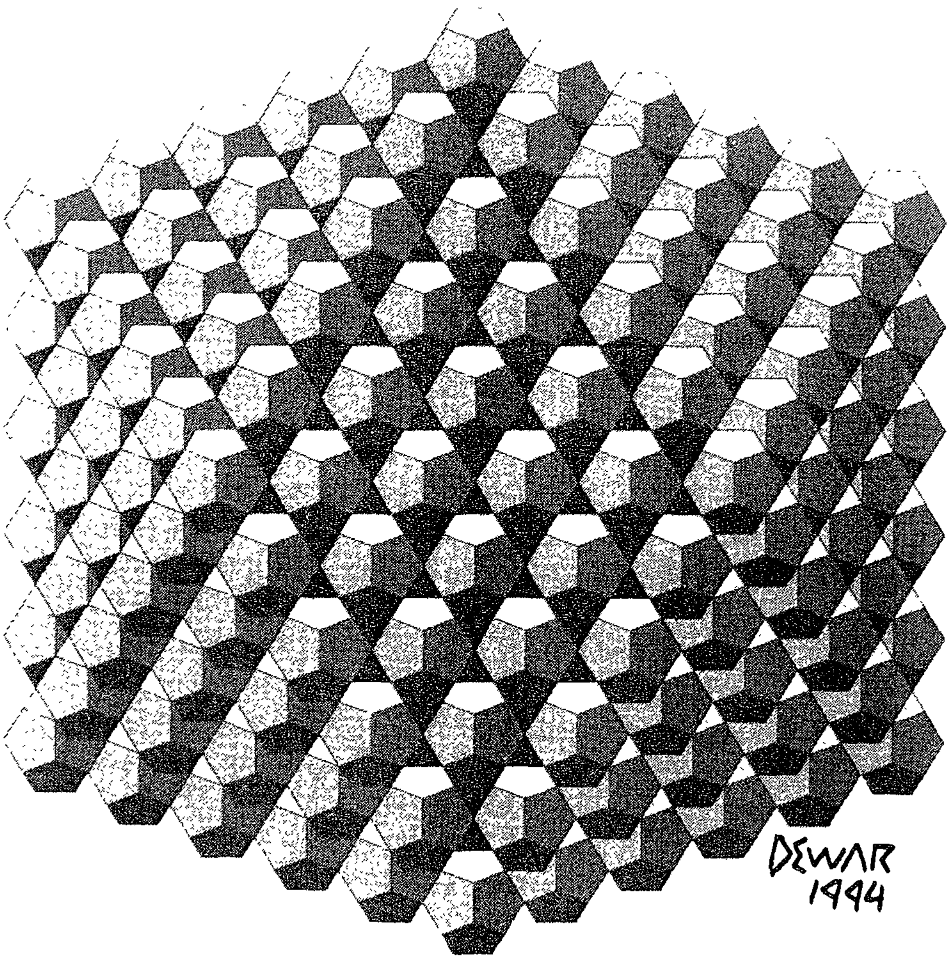
Symmetry: Culture and Science

Symmetry: Natural and Artificial, 2

The Quarterly of the
International Society for the
Interdisciplinary Study of Symmetry
(ISIS-Symmetry)

Editors:
György Darvas and Dénes Nagy

Volume 6, Number 2, 1995



Third Interdisciplinary Symmetry Congress and Exhibition
Washington, D.C., U.S.A. August 14 - 20, 1995

SYMMETRY: THE NEEDED BRIDGE BETWEEN THE ARTS, THE SCIENCES AND THEIR MATHEMATICS, AND THE HUMANITIES

Melvyn L. Fisher
809 North Third Street
Philadelphia, PA 19123, USA
E-mail: fisherp@hal.hahnemann.edu

The search for a picture, a symbol of how the world works in principle, is a contemporary activity that began in ancient Greece (six centuries B.C.) when Thales asked: What is the world made of? He speculated that water was the fundamental element. Today we think in terms of quarks, although they have never been found. How does Nature work? He wasn't sure. And today we are still not sure. We have some answers but no pictures. Or so it seems.

For the modern period, artists have often referred to how the world works in principle as the "ultimate" or "pure" reality; physicists use the term "physical reality." To the physicist, in terms of partial differential equations or group theory, physical reality is entirely mathematical and does not lend itself to pictures. Is the same true for art?

With all due respect, the representation of the structure of reality is too important an idea to be left to the obscure mathematical symbols of the physicist. As Susanne Langer put it in her book, Problems of Art , "Nothing is so elusive as an unsymbolized conception." Therefore, any effort by artists to create a deeper comprehension of the abstract, ethereal realm of physical reality, no matter what structures are employed, is, at best, tentative and should be a starting point and not a conclusion.

Like poetry, this is a search for an image, not for facts. This is a search for a symbol that could help organize the facts. "It is an effort to make reality conceivable, memorable." said Langer. My venture into this "invisible, intangible, unknowable" realm of physical reality began in 1986 after I had created a vocabulary of ideal geometric forms, all from the same underlying structure of interacting waves of energy. This theory is based entirely on my struggle to develop a language to communicate the meaning of my patterns and the resulting realization of a loose correspondence between the symmetries I was discovering in my work and the analogous symmetries that one finds at the heart of Nature.

My work's meaning is intended to bridge the gap between the nonvisual mathematical reality of the physicist and the need for a symbolic representation. In bridging the gap, I investigate the boundary between chaos and order, between simple and complex patterns, between reality and appearances.

The modern idea of symmetry, or *invariance* in the laws of Nature, is derived from the ancient Greek idea that underlying all change in the material world, something--an ultimate reality--does not change. A hundred years after Thales, Plato employed simple geometrical symmetries, like translation, rotation and reflection, and the right angle triangle as an analogy for the basic building blocks of the material world. To Plato, the ultimate reality was mathematical. Today the modern mathematical conception of physical reality with its inherent geometric and abstract symmetries is sometimes referred to as being fundamentally "Platonic."

The ancient Greek search for unity has lead in modern times to classical concepts of "atoms and the void" and Relativity Theory, and, in contemporary physics to Quantum Theory and quarks, and a new and deeper respect for the fundamental role of symmetry of the laws of Nature. Astronomer John Barrow sharpens our focus by explaining that Einstein's special insight was to recognize that while our perceptions of Nature may be relative--the same experiment will yield different results for different observers--the laws of Nature are *not* relative. In order for the laws derived from these experiments to be the *same* for "everyone, everywhere, everytime," Einstein required that all physical laws be *invariant* under various geometric symmetry operations, like a translation in space, a translation in time, and a rotation in space. In Barrow's words: "The principles of special relativity are statements of *invariances* in Nature. They are laws about laws."

Regarding his work, Heinz Pagles writes, "Today physicists look for new symmetries . . . knowing that these imply new conservation laws. The idea of *invariance*, which was the ancient [Greek] idea of physical law, has in modern physics become the idea of symmetry, and the task of modern theoretical physics is to uncover the symmetries of the world. Most of the history of modern physics is the discovery of new symmetries."

Recognizing these connections, it became important to figure out the patterns through which the laws of Nature show themselves in principle. It seems that I have constructed ideal geometric structures, similar in symmetry content to Plato's ideal forms, not made of triangles, but, of resonating waves of positive/negative energy, a twentieth century analogy of physical reality. Some symmetry concepts explored are: translation in space, translation in time, rotation in space, reflection in space. Indeed, these same geometrical symmetries are common not only in poetry and music but also, said anthropologist Dorothy Washburn and mathematician Donald Crowe, in the carving, tile, pottery, basketry and textile patterns of widely separated and diverse cultures.

My art is not a picture of reality. Rather, in broad principle, in terms of energy, symmetry and structure, my work is a reflection of some of the deepest symmetries that we call the laws of Nature, like our conservation laws. Like the modern conception of physical reality, the process of creating my patterns can first be described in terms of partial differential equations (two waves of energy interact, like light--electromagnetism). Then, several layers of symmetry later, the work can be described in terms of group theory, mathematical forms I was unfamiliar with, forms that describe physical reality and our own ultimate reality.

The common ground for artists, physicists, mathematicians, philosophers, anthropologists, crystallographers and others is that we are all searching for the same fundamental structure, a structure that somehow explains how Nature works in principle. There is no reason to expect that at the deepest levels of reality there would be any correspondence between views, yet there is no reason why there shouldn't be, at least in broad principle.

For the arts, the sciences and their mathematics, and the humanities, symmetry is the aesthetic bridge that makes visible the invisible architecture of Nature. By calling attention to these concepts of symmetry as an aesthetic bridge between the divided cultures, it is hoped that more of the general public will become aware of the difficult and complex, yet aesthetic, struggle of humanity to understand its origin. This is the struggle to better our lives by creating order from the fundamental chaos of our origin.

Selected Sources:

John D. Barrow, The World Within the World, Oxford University Press, 1990.

Linda Dalrymple Henderson, The Fourth Dimension and Non-Euclidean Geometry in Modern Art, Princeton University Press, 1983.

Karl Gerstner, The Forms of Color, MIT Press, 1986.

Stephen W. Hawkins, A Brief History Of Time, Bantam Books, 1988.

Morris Kline, Mathematics and the Search for Knowledge, Oxford University Press, 1985.

Susanne K. Langer, Problems in Art, Charles Scribner's Sons, New York, 1957.

Lawrence LeShan and Henry Margenau, Einstein's Space and Van Gogh's Sky, Physical Reality and Beyond, MacMillan, New York, 1982.

Heinz R. Pagels, The Cosmic Code, Quantum Physics as the Language of Nature, Bantam Books, 1984.

Charles Van Doren, A History of Knowledge, Bantam Books, 1991.

Dorothy K. Washburn / Donald W. Crowe, Symmetries of Culture, Theory and Practice of Plane Pattern Analysis, University of Washington Press, 1988.

Anthony Zee, Fearful Symmetry, A Search for Beauty in Modern Physics, MacMillan, New York, 1986.

DISPLACEMENT VECTOR DETERMINATION THROUGH USE of FRINGE PATTERNS SYMMETRY PROPERTIES PRODUCED BY HOLOGRAPHIC INTERFEROMETRY

Konstantin Frolov, Nina Cherpakova and Geronti Sakhvadze;
Mechanical Engineering Research Institute of Russian Academy of Sciences, 101830,Moscow, Griboedov Str.,4,Russia

In the field of experimental mechanics the analysis of the fringe patterns symmetry properties produced by holographic interferometry provides to get information on the displacement components vector relation: the component normal to the surface under examination and the component that is in the plane of this surface.

The measurement of the displacement distribution well-known holographic interferometry method is applied [1]. For this purpose two holograms of the rough surfase in its undeformed and deformed states are superimposed on the same photoplate, the interference pattern characterises the displacement initiated between two exposures. In the case of flat surface the image-plane technigues can be used, where surface image is located close to the hologram by means of objective. Application of image-plane holography provides data of displacement vector in discrete points of the surface using technique of the optical filtering [2]. This procedure cousists of scanning of hologram by narrow laser beam and the following analysis of the produced fringe picture.

Real images of small parts of the surface (in board of small viewing aperture) in their primary and moved positions play role of two point sourses displaced in space.

It`s known the interference patterns of two point sourses are presented by the second order curves, and quantative analysis of which is rather difficult. It is possible to show that under condition of small aperture of applied objective these curves may by approximate as sections of circles radius of which is defined by normal component, and displacement of the centre can be calculated by the relation between tangential and normal components.

Consider particular cases where only one component presents in the three-dimensional displacement vector: Tangential displacement U results in well-known type of straingth interference fringes analogous to the classical Young`s fringes. The fringes width (a) defines the value of displacement according the relation : $U = \lambda R/a$, where λ - laser wave length ($\lambda = 0.63$ µm for He-Ne laser) and R - distance between hologram and flat screen. The direction of fringes is perpendicular to the direction of displacement. Example of this picture for given U = 10 µm in horizontal direction is presented at the fig.1. Symmetry of these pictures depends on phase propeties of interference beams (object and reference), defined by the geometry of experimental setup and displacement value.

The component W normal to the surface results in producing of fringe pattern in a view of concentric circles like Newton`s ringes. Radius of such ringes is defined according to expression: $r = R\ 2(1-N\lambda/W)$, where N - absolute number of the fringe. It is more convinient to present N as $N = N_{max} - m$, where N_{max} - maximal order in the centre of picture symmetry. By measuring radius of fringe r_m with the number using the expression: $W = 2R^2m\lambda/r_m^2$, it is possible to calculate value of normal displacement. The example of this picture corresponding to W = 2000 µm is given at fig.2.

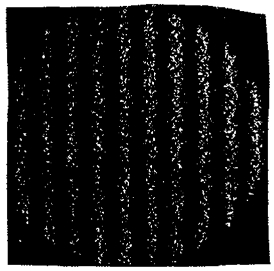
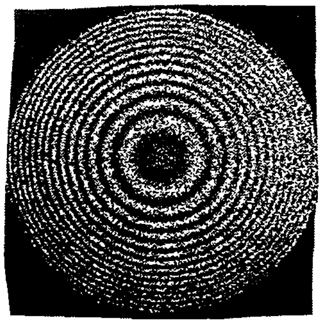


Fig.1 - Interference pattern for in-place displacement

In common case when displacement vector containes both normal and tangential components results in appearing of interference fringes as plots of ellips, parabolas and giperbolas. Under condition r << R, where r - aperture radius of observation field their approximation is possible to present as plots of circles. The centre of these circles doesn`t coincide with the centre of field aperture. As a result the pictures become asymmetric.

The normal component using the previous formula can be defined. Asymetry of measured as a displasement of the circle centre relatively to the centre of observation field is defined by relationship between normal and tangentional components: p = UR/W. In particular cases when tangentional component U equal to zero (U=0), than displacement p = 0 and the picture becomes symmetrical; when normal component w = 0 radius of circles aspires to infinity and fringes look like straight Young`s fringes.

Recieved equations were used for analysis of interference pattern and determination of the displacement vector contained both normal and tangentional components. This pattern for given W = 1500 μm and U = 24 μm is shown at fig.3. The displacement determination error didn`t exceeded 3 %.



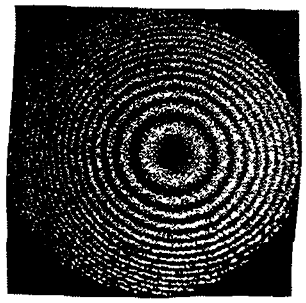


Fig.2.-Interference pattern for normal displacement

Fig.3.- Common case of three-dimensional displacement

From the point of view of the measurement precision the worst case has place when both components have the same order of magnitudes. It results in asymmetrical pictures, centre of which is lokated out of the observation field. Special procedures must be applied for their analysis. Under these conditions the measurement error increases till to 10-15 % .

References

1. Vest C.M.Holographic Interferometry. New York, 1979. 504 p.

2. Boone P.M., De Backer L.C. Determination of Three-ortogonal Components From One Double Exposure Hologram. Optics, 1973, v.37, p.61-81.