Three Problems of the Theoretical Physics as Seen by a Geographer. An Essay.

Supplement 1 to the treatise „Processes Constitute Our Complex Reality" (2005)

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1. The background:

"Today, the entire science of Physics rests on two pillars, the theory of relativity and quantum physics" (WIKIPEDIA "Physik" 10.10.2006, p.3). To an outside observer, it is not easy to understand that these theories, which were first presented in the first quarter of the last century and which have been much discussed and repeatedly verified since then, have not yet been reconciled in such a way as to produce a logically satisfying unified system of thought. The explanation may well lie in a methodical problem.

That is the reason for this contribution to the discussion of these central theories; the author is a non-physicist, whose sphere of endeavour is the mesocosmos, i.e. the world as we experience it day by day.

During a private conversation at a symposium in Göttingen in 1986 I asked an astronomer "What task do galaxies fulfil in the universe?" The reply I received was "That's not the way we ask". During the conversation that followed, it became clear that we are pursuing different aims in our work, and that the methodical approaches we use are also different. The astronomer examines the actual state of objects, describes it in models by mathematical means and analyses causes and their chains of effect. The quantum physicist proceeds in a similar way. He is also interested mainly in the existing state of the objects under examination and how they came to be that way. The fact that in the atomic and sub-atomic spheres, matter appears in quantised form, presents a particular challenge.

The term "task" as used by me, belongs in a different field. It indicates a) a process to be carried out and states b) the nature of this process. Thus, an object, as an element, has a task in a system and thereby fulfils the conditions for its participation in the processes maintaining and/or altering the structure of the system. We are therefore mainly concerned with interrelationships of process and function.

This problem was a focal point of research in the first half of the 20th century, initiated in the field of ecology (L.BERTALANFFY, W.BEIER und R.LAUE 1952/77, p. V f.; G.LEPS 2000/04, p.613 f.) and was adopted and developed not only by the natural sciences, but also by the social and economic sciences (J.W.FORRESTER 1968/72; N.LUHMANN 1984). Cybernetics (N.WIENER 1948/68) and information theory (C.E.SHANNON 1949/76) created practicable methods. From the point of view of physical chemistry, the "physics of being" changed into the "physics of becoming" (I.PRIGOGINE 1979, p.115 f.). However, it appears that this way of looking at things met with no real interest in theoretical physics outside the mesocosmos, i.e. in cosmology and

the quantum physics - perhaps because the observations and theoretical deductions could be described impressively by mathematical means at that time.

From today's point of view, it is plain that the system theory opens up new fundamental prospects. It gave rise at a later date to chaos research and complexity research. The Process Theory also belongs to this tradition
http://scidok.sulb.uni-saarland.de/volltexte/2005/482/
(quoted below using the abbreviation "Proc.")[1)] . It considers the systems not only in their complexity, but also their development. The processes (i.e. the flows of information and energy/material) structuring and shaping them form the focus of attention and their own momentum analysed. The systems supporting them are identified and the participating elements defined with regard to their specific meaning. Human society is the preferred object of study, but reference is also made to other areas of being, e.g. inorganic nature. The question arises as to whether the process theory might be of assistance in solving the problem of unification.

The following essay should be treated within this context. As examples, it refers to three questions from the spheres of quantum physics and the theory of relativity. These are "wave-particle dualism", "relativity" and "gravitation". Observations from the mesocosmos will be used for purposes of comparison.

2. Wave-particle dualism:

2.1 The question:

In his famous "double-slit experiment" Th. Young (1801) succeeded in demonstrating interference phenomena, thereby finally proving that light is made up of waves. Chr. Huygens had already developed arguments for this thesis in the 17th century (SIMONYI 2004, p. 276 f.). On the other hand, further results showed that light is made up of photons. This had already been demonstrated by Newton. Similarly contradictory results are produced when other particles (e.g. electrons, atoms, molecules) are used under suitable experimental conditions. This "wave-particle dualism" contradicts the general experience of classical physics. Is the quantum sphere therefore of a different nature than that of the mesocosmos, i.e. the sphere of our day-to-day experience?

Or perhaps it is not: In some of the experiments demonstrating the wave-like character it was observed that if the intensity of radiation is strongly reduced, the existence of individual particles becomes apparent. The question remained unresolved as long as the objects of study (photons, electrons etc.) were treated in isolation i.e. without taking account of their contacts with their surroundings. This remained the case until the 1970s, when the theory of decoherence (associated particularly with the name of H.D.ZEH; e.g. 1996) explained that particles are increasingly integrated into overriding chains of effect the larger they become. On the other hand, the coherence between particles of the same kind is loosened, with the result that the wave-like character shown by interference ability is lost. Outside the quantum sphere e.g. using marbles or stones, the wave character is not apparent (e.g. STRUNZ,W.T., G.ALBER and F. HAAKE 2002).

2.2. Observations in the mesocosmos 1: Systems and elements:

Continuing this line of thought, it may now be asked in what way the objects of the quantum sphere are integrated in the surroundings. Perhaps a number of observations may help here which were made in the mesocosmos in the course of the development of the Process Theory mentioned above (section 1). They provide information on dissipative systems, i.e. on such structures which are in contact with the environment through flows of information and energy and owe their existence to these. Flows of information and energy are verified by goal oriented systemic processes.

Environment here means the totality of systems joined together by structural bonds in spatial surroundings. As taught by the sciences of ecology and economics, we should distinguish between two environments. In the first (the "superior" environment) the flow of information starts, stimulates the demand for energy (in the broad sense) in the system and leads into the second (or "inferior") environment. From here, the demanded energy is then introduced into the system and supplied as a product (Proc. p. 75) within the context of the flow of energy of the superior environment. For us, three types of dissipative system are of interest here:

1) Non-equilibrium systems (abbreviated to NES; Proc. p. 119 f.) are compact in shape and clearly defined in structure and space.[2)] They are organised on the basis of division of work and capable of spatial self-organisation, i.e. they can arrange their elements (inferior NES) internally according to their requirements in such a way that they are able to maintain or alter themselves (Proc. p. 136 f.). In the NES (e.g. an industrial company) information and/or energy are transformed into transportable messages or products. It contains (in the flow of information) the demand from the superior environment (e.g. the market) and procures (in the flow of energy) from the inferior environment (e.g. suppliers) the energy and raw material necessary for production. The material is processed in the NES and supplied to the demanding superior environment. The process with its numerous stages (Proc. p. 138) is precisely defined and controlled. The industrial company is an example of a NES within mankind as a society, i.e. a population (because it is "operated" by humans). It is one of the organisates, i.e. one of the six types of population of which (as sub-systems) mankind as a society is constructed. The elements of these populations (as of the entire hierarchic system of mankind) are the individuals with their various tasks (including these, there are therefore 7 hierarchic levels, Proc. p. 206 f.). The task of the organisate in the system mankind is to process a message and/or energy/material. Other examples of populations are cultural populations, the "city-umland" population (the city-umland system)[3)] or the community all with different tasks. All these types of population are necessary for the existence of the hierarchic system "mankind as a society".

2) The autopoietic systems (abbreviated below to AS; Proc. p. 245 f.) are related to the NES. However, these systems organise themselves not only structurally (as the NES do) but also create material themselves. In the mesocosmos these are exemplified primarily by the living organisms (H.R.MATURANA und F.J.VARELA 1984/89). But this type is also widespread outside (section 2.4; 4.3). For our purposes, it is important to understand that the AS also possess characteristics of the NES which means that we can compare them in this context using examples from the mesocosmos. They produce in the same way as these, even if their product is not only a transportable package of information or energy, but also the structured matter of which they themselves consist. They are defined outwardly in space and time. In particular, they are located in the flow

of information and energy i.e. they are situated structurally between the superior and the inferior environment.

3) A number of NES and AS demanding and supplying the same products in the environments occur in groups, in flow-equilibrium systems (FES; Proc. p. 69 f.). They form their elements and compete with one another for the best position in the flow of information and energy. The FES are specific in nature and distinct from their superior and inferior environments although not spatially. They are areas differing in extent depending on the configuration of their superior and/or inferior environments. These environments are also FES, which means that in the vertical flow of information and energy several systems of this kind may be arranged above one another (e.g. in ecosystems the "ecological niches" form the sphere of activity of single species and define their functional status).

2.3. Observations in the mesocosmos 2: Oscillations and waves:

In order to answer the above question regarding the relationship of the quantum sphere to the mesocosmos (section 2.1), we must look more closely at the flows of information and energy. These cross the FES a) in vertical and b) in horizontal directions:
a) The vertical flows of information and energy supply the NES and AS. Otherwise the systems (being dissipative in nature) would disintegrate. As indicated above (section 2.2), the FES acts as intermediary in the transfer of information from the superior environment (demand for energy), and of energy from the inferior environment (supply of energy), although not at the same time. On the contrary, the effect follows the cause, i.e. the supply of energy follows the demand for it [4)]. This takes place repeatedly, causing the system to oscillate around a centre level, thereby achieving a flow equilibrium as v. Bertalanffy expressed it in 1952 (L.v.BERTALANFFY, W.BEIER und R.LAUE 1952/77). The system regulates itself by means of feedback (Proc. p. 77 f.). An example of this in the field of physics is the flow of electric current between coil and capacitor, in ecology by the predator-prey relationship, and in economy by economic cycles (Proc. p. 103 f.). The oscillations can be represented by the so-called Lotka-Volterra equations (Proc. p. 90, formula 15). The frequency of the oscillations of the FES corresponds to the production speed of the NES and AS (as its elements). In this way, the flow of information and energy is divided into packages. The frequency determines the rhythm at which the information or energy is processed, i.e. the chronological component of production. On the other hand, the frequency of the oscillations also dictates the rhythm of production (for the quantity component of the production speed, see below, section 3.3). The rhythms themselves are also dependent on the hierarchic position in the superior system. An example of this is mankind as a society. It contains seven frequencies corresponding to the seven hierarchic levels (see above, section 2.2). In each case, the inferior FES and their populations (NES) oscillate approximately ten times as fast as the superior ones (Proc. p. 215 f., p. 233 f). In this way the time cycles of the systems are coordinated with one another.[5)]
b) In order to understand the horizontal (i.e. spatial) process (Proc. p. 79 f., p. 105 f.), we must look more closely at the NES and AS, where the production takes place. As already stated (see above, section 2.2) they form the elements of the FES and oscillate at their demand-supply rhythm.
- With regard to the FES with NES as elements, each piece of information as such can be spread quickly, but it has to be adopted, otherwise it remains ineffective. The flow of information requires integration into the system as does the flow of energy. Let us

assume that the FES is also stimulated by information from outside, to increase production in the NES within the stated oscillation frequency (e.g. in the case of the industrial company by adopting a technical innovation). This message from the superior environment is adopted at a structurally and spatially defined point of the FES (the initial location) by one or more elements (NES), i.e. it is implemented in their production program. If the innovation has proved successful for those previously informed (i.e. if their production quantity has actually increased) it will also be adopted with a certain degree of probability by those subsequently informed. In this way new elements of the FES can be continuously adopted in an exponential progression. A wave is created which is distinguished by increased production of the elements and whose front advances successively. Its impetus depends on the one hand, on the information content of the message (the stimulus) but also on the receptivity of the elements, i.e. on the individual local circumstances (Proc. p. 80 f.). In this way the information passes through the FES as a wave. The elements produce the energy driving the diffusion process. They procure the energy they need from their inferior environment. When about half the elements (NES) in the FES have accepted the innovation, the increase diminishes (logistic curve, Proc. p. 84, formula 7). The oscillation curve again tends towards the centre level . In the meantime a new innovation may have been developed so that a new process can begin (Proc. p. 142 f.) involving in its turn an increase in production.

- With regard to the FES with AS as elements, the process of diffusion is basically similar although differing slightly in detail. An example of this is the settlement colonisation of new territory. As AS, the individuals form the elements of the FES. They need a continual supply of energy (and substance) in order to secure their existence. In the simplest case, this is obtained by cultivation of the soil. If the supply of food is no longer assured for any reason (e.g. overpopulation) and there is no other way to feed the population, colonisation may provide a solution. First of all (as with the NES) the stimulus is diffused (from an initial location) into the group (FES) of the AS, i.e. the demand to procure additional food. However, this implies a change of location from the accustomed place of residence to virgin country and the creation of arable land. If at the start movement meets with success, the information is adopted by other potential colonists with the result that a wave front forms in the territory being colonised (e.g. the "frontier" in the USA). The wave is comparable to that of the increasingly producing NES (see above), with the exception that the AS themselves form the advancing front of the wave, thereby extending the existing FES. Thus, it is not only the impetus at the initial location which determines the extent and path of the wave. The local circumstances of the inferior environment (in taking new ground into cultivation) also have to be taken into account because it is here that the new energy is absorbed. When demand is satisfied by increasing the area under cultivation and growing more food, colonisation again begins to diminish. If the pressure of population continues to rise, the stimulus to cultivate new land may again appear and a new colonisation movement begin. If this happens repeatedly, a wave pattern may be observed with the size and shape of the areas covered by the waves varying according to local conditions (Proc. p. 255 f.).

2.4. Attempt at an answer:

Oscillations and waves are omnipresent in the mesocosmos. They are part of normal processes. Referring to the remarks made above (section 2.1), the question arises as to whether similar mechanisms are in operation outside the mesocosmos.

As AS we mentioned the living organisms (section 2.2). However, by definition the particles of the microcosmos i.e. the elementary particles, atoms and molecules, must also be AS. They appear and disappear, replace themselves, although varying periods of time are required for this. They are organised in FES. If they encounter a ray of light [whether it originates in the photosphere of a star (section 4.3) or in a scientific experiment], they presumably receive information and are stimulated to additional activity. The ray of light may be seen as the diffusion of information.

If these analogies are accurate, it would be logical to regard the FES on the one hand and the AS on the other as two sides of the same coin in the quantum sphere as well. Depending on the aims of the enquirer, either the wave-like (FES) character or the particle-like (AS) character of the quanta could be made visible by a measuring process (see fig. 1). The "wave-particle dualism" would therefore have an obvious explanation.

Using a diagram to obtain an overall view (see fig. 1), we can distinguish 4 different levels[6)]:

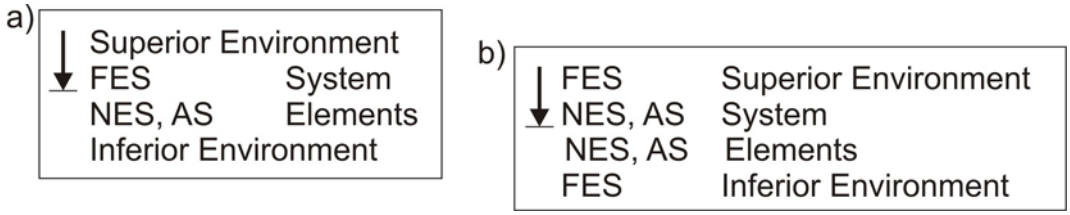

Fig. 1: Depending on the viewpoint, the hierarchy of the systems presents itself in different ways. The focus of attention is either directed at a) the FES or at b) the NES or AS (wave-particle dualism). The arrows show the flow of information in the area affected by the double-slit experiment.

However: according to current opinion, it is assumed that electromagnetic waves do not require a medium in order to multiply, i.e. they spread without limit in a "vacuum" without absorbing energy and the electrons in Bohr's atomic model move in their paths without driving power or friction. May we now assume that the rays not only stimulate the given FES and its elements (the AS) in the environment of the star, but also use it as a source of energy (according to the stimulating waves in the mesocosmos)? As elements of the FES, the AS would then be located in the vertical flow of energy, because they constantly require new energy (and mass) from their inferior environment in order to maintain themselves. However, this assumes that the "vacuum" between the (galaxies and) stars is taken up by a background field producing energy and mass, which may play the part of the inferior environment. The existence of this field still has to be demonstrated.

3. The problem of relativity:

3.1. The question:

The theory that the speed of a moving object in relation to another object in absolute space and time can be calculated according to Galilei's linear transformation was a central principle of classical Newtonian physics until the failure of the experiment by Michelson and Morley (1887; K.SIMONYI 2004, p.397 f.) attempting to measure the

speed of light in relation to supposedly static ether indicated that a new approach was required. The problem was solved by EINSTEIN 1905/74. He showed (1) that the speed of light is constant and equal for all moving objects (or observers). It is the highest reference quantity and represents a limiting speed; (2) that the laws of physics are the same for all inertial systems moving at a uniform speed and in a straight line relative to one another. This means, for example, that the motion of an object in a system A is perceived differently by an observer in that system than by an observer who sees this motion from another system B which is moving (for example) in the opposite direction. This apparently contradictory phenomenon can be represented with the help of the Lorentz transformation.

It is possible to derive a mathematical equation equivalent to the Lorentz transformation in a different way by means of the Process Theory. Is the phenomenon of a limiting speed to which the motions of all objects are subject, not restricted only to the speed of light in the universe but inherent also in such systems which are differently related to one another?

3.2. Observations in the mesocosmos:

When discussing the oscillations and waves in the mesocosmos (section 2.3), we saw that the NES and AS are stimulated from the superior environment to increase their production, and that they take the energy required for this from the inferior environment. The question now arises as to how these systems with their superior and inferior environments (which on their part are also made up of systems) are linked together, i.e. how the vertical flows of information and energy enter the system. Here, the two opposing processes are the giving and receiving of information (stimulus) and/or energy (products) between the demanding and supplying systems. During the actual process of giving and receiving, the speeds have to be adjusted to one another as at the moment of transferring the baton in a relay race.

In the Special Theory of Relativity (as in physics generally), the term "speed" is defined by the quotients between the distance covered and the time required. In the Process Theory on the other hand, the term is understood more broadly and postulates that all change and motion – whether it concerns the transformation of stationary object, or involves a change of location, whether it is constructive or destructive in nature – is linked to a system and is part of a flow of information and energy. I.e. it is the processes themselves with which we are dealing. "Process" and "process speed" are used here as widely applicable terms.

Processes are fixed in purpose and have a specific objective in mind (section 2.2). The time cycle is dictated by the frequency of the oscillations. In order to describe the speed of the process a quantity component is also required, which is provided by the amplitude of the oscillations. This is what concerns us here.

3.3. Attempt at an answer:

In order to achieve quantifiable results, a scale has to be defined to describe adequately the speed at which information and energy pass through. It is suggested using the element as a standard unit either as stimulating unit of information or as energy-

transmitting unit (Proc. p. 89, formula 14). The greater the number of units *w* is, the more (information or energy) units are achieved per time unit, i.e. the faster information or energy can be produced in the NES and AS. For example, a situation in which stimulating elements (i.e. containing information) are being given by the superior environment and received by the system.[7)] The capacity *c* of the system has to be taken into account, which determines its limiting speed, i.e. the maximum number of element units to be received. Some elements are always active because the systems are dissipative in the flow of information and energy. Thus, the receiving system can take c – w elements from the superior (giving) environment. This difference forms the scope for increasing the speed of giving and receiving (see fig. 2).

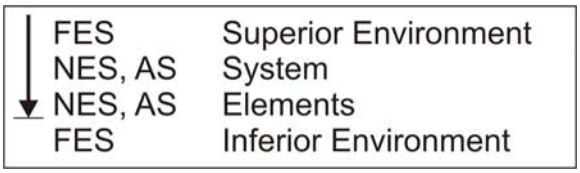

Fig. 2: Hierarchy of systems to illustrate the relativity problem. In this example, stimulating element units are directed from the superior environment (FES) into the NES or AS with a limited capacity to absorb them. The arrow indicates the flow of information in the area under consideration.

The result is the equation formulated according to the Lorentz Transformation (see above, section 3.1) which connects the speed of giving by the superior environment and of receiving by the system (reduced by limited capacity).

According to the ideas proposed here, it is no coincidence that the resulting formula corresponds to the Lorentz contraction of the Special Theory of Relativity, although both were derived in different ways. The decisive factor is the extension of the term speed, the acceptance of the number of elements as indicators for the "throughput" speed in the flow of information and energy and the equating of capacity with the limiting speed of the system.

One could therefore assume that the order on which the Special Theory of Relativity is based is present everywhere in the cosmos and that this forms the basis of a controlled cooperation between all systems. In this way a controlled interlinking of the vertical flows of information and energy becomes possible (Proc. p. 211 f., 215 f.).

4. The problem of gravitation:

4.1. The question:

I. Newton regarded gravitation as an instantaneously effective force of mass attraction (i.e. acting from a distance) in absolute space. However, he doubted whether gravity was property peculiar to matter itself which permits a body to affect another body from a distance in a vacuum (quoted from J.D.BARROW 1992, p. 101, and GREENE 1999/2006, p. 76).

For EINSTEIN (1916/74) on the other hand, gravity was not a force acting from a distance but one acting from close range. In his General Theory of Relativity, he shows that time and space on the one hand and matter and energy on the other interact with

one another. The precondition is that the force causing an acceleration and the force behind gravity are equal (principle of equivalence). Mass and energy (according to Einstein these are also equal to one another) bend space. When a large object (e.g. a star) is approached, the bending of space in the field of gravity increases. The motion of bodies (e.g. planets and meteorites) is accelerated here and follows geodetic lines (as do rays of light, which possess energy but no mass). Einstein therefore regarded gravitation as a characteristic of space, i.e. as a false force. The question remains whether mass and/or energy are really able to bend space. Perhaps a number of observations in the mesocosmos and reflections based on the Process Theory can help in resolving this question.

4.2. Observations in the mesocosmos:

It is striking that the configuration of fields of gravity is similar to that of the catchment areas of the cities in city-umland systems (Proc. p. 191 f.; see also note 3). There have even been attempts to apply Newton's Law of Gravity directly to the relation between a city and its umland (using fields of migration: E.C.YOUNG 1924; also Proc. p. 54 f., 258 f.). What connects the city with its umland?

The superior environment, i.e. the regional or the world market etc. demands certain products which can be produced in the factories of the city. The inhabitants and industrial plants etc. of the city have a high requirement for energy (in a broad sense also including matter and additional workers). These manifold requirements are reflected structurally in the relations with the inferior environment (see above, section 2.2) situated in the umland. The requirement for energy is communicated to the systems in the umland, i.e. as a piece of information. These then supply this energy e.g. in the form of various agricultural products (section 3.2) and raw materials, of electricity, of working power (i.e. commuters) etc.. The raw materials are processed in the city (by adding information) and the resulting products then supplied to the demanding systems in the
superior environment. Put in its simplest form, it is mainly information which is sent from the city to the umland (flow of information) and it is supplied in turn with energy and matter from the umland (flow of energy).

From the centre towards the periphery it is possible to trace zones of varying utilisation (Proc. p. 57 f., 191 f.). Of these zones the three most important are as follows:
1) At the centre there is the central business district with its retailers, banks, insurances, public administration etc. This is the part of the system concerned with processing information. It is here that the requirements of the consumers are linked with those of the producers in the umland and the financial and legal conditions necessary for orderly processes of exchange created. In other words, the demand for products is received here from the superior environment (partly in the outer parts of the system) and the information basis prepared for the actual production process.
2) Moving outwards, this core is surrounded by the residential belt in which a large proportion of the consumers and that part of the population live which is employed in the central business district and (further out) in the production plants (e.g. of industry). This zone is therefore an intermediary between the information and the energy- and material-processing part of the city-umland system.
3) The production, i.e. the processing of energy and materials takes place in the factories on the outskirts of the city and in the umland. In this zone the land is taken up

by industry, traffic systems and (for the most part) by agriculture. The factories manufacture the products according to the stimuli received from the central business district and outside and supply them through business to the market as the demanding superior environment. This area itself is subdivided by central places of less importance, i.e. smaller city-umland systems (Proc. p. 258 f.).

In this context we have described only the relationship between the city and the umland. From a typological point of view, the city forms an NES. The inferior environment is located in the umland. In practice however, this system is part of a complex network of central place structures. Accordingly, many of the demanded and supplied products and information as well as the materials required for production are transported over wide distances (Proc. p. 230). This means that the inferior environment also extends into the umland of other cities. This is a consequence of a continuing process of differentiation which itself has its origins in the division of labour in human society.

4.3. Attempt at an answer:

The structure of the city-umland system outlined above apparently has a counterpart in the sphere of the stars. This can be seen in the example of the solar system, i.e. the sun and its field of gravity. Here too it is possible to distinguish three areas which are themselves further subdivided into smaller areas.
1) The energy required for the existence of the solar system is created in the interior of the sun.
2) The photosphere acts as an intermediary between the interior and its surrounding area. Radiation forms here.
3) the outer area, the field of gravity begins at the edge of the photosphere and extends into the surrounding area containing planets, comets, meteorites etc.

Let us now assume that the stars are AS. Scientific studies of the sun clearly show that we are dealing with systems which maintain and shape themselves not only structurally but also materially in accordance with their own laws. In this case, the particles of the microcosmos (also AS, section 2.4) would then be their elements. The surrounding field of gravity could therefore be the inferior environment. The star is linked with its surroundings in two ways:
1) The radiation transports energy (in the case of light waves, mainly in the form of photons) as well as mass (in waves of matter). By this means it becomes possible for the umland and its planets to create differentiated forms of being (chemical substances, life). On the other hand, during the process of fusion in the interior of the star, energy is continuously replaced by the combustion of hydrogen to helium, but mass is lost.
2) The question arises as to whether the lost mass does not have to be replaced in order to keep the process of fusion going. If this is the case, the demand would have to be communicated (perhaps by the radiation itself) to the inferior environment in the space surrounding the star in order to stimulate it to production (output of mass). Then it would not be the mass as such which causes the centripetal pull typical of gravitation but its absence and/or its consumption by the star.The "bent" space of the field of gravity would trace out the transport paths (geodesic lines) in detail. Where the mass withdrawn from the inferior environment in the surrounding space comes from is open to question. The path of the information and energy can be represented in diagrammatic form (see fig. 3).

Fig. 3: Hierarchy of the systems to illustrate the problem of gravity. Because of their high requirement for energy and mass, the NES and AS are linked to the inferior environment. The information (left-hand arrow) is sent out to the inferior environment while energy and mass enters the AS in the opposite direction.

In interstellar space the fields of gravity of individual stars overlap one another. The flows of energy and information pass through one another. This is also similar to the complex pattern of links between the cities and their environments. The other AS all the way down to the quarks and electrons also need energy and mass to maintain themselves. Thus, marbles and stones also possess a certain amount of gravity, not as such (see above, sections 2.1, 2.2) but through the dissipative components of which they consist (molecules, atoms etc.).

However, cities and stars belong to different levels of complexity (Proc. p. 119 f., 245 f.). The cities (as NES) do not shape space as such, but only the structure in a given natural space (the surface of the earth), whereas space itself is bent by the stars (as AS).

As argued above (section 3.3) the Special Theory of Relativity describes how the difference in the process speeds between systems giving and receiving energy and information is overcome. The General Theory of Relativity goes further and explains how, in complex reality [characterised by knots (AS) and fields of gravity (FES)], the flows of information and energy, whose process speeds are coordinated with one another, are launched and guided through "bent" space.

5. A conclusion:

In this essay it has not been possible to provide an answer to the question concerning the task of the galaxies (section 1). However, I hope I have explained why I quoted the question:
It concerns the problem of whether the causal method (whichever variant one may choose) is suitable for "unifying" two such widely differing theories as relativity and quantum physics. The causal method is directed mainly at the single object. Without it, there is little doubt that any substantiated scientific knowledge would be impossible. Moreover it appears that another approach is necessary, in order to understand the overlapping structures and gain an insight into the architecture of the universe (which also includes that of the mesocosmos).

Whether the process theory represents such an approach still has to be shown inductively. Unlike many other much-discussed approaches, it offers the possiblity of verification (falsification in the sense used by POPPER 1934/89, p.7 f.). Its most important message is that the FES, NES and AS are integrated as dissipative structures in the flows of information and energy. In my view, the student must examine these processes. They have their task in the system in which they act. They are therefore teleonomically directed, i.e. defined by the program (Proc. p. 13). By examining the processes, it is possible to determine the structures enveloping the objects and the ways

in which they are linked with one another. These are what give the wholes (including the universe) their unity.

However, this requires that the basis of study be broadened, i.e. that new empirical material be taken into account. The material available for study in the extraterrestrial universe and the quantum sphere is probably not sufficiently differentiated and therefore only of limited suitability. If the material is not sufficiently varied it is not possible to study the organisation of complex system structures or the sequence of processes. The mesocosmos, in particular human society, would seem to be suitable for more advanced research. The much greater complexity of the social sphere compared to the matter studied by physics opens up new prospects. In addition to this, it is the sphere with which we are familiar, which makes observation and interpretation considerably easier.

To arrive at quantifiable results it is necessary, in the course of analysis, to deduce from the material, i.e. to proceed step by step from the specific to the general, from the concrete to the abstract. The processes of typification and comparison are helpful here, as well as hermeneutic and phenomenological methods developed by the social sciences. Although these are "soft" methods, they point the way (at the level of the information and energy flows) to definite ("hard") results which permit the development of models and algorithms.

This also shows that for many fields of research, fundamental problems such as the structure of reality in which we exist, an interdisciplinary or even a transdisciplinary approach is essential (J.MITTELSTRASS 1995-96/2004). Perhaps this is the way to fulfilling the hope of diminishing the gulf between the natural and the social sciences. It seems to me that they both need one another.

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Notes:

1) Printed in 2006 as "Saarbrücker Geographische Arbeiten", Vol. 51. Saarbrücken (Selbstverlag der Fachrichtung Geographie der Universität des Saarlandes).
2) The term is understood more narrowly here than by I.PRIGOGINE 1979, pp.150.
3) The city and its umland form a population which is joined into a unit by commuters, business relations etc.: “city-umland population”. The term "city-umland system" is older and occurs more frequently in specialist literature. It emphasises the distinction between the city as a cohesive body of buildings (and as a community) and the more extensive area surrounding it. The umland is composed of smaller generally rural communities and has an economic character differing from that of the city. In contrast to the paper describing the Process Theory (Proc.), the second term is preferred in this essay, because here we attempt to illustrate the difference between the NES and the FES by means of this example.
4) It may also be the other way around, e.g. in ecology. The delay in time is essential for the creation of oscillations.
5) Here it should be noted that in identifying the individual rhythms in the hierarchic levels, not the length of the whole processes is used as a base, but only that of their stages (Proc. pp.208).
6) On the other hand, NES and AS contain various FES. However, that is not the subject of the present essay (Proc. pp.72; 221).
7) This process of transfer is part of the process sequence which forms the system. It must first be ensured that the giving and receiving systems are structurally compatible. The system is first opened up for the stimulus from the superior environment (Proc. pp.88, formula 13). The equation mentioned in this essay forms the second phase of the process sequence. It describes the valve controlling the quantity of stimulating elements. In the third phase, the result is introduced into the oscillation itself (Proc. pp.90, formula 15).