VIRTUAL AND REAL STATES.
INNER STRUCTURE OF THINGS AND OBJECTS

TOMASZ MICHNIOWSKI

Name: Tomasz A. Michniowski (b. Radomsko, Poland, 1963)

Address: Division of Physics, Catholic University of Lublin, Raclawickie Ave 14, 20-038 Lublin, Poland, e-mail: pool@kul.lublin.pl

Fields of Interest: relativistic and Quantum Cosmology and Astrophysics, Philosophy of Science, Methodology of Physics

Main publications (in reverse order):

"*Mathematical Representations of Physical Reality in Quantum and Relativistic Model*", a part in a book: Philosophical and Scientific Elements of the Universe's Description. Part 2, ATK, Warszawa, Poland 1998, p.121-39

"*Geometry of Space-time; Groups of Symmetry as the Representations of Physical Laws in Cosmological Models*", ISIS-Symmetry, 1999

"*Questions and Working Hypotheses in Recognising the Universe*", The Man and the Nature 6, p.93-108, Lublin, Poland 1997

"*Basic Research Schemes in Constructing the Models of Universe*", Yearbook of Philosophy of Catholic University of Lublin, Part: Philosophy of Nature 44 , 3, p.75-87, Lublin, Poland 1996

"*Inflationary Universes and Serial Model's Conception*", KUL, Lublin, 1993

Abstract: *Constructing the models of physical reality takes place in science with use of specific method. This method is based on general mathematical features of the Nature, called 'mathematization' and 'idealisation'. Thanks to it, there is possible to construct quite good emulators of reality, when having only limited knowledge about itself. The models are cognitive efficient, what means, that they are able to product verifiable predictions on Nature's behaviour. Symmetry is a tool for all formal verifications of these predictions and, as well, a tool for planning experiments for empirical verification. In the article there is shown, how in practice the method is being used in science. An example of advanced specific speculation with use of some features of main mathematical models of reality is being shown. It is pointed, what kind of strict scientific results may we expect when using the method. Cognitive importance of the procedure is being emphasised. Figures illustrating the content are included.*

1. SCIENTIFIC METHODS ANS COGNITIVE RESULTS

Scientific recognising the universe is possible thanks to a specific feature of the physical world called 'mathematization'. Well-known Einstein's joke about non-malicious way of creating the world by God identifies main idea of 'mathematization'. In simple words, the feature consists in being able to construct mathematical structures, which are able to emulate behaviour of physical objects up to the high level of conformity. These structures, called models of reality (or, shortly: models), allow calculating inside themselves. Results (often called 'predictions') derived in analytical way, are fully experimentally verifiable. Sets of predictions derived form models, until being checked experimentally, are usually called 'theories'. Sets of results verified positively in experimental way are known as 'scientific knowledge'.

These relationships are obvious at all levels of scientific recognition. Both in the extremely simple, separate cases, as well as in very complicated physical situations, recognition with use of mathematical models goes always the same way. For example, simple, local model, created for emulating the process of falling down small balls (and being able to predict only point and/or moment of the fall of dropped ball), uses the same mathematics for emulating the phenomenon, as does it each one global cosmological model, constructed for finding behaviour of groups of galaxies in the far space. The only difference lies in the scale of mathematical complexity of both models and subtlety of accepted assumptions.

Constructing models, of course, is not the easy task. It usually starts from very few separate information or only intuitions we have on the area of physical reality we intend to discover. The method of science (see Fig.1) allows us finally to reach the model and to derive its predictions (testable in the experimental way), which may lead us to new knowledge we hadn't got earlier.

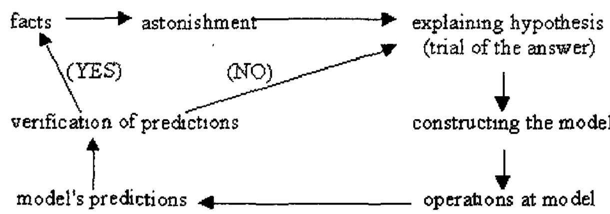

Figure 1: Scientific method.

Discovering unknown areas of physical reality in this way may be efficient enough thanks to special feature of mathematical models called sometimes 'idealisation'. It concerns in making models cognitive efficient even if their structures are not especially reliable. This means, that there may exist many models emulating the same set of phenomena in a quite good way. All of them may be useful for discovering new physical facts in the same area of investigated reality. For better explanation see Fig. 2. Here are shown cosmological evolutions of the universe predicted by two different models: deSitter's and Opened Friedmanian ones. Both of them have been constructed in the same mathematical environment, but with use of different sets of dynamical assumptions. The model of deSitter (from 1917) assumes, that space-time of the universe is empty (no matter at all). Friedmanian model (from 1920) accepts the presence of matter of isotropic distribution inside the space-time. Both models predict expansion of the universe. It is easy to perceive, that both predictions unify for far future of cosmic evolution, when the average density and pressure of matter in Opened Friedmanian world vanishes and becomes close to assumed in deSitter's model.

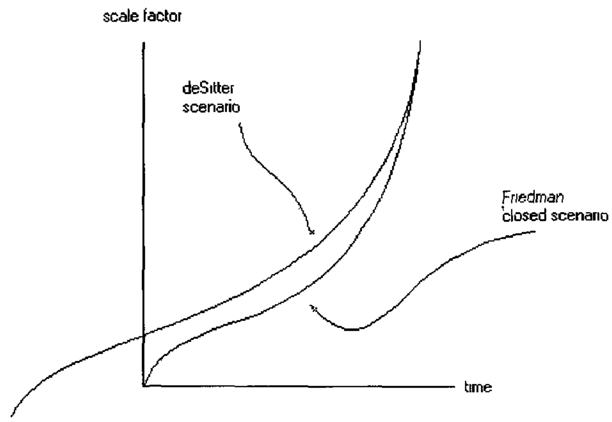

Figure 2: Cosmological evolutions of Friedman and deSitter.

Another non-trivial property of mathematical constructions and mathematics as a whole is impossibility of lying. In a well-known example [i. e. $A = B \Rightarrow 3A = 3B \Rightarrow 3A - B = 2B \Rightarrow 2A - B = 2B - A \Rightarrow 2A - 2B = B - A \Rightarrow 2\ (A - B) = -\ (A - B) \Rightarrow 2 = -1$. Notice, that $(A - B) = 0$, because $A = B$ (first term of calculation)], there appears a trial of banned operation (dividing by zero). As a consequence of it, in last term there appears a hard contradiction, which is not allowing any further continuation of calculation.

All these mentioned (and others) features of mathematical structures being an element of scientific methods, allow us to feel relatively safe in our trials of discovering unknown physical facts. The knowledge reached in this way (including final experimental verification of all predictions of models) is really reliable and unquestionable. Usually is yet much wider and richer than we expect. Except of having answers for what we wanted to know, we get much more. Large part of the knowledge obtained in this way is completely unexpected, mostly incomprehensible and – at least at the very beginning – seems to be incoherent with the rest of science. What is the reason?

2. MAPS AND SCIENTIFIC KNOWLEDGE

Mapping the land in geography is not easy operation. One must create the model (usually graphical one) of chosen area, respecting all details of its surface. Of course, it's possible only when we know exactly each one point of it. If not, on the map there exist 'blank spots' (for example see old maps of African interior from the beginning of 20-th century).

In science, situation is quite different: 'blank spots' never occur. If we try to construct the 'map' of investigated area, we are not able to represent all details of reality by appropriate mathematical objects, because we don't know too much about them (and usually are even not conscious their existence). We rather try to create the model with use of only a few facts we suspect we know and are able to represent by mathematical objects. These objects, existing in their specific mathematical environment, thanks to the features of 'mathematization' and 'idealisation', do fix the main structure of the model (i. e. the 'map'; in mathematics, a 'map' is each opened sub-set and a function, which represents the sub-set in Banach space. The set, together with all sets of maps being modelled in Banach space, is a manifold. Manifolds are natural environments for smooth functions, essential for emulating phenomena in all realistic models of physical space-time). If we are really lucky, we sometimes can guess a set of assumptions and boundary conditions for this structure, appropriate enough to allow the model quite good emulation of reality. This means (see Fig.3), that 'map' we constructed, shows us investigated area of reality, but only approximately, not exactly (as geographical maps should do).

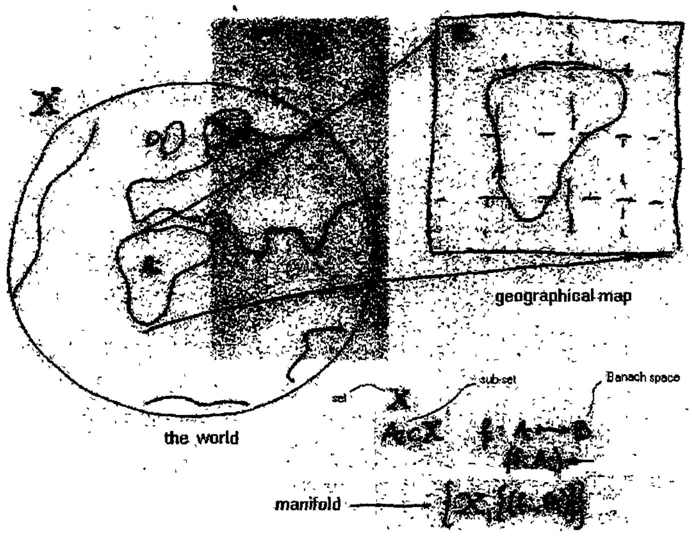

Figure 3: world and maps.

As luckier we were finding mathematical representations (for facts we had chosen as representative for investigated reality) and defining the set of conditions for the model, as better our 'map' emulates details of world it should do. This means, that the 'map' allows us to spot physical facts (mathematical details on the 'map') we couldn't find in any other way at all (note that these facts, being formally predictions of the model, must be verified in experiments until being accepted as elements of scientific knowledge).

Of course, less luck or formal errors we could do in the process of constructing models imply that our 'map' emulates reality in a wrong way, up to the level of full fiction. Such situation means, that the 'map' shows reality, which doesn't exist within the space-time of our universe. Practical usefulness of such model disappears than.

3. SURPLUSAGE OF MATHEMATICS

The cognitive limitations for scientific model's domain are the consequence of assumptions we must accept in the process of constructing each one model. Arbitrary conditions we bring, don't deprive the mathematical structure of the model of possibility of emulating much wider areas than same model is intended to do. All models we use in physics and natural sciences have been constructed with use of the mathematics of very special kind, namely highly regular one. The general structure of manifolds we permanently use for emulating 4-dimensional space-time, is very comfortable. It assures the best possible environment for smooth enough functions (thanks to it analytical calculations are possible) and, as well, requires no more general environment for itself (in mathematics, manifolds often have been called self-contained structures).

Very interesting question is - what do emulate mathematical structures of less regular kind than manifold is? Fig. 4 shows the situation. Manifold-like structure is good enough to emulate relativistic 4-dimensional world. But in whole body of mathematics, the area of regularity is of a very small measure. It would be strange, if the physical world would be created in such primitive way to have to be represented by such small part of mathematics only. Increase of scientific knowledge during the 20-th century shows, that physical phenomena have got much more complicated roots than classical only.

Mathematical models of their mechanisms have got quite different nature. For example, model of quantum mechanics needs allowing, in general, the complex multidimensional spaces, instead of real ones.

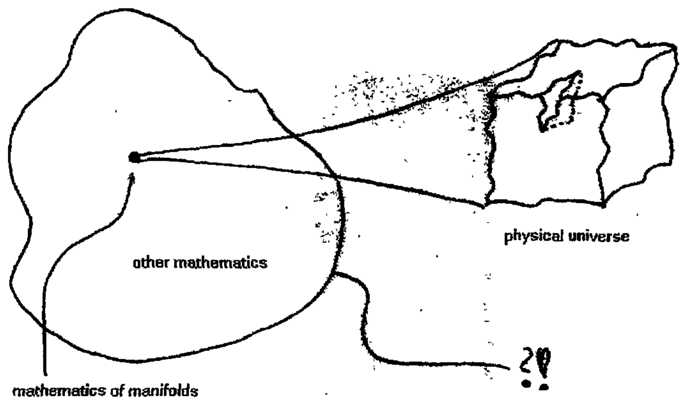

Figure 4: Physical universe and its mathematical model.

4. QUANTUM AND REAL STATES

Scientific experiences of last century teach, that mechanisms of all physical phenomena we know are, in general, not explainable at the ground of classical paradigm only. This means, that everything what we can perceive and measure in physical universe, is only a part of much more complicated system of dependencies, not accessible to our senses. More simplified illustration of what we speak, is each quantum system; for example: quantum model of an atom. Fig. 5 shows measurable levels of energy in the atom. Understanding and possibility of making predictions of its behaviour is being possible thanks to Schroedinger equation only, solved for the specific set of boundary conditions. The mathematical environment of this model is not classical one. So, speaking clearly, we do use mathematics of complex spaces for predicting real behaviour of physically perceived system, called atom.

The good question in this context is "how really the atom looks like"? It is hard to call "atom" the diagram shown at Fig. 5. But we really haven't got any other, different in quality, visualisation!

It seems, visible world and phenomena in it, are only one of possible cross sections of much richer 'super reality' (see Fig. 6). Knowledge about it is highly desirable in context of our scientific and technological needs. Such statement, one hundred years ago was shocking, now presents itself as serious difficult technical and analytical scientific problem only. It is namely extremely hard to construct and to derive mathematical structures of unknown and (even potentially) not measurable areas of reality. It is difficult to solve them and to localise their separate predictions as well. But it isn't impossible!

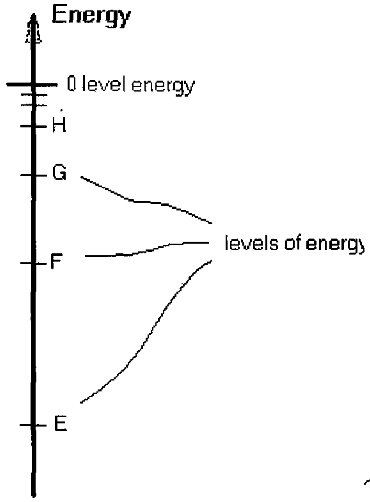

Figure 5: levels of energy in the atom.

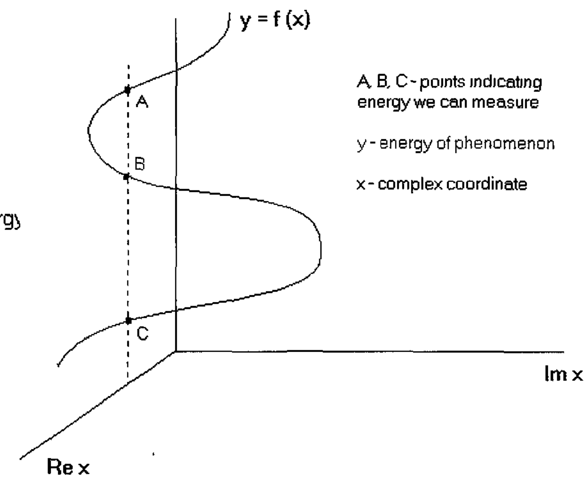

Figure 6: Quantum phenomenon.

5. PRECAUTIONS: EXPERIMENT AND SYMMETRY

There are two important problems connected with practical applying discussed method of science. The first one is: "how far may we be sure, mathematics is not showing us not-existing worlds?" The answer is simple: as far, as our physical experiments are able to verify predictions of models. Fig. 6 shows what part of 'super reality' may be checked by experiment. Until experimental methods are applicable (Nobody says it's easy task. Sometimes experiments seem to be more complicated than predictions of models, which should be verified), the danger of loosing scientific dimension of recognition doesn't exist. Up to this level, science is not being imminent by philosophy.

The second concern, connected with previous, is: "how can we differentiate predictions of physical meaning from other coincidences or interferences, without any cognitive dimension?" In this case, the solution lies in symmetries. Careful exploration of mathematical structures for identifying symmetrical structures leads us to tools, which allow us practically to find essential (in cognitive sense) objects among the formulas and equations of local importance (more about this was explained in a previous ISIS-Symmetry World Congress in Haifa 1998, see conference papers for details).

6. IDEAS

Cognitive efficiency of discussed scientific method manifest in practice. Historically, this efficiency had been tested many times with good result. It is interesting whether this method's opportunity of applying is of temporal or universal kind. For test, let's have now some speculations. For the moment we would try to apply our method for finding results of cognitive (or not) dimension, using the scientific facts from 'the edge' of present knowledge. In simple words, we would try to discover 'something' we don't know yet. If result is satisfactory, we will be able to accept main trains of our presentation.

Let's take into account the problem of entropy. Equations of physics, including the most fundamental ones (for example, mentioned Schroedinger equation), don't distinguish the arrow of time. Therefore, physical phenomena ought to be reversible in time. Unfortunately, in real world we don't observe it: broken glass is not going to consolidate again and old houses don't transform themselves into new ones. For justifying the situation, we define the quantity called entropy, understood as the measure of sets of permissible configurations of the system. Second Law of thermodynamics says, that entropy of adiabatic system never decreases, what implies, that only some configurations of the system are permissible in physical processes (consequence of it is the arrow of time).

This interpretation is a source of serious problems of modern physics. Steady rise of entropy forces the whole universe to be of zero-like entropy kind at the beginning, what is probabilistically negligent. What more, rise of entropy is not going to reverse after turning the arrow of time away (Exact explanations of this mechanism one can find in Penrose's books, for example "Emperor's new mind). All trials of justifying the effect by respecting expansion of space-time lead to other problems, for example to non-existence of 'white holes' (After turning away the arrow of time, black holes should spit the energy and matter away - to inverse themselves into 'white holes' -, what doesn't happen) or lack of the effect of reverse of time in very strong gravitational fields. This suggests, that rise of entropy is not connected with expansion of space-time, what was conceptual included into the definition of the term 'entropy'. It seems, such model produces contradictory predictions and mayn't be accepted for emulating evolution of the universe in a whole.

7. SPECULATIONS

Let's agree, that both models: relativistic and quantum ones, are simplifications of the more general structure (Finding it exactly, is a dream of probably all physicists in the world). Hoping, that 'super reality' in which our world does exist is physically and mathematically uniform, and, in general, it is able to create their models, we will try to 'guess' and to verify in formal way the mechanism of entropy. We'll do it using the scheme of discussed method, accepting separate elements of relativistic and quantum models as not contradictory.

According to what we said before, we will now consider the 4-dimensional space-time of our universe as being the quasi-continuous (outside of singularities, of course) and smooth enough ensembles of quantum sub-space-times. Local and global curvatures of it will be interpreted as non-zero gravitational fields. The observer, travelling through this space-time, always perceives one real stratification (sub-world) from the quantum set of them.

There are two quantum procedures of modelling systems. The first one describes the general evolution of quantum systems and is not breaking the symmetry of time. The second one, used for determining possible real manifestations of the system (levels of energy, by which the system is able to manifest their existence in physical world), *is* breaking symmetry of time permanently. It seems, the arrow of time comes out only in the act of reduction to one of real sub-worlds.

Our observer, walking through the space-time, admires the reality of sub-worlds. Independently on the geodesic line he chooses, he always, with each step along the line, must perceive something. Each act of such perceiving is equal to observer's reduction to one of sub-worlds, what is connected with breaking the time-symmetry. Number of acts of breaking is proportional to the value of entropy measured by the traveller. Here we have another sense of the term 'entropy'. The quantity may be understood now as a parameter of reduction procedure. Let's check whether such interpretation helps in aborting mentioned cosmological problems connected with time-symmetry braking.

Let's suppose that our observer starts his travel through the universe from the point very close to Big Bang. The space-time there is being described by extremely high values of Ricci tensor. This implies rapid expansion of the universe (Thanks to a specific shape of effective potential of vacuum and repulsive character of forces, existing in this symmetry of space-time). But each expansion ends very quickly in the Big Crunch singularity or in deSitter epoch, if only in the closest area of Big Bang there exist any, even the smallest, curvature of Weyl-type (Riemanian geometry distinguishes two types of curvature: Ricci- and Weyl-like). The second one is being understood as gravitational tide-force. To allow our observer travelling through the non-trivial world, we must accept the fact, that the whole area close to Big Bang is permanently flat in the Weyl sense (No world, which doesn't satisfy this condition, is able to exist much longer than the period comparable to Planck time, i. e. 10^{-44}s.) Any measurable Weyl-like curvatures are possible only quite far from Big Bang.

Penrose suggests, that reduction procedure may happen when local Weyl-like curvature is more than so-called Planck mass (i.e. local gravitational gradients are strong enough). If he's right, our hypothetical observer will be able to notice growth of entropy as faster, as further from Big Bang he travels. At the beginning of his journey, in the almost completely flat universe, the traveller has nothing to observe, because reductions to real sub-worlds are not possible. Further from beginning singularity, where the universe comes not to be so flat, reductions are permissible and the observer is able to admire reality around, measuring in the same time the growth of entropy with his each next step along the geodesic line he had chosen. Let's notice, that if our observer is trying to reverse the line he came, he won't be able to visit again sub-worlds he admired before (reductions to the same sub-worlds are probabilistically impossible). Still the entropy he is permanently measuring, will decrease again when he approaches to Big Bang. This happens, because each reduction that observer notices, eliminates rich set of reductions, he potentially would be able to suffer a step earlier. Approaching to Big Bang by any possible geodesic line restores amount of sets of potentially possible reductions in different (not flat) areas of space-time. In this visualisation, 'further' to Big Bang means 'later' in the observer's time measure. This is equal to the growth of entropy.

The effect of growth of entropy will happen as well each time when the observer approaches to local singularity (for example black hole) or other strong gravitational field source. Responsible for it is the fact, that strong fields reduce rapidly number of geodesic lines in the area (and even, after passing the Chandrasekhar border, cut off all the geodesic curves at all), what imposes strong limitations for set of potentially accessible reductions the observer could suffer.

8. RESULTS

As being announced, we tried to discuss importance of the term 'entropy', which is, in its classical concept, a source of serious problems of scientific and cognitive dimension. For clarifying the problem, we used traditional scientific method. We shaped the general outline of the new model, assuming only general conformity of well-known scientific models and mathematical character of investigated 'super reality'. We used as well some elements of presently accepted scientific knowledge and one hypothesis of quite nice likelihood of truthfulness.

As expected results we had:

another and more universal understanding of the term 'entropy' elimination of conceptual and model contradictions, which were the consequence of traditional definition of entropy

preservation of old models of thermodynamics, which work in the same way for both definitions of entropy.

nothing discovered here is contradictory with what we know up to now

Unexpected, but, as always, occurring results (scientific predictions) of physical importance, accessible for experimental verification, are:

thermodynamical evolution of the universe satisfies symmetry of time (entropy increases after inverting the arrow of time),

as closer to beginning singularity, as smaller is probability of virtualisation (reduction) the energy in real state,

irreversible nature of reduction procedures is obvious,

entropy increases near all sources of strong gravitational fields,

Weyl-like flatness of space-time near the Big Bang singularity is necessary for existence of the universe,

limitations for tracing time-like geodesic lines through the area of quantum stratification of the universe are of the Weyl-like curvatures shape.

9. COMMENTS

Let's finally collect everything what we discussed and discovered. The result is being shown at Fig.7. Phase space of vacuum curvatures, with diagrams drown for opened and closed Friedman-like evolutionary scenarios, is valuable and verifiable scientific result. Occurrence of it confirms correctness and cognitive efficiency of discussed scientific method.

Explaining advanced problems of modern science seems to be, again, impossible with use of formalisms and complete, systematic knowledge only. This is a manifestation of Goedel statement (it is not possible to prove each one theorem, which can be formulated in specific system, with use of logical tools of this system only). Fascinating features of reality – mathematization and idealisation – give us opportunity of having deep insight into the nature of phenomena of our universe, even if we are not pretty sure what are we looking for.

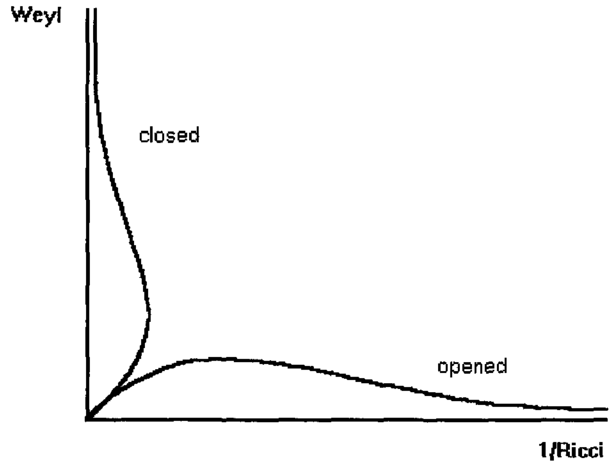

Figure 7: phase space of curvatures of Friedman universes.

References

Penrose R., "Emperor's new mind", Oxford University Press 1989

Hawking S., Penrose R., "The Nature of Space and Time", Princeton University Press 1986

Michniowski T., "Cognitive function of physical models", in: Philosophical and Scientific Elements of the Universe's Description. Part 5, UKSW, Warszawa, Poland 1998, p.121-39.