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Art from science or science from art?

Eternal problem:
What precedes what?
What determines what?
What affects what and how?
Can a possible marriage between art and science be a partnership or will it always be a misalliance – at one time for science at another time for art?

In antiquity it was not a problem, in modern times it is. The issue has become delicate along with the appearance of more and more similarities between those two realms. A clear-cut distinction between rationality and spontaneity, reasonable approach and intuitive revelation has ceased to apply. The areas of penetration began to overlap each other, especially in the area of ideas. In its many aspects art has become scientific and science has become artistic. Philosophy has tried to combine some issues, explaining why complete separation is impossible or even undesirable.

How would the impressionists paint without knowing the theory of colors? What would cubism be like if the geometry of four-dimensional space didn't exist? What way would Escher go without recognizing the findings of Łobaczewski? Would optical art create all of its visual solutions without the use of psycho-physiology of vision?

What about mathematics with its topology and physics with its visionary claims and attempts at understanding the whole world – what would they be without their pro-aesthetic qualities? What about the similarity between the appearance of impossible figures drawn for different reasons and for different purposes by artist Oscar Reutersvärd and physicist Roger Penrose?

Thinking about the mutual views of the two realms I decided to ask Professor Roman Duda, a topologist, about his opinion on that subject.

J.O.: Scholars and artists share one conviction that every thought, regardless of its direction and conditions, should be aware of its limitations. However, there immediately appears a dilemma regarding areas in which they overlap with each other, and consequently there is a disappearance of clear differences between science and art. Heidegger claimed that *art is a revealing of what is.* However, the same can be said about science. In both cases, then, it is about "what is" and "how it is."

R.D.: *In my opinion both science and art are entitled to talk about the ways of reaching the understanding the world. Science follows the path of truth, whereas art follows the path of beauty, but beauty is truth and truth is beauty. They both deeply penetrate, inspire and need each other.*

It is natural for man to look for unity, for one perspective, for one way, though at the moment it is too early to tell what this common way will be. For people who can think it could be philosophy, because modern science grew from philosophy, philosophy still includes aesthetics, that is reflection on beauty.

J.O.: In the first sentence of the preface to his *Philosophiae naturalis principia mathematica* Newton wrote: *I have in this treatise cultivated mathematics so far as it regards philosophy*. Mathematics, and specifically its approach to reality, can be as tenuous and mysterious as that of poetry or art, though art is always somewhat related with rationality and spirituality...

R.D.: *So is mathematics and science, because modern science is moving further and further away from concrete material phenomena. It is moving closer and closer to the area of ideas. Creating the theory of relativity and the quantum theory, it moved far away from its natural substrate. When we talk about the differential manifolds or Hilbert space, we use a language which is very far from the imagistic transmission of what we observe. Quanta as well as bigger elementary particles are objects of thought more than a result of experiments. It is not known if some particles exist at all although they should exist for the picture to be coherent.*

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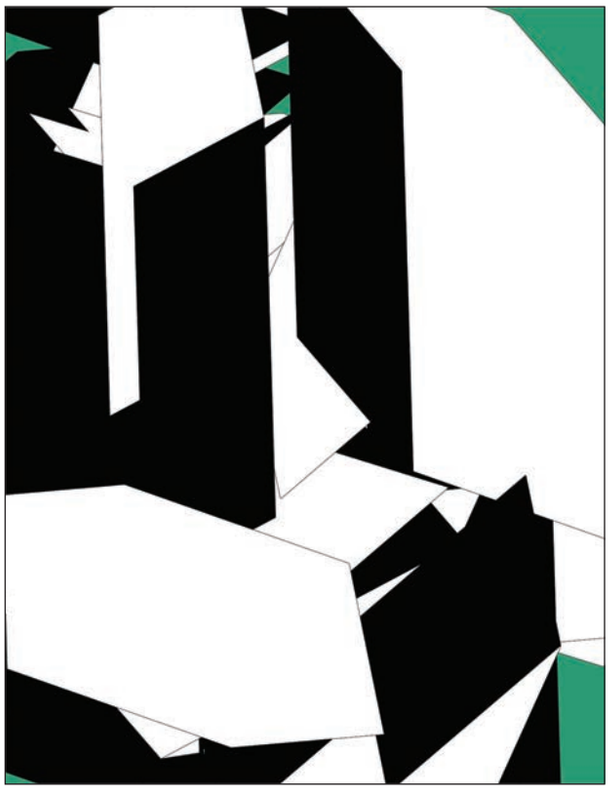

Fig. 1. P1011-C, pigment-ink on canvas, 2004, 144 × 112 cm (Manfred Mohr)

Il. 1. P1011-C, tusz na płótnie, 2004, 144 × 112 cm (Manfred Mohr)

J.O.: Ultimately it is man that gives meaning to things by putting the data into order in his own consciousness as well as making use of simple models which are the result of the assumed reduction. We perform similar activities also in art.

R.D.: *Thinking is often similar and models are needed in both realms. Quarks, which due to their scale are unimaginable, organize the smallest structures of the universe. On the other hand, the structure of the universe, in macroscale, scares us with its magnitude. In order to explore it, we present it as an idea full of manifolds and we use mathematical tools. What drives us in selecting these tools? I think that the sense of beauty is very important. The world is somehow ordered in such a way that a strong and efficient theory impresses us with its beauty. If we create something beautiful, it seems to us to resemble the world which the mathematician seems to be describing.*

J.O.: This means that the world in its nature is beautiful…

R.D.: *There is an amazing correlation between the human mind and the world. There are a lot of ways which we can follow in interpreting the world, but we choose a few specific ones which seem to us beautiful. In such a case what happens is a very dramatic interpenetration of aesthetic and rational thoughts as well as of spirit and matter, however, a sense of beauty remains the fundamental conductor. Thought, that is intellectual construct, is an object of modern science to a larger extent than its basis, namely matter.*

J.O.: The difference between art and science is that the boundaries of art are fluid or maybe even it doesn't have any. Once in a while the slogans from half a century ago return like a boomerang: "everything is art" or "everybody is an artist," which results in categories getting blurred and the disappearance of any criteria. I think that science is more disciplined.

R.D.: *Not necessarily and fortunately not entirely.*

J.O.: Is absolute originality possible in science?

R.D.: *Only within certain limits. Once you enter the canon, you should try to break it. Making such attempts generates the most precious moments in the development of science. A very important breaking of the canon took place during Copernican times when the traditional order of the world which had been revered for centuries – the order based on Greek mathematics – was questioned and refuted. It was accompanied by great resistance from the scientific community but it was exceptionally creative for science. There have been numerous examples of this during the development of science when something new evolves from the old.*

J.O.: There is an infinite number of such revelations in art. It is the innovators who by breaking earlier conventions give shape to newly created directions and with their relentless attitudes begin new periods. In modern times, they often find inspiration in science. A good example is the interest of the impressionists in the nature of light or of cubists in the fourth dimension.

R.D.: *Both impressionism and cubism were very important for art. Although they disappeared, their achievements were absorbed by modern graphic art. Similar phenomena regard scientific matters. Frequently, it seems that scientific production is similar to the evolution of the living world. A lot of creations, claims, currents and directions appear, but most of them fall to the side and are forgotten.*

J.O.: Time cleanses.

R.D.: *Many solutions sink into oblivion. Only some remain.*

J.O.: In art the reasons why people fall into oblivion are different. Often they are authors with huge achievements appreciated only after their death, often accidentally. The world suddenly discovers that somewhere far from artistic centers there was a genius who tried to break through in his own time, or who by choice was active only in the margins, or because of his own modernity was unacceptable for his contemporaries. And the world recognizes the genius of such individualists who have passed away only much later. Do similar phenomena take place in science?

R.D.: *To some extent they do. The development of science consists in the appearance of certain ideas. It happens that they get formulated in different places independently and even at different times. This is what sometimes happens. For instance Bolzano, a Czech mathematician who lived at the beginning of the 19th century, had brilliant concepts, a clergyman by education, professor of philosophy at the university in Brno and Prague who did not manage to popularize his ideas in his times. They were rediscovered years later and when his achievements were remembered he was fully recognized because he did confirm the direction of the development of mathematics by imposing a new meaning on it. These kinds of stories do take place but they don't really affect modern* science.

J.O.: Wasn't Riemann, the author of multi-dimensional geometry whose principles became the basis of the theory of relativity, also ahead of his time? Einstein used his findings much later.

R.D.: *I don't know if this can be considered being ahead of his time. Riemann asked the question "What is space?" In his time, it was a commonly accepted rule that space is described by Euclidean geometry. Riemann assumed that this is a wrong point of view, that it imposes on our physical space a certain mathematical concept which does not hold up when confronted with reality and he asked himself a mathematical question: "What is space and how should it be defined anew?" His deliberations resulted in the concept of manifolds, that is, a concept of space which locally resembles a Euclidean one, but these parts can become much more elaborated structures. When Einstein developed the theory of relativity he lacked a mathematical apparatus to specify it. Then a mathematician friend of his told him that something like this already exists and for him it was a gift from heaven. There are a number of such events in science and they confirm my conviction that mathematics is a kind of physics.*

J.O.: Is it also the case in art?

R.D.: *I don't think so as I believe that art is more autonomous. There were such artists who were greatly inspired by mathematical ideas, for instance, Escher*.

J.O.: Among many others.

R.D.: *Yes, and they did have their followers. Some of them were original artists, yet when I look at their works I have the feeling that they are too perfect to be beautiful. The same regards music. Some time ago, the Japanese recorded a Beethoven symphony in absolutely sterile conditions. There were no coughs and all of the violin strokes were ideal. A perfect work, but it's just not possible to listen to it*.

J.O.: On the one hand, we pursue the ideal in all spheres, however, on the other hand, we are aware that perfection happens to be inhuman.

R.D.: *In science we constantly pursue the ideal, perfecting the models constructed in theory. However, the close presence of already existing art warns us against idealizing too much and it seems to say that we are still far away from true perfection, that it's still ahead of us and that beauty and truth are still to be found. It also appears that if something is too sterile, it loses its charm and its allure disappears.*

J.O.: What is the source then of the idealistic hopes of scholars that they will be able to grasp the whole? Why try to develop the Theory of Everything? Why the desperate need to precisely define the absolute categories? Why develop the notion of hyperspace?

R.D.: *We are on the way. There is a misunderstanding about the Theory of Everything because this theory is not really a theory of everything – it is supposed to be a theory combining four basic forces in the world. So far this has not been done, but if this is achieved, it will be something really magnificent. I hope that this will happen one day because if there is one world, there should be one description of it too, but this will not be a theory of everything. I don't believe in the Theory of Everything*.

J.O.: What are your views on *space*, which is something that has been so richly interpreted in topology? These problems were and still are interesting for many artists such as Dali who was fascinated by the tesseract or

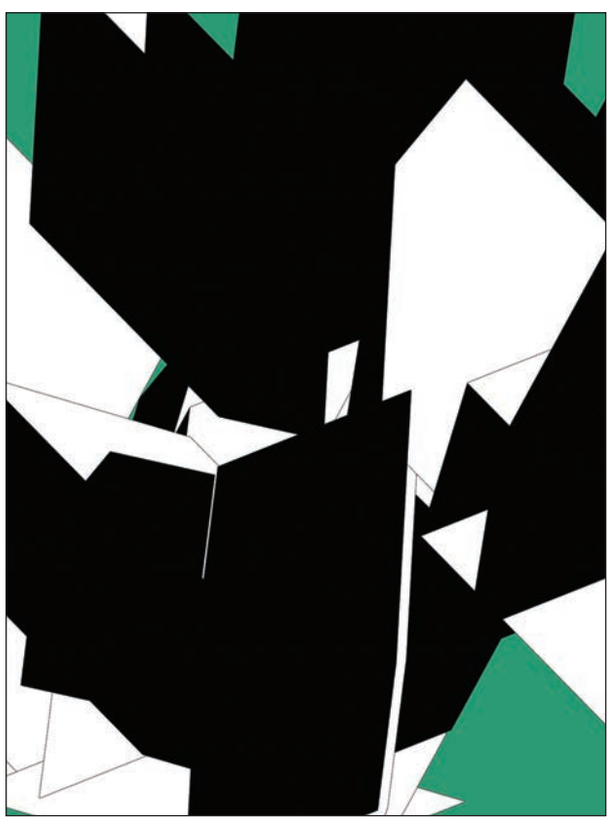

Fig. 2. P1011-L, pigment-ink on canvas, 2004, 144 × 112 cm (Manfred Mohr)

Il. 2. P1011-L, tusz na płótnie, 2004, 144 × 112 cm (Manfred Mohr)

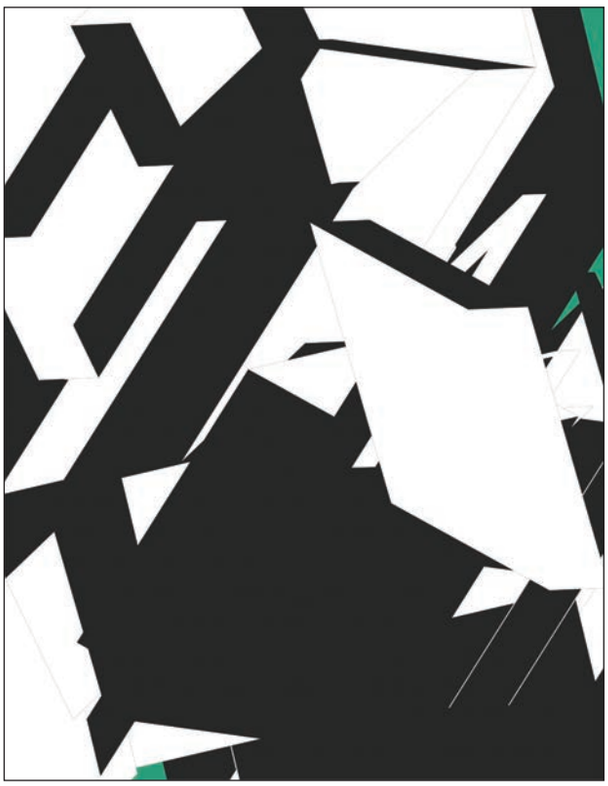

Fig. 3. P1011-R, pigment-ink on canvas, 2004, 144 × 112 cm (Manfred Mohr)

Il. 3. P1011-R, tusz na płótnie, 2004, 144 × 112 cm (Manfred Mohr)

Duchamp and Picasso who explores the essence of the fourth dimension; they all seem to be dreaming of getting to the other side of the mirror. This may be a symptom of a deep human need to go beyond the third dimension, that is, leave even momentarily the world which we know.

R.D.: *My view is very naive. For me it is an indisputable fact that we live in a three-dimensional world. We are, however, aware of how limited such a perception of the world is. More importantly, reality alone forces us to go beyond the mathematical apparatus which derives from the three-dimensional and creates additional dimensions. The notion of timespace helped to better understand the world and has today the notion of multi-dimensionality which appeared in string theory. However, I consider all these to be constructs of thought. But the fact that they are beneficial gives us proof that our thought is on the right path, reaching a better and better understanding of the world.*

J.O.: In a word, there is a constant discord between idea and factuality, theory and practice.

R.D.: *Indeed we live in a flat world from which we are trying to escape. This pursuit can be illustrated by climbing mountains or building towers and pyramids which elevate us a little above the flat world and give us a sense of deeper knowledge. Speaking about space, our world is actually three-dimensional and that is why I believe that the attempt to reach the fourth dimension physically not mathematically – which is simple – has no chance of succeeding.*

J.O.: This sphere can be then penetrated only by the visions and dreams of artists.

R.D.: *These can be even creative dreams which, however, does not change the fact that this cannot be done. There is another interesting issue. Our world is locally Euclidean and globally probably not. Modern cosmogony likes to use Łobaczewski's hyperbolic geometry. There are people who ask themselves the question what would happen if we rejected the Euclidean harness and learned a different geometry from childhood. Maybe we would be better adjusted intellectually to understand the world.*

J.O.: The mutual effects between mathematics and art as well as their directions are different. Initiatives construed as a creative impulse come to a related and at the same time distant realm somewhat alternately – once from mathematics to art and once from art to mathematics. Moholy-Nagy believed that *mathematically harmonious shapes which have been thoroughly studied are filled with emotional values and they express a perfect balance between feelings and intellect* [1], which he explained in his book published in 1946 *The New Vision and Abstract of an Artist*. On the other hand, contemporary American mathematicians such as Banchoff or Séquin, while making computer visualizations of complicated equations, achieve outstanding aesthetic results which as images or objects can easily emanate an original glamour in galleries promoting the newest art, in which in any case, taking into account the tradition of constructivism, op-art or minimalism, an area could be separated out which could be called **mateart**, and I do mean to say mate- not meta-.

R.D.: *Those registers should not be confused. Mathematics is an art in the sense of freedom. We also choose what is beautiful. Although art also pursues the truth, they still remain different registers despite interpenetrating and inspiring each other.*

There are a lot of examples when ideas overlap with one another and there are a lot of ways of imaging and mutually inspired creation. There are mathematicians who while making scientific findings create images and objects which meet the typical requirements of works of art. Visualizing equations or graphically animating formulas to present their formal essence, they often unintentionally call into existence something that meets the criteria which apply in art. Good examples include short films by Professor Thomas Banchoff that show complicated solids in a geometrically four-dimensional space, displayed as sculptures, or the openwork structures by IT specialist Carl H. Séquin or the intriguing computer graphics presenting mutations of a torus by Nick Schmidt dealing with electronic geometry. A separate group includes fractals which are artificially generated and at the same time fabulously colorful images self-creating in a constant operating process, released from the computer by Benoit Mandelbrot and his colleagues.

Mathematics and art share more than they seem to. Although in the world of art, objectivism, which is so

important in evaluating mathematical results, doesn't really matter, the standards which apply in mathematics as well as the assumed motivations are not similar to those which are known in other sciences but to those which apply in art. This is amazing but when classifying mathematical theorems, it often happens that aesthetic aspects prevail over logic. The categories of beauty and elegance co-create the values of ideas no less than their correctness and even more so their potential usefulness. The English theoretician of numbers Godfrey Hardy, calling mathematicians creators of patterns and ideas, noted that for them, just like for other artists, *beauty and eminence are criteria with which their works should be evaluated* [2]. What's more, when he was talking about their achievements, he was especially proud not to have ever done anything useful, anything that would have any practical significance as such. He was dealing exclusively with mathematics for its own sake. Complete disinterestedness. Real art for art's sake. Pure freedom unblemished with any constraint of practicality.

I believe it is an indisputable fact that a great part of mathematics was born, lives and enjoys admiration as well as respect only because it is interesting... I like the idea of things which are done only for their own sake. Those words were spoken by American algebraist Paul Halmos. According to him, mathematics *is creative art because mathematicians create beautiful new ideas; it is creative art because mathematicians live, act and think like artists; it is creative art also because mathematicians consider it to be such.* Halmos compared mathematics to music and literature, however, primarily to painting. He said that*: the origin of painting is physical reality, and so is the origin of mathematics – but the painter is not a camera and the mathematician is not an engineer... In painting and in mathematics there are some objective standards of good – the painter speaks of structure, line, shape, and texture, where the mathematician speaks of truth, validity, novelty, generality – but they are relatively the easiest to satisfy* [3]. Maybe that is why both mathematics and art are sometimes barren – when they are full of boring formalism; it can be also truly deep – when it is relevant.

I am turning now to Professor Jerzy Lukierski, theoretical physicist:

J.O.: There are numerous attempts at visualizing different figures in a four-dimensional space: cube, torus, Klein bottle … As a result we have both material solids which are like mathematical sculptures and computer simulations taking us into a world with two more dimensions than Flatland. In your opinion are these attempts at "imaging the impossible" important for science or are they only artistic impressions?

J.L.: *Visualizing figures in dimensions greater than three can have some educational significance. The transferring of easy to imagine geometrical relations from three to more dimensions can be helpful even in scientific research. However, in contemporary mathematics geometry is more about mathematical formulas than images.*

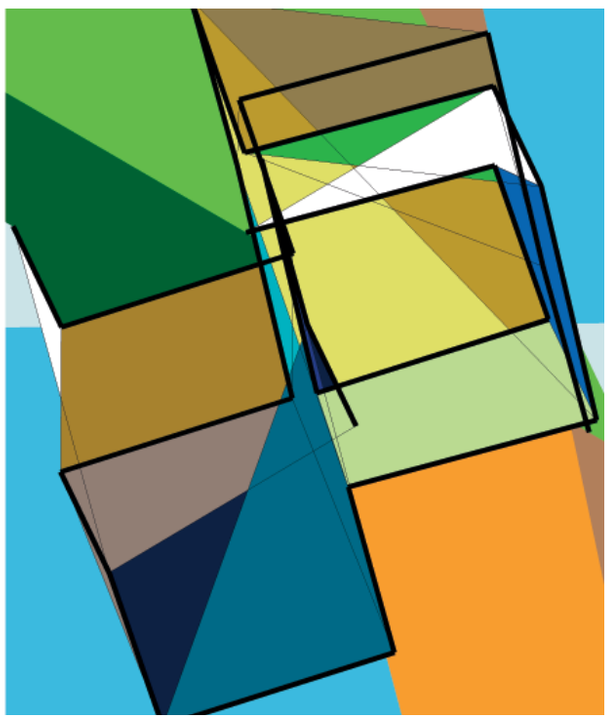

Fig. 4. P-701/B, enduraChrome / canvas, 1999, 141 × 114 cm (Manfred Mohr)

Il. 4. P-701/B, enduraChrome / płótno, 1999, 141 × 114 cm (Manfred Mohr)

J.O.: And how do the cosmological models created by such scientists as Hawking or Penrose present themselves in the context of the strict paradigms of physics? Are they only visions of the "poets of science" or timeless truths formulated by the giants of knowledge?

J.L.: *The concepts of Hawking or Penrose are bold scientific hypotheses and not timeless truths. Their strength*

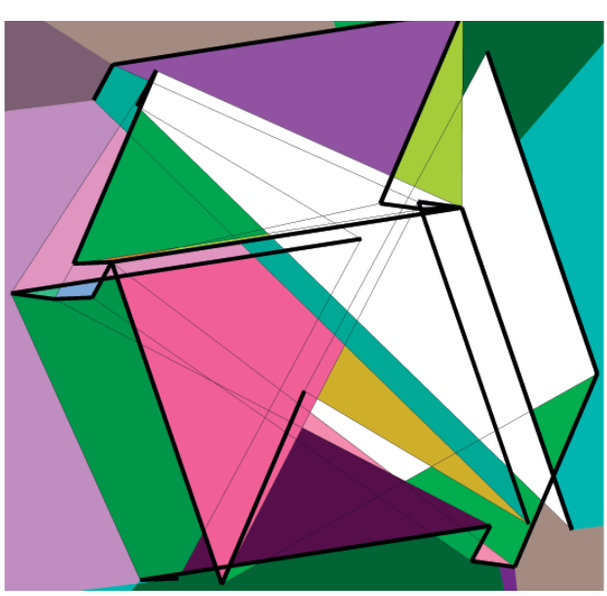

Fig. 5. P-706/B, enduraChrome / canvas, 2000, 140 × 135 cm (Manfred Mohr)

Il. 5. P-706/B, enduraChrome / płótno, 2000, 140 × 135 cm (Manfred Mohr)

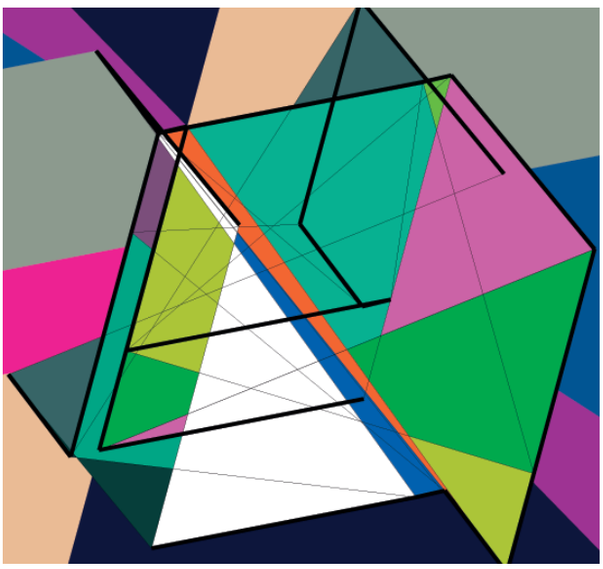

Fig. 6. P-707/F, enduraChrome / canvas, 2001, 140 × 143 cm (Manfred Mohr)

Il. 6. P-707/F, enduraChrome / płótno, 2001, 140 × 143 cm (Manfred Mohr)

lies in the fact that they concern the most fundamental problems of the descriptions of the universe (the beginning of the universe, the elementary structure and complex geometry of spacetime) and the fundaments of our views on the description of nature.

J.O.: The area where you "surf" is riddled with various unknowns, marked with zones of indeterminacy and refuses to be described with the use of holistic definitions. Often it is more similar to the exuberant and free terrain of art than the disciplined cultivation of science. Is this where the ambitions of many physicists to impart aesthetic value to scientific formulas come from?

J.L.: *In science there is as much discipline and rigor as is allowed by the possibilities of verifying hypotheses. There are such hypotheses which by definition cannot be verified in "earth conditions" as they require too much energy and sometimes they resemble artistic manifestos. On the other hand, imparting aesthetic values to scientific formulas is a harmless hobby of some researchers*.

J.O.: I am trying myself to express, possibly in a simple form, some aspects of the infinity of space. Many artists have dealt with and still deal with this issue. Some of them closely cooperate with mathematicians and physicians, which has been a tradition since the Renaissance. My dilemma is finding out whether imaging various spaces, including four-dimensional ones, is possible. There have been a number of more or less satisfactory solutions. So far I have been more into non-dimensionality than into multi-dimensional measurability. I create illusions. I form delusions. Don't you think that this is the only way to touch the mystery?

J.L.: *Art often outstrips science but it also has much fewer rigors and it cannot be treated too seriously by science. The ambition to imagine different geometrical structures can be a task for an artist too and even more so because its constructs are judged by aesthetic and not scientific criteria. In regards to multi-dimensionality, the analytical description with the use of numbers presents more possibilities than geometrical structures – one can create objects in an incomplete dimension (e.g. 1/3 or pi). In this area the domains of mathematics and art can join.*

J.O.: Why is a theoretical physicist asked questions about art? Well, in the opinion of many, science has lost its privileged position in the hierarchy of cognition and it no longer guarantees – as it once seemed to – absolute and indisputable knowledge. What's more, it also occurs that it is inspired by art which reflects a changing life. It is a different matter that it also wants to be certain of discovered laws which it finds on an abstract and mathematical path.

J.L.: *Science has always coexisted with art peacefully for the most part. In my opinion, the role of science which broadens our knowledge of the world around us plays the leading role in this duet. It provides verifiable knowledge which grows at an incredible rate. Science constantly asks new questions – and it may happen that there are more new questions than answers, which sometimes leads to some confusion, indeterminacy, intuitive answers and a shift a little closer to art. However, when we look at significant steps toward the development of human civilization, they result more from the development of science than art.*

Sometimes I have the impression that science carefully guards the autonomy of the area it penetrates and yet it eagerly declares its openness to interdisciplinarity. On the other hand, some excellent scholars demand that artists be interested in the results of their work. Nobel-Prize winner Richard P. Feynman asked: *Can't our contemporary picture of the universe inspire anybody? Nobody sings about the values of science and you are forced to listen to not a song or a poem on that but an evening lecture. The age of science has not yet come* [4].

Has the age of art already come then? Or maybe it has already passed with its total technologization and banalization? Many claim that by more and more spectacularly demonstrating its helplessness in cognition and attempts at changing the world, art has become nothing. Its spectacular nature conceals a lack of message without any significance under a formal glitter. Often it boasts of a refined simplicity while hiding under this sophisticated euphemism ordinary crudeness. At times it happens to be, however, original, revealing and fascinating.

Robin George Collingwood had a rather radical and at the same time critical attitude to works of art. Analyzing his opinions in *The Philosophy of the 20th Century,* Alfred J. Ayer explains: *A work of art is real in so far as it is imagined, but it also aspires to meaning and as thus led into contradiction, for meaning is conceptual and 'a concept can only be conceived, not intuited'; it cannot be 'fused or identified with its sensuous vehicle'*. […] *science comes closer to a grasp of literal truth, but its defect*

lies on its being abstract. Whereas 'art ignores the real world altogether' 'science *alone tries to bring the concrete world into the unity, but destroys its concreteness in the attempt'* [5].

Ilya Prigogine, author of *The End of Certainty*, stated that: *Where science wants to be abstract, mathematical and absolutely certain it often makes art join it in search of absolute certainty of laws but where art becomes an advocate of a changing life it makes science go sometimes towards it (e.g. that which regards the deterministic chaos or "systemic" science)* [6].

Art of the 20th century, and even more so of the 21st century, seems in many ways rational, concrete, systemic, structural. These kinds of ideas and programs result, on the one hand, from the need to introduce order into the disorder of reality and of experiences connected with it as well as, on the other hand, from the belief that through organized beauty one can find simplicity in complexity which is the hope also of some mathematicians and physicists.

One of the artists who rationalizes art is Manfred Mohr. His "P – 1011/C subset.motion" from 2005 is a screen with an infinitely variable content. This dynamic composition was created by Mohr with the use of an algorithm whose function consists in selecting a different subset each time from a set of 42 240 cubes (creating an eleven-dimensional hypercube) and determining which sides shall be black and which white. *My art-work is always the result of a calculation* – he noted explicitly. *– At the same time, however, it is not a mathematical art, but rather an expression of my artistic experience. The rules and processes I invent reflect my thinking and feelings. Even if we assumed that my work process is rational and systematic, its results can be unpredictable. Like a journey, only the starting point and a hypothetical destination are known. What happens during the journey is often unexpected and surprising* [7] (Figs 1–6).

In the case of this kind of creativity, questions of a fundamental nature appear: Who is the author of the work – the artist or the algorithm? What is creation – creating an algorithm or generating an artistic object with its use? Which role is the leading role – that of the artist or the programmer?

A methodically technical, if not to say "scientized" example of the process which takes place in the area of art is the achievement of Joachim Sauter and Dirk Lüsebrink displayed in 2008 at the collective exhibition titled "From Spark to Pixel" in Berlin's Martin-Gropius-Bau. Inspired by the achievements of the film avant-garde from the beginning of the 20th century, they decided to reverse earlier situations regarding games with time and space and create architectural objects made of existing film frames with the use of their own method called "Invisible Shapes of Things Past." It consists in transforming movie sequences into interactive virtual objects. Moving the movie camera along a straight line results in cubic objects and panning results in cylindrical objects. The artistic assumption was to resist the overwhelming hyperrealism which prevails in computer graphics as well as to find in images architectural and sculptural forms which develop from voxels (Figs 7, 8).

Thinking in solids cannot always be adequately visualized. Problems begin when a thing is supposed to come to be in a space which is more than three-dimensional. So far, with the help of computers, we can see models in *n*-dimensional spaces only in the form of shadows cast by them on a plain. It would be great to see a four-dimensional hypercube in nature. Sometimes artists manage to create simulations of multi-dimensional objects – by abbreviation, metaphor, ambiguity of an image. In his book *Surfing Through Hyperspace*, Clifford A. Pickover presents such examples, publishing also what was erased by computer e.g. 7-D cube drawn by moving a 6-D cube in a six-dimensional space.

Researchers in the natural sciences and especially theoretical sciences share differences with artists but primarily they share the same longing – wrote Jan Berdyszak, who deals with unconventional sculpture, in my exhibition catalog. *– They both want to fulfill their need to provide statements about realities through knowledge and the different nature of their intuitions as well as with the effort of a disciplined imagination and they also want to develop possible realities* [8].

But only possibility; aesthetic possibilities which occur in nature and in artificial reality seem to attract both

Fig. 7. Berlin 07 Inside, fragment, from "From Pixel to Voxel" exhibition, Martin-gropius-Bau, 2007 (Joachim Sauter, Dirk Lüsebrink)

Il. 7. Berlin 07 Inside, fragment, z wystawy „From Pixel to Voxel", Martin-gropius-Bau, 2007 (Joachim Sauter, Dirk Lüsebrink)

Fig. 8. Berlin 07 Develop, fragment, from "From Pixel to Voxel" exhibition, Martin-gropius-Bau, 2007 (Joachim Sauter, Dirk Lüsebrink)

Il. 8. Berlin 07 Develop, fragment, z wystawy „From Pixel to Voxel", Martin-gropius-Bau, 2007 (Joachim Sauter, Dirk Lüsebrink)

scientists and artists in a special way. In his *The Essential Tension: Tradition and Innovation in Scientific Research* Thomas S. Kuhn expressed his opinion on this: *in both realms an important role is played by deliberations on symmetry, simplicity, elegance of symbolic expression and on other forms of mathematical aesthetics. In art, however, the objective of artwork is aesthetics, whereas in science it is again at best just a tool* […] *Only when* […] *the aesthetics of a scholar is in line with the aesthetics of nature, does it play some role in the development of science. In science aesthetics is rarely a separate objective and it is never its main objective* [9].

Cases of falling into triviality, naivety or pure illustrativeness without any original creative invention are not infrequent. This concerns different aspects of activity taking place in both areas. On the other hand, no idea or theory can claim the exclusive right to express absolute truth. Bertrand Russell expressed his straightforward opinion in that respect in *My Philosophical Development*: *Science is at no moment quite right, but it is seldom quite wrong, and has, as a rule, a better chance of being right than the theories of the unscientific* [10]. Consequently, artistic theories can by definition be considered doubtful. But they do have absolute autonomy. Certainly, however, in both cases one should avoid naive realism. Russell even claimed that its falsehood can be proved logically. Einstein admirably commented the conciseness of Russell's statement: *Naive realism leads to physics, and physics, if true, shows that naive realism is false. Therefore, naive realism, if true, is false; therefore, it is false* [11].

Fig. 9. Hubble Deep Field

Il. 9. Głębokie Pole Hubble'a

Yes, nothing is certain, nothing is ultimately defined and nothing is irrefutably claimed once and for all. Especially in art which is totally free and bound by this freedom.

A lot of philosophers of science believe that the greater knowledge there is, the deeper the mystery will be revealed and draw its leading figures to further penetrate and explore. Is this also a paradigm in art? Yes and no. There can be no straightforward answer, which is always a simplification, anyway. How else can science be qualified but exclusively as objective and art as subjective?

Thomas S. Kuhn, whom I already quoted, was one of those who objected to associating science with objectivism. He claimed that the neutral language of observation is fictional and that its presentation as such is an unjustified idealization. He formulated the concept of paradigms as "perspectives of cognition" which reveal a constant evolution and variability of patterns of interpreting the world which does not always involve replacing a worse paradigm with a better one. Although assigning objectivism to science and subjectivism to art is a far-fetched simplification, it still prevails. John D. Barrow in his book *The Artful Universe* straightforwardly described the character of science and art and wrote that these realms are *a testimony of success of the objective and subjective view of the world* and in another place: *science had great success in explaining what we see with the use of invisible laws of nature – whereas art became more and more subjective, metaphorical and moved further and further away from realistic representation* [12]. Each of the statements quoted above raises the most basic doubts. It would be too nice if it were so simple.

In both realms internal tensions may be inspiring, including such a conceptually fundamental one as that existing between finiteness and infinity – this is an important philosophical, physical, mathematical and artistic problem. Fuel for deliberations in this intriguing field of limit and limitlessness is provided by the structure of the Universe and the way in which it exists.

The sum of statements and conjectures gathered by astrophysics and cosmology fuels the uncontrollable invention of researchers and artists. The peculiarity of the findings which have been made so far and the abundance of suppositions which supplement them provide fertile ground for invention. The multitude of interpretations is dominat-

ed at times by correctness and at other times by pure coincidence. It happens that the claims which are put forward and model visualizations are universally considered adequate, but it also happens that they are negatively evaluated as unacceptable. Such analogies exclude anomalies which resurface after some time and try to replace the previous ones. Innovation gives way to randomness which often becomes the driving force of another innovation.

The results of space research are becoming more and more often a medium for the use of artists such as Stefan Wojnecki – a physicist by education and a photographer by choice. He became fascinated by an image of the so-called Hubble Deep Field which he commented as follows: *One insight presents the whole evolution of the Universe – it reveals all of the time which has passed since the moment of creation in the Big Bang until the present. This is an image of the highest metaphysical significance. I know*. He presented his views on the mechanical potential of the medium in the following statement: *I associate the photographic existences of persons or things that no longer exist in reality with the image of the universe which we perceive, the memory of the stars whose rays reach the earth as echoes of reality from millions or even billions of years ago* [13] (Fig. 9).

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Clear similarities and stark differences – this is how we could describe the connections between science and art which appear on various plains and in various dimensions. Scholars and artists differ a lot, yet they share a lot too. For instance, they have to abandon their previous beliefs and free themselves from procedures which they used to comply with if they want to increase their chances of becoming innovators. Alternative thinking usually guarantees the making of new discoveries and the application of solutions which were earlier unknown. In science, original findings usually complete and add to the existing ones. In art, new artistic directions are formulated mainly in opposition to the existing ones. This is true, and in both science and art, the attitudes, patterns and trends do emerge and affect one another, however in art, unlike in science, this is something which is not advertised.

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Sztuka z nauki czy nauka ze sztuki?

Matematykę i sztukę łączy więcej, niż się na ogół wydaje. Wprawdzie w świecie sztuki nie ma większego znaczenia obiektywizm, który tak istotną rolę odgrywa w ocenie wyników matematycznych, niemniej obowiązujące w matematyce standardy, a także przyjęte motywacje zbliżone są nie do tych znanych z innych nauk, lecz właśnie do panujących w sztuce. To zdumiewające, ale w klasyfikowaniu twierdzeń matematycznych nierzadko nad logiką górują względy estetyczne. Kategorie piękna i elegancji współtworzą wartość idei w stopniu nie mniejszym niż ich poprawność, a tym bardziej potencjalna użyteczność.

Sztuka XX, a tym bardziej XXI wieku w licznych odsłonach jawi się jako racjonalna, konkretna, systemowa, strukturalna. Tego rodzaju idee i programy biorą się z jednej strony z potrzeby wprowadzania ładu w bezład rzeczywistości i związanych z nią doświadczeń, z drugiej – z wiary, iż poprzez uporządkowane piękno można znaleźć prostotę w złożoności, którą to nadzieję mają również niektórzy matematycy i fizycy.

Zdecydowane podobieństwa i wyraźne różnice – tak dałoby się określić koneksje nauki i sztuki, spełniające się na rozmaitych płaszczyznach i w różnych wymiarach. Uczonych i artystów sporo dzieli, ale i łączy niemało. Chociażby to, że muszą porzucić swoje poprzednie przekonania i uwolnić się od procedur, do jakich przywykli, jeśli chcą zwiększyć swoje szanse stania się nowatorami. Gwarantem dokonania nowych odkryć i zastosowania rozwiązań wcześniej nieznanych jest na ogół alternatywne myślenie. W nauce oryginalnymi ustaleniami dopełnia się zazwyczaj i wzbogaca stan istniejący. W sztuce nieistniejące wcześniej kierunki artystyczne formułuje się głównie w opozycji do zastanych. Owszem, i tu, i tu postawy, wzorce i trendy wyłaniają się z siebie i oddziałują nawzajem, jednak w sztuce, w odróżnieniu od nauki, nie jest to czymś, czym należy się afiszować.

Key words: art, science, space, computer graphics

Słowa kluczowe: sztuka, nauka, przestrzeń, grafika komputerowa