describe the true but oblique object of interest.

For the information environment is not under control because we are limited by our detectivity, which comprises the receiving aperture, the frequency response and sensitivity of our sensors. In general terms we only receive a limited amount of relevant information which will enable us to reconstruct the response of the object only if the influence of the information environment upon our information channel contains less interference or blurring information than the real information itself is made of. Of course, we may enhance this ratio by repetitive measurements or by increasing the receiving aperture by so-called synthetic aperture procedures, but at

the very extent we should be able to have a 4π receiving aperture for each individual δ (**delta**) probing beam to get all necessary information to reconstruct the object of interest completely.

And since even in very idealistic cases it is almost impossible to implement such communication geometry, we have to accept what is called the inverse problem which is nothing else than that it is impossible to regenerate lost information by theoretical assumptions on the information channel. Such a situation would be possible only if we can describe the information environment and hence the information channel as precisely as we can send out our probing signals, that means questions, and having proceeded to that situation the information environment becomes part of our object.

That means from a philosophical point of view that the inverse problem has to be categorized as an oxymoron and can be solved and answered to at limited accuracy, only, whereby this accuracy is determined by noise.

As a matter of consequence **the resolution criterion** for radiative transfer of information has to be redefined as: “**The noise equivalent contrast- threshold of the modulation transfer function**”.

To summarize: Starting from some general considerations on how information has to be valued as a third philosophical entity between subject and object, and looking at the problem on how signal transmission will be influenced by the environment, one will understand that each measurement is nothing else than a question to nature, whereby the answer is influenced by non-predictable and unknown statistical fluctuations of the information environment and its influence on the actual information channel in use.

This simply means that fluctuations of information signals, what we may call noise, become the ever important entity in questioning how we could understand our world.

Therefore, modern philosophers started about 50 years ago by defining information as the third most important part in logic and consequently came up with the philosophy of hermeneutics [3] which is the idea of sending a messenger – In ancient Greece called Hermes – to transfer our messages, and questions and nowadays has led to a new philosophical field called angeletics which deals with the more realistic problem of multiple information channels.

However in this case we do have a very complex, but still simple experimental setup for further research. It is the well-known internet.

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