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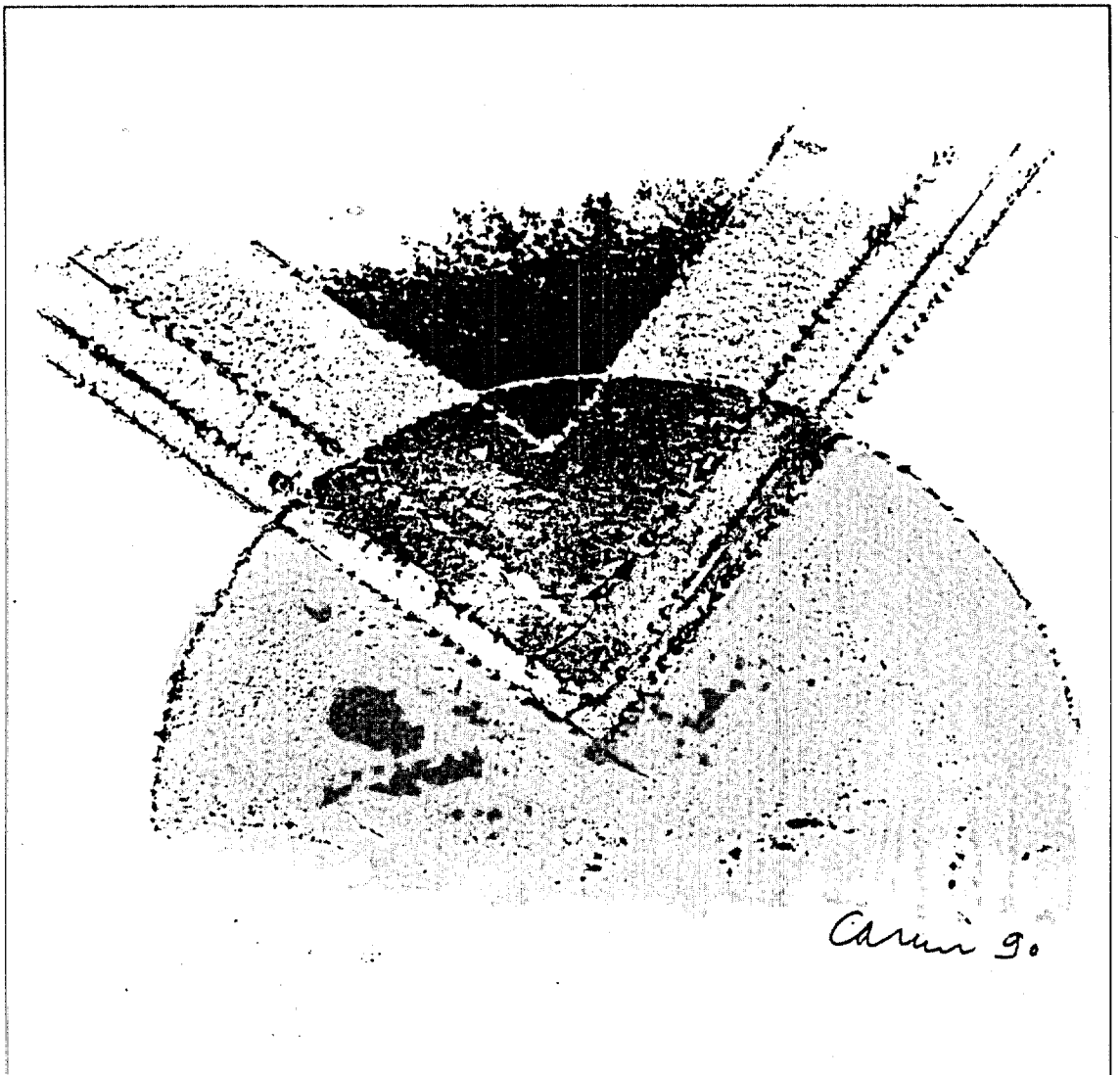

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SYMMETRY ARGUMENTS IN ROMANTIC NATURPHILOSOPHY

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"CONSERVATION": PHILOSOPHY TURNED TO SCIENCE

In 1992, it is 150 years ago that some kind of *Galilean revolution* happened, which founded science in a specific modern sense. This revolution is closely connected with "Romantische Naturphilosophie'' (Romantic Philosophy of Nature = RNP), and is characterized by tendencies of interdisciplinary unification of science that make ample use of symmetry arguments. These argumentative streams are hardly known in a wider scientific public, and if, though, are frequently accompanied by harsh criticism, even condemnation of their philosophical basis. My intention when speaking about this stream here is to correct this view by widening our knowledge about this stream in history of science that to great extent coincides with the history of interdisciplinary study of symmetry.

In that year 1842, the 31st of May, Julius Robert Mayer, a Swabian Medical Doctor, published a paper "Bemerkungen über die Kräfte der unbelebten Natur" ("Observations on Forces in Inanimate Nature") in Friedrich Wöhler's and Justus Liebig's "Annalen der Chemie und Pharmazie" (Fig. 1). This paper commonly is understood as the prior publication that clearly expresses the law of conservation of energy, scientifically valid by giving the first calculation of the thermo-mechanical equivalent. This latter aspect is important, because in fact many papers had been

ANNALEN

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PHARMACIE.

Vereinigte Zeitschrift

des Neuen Journals der Pharmacie für Aerzte, Apotheker und Chemiker. Band LIX.

und des Magazins für Pharmacie und Experimentalkritik. Band LXXVII.

Herausgegeben

von

Friedrich Wöhler und *Justus Liebig*.

Band XLII.

Heidelberg.

Academische Verlagsbuchhandlung von C. F. Winter.

1842.

Figure 1: Title page of Mayer's 1842 paper on energy conservation

Bemerkungen über die Kräfte der unbelebten Natur;

von *J. R. Mayer*.

Der Zweck folgender Zeilen ist, die Beantwortung der Frage zu versuchen, was wir unter „Kräften" zu verstehen haben, und wie sich solche untereinander verhalten. Während mit der Benennung Materie einem Objecte sehr bestimmte Eigenschaften, als die der Schwere, der Raumerfüllung, zugetheilt werden, knüpft sich an die Benennung Kraft vorzugsweise der Begriff des unbekannten, unerforschlichen, hypothetischen. Ein Versuch, den Begriff von Kraft ebenso präcis als den von Materie aufzufassen, und damit nur Objecte wirklicher Forschung zu bezeichnen, dürfte mit den daraus fliefsenden Consequenzen, Freunden klarer hypothesenfreier Naturanschauung nicht unwillkommen seyn.

Kräfte sind Ursachen, mithin findet auf dieselbe volle Anwendung der Grundsatz: *causa aequat effectum*. Hat die Ursache c die Wirkung e, so ist $c = e$; ist e wieder die Ursache einer andern Wirkung f, so ist $e = f$, u. s. f. $c = e = f \ldots = c$. In einer Kette von Ursachen und Wirkungen kann, wie aus der Natur einer Gleichung erhellt, nie ein Glied oder ein Theil eines Gliedes zu Null werden. Diese erste Eigenschaft aller Ursachen nennen wir ihre *Unzerstörlichkeit*.

published before arguing in favor of an overarching theory apt to comprize the different kinds of "force" (as was the common contemporary expression). On the other hand, several publications by professional physicists appeared immediately afterwards expressing Mayer's law more clearly and based on better empirical data, whilst Mayer's kind of argumentation, uncommon even in his times, involved him for decades into a fight for his priority.

Before his 1842 publication a prior paper, dating from 1841 had even been refused by the editor, Poggendorf, because Poggendorf definitely had not been able to understand it. As this manuscript still exists we may control Poggendorf's criticism, and to my eyes, Poggendorf was completely right - I could not understand it, either, though we know now what Mayer really had intended. For a modern physicist, the same criticism would also hold for the 1842 paper: 7 1/2 pages of philosophy, and 1/4 page of calculations! Nevertheless, Mayer was well conscious of the physical meaning. He also was familiar with the state of technology of his time: in his paper he immediately compares his numerical value of the energy equivalent with the degree of effectiveness of usual contemporary steam machines, even renders some ideas for their improvement.

Three years later, in 1845, in a paper titled "Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel" ("Organic Movements Considered with Respect to Metabolism") he generalizes the thermo-*mechanical* principle as to comprize *all* known forces, as mere specifications of one basical: "Truly, there exists only one force" (p.6) and proclaims a conservation law for them all: "In all physical and chemical processes, the given force is a constant magnitude" (p.32, my transl.) He applies this theorem to organic systems (organisms) and even succeeds in deriving some kind of *energetic theory of self-organization*, at least for plants. At the same time, especially Joule made the hard labor apt to *prove* the general idea by measurement and calculation.

In fact, Mayer's idea "lay in the air" in those days. Mayer just comprized a multitude of preceding discoveries and considerations under a general idea. Some of these, like Rumford's experiments on the production of heat by mechanical movement, took place in connection with efforts to control (and expell) obsolete ideas about thermic energy, like phlogiston. Others, like Oersted's discovery of electro-magnetism in 1820, and it's reciprocal counterpart, Faraday's magneto-electric induction from 1836, like Sebeck's thermo-electricity, discovered in 1822, and *it's* reciprocal, the Peltier-Effekt (1837), were already stimulated by the same paradigm of unification of forces and processes in nature that had guided Mayer.

Most of these scientists were deeply influenced by RNP which gave them a philosophical basis, apt to act as a guide to scientific strategies. And I will now show which ideas make this philosophy apt to generate the paradigm of unification, and why it leads to arguments that make use of symmetry.

This holds e.g. for Mayer: He starts his argumentation by referring to the antique principle "causa aequat effectum" (Fig. 1). This general philosophical principle that, vague as it is, at least states some kind of equilibrium or equivalence of correlated qualities in phenomena during natural processes. In *modern,* i.e. quantitative, causal science, this can only mean a *quantitative equality of causally connected magnitudes.* Insofar as certain phenomena, as "causes", are understood as

the reason of new effects, asf., this principle states a transitive relation from causes to effects - a (uni-directional) *processual* transitivity, to which Kant had added, as a philosophical interpretation of Newton's third law, a (bi-directional, *reciprocal*) relation, called "interaction". Their relation lacked scientific elucidation.

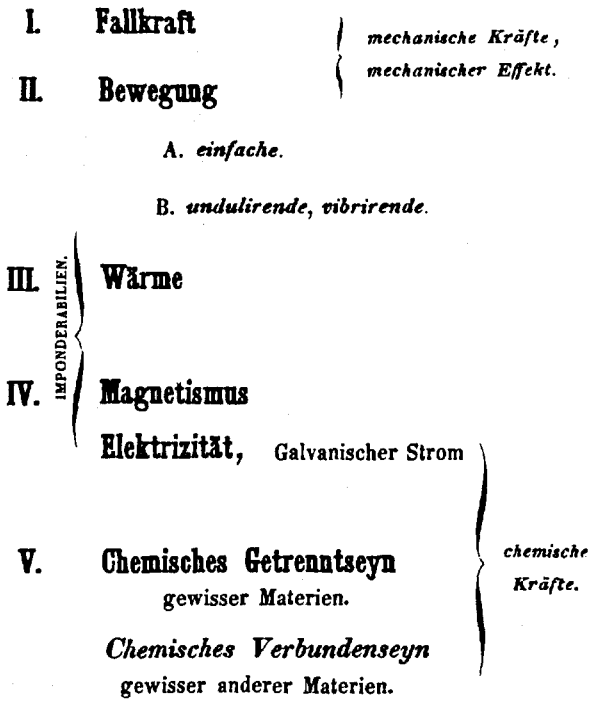

Figure 2: Synopsis of the system of forces (Mayer 1845)

It is also an antique tradition to understand non-material ("imponderous") causes as "forces". After Galileo had changed the qualitative Aristotelian scientific method into a quantitative, experimental one, the question arose by which *magnitude* these forces could be made measurable. Concerning the mechanical forces, two opinions existed in 17th century: - the view of Descartes to identify force as momentum ($m \times v$), and the view of Leibniz to understand it as what we call now energy ($m \times v^2$) (the factor ½ was lacking until Helmholtz added it in his paper on energy conservation from 1847).

Descartes had favored momentum, because in his atomistic philosophy there was only room for kicks of atoms as causes for natural processes, an understanding that resulted the law of conservation of momentum (or impulse). On the other side Leibniz' more dynamical philosophy layed emphasis on force as energy and it's mechanical metamorphoses. Thus he stated the law of conservation of mechanical energy: the sum of "living" and "dead" force ("kinetical" and "potential" energy) being a constant.

Now in 1781, by his "Kritik der reinen Vernunft", the former professor of physics, now professor of methaphysics, Kant, "critically" examined the basic ideas that human beings use when they think or make research in science. He came to the conclusion, that the most basical of them must not be understood as qualities of the world itself, but as structures of our mind, which are constitutive for the construction of cognitive objects at all. These are supposed to act as some kind of a filter, by means of which sensual perceptions are composed to form objects of cognitive thinking. Thus they denote strategies of our mind in getting knowledge about the world - as such, they also act as formal guiding principles of scientific research. Kant calls these constitutive, object-formating mental structures "categories". Kant states four groups of categories, the most important of which for scientific purposes is the group of the "categories of relation", because all modern science aims for relational laws. The first relational category now is "conservation" ("Erhaltung") and it's correlate, "change" ("alteration" or "modification", or whatever translation one may chose for "Wechsel"). It means that all objects of cognition are constructed that way, that they allow the application of cognitive strategies that discriminate conservative from changing qualities and make this a basical scientific task. Conservative qualities are called "substantial", those changing "accidental".

As one might expect, this discrimination itself is an old and venerable one. It plays a fundamental role already for the pre-platonistic Greek philosopher-scientists, and a fortiori for Plato himself, who discriminates his eternal "ideas" from their changing appearances, which quality makes the world of appearing objects a mere tool for the main task of true science: the study of ideas, thus giving the special philosophical dignity to denote truth only to those constant and enduring entities. Kant just gave this old view a modern scientific outfit: the essential task of science is to examine the laws of *conservative magnitudes*! Only these magnitudes inherited the philosophical dignity attributed to ideas on behalf of their eternity. From then on conservational laws became of profound importance in science as dignified by expressing the truth of substances in nature (- for Kant, of course, in his specifically restrictive, "criticistic" understanding: insofar nature comes into our mind at all).

Within the traditional mechanistic scientific tradition, now, those true, unchanging and eternal substances alsways had been identified with atoms, whilst their movements were understood as the reason for changes in nature. Unfortunately however, venerable as this idea might be, it's explanatory power for the problems of "new science" was small through 17th and 18th century, and even through 19th century, up to van't Hoff and LeBel.

On the other hand, the "dynamical" tradition (in Germany connected with authors like Paracelsus, Kepler or Leibniz) could more flexible react on suggestions of other substantial qualities. In particular it was open for scientific ideas that were not essentially based on "matter" in a Cartesian sense, but proposed "immaterial" notions like "forces" as objects of science (Mayer e.g. in 1842 (p.234) simply defines "forces" as "undestroyable (= quantitatively constant), (yet qualitatively) changeable, imponderous (= non-material) objects" - a versatility of imagination, impossible in the atomistic tradition!)

Kant, who is aware of and open to both sides, in his "Metaphysische Anfangsgründe" (1786) discriminates "mechanistic" science, defined by

considering only mechanical collisions between atoms, from "dynamical" natural philosophy that also takes into account the interaction of attractive and repulsive forces. Kant, too, relates these substantial qualities with his two other categories of relation: "causality" and "interaction". Similar to the category of Conservation/Change, these denote basic principles of concept formation for scientific purposes. And both denote basic *symmetries* in natural processes:

"Causality", taken as a category, i. e. as a strategy of cognitive thinking, means, that our mind tries to understand natural processes, insofar as they happen in *temporal serial order*, as depending from each other in a causal manner: preceding phases in processes must be examined whether they "cause" the subsequent by following a natural law. All objects of cognition must be constructed that way, that they allow this empirical examination.

The category of "interaction" supposes objects of cognition happening *simultaneously* as depending from each other, e.g. by the exchange of reciprocal forces. This idea in fact became the cornerstone of symmetry considerations in science. Already in 1687 it had led Newton to discover his Third Law. In 19th ct. the concept of chemical "equilibrium" expressed the symmetrical character of interaction in an even more marked sense: the processual conditions themselves determine which partners act as "cause", which as "effect" in chemical processes - in fact a "symmetrical" extension of the so to speak uni-directional concept of "chemical affinities" being state of affairs at about 1800, the time of RNP. Kant himself already in 1755 ("Allgemeine Naturgeschichte und Theorie des Himmels") had completed Newtons attractive force of gravitation by stating that the assumption only of an attractive force would make the world collapse: A stable universe would be possible only if a repulsive force balances attraction - then merely a formal postulate and far from empirical verification, soon afterwards, however, empirically verified by the discovery e.g. of positive and negative electricity, much later by the various effects of weak and strong interaction, but already in romantic times also by those quasi forces formally established in analytical mechanics (Lagrange, Hamilton asf.). All these scientific ideas are not identical with RNP, but either prepared it or resulted from it as a guideline of research, thus expressing essential qualities of RNP insofar it focused on the aim of unifying causality, conservation, and generalized concepts of symmetry. For some authors, like Mittasch, the law of energy conservation even is nothing more than the scientific concretization of the logical principle of sufficient reason.

RNP - THE PHILOSOPHICAL BASIS

Before exposing the basic ideas of RNP now, we add a final aspect that is usually related to symmetry, namely *beauty*. Usually we state the feeling of beauty as an expression of human insight into the general harmony of nature. For Leibniz, e.g., "the final aim of nature", which God himself had laid into it, is the harmony of all entities. The criterium now of assuming to have really understood His ideas with the harmony of His creation is the ability to comprize the widest range of phenomena under the most simple principles. In this sense we understand "beauty" as not primarily meaning *visual* beauty, but rather a spiritual, especially a mathematical one: The harmony of nature mainly becomes obvious to us by insight

into the mathematical laws of nature. According to Kepler, the divine spirit is a calculating, a mathematical spirit. So that whenever Man thinks mathematically, he may understand himself as participating in the divine - in some respect he even becomes divine himself, as Novalis wrote, one of the romantic philosopher-poets (and originally a mining engineer).

The verbal coincidence of baroque Kepler and Leibniz, and of romantic Novalis is not casual! Historically, in fact, RNP has started with a characteristic relaps into pre-Kantian metaphysical views of the ontological status of cognition (a view against which Kant, as referring to him, immediately protested). As mentioned, Kants "criticistic" approach consists in the idea that our cognitions are but *images* of their respective objects, filtered and shaped by the specific structures of cognitive mind. In particular, the most basic principles of *science* are grounded closely upon the basic (categorical) *mental* structures. So the eternal hope of Man for reliable knowledge of the truth of things through science definitely is a hopeless illusion - an idea an ordinary mind hardly can stand. But also scientists - though the idea is simple enough - usually are unwilling to accept this restriction in the validity of all scientific findings; though verbally speaking of the mere "modelling" method of science, also scientists tend to attribute greater truth to conceptual ideas like "atoms", and "fields", and "quanta", and similar theoretical constructs, than to mere sensual data.

So when Kant was still alive, pretended "followers" and "completers" of his philosophy reintroduced methods of thinking which, they asserted, would render cognitive truth. These pseudo-disciples are commonly known as the philosophers of (German Absolute) "Idealism". The two most renowned, Fichte and Hegel, tried to gain true knowledge about the world merely from the structures of mind itself; that's a rationalistic attempt which we must not care about here.

The less-known Friedrich Wilhelm Josef Schelling (a school friend of Hegel and H÷lderlin, and prematurely a professor of philosophy at Jena at age 23), however, instead considers human mind as a product of *nature* - and he had true knowledge of the scientific situation of his time, quite different from Hegel and Fichte. So, *his* basic question is this: If mind is understood as a product of nature, what then must nature be like, so that it *was determined to generate a human mind of that kind we find empirically*? As a veritable philosopher, however, Schelling immediately generalizes this question: Nature in general comes into our mind not as itself, but it appears to us in the manner of it's products and processes. What then must it's *true* character be like, *so that it appears to us* in that way? Schellings intention, thus, is twofold: aiming for a unified theory of nature, that explains both, the phenomena as appearing products of nature in our mind, and this very mind as a product of nature itself. Schelling thus intends a parallel treatment of Kants human-centered criticistic theory of mind, and of the traditional metaphysical theories of knowledge of true nature. In fact, he aims for a complementary unit of a whole, symmetrical in that respect that it does not matter whether nature or mind have priority. The result might be expected: it is the postulate of an essential identity of mind and nature ("IdentitÄtsphilosophie").

Within this approach the distribution of the tasks between "science" and "philosophy" is clear:

The overarching aim is getting knowledge of true nature. *Natural science* is the empirical basis and definitely has priority, though what it is able to render is not truth, but only knowledge about nature in so far as it falls into our mind: that is Kants critical heritage.
But then, *natural philosophy* has to take command: By "speculative" guessing it has to reconstruct what truly *lies behind* physical appearance of nature: *meta ta physica*, as the philosophical tradition understands this Aristotelian title.

Now, here is what philosophy of nature makes us to guess about true nature (please mention, and keep in mind, that we report only the *formal* side): *If* nature appears in the manner of it's seemingly stable *products* (as "natura naturata"), which throughout result from *processes*, then the true character of nature must be conceived as essentially and continuously *productive* (as "natura naturans") - that's the way we explain the processual character of nature *for us*. If so, however, then the problem arises, how this continuous activity can apparently end up with stable *products*, which we understand by natural laws of stationary character: not activity, movement and change are the real problems for understanding nature, as was the traditional interpretation, but the apparant, seeming *stability* of nature (note: it is the same problem that philosophical theology had with God as an eternal, yet once and suddenly active creator!).

In order to explain an apparent ending of a continuous productivity, nature itself must be constituted by inner contradictions: There must be internal inhibitions in nature, that originally and continuously stop nature's activity, so that it will not vanish without a processual result. The problem for understanding nature is not it's activity and it's change, but the existence of rest, of results, of products. Yet, these products, to their side, must not be thought of as final, so to speak as "dead" products. An assumption like this would contradict the basic and never ending activity in nature. Rather, they must preserve activity, inspite they appear to us as finally ready. The key word for this idea of comprehension is "reproduction": whatever appears to us as a stable product of nature, really is a continuous demolition and self-reproduction of nature that preserves, even *promotes* the original internal activity. Schelling uses an illustrative example: A stream of water flows continuously, identical with itself, unless it is hindered by an obstacle. Then wirls will occur. Wirls are not a stable phenomenon, rather they appear and vanish. Important now is this: they gain their energy from the stream itself, which they hinder when they are generated, but when vanishing again, they give back their energy to the stream, thus again promoting it's flow. - O.k., o.k., that's only an analogy, and the whole argument sounds rather esoteric. So back to science, which it inspired!

ROMANTIC SCIENCE: THE ROLE OF "SPECULATION"

The general philosophical image of the productive activity in nature, and the reproductive character of it's products must be specialized by three aspects which are apt to turn natural philosophy into science:

(1) We speak about products because we may identify them by their qualities. Pure activity has no qualities, but only the products have. Qualities are

something special. To identify them, experience, empirical investigation and logical definition are necessary.

For Kant again this happens by making use of specific "qualifying" strategies of our mind, defined as the three "categories of quality": "attribuition", "negation", and their synthesis: "limitation". That means: The three categories of quality define the strategy of mind to qualify objects of cognition by attributing them certain qualities and negate the opposite, and, as the scientific synthesis of these, to characterize precisely in what *degree* the respective qualities and their opposite have to determine each other mutually, in order to render a correct description of the respective object (e.g., an object is never absolutely "white" or "black", never absolutely "hot" or "cold", but always something inbetween that can be measured). In Aristotelian logic this method of limitation was called "dialectics". This dialectic task in modern science has been sharpened by quantification and measurement. For Schelling, however, this dialectic quality of our mind is a correct expression of the true "dialectics in nature" (an expression of Engels, later in Marxism coarsened to the idea of a "fight of dialectic opposites" in both, nature and society). So for Schelling the limitation of qualities of objects in our cognition expresses the real mutual limitation of *polarities* in nature.

(2) If we understand objects as products, as effects of natural activity, we must understand them as effected by forces. Forces are the grounds, the reasons for specifically effected objects. The term "reason" again expresses this double-sided character of Naturphilosophie: that there is something in nature that effects objects which *we think about as* forces. Forces must not be understood as arbitrary qualities simply added to matter, which to it's side is given and exists autonomously. Rather forces *constitute* matter, the first as the ground, the latter as the result. Insofar forces are prior to matter. Forces, thus, are our expression of how nature effects products. They express both, the generative power ("Energeia") and the produced result ("Ergon").

(3) Within this concept of productive nature, organic life no longer remains an inexplainable mysterium, as even Kant had stated in his "Critique of Judgement" (in the famous §90). On the contrary, living organisms come closer to real nature and express it's true character better, because in a much greater extent than inorganic matter they give evidence of the reproductive power in nature, because they appear as material objects as well as spontaneously active entities.

In fact, it is this very *problem* of organic nature - namely it's "organismic", holistic character: that it cannot be split into single parameters - that gives authentic notion of the holistic organic character of nature itself: nature as a whole must be understood as an overwhelming universal organism. From this view results the continuous incentive admonition that has become urgent again in our days: that the manner how to pursue empirical science has to take into account this true philosophical task of science. Not must it act only in an analytical, parametrizing, subdividing, isolating manner, as usual in science, but, justifyable and inevitable as also this method might be as a instrument, it must finally be guided by the holistic

concept of nature, has to be respectful, patient, even open for some kind of nature's sanctity. It must not only live with measurements and magnitudes, but has to widen their understanding towards unities of perception, of holistic forms ("Gestalten"), of ideas in the sense of *ideals*. Active synthesis must be part already of the receptive empirical process of investigation (especially Goethe, in his "Farbenlehre" ("On Color", 1805) by opposing Newton's "Optiks", had tried to give a vivid, yet misunderstood, example of that method).

These in fact, I confess, are strange ideas. And similarly strange were many of the consequences, which Schellings students and friends have derived from them. For decades the term "Naturphilosophie" became an invective, causing scientific exitus among "serious" scientists as also in the public. Helmholtz opposed the "dogmative and speculative" character of this philosophy. Humboldt (Wilhelm von!) when writing to Schiller for help to find a teacher for his children, wishes that this person should have studied classical language or physics, but exclaims: "you certainly will not send me a natural philosopher!" Schopenhauers criticism boasts terms like "nonsense", "impertinent claptrap", "unabashed swindling". Poggendorf, as we mentioned already, refused Mayers first version of his energy paper, but Mayer himself distanced himself from mere speculation and the "miserable twaddling" of natural philosophy, that pretends to reconstruct the world by mere speculation instead of empirical data - the term "speculation" in fact seems to be discredited for all future, at least in the German language.

So we may in part understand the disregard of Naturphilosophie as addressing exactly those meagre and insufficient philosophers and their boasting, merely speculative towers of ideas, who uncritically exhibited their ideas and celebrated themselves in the public - so e.g. was the reaction of Goethe, himself being an inaugurator of RNP ideas and a promotor of young Schelling, later a hard critic of him and of the noisy activities ("lautes Treiben") of his disciples.

In part, however, and more important for our purpose, we must understand the general criticism of speculation in RNP as a complete misunderstanding of the true, well grounded and serious intentions of RNP and of it's methodological correlate - misunderstanding even the scientific method at all. Criticism of RNP mainly came, and still comes, from the side of a strictly empiristic understanding of science. Science, these empiricists claim, must be based on empirical, in the last instance: sensual data, and *nothing else*. Any speculation then would mean the end of true science, because it would add something to the data that does not stem from experience. But a closer look will inform us of the important and inevitable role of speculation in science, if we understand science as coping for general laws by experiment and induction. Speculation then must be understood as the productive part of guessing at these general laws - motivated and induced, indeed, by experience, but autonomously imaginative. General laws cannot be derived from data, which are always single and finite, but have to render a theoretical surplus of generalization and systematization, which can be gained from various, not necessarily "scientifc" sources, e.g. from pre-theories, phantasies, fashion, cultural change, or whatever. In this respect, inductive guessing and "speculation" are the same. The scientific task then is "to keep strict empiricism and precise speculation in a continuous balance", as Johann Wilhelm Ritter wrote (a disciple, yet rival of Schelling at Jena, and the founder of electrochemistry).

An overarching philosophy, that comprizes venerable philosophical traditions with a holistic feeling for nature, then might be the most serious guide into science in times when new developments and findings in science call for basical reform and reformulation of paradigms. Thus, for some authors RNP is the "heroic attempt to try a daring and energetic synthesis of the epoch-making discoveries of great scientists" - less boasting we may say: in times of radical changes in science, it was some kind of brain-storming on a philosophical basis, which sometimes fell into errors and mistakes, as usual, but in it's best authors created no less than the basic formal ideas of modern science. In fact RNP was such a philosophy adequate to solve the scientific problems of it's time. But what makes us speak about it here: it became applicable for science essentially by the development of comprehensive interdisciplinary concepts of symmetry.

ROMANTIC SCIENCE: SYMMETRY IN NATURE

Let us first complete our considerations on energy conservation by connecting them with symmetry: Mayer worked under the guideline of these strange romantic ideas. But he was one of those scientists who made them a fruitfull scientific paradigm because he felt he was to leave the old one as basically insufficient. He faces the challenge to explain forces - those many new kinds of forces which his time had learned to know - as autonomous magnitudes instead as mere qualities of a given matter. By making forces conservational entities he combines the systematic interrelation of forces, as a postulate of RNP, with the traditional "substantial" dignity of categorial "conservation". In accordance with RNP he understands forces as the "true" causes of natural processes, but bases this speculation on scientific methods: on measurement and quantitative comparison of these magnitudes. Thus, though an applicant of RNP, proves to be a critical scientist, in striking contrast to some of his followers even 50 years later (e.g. W. Ostwald), who declared "energetism" a universal explanatory principle, uncritically including mental and social phenomena (ironically these authors based their ideas on "progressive" atheistic, mechanistic, "critical" traditions - a wide-spread phenomenon in our days as well!).

This ideology of energetism certainly was not the fruitfull application of Mayers ideas. Their truly universal power instead became obvious not earlier than when they were extended to cover also the other conservational laws, and when these were connected with symmetry principles: Emmy Noether's theorem (1918) states the equivalence of each conservational law with a corresponding symmetry (invariant structure) in scientific description of nature. As is well known, this theorem became the cornerstone of modern physics. To conclude: By Romantic attempts of unification of forces which finally established Noether's theorem, *symmetries, as correlates of conservational magnitudes, became "substantial" entities*, participating in their status of basic principles in science, possessing the same structural importance and philosophical dignity, as Platonic ideas have in metaphysics.

The idea of RNP, that different forces are but different manifestations of the one generative power of nature, the idea of symmetrical interchangeability of forces, made the search for missing phenomena apt to prove these equivalences a favorite

sport of RNP-guided scientists. For the "new" forces electricity and magnetism young Schelling himself had postulated a symmetrical relation, which, by the research of Oersted (1820) and Faraday (1836) directly lead to modern field concepts. This paradigm rapidly had taken command: Not earlier than in 1799, Ritter had demonstrated electricity as an anorganic force ("Beweis, daß der Galvanismus auch in der anorganischen Natur zugegen sei" = "Proof that Galvanism Exists also in Inorganic Nature"), only one year after his "Proof that the Life Process in Animals is Accompanyed by a Continuous Galvanism", - imagine the unifying power of only these two symmetrically correlated ideas (the more under the auspices of contemporary confusion of the problem by fashionable "Mesmerism")!

Oersted - a disciple and friend of Ritter's - turned these ideas into experiments. His considerations on symmetries in electric circuits might seem rather simple, when taken as mere descriptions of observations: In his paper from 1820 "Experimenta circa effectum conflictus electrici in acum magneticam" (the term "conflictus electrici" simply denotes what we today call the "magnetic field" of an electric current), he correctly observes (and "symmetrically" explains) that "all non-magnetic bodies seem to be penetrable for the electric conflict, the magnetical bodies, however, or their magnetic particles, seem to resist transition of conflict. That's why they move by means of pushes originating from the fighting forces. Our observations show, that the conflict moves in circles; for without this suggestion one could not understand why the same part of the wire, set *below* the magnetic needle, forces it into eastern direction, but to the west if placed *above* the needle: for a circular movement has opposite direction on opposite sides of a diameter." (Shortly after this experiment bussoles where constructed apt to demonstrate the whole circle, and the new problem of all electro- magnetical machines now was the "conflict" between a *polar* force and a *circular* movement - again a *symmetry* problem, as is also the not yet sufficiently solved transformation of *polar* electricity into *linear* movement.)

In combining this circular component with the *linear shift* of charge in electric currents Oersted originally comes to the wrong conclusion of a helical structure of the electro-magnetical field, an error that soon afterwards - hundreds of interested people of course immediately repeated Oersted's experiments! - was corrected by Ampère's laws. Oersted's helical error, however, did not happen by chance. Rather it was generated by his deep attachment to RNP. In his collected philosophical writings, published under the characteristic title "Über den Geist in der Natur" ("On Spirit in Nature"), he continuously speaks about "the whole being a reign of reason", about the "spiritual in the material": "Nature by no means is just something corporal, but is penetrated and governed by spirit, as we understand by nature's unlimited laws." "Nature is governed by eternal reason," it's "natural laws generate from divine reason itself" - the secular autonomy of nature in RNP here by Oersted is re-placed into divine reason in the same manner as e.g. Kepler had postulated at the begin of modern science.

Moreover, Oersted finds his insight into the divine on basis of that specific unity of cognition and beauty that is typical for symmetry. In a "Conversation on Symmetry" ("Gespräch über Symmetrie"), hidden in the rare volume 5 of "Spirit in Nature", he recommends to "treat the beautiful as a part of natural science" (141). He understands this in an educational sense: As usual, instruction should not begin

begin with the highest ideas, but with elementary subjects; symmetry is the elementary esthetical phenomenon (146). Oersted looks on symmetry both from a psychological and scientific standpoint: The same "mathematical" symmetry may be perceived psychologically different, depending from the relative situation, e.g. the axis orientation of mirror symmetry: gravity is perceived as directed downwards, light appears as coming from upside: the mathematically identical causes different affection (148). Now symmetry is both, law of reason *and* law of nature, since in the core both are the same (149), and the law of polar opposites would lead to symmetrical entities, if only all forces could act "purely" (149): "Symmetry is the basic shape of harmony" (150). Yet, symmetry is only a basic scheme, it cannot express the full wealth of natural beauty; if isolated, it may even seem boring. Symmetry gains it's full beauty only by means of a rich semantics (150ff). Then, however, it may express also "higher" beauty, as the "vivid", or the "serene" (152ff).

Intellectual insight can be stimulated by stimulation of the sense of beauty: the true reasons of phenomena are not yet known. But laws lying behind may be suggested - no, they are *known* to exist (159). So we must postulate an esthetic character of nature (165). This postulate, however, also demonstrates our human finiteness, for not all natural phenomena appear to us as beautiful. The reason for this is that we are capable only of the simplest facts in nature. Yet: "Unity will render us survey" (161), and by continuous scientific efforts nature *becomes* beautiful through "getting *sense* by being understood as a unit of a whole" (162).

ROMANTIC SCIENCE: ON HELICAL TENDENCIES IN NATURE

For Carl Gustav Carus - a medical doctor, too, but also an important romantic painter - in his "Natur und Idee" ("Nature and Idea", 1861), in fact comprehensive considerations on the whole "Reigndom of Nature" ("Naturreich"), the "typus of the helix" figures as "the most characteristic of all cosmic movements", for it combines circular and translatory components. He applies this "concept of the helix" to the movement of planets and star systems (as Kant had already done in 1755), to geological and meteorological processes, to crystals, and in the greatest extent to *plants,* because "only plants represent pure formation, i.e. essential, pure generation of organisms". For Carus (as also for Goethe, to whom I owe the title of this chapter, as an extension of his empirical paper on plants: "Über die Spiral-Tendenz der Vegetation", 1831) the manifold plurality of plants may be comprized under the universal scheme of the "Urpflanze" ("original plant", Fig. 3). Goethe, in his "Die Metamorphose der Pflanzen" (1790(!)), had conceived this idea as a generalized scheme of empirical findings, that to great extent already prepared an *evolutionary* explanation of plant organization. By his much more formalized scheme Carus, in accordance with RNP and beyond simple scienctific function, mainly intended to express the internal dynamics of plant growth at all: Generating from an "original cell" in a central "knot", as the bearer of vivid force, and with each cell comprizing the "Ur-polarity" of vertical formation (a kind of "pre-fractal" view!), plants grow, unfold and diversificate determined by their tendency down to the *ground* and towards *light*, as the sources of nutrition and of energy, resp. Both, however, also have an inherent symbolic meaning: turning to the ground means turning to the roots, to the source of life (also to "darkness", as life's "night-side"),

to it's basic driving forces; turning to the light symbolizes the will of all life to set itself free - free for light, for the self, for ideals (in that order!!).

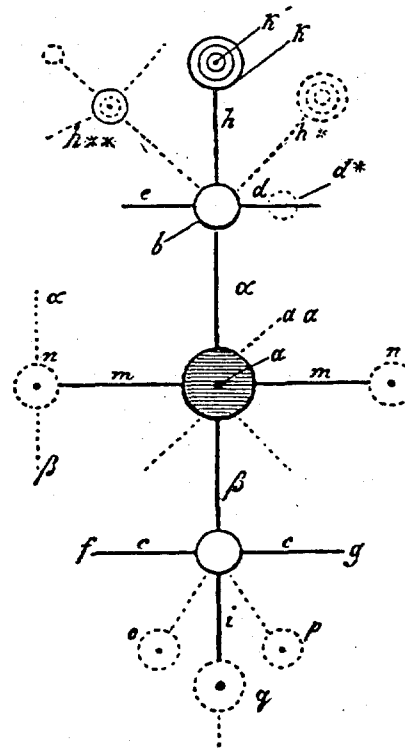

Figure 3: The "Urpflanze" according to Carus

Now, as Schelling had taught, these tendencies are restrained and inhibited, they are unable to unfold straightforward. They are, so to say, compressed, and this restriction results a *helical movement*, as in fact meteorology, crystallography and especially the morphology of plants give evidence of. Thus, for Carus helical movement is the typical movement in (empirical) organic nature, and in a more hidden sense also in those inorganic phenomena that come close to organic growth, especially in crystals. Carus' argument also gives evidence of the "dynamical" meaning of the term "morphology": it is not only a description of the forms of natural objects, as the literal translation would indicate, but it strives for causal explanation of these forms through insight into the inner principles of nature, which become empirically manifest by forces that determine those forms.

Meanwhile, as we all know, we in fact have found helices as the typical structure of products of organic or quasi-organic movement: from the generation of galaxies to organic molecules and organisms. Helices in fact have become the very paradigm of those processes of "self-organization" to whom we attribute a kind of "evolutionary" development. Sometimes a causal explanation is quite simple, as for

the logarithmic helices that figure as solutions of the differential equations of growth processes; sometimes we still are in search for causal explanation. The symbolic meaning, however, has been totally excluded from these scientific explanations: the aim for our roots, the claim for ideals have been excluded from science - thus we are without basis as also without targets for our life - though their "causal" reformulation by an adequate scientific anthropology could be as simple as helpfull in our time - we need not turn to esotericism in order to regain sense and holism for nature!

ROMANTIC SCIENCE: CRYSTALLOGRAPHY

TRAITÉ

DE

MINÉRALOGIE,

PAR M. L'ABBÉ HAÜY,

Chanoine honoraire de l'Église métropolitaine de Paris, Membre de la Légion-d'Honneur, Chevalier de l'Ordre de Saint-Michel de Bavière, de l'Académie royale des Sciences, Professeur de Minéralogie au Jardin du Roi et à la Faculté des Sciences de l'Université royale, de la Société royale de Londres, de l'Académie impériale des Sciences de Saint-Pétersbourg, des Académies royales des Sciences de Berlin, de Stockholm, de Lisbonne et de Munich; de la Société Géologique de Londres, de l'Université impériale de Wilna, de la Société Helvétienne des Scrutateurs de la Nature, et de celle de Berlin; des Sociétés Minéralogiques de Dresde et d'Iena, de la Société Batave des Sciences de Harlem, de la Société Italienne des Sciences, de la Société Philomatique et de la Société d'Histoire naturelle de Paris, etc.

SECONDE ÉDITION,

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TOME PREMIER.

PARIS,

BACHELIER, LIBRAIRE, SUCCESSEUR DE Mme Ve COURCIER, QUAI DES AUGUSTINS.

1822.

A n h a n g.

Dynamische Ansicht der Krystallisation

von

Christian Samuel Weiſs,

d. W. W. D.

Es soll die Form, die Figur, dynamisch erklärt werden. Der Atomistiker kennt die Frage nach dem Grunde der Form, fühlt das Bedürfniſs einer Erklärung aller Form gar nicht. Ihm ist die bestimmte Form mit der Existenz der Atome unmittelbar gegeben. Der Dynamiker läugnet ihm diese; er läugnet ihm sogar die *absolute*, unbedingte Existenz der Materie q); er lehrt ihre individuelle Existenz als gegeben bloſs in der Erschei-

q) Jede Materie existirt nur in Beziehung auf andere, als Glied einer allgemeinen Wechselwirkung. Die in stetigem, aber durch immer neue Modificationen fortschreitendem Conflicte wirkenden allgemeinen Naturkräfte geben, auf jedem Schritte, zum Produkte die bestimmte Materie; und so wie diese bestimmte Materie in ihrem innersten Wesen nichts als das Produkt dieses Conflictes ist, so ist auch ihre Existenz nur die Existenz des Augenblicks. *W.*

Figure 4: Title of Haüy's book on crystallography, and Weiß' annex

More directly, we may even say: immediately in those times, the morphological, dynamical view of RNP took command in crystallography. In fact it nearly completely expelled the former "structural" yet only formal atomistic approach to crystals for a century. At the end of this (19th) century, atomistic theories had nearly generally been substituted by field concepts of matter (at least in physics, where atoms counted as "reactionary", whilst the atomistic "balance" survived in chemistry, until their synthesis in 20th ct.).

The change of paradigm is exactly datable and bound to the name of one man, Christian Samuel Weiβ. In 1804, aged just 24, Weiβ was selfconfident - or cheeky - enough to publish his dynamical ideas as an annex of his own translation of the representative text book on atomistic crystallography, René Just Haüy's "Traité de minéralogie" (Fig. 4). The attack of Weiβ came not by chance or without good reasons, for in fact, atomism in those days was lacking true explanatory power exactly in those fields which it declamatory covered, namely explanation of the structures of crystals and, soon afterwards with Dalton, of molecules. Of course -

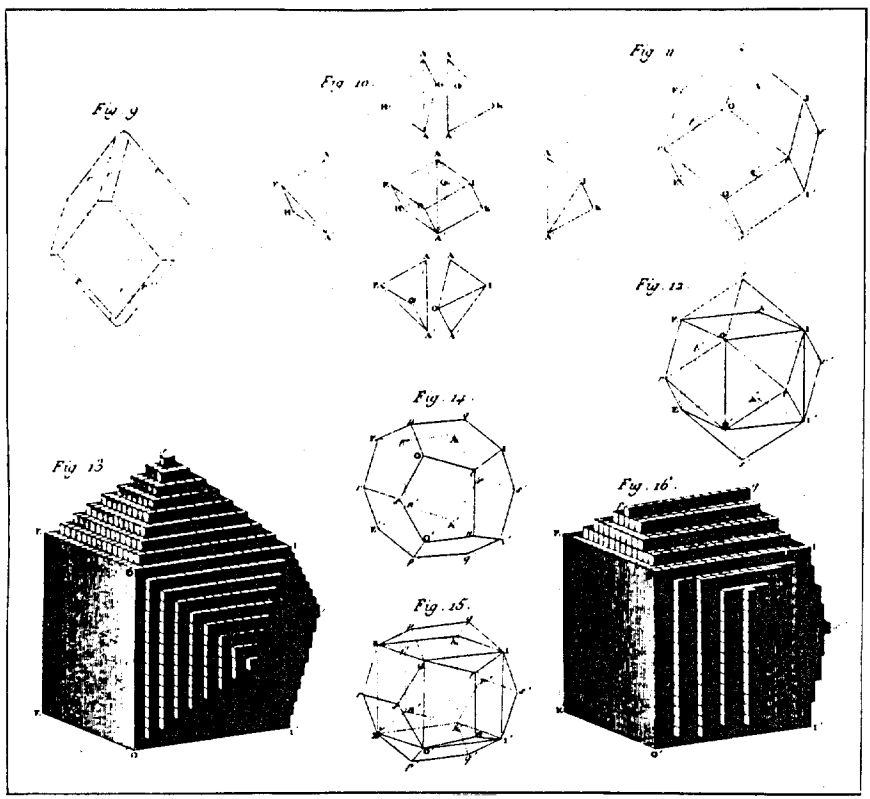

Figure 5: Haüy's explanation of "decrescenees" of crystals

otherwise Haüy would not have published it - the atomistic approach was able to "explain" the forms of crystals and the general law that ruled them: the law of constant angles (quantitatively verified 1785 by Romé de l'Isle, after Stensen's discovery in 1669) by his famous law of "decrescence" (Fig. 5) - a standard illustration since in all text books on solid state physics. Yet this was a mere descriptive explanation, it failed, as Haüy confessed, in answering the question for the dynamical reasons which determine this law. Of course, Weiβ could not directly answer these questions either, but his new paradigm induced a radiating set of sub-problems which gradually rendered the solution that turned out as the modern synthesis of atomism and dynamism, namely as a "field" concept of the atom. Weiβ' arguments where throughout based on symmetry which were motivated by the RNP view of natural dynamics.

As a disciple of Abraham Werner, of the montan-academies of Freiberg and Berlin, Weiβ was a well-trained mineralogist and was clearly concious also of the practical requirements of mineralogy. He first developed a system of crystal classification in a descriptive sense by indexing the cut-offs of crystal planes in a suitable coordinate system. Slightly changed by Miller in the 1830th ("Miller indices"), this scheme is valid up to today (Fig. 6). These indices, at first glance simply phenomenological, avoid Haüy's premature arbitrariness of ad hoc postulated specific building blocks.

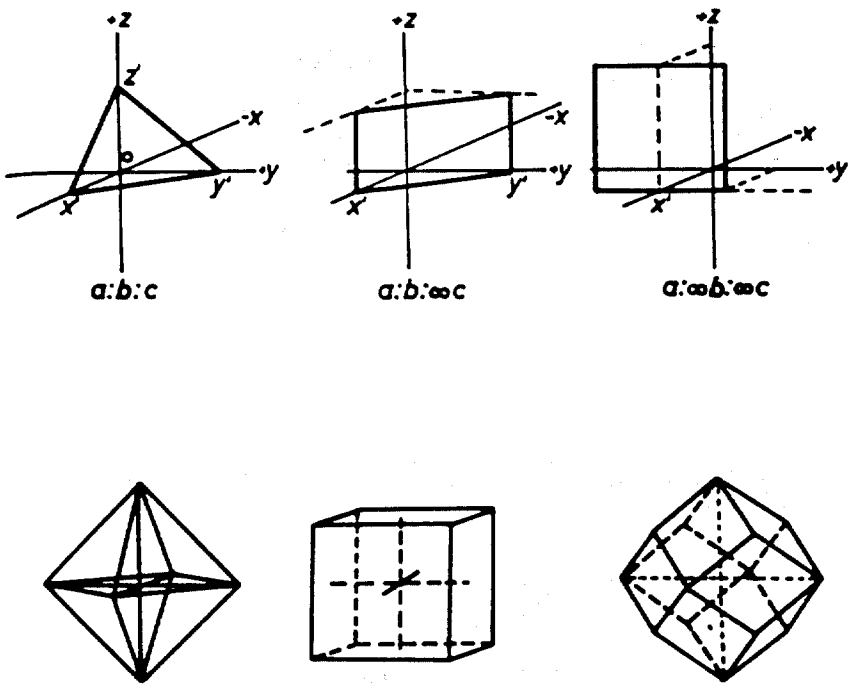

Figure 6: Rational indexication of crystal planes (Weiβ/Miller)

As triples of rational numbers ("law of rational plane indices") they also express the regularities of crystals much more systematical and versatile for a classifying application than the angles did: they proved to be of universal validity not only for crystal species and systems, but also for the systematic relationships betwen them (with the remaining problem of isomorphy, however, that turned out as genuine atomistic). This system of morphological indexication incented the derivation of the system of point groups by Schoenflies and Fedorow, a derivation, originally - and very characteristic! - done without any reference to atomistic interpretations of the lattice points, and also - even more surprising - without any use of the long known group theory! This certainly can only be understood by the profound influence of the morphological view, but was it a detour, then, as one might judge from a modern standpoint?

This is not the case, if we regard Weiβ' second approach to crystal structures, his "Zone Law". Empirically, the forms of crystals are determined by pairs of parallel crystal planes, arranged in families parallel to a common axis, called "zones", and these again are combined in a system of zone axes, which now really express the complete system of crystal morphological relationships, the "Hemiedrie", geometrically verified by truncations of basic polyhedra, as the visual shape of the dynamical inner symmetries of a crystal (Fig. 7). To explain them, Weiβ again turns to symmetry arguments on the basis of RNP. The argument is already that of Mayers:

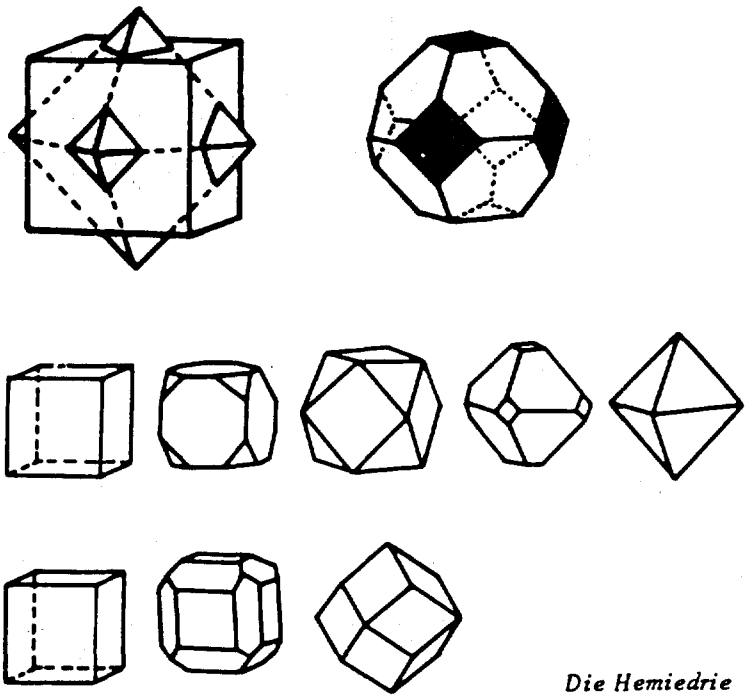

Figure 7: The "Hemiedrie", according to Weiβ

Basical assumption is not: Here is matter (e.g. atoms), and added to them forces (that would be mechanism); but: Forces constitute matter and it's structures: dynamism.

Like Kant, like Schelling, Weiβ formally introduces two kinds of forces to explain the morphological regularities, one called "chemical attraction", defined as an attractive force that tends to unify different matter; the other, opposite, called "repulsion", tending to split or solve homogenous matter. Crystallisation should always happen if repulsion is inhibited, so that splitting does not occur completely. That it stops halfway, yet specifically between specific partners, makes that specific crystals can be identified by their specific angles (or indices, or zones).

It must be admitted: This does not look like an explanation in a sense we are used to. In fact: Weiβ, as Haüy, could not identify the interacting forces and their interaction with matter, thus also could not give a really dynamical explanation of the specific crystal shapes - that was possible not earlier than 120 years later!

But what really he did, was of twofold future importance: He emphasized detailed study of the relations between global outer shape and inner symmetries, some kind of dynamics of the Hemiedrie, that prepared the modern "structural" view of crystals.

And he inaugurated the "dynamical" understanding of atoms as centers of oriented forces, thus preparing contemporary concepts about the self-constitution of atomistic matter by the interaction of forces, and the explanation of their chemical interactions by the symmetries of their fields.

SUMMARY

RNP surprises us with strange ideas about productive nature and about spirit as it's self-fulfilling destiny. They seem far from modern scientific ideas, and so are the so-called scientific ideas that philosopher-scientists of early 19th century derived from them. Thus RNP became ill-famed since. Surprising enough, however, just in those days many basically new and fruitful scientific ideas and devolopments could be gained, which in history of science then frequently where understood as having happened by chance, *in spite* of their silly basis. I have tried to demonstrate an opposite view:

(1) The development of new ideas was necessary. By the end of 18th ct., the unity of science as based on mechanism, sufficient perhaps for early 18th ct., had broken and proven as obsolete. Many auxiliary ideas introduced to support and "save" mechanistic science, like phlogiston, organic preformation theory, of human mind as a "machine", asf., had proven false or dysfunctional. On the other hand new phenomena and ideas, like galvanism, oxydation, chemical physiology and early evolution theory - not to speak of the simultaneous neo-humanistic attempts for a scientific, yet non-reductionistic understanding of human mind - could not be incorporated into that old mechanistic paradigm. In general: the "analytical" approach in science that splits holistic phenomena into isolated parameters seemed to lack explanatory power. A completely new

approach was necessary, esp. for the science of organisms. This new approach, as usual, focused exactly on those problems the old paradigm could not answer, and perhaps over-emphasized them.

(2) It conveived an idea of nature as a continuously productive entity that constitutes itself by it's activity and becomes conscious of itself in human mind: Laws of nature and structures of mind coincide. Nature's spontaneously active and holistic character makes us to understand it as a universal organism. Mechanistic explanations were replaced by "dynamical" ones, apt to explain the self-constitution of matter and the structures of the world by inherent forces. Symmetries, that comprize mathematical structures with visual or intellectual experience of beauty, became mighty tools of scientific explanation in wide fields of science. As the unity of conservational laws and descriptive symmetries they inherited the essential dignity of former platonistic ideas.

(The impact of RNP-contextual symmetries on Man, his culture and development, constitutive for both due to their metaphysical identity, but left out of consideration here, will be treated in a subsequent paper.)

Thus, for some authors RNP is the "heroic attempt to try a daring and energetic synthesis of the epoch-making discoveries of great scientists" - less boasting, one might say: RNP was a kind of brain-storming that turned out to become a complete philosophy, causing errors and ideologies, as usual, but by it's best protagonists also creating empirical findings and "classical" ideas that later became corner-stones of contemporary science. The comprehensive study of nature and of mind, of mathematical and natural laws tied together as expressing both, "laws of nature" and "laws of mind", focused on symmetry arguments in a manner that made symmetry - and it's correlate: self-organisation - the overarching ordering parameters in science today.

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