Concepts of the
phenomenological and conceptual strurture of physics

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(1) The two basic facts about physics: scale dependence & decoupling

Physics is scale dependent. Physics at large scale (largely) decouples from the physics at a smaller level. In classical mechanics we deal with three scales according to its 3 basic measurements (distance D, time T, mass M). In non-relativistic quantum theory (M can be expressed through T & D using the Planck constant) and classical relativity (T can be expressed via D using the speed of light) we have 2 scales. In relativistic quantum theory we only have 1 scale – the scale of distance D (or equivalently – the (inverse) scale of momenta), (BrK14) p. 9.

(2) Renormalization groups

The behavior of a physical system depends on a scale (of energies, distances, momenta, etc.) at which the behavior is studied. The change of a behavior when the scale is changed, is described by the renormalization group equation. In quantum field theory, the dependence of the behavior on the scale is often expressed mathematically by the fact that in order to regularize (i.e. render finite) Feynman diagram integrals one must introduce auxiliary scales, cutoffs, etc. The effect of these choices on the physics is encoded into the renormalization group equation. This equation then becomes an important tool for the study of physical theories. Very generally speaking, the method of renormalization group is a method designed how to describe how the dynamics of some system changes when we change the scale (distance, energies) at which we probe it, (BrK14) p. 9.

(3) Temperature on microscopic and macroscopic level

Temperature on microscopic level is basically nothing else than the average kinetic energy of a particle established by the law of nature m*v*v = 2*k*T, (UnA1) p. 181.

Temperature on the macroscopic (gravitational potential) level is simply *energy per mass, i.e. the combination of* Einstein's mass-energy conservation law (E=m*c*c) and the definition of temperature in the form 1/T = (k/W) * (dW/dE).

(4) The Planck action constant

The Planck action constant is independent from any weak or strong gravitation field. It therefore somehow mirrors the fundamental difference of physical macro and micro world, (DeH), see also (RoP1).

(5) Only Stewart's law of thermal emission, not Kirchhoff's, is fully valid

Kirchhoff's law considers blackbody radiation to be a universal process, independent of the nature and shape of the emitter. Nonetheless, Kirchhoff did require, at the minimum, thermal equilibrium with an enclosure. … Blackbody radiation, as experimentally produced in cavities and as discussed theoretically, has remained dependent on thermal equilibrium with at least the smallest carbon particle. … Planck's treatment of Kirchhoff's law is examined in detail and the shortcomings of his derivation are outlined. It is shown once again, that universality does not exist. Only Stewart's law of thermal emission, not Kirchhoff's, is fully valid, (RoP3).

(6) The conservation of energy

The conservation principles of energy, linear momentum, angular momentum, and electric charge are amoung the most fundamental principles of physics. ... The notion „conservation" as in „conservation of energy" is not the same as „invariant". They are related, ..., but they are not synonymous. The momentum or energy of a system of particles may be conserved but not necessarily invariant, (NeD) pp. 1, 4. A second fundamental principle in physics is the least action principle; here physical action requires a potential difference or a pressure. There is no action just due to the presence of energy or a potential.

(7) Invariant quantities

The invariant quantities in energy conservation laws are governed by functionals. The simplest model of functionals is a constant. In a Hilbert space framework such a functional is provided by its norm.

(8) The Noether theorem

The probably most fundamental mathematical theorem in physics is E. Noether's theorem. It effects a huge class of conservation laws governing symmetries of space, time, and „internal" variables. Noether's theorem relates conservation to invariance, and thus to symmetry. This theorem provides the mathematical foundation of the whole quantum mechanics. However, the conservation of electric charge emerges from a more abstract symmetry called „gauge invariance".

(9) (Plemelj's) *mass element* and *flow* on the surface w/o normal derivative

The potential function representations of the standard single and double layer potental integrals are based on the concept of a *mass density dm/dx*. J. Plemelj proposed an alternative definition of a normal derivative, based on Stieltjes integral, where the *mass density dm/dx* is replaced by the concept of a surface intrinsic *mass element dm*. Accordingly, there is no longer a need of a well-defined exterior normal derivative, as the *mass element* concept and a related extended *flux* concept are well-defined just on the considered surface. Accordingly, the new concept is accompanied by a corresponding extended scope of validity of the Green formulae, (PlJ), www.navier-stokes-equations.com.

(10) The d'Alembert "paradox"

The d'Alembert "paradox" is about the failure of the Euler equation as a model for fluid-solid interaction as there are no frictional forces in incompressible fluids; www.navier-stokes-equations.com.

(11) Potentially incompatible NSE and intrinsic (pressure) Neumann equations

"In the NSE with the unknowns velocity v(x,t) and the pressure p(x,t) fields *the field p(x,t) can be formally obtained - by operating with "div" on both sides of the NSE - as a solution of a Neumann problem. From this it is clear that to describe the values of the pressure at the bounding walls or at the initial time independently of v, could incompatible with the NSE and, therefore, could render the problem ill-posed*", (GaG). The pressure p of the solution pair (u,p) of the NSE systems are related to each other by the Riesz transform operator. It enables a representation the sume of the non-linear NSE-term and the negative pressure p, enabled by the Helmholtz-Weyl projection operator and the divergence of the row vectors of th matrix u x u, (CuS).

(12) For a closed connected surface in the three-dimension space the Prandtl operator as a mapping from H(r) to H(r-1) is defined by the double layer potential providing the unique solution of the Neumann boundary value problem for values r which are greater or equal than 1/2, and less than 1. The related H(1) regularity of the solution in the exterior domain may be interpreted as the mechanical energy field of the exterior space, (LiI).

(13) Exterior space problems in general relativity and quantum mechanics

Exterior space problems in physics primarily revolve around the limitations and inconsistencies between general relativity and quantum mechanics, particularly when dealing with extreme conditions and the nature of space-time itself. Key areas include the nature of dark matter and dark energy, the unification of gravity with other forces, and the behavior of space-time at the Big Bang and black holes. Additionally, the concept of quantum gravity and the potential for emergent space-time are active areas of research, Wikipedia

(14) Photophoresis: light beams causing particle motions

*„Particles illuminated by a beam of light or infrared radiation, having sufficient flux density, can move in various directions. This phenomenon has been mentioned by Thoré (1877), first described and later intensively studied by Ehrenhaft (1918) and co-workers/students. Since light is the cause for motion, the expression „photophoresis" has become common. Preining (1966) gives a concise description of the important factors influencing photophoretic motion: „*This motion can depend on the illumination, color, structure and shape of the light beam, on pressure and composition of the gas, on the particle's size, shape and material, and on additional fields such as electric, magnetic, and so on", (HoH).

(15) Einstein, Lorentz, and Ehrenhaft and the phenomenon of light

Einstein considered Maxwell's equations in combination with the requirement that light moves with a certain velocity as laws of physics.

Lorentz envisioned „*various kinds of ether pressures, objects would be squeezed and therefore shortened*", (SuL) pp. 60-62.

Ehrenhaft interpreted his discovery called photophoresis, as „*light induces electric and magnetic charges (poles) upon the particles if they are illuminated by concentrated light preponderantly shorter wave lengths*", (EhF) p. 242.

(16) An indefinite metric in a Hilbert space

*An indefinite metric in a Hilbert space is one of the unconventional features of Heisenberg's "*Introduction to the Unified Field Theory of Elementary Particles*", (HeW).* The subject of an indefinite inner product space first appeared in a paper of Dirac (DiP3) on quantum field theory. Soon afterwards, Pontrjagin (PoL) gave the first mathematical treatment of an indefinite inner product space, (BoJ) preface.

(17) The Stern-Gerlach experiment

The Stern-Gerlach experiment showed that there is a magnetic property of the observed "electron", which is not reflected by the "Schrödinger" energy term.

(18) The Dirac equation

The conclusions out of the Stern-Gerlach experiment lead to the theoretical concept of the "hypothesis of an electron spin" accompanied by an additional assumed angular momentum (energy) of an "electron", resulting into Dirac's model of a bounded electron in a hydrogen atom. Later, the Dirac model turned out to be a relativistic model of an "electron" in contrast to the non-relativistic Schrödinger model.

(19) The Lamb-shift phenomenon

The Lamb-shift phenomenon falsified the Dirac model. It is interpreted as a consequence of interaction between the electron and fluctuations of a quantized radiation field. Assuming that the bounded electron has two complementary kinetical energies, a spin-orbit momentum and a spin-angular momentum, Sommerfeld derived an adapted energy (*approximation*) formula to the Dirac energy, which mathemtically required the introduction of the so-called "fine structure" constant, (MaW) S. 71 ff. The „Lamb shift" phenomenon is interpreted as the radiation correction term of this approximation, (BrK14) p. 13.

(20) The Beta-decay process of a „neutron“

On average the Beta-decay change process of a neutron into a proton, an electron, and an antineutrino lasts 15 minutes; its root cause is unknown.

(21) Dissolution decay of the sun‘s pentagonal surface structure

The sun surface shows mainly a pentagonal structure. On average they dissolve after 15 minutes, (UnA4) S. 85.

(22) Dirac‘s single atom-radiation system

Dirac's single atom-radiation system deals with energy, which is the sum of three terms: one representing the energy of the atom, a second representating the electromagnetic energy of the radiation field, and a small term representing the coupling energy of the atom and the radiation field“, (FeE).

(23) Dirac's nucleon model

Dirac‘s physical substance called „nucleon“ has two states, called „neutron“ and „proton“. The „folding over/flipping“ between the „up“ and „down“ states is called „weak (force) interaction“.

(24) Dirac's „Large Number Hypothesis“

Dirac's „Large Number Hypothesis“ links the size and mass of the universe with the ratio of the two forces at work when a „proton“ and an „electron“ in a hydrogen atom orbit one another, (UnA1) p. 152.

(25) The spin(1/2) hypothesis and SU(2)

The spin(1/2) hypothesis is a consequence of the Stern-Gerlach experiment demonstrating that in quantum physics the spatial orientation of angular momentum is quantized. The experimental observations of the spectra of atoms and their decomposition into magnetic and electric fields showed a decomposition of spectral lines or of electron beams into an even number of components, while the angular momentum multiplets were only composed by an odd number of multiplets with the numbers , (RoH) p. 217. The spin of an elementary particle is its eigen-rotation with exactly two rotation axes, one parallel and one anti-parallel axis to a magnetic field. This is the 2x2 complex number scheme SU(2), where every „normal“ rotation is contained twice. Consequently, an electron has a charge only half of the Planck's quantum of action.

(26) The unit quaternions and SU(2)

The unit quaternions are isometric to SU(2), (EbH).

(27) The quaternion rotation operator

The quaternions provide an appropriate field to address the „translation-rotation“ (linear and angular rotation) „permutation“ requirement. The perhaps primary application of quaternions is the quaternion rotation operator. This is a special quaternion triple-product (unit quaternions and rotating imaginary vector) competing with the conventional (Euler) matrix rotation operator.The quaternion otation operator can be interpreted as a frame or a point-set rotation, (KuJ). Its outstanding advantages compared to the Euler geometry are

- the axes of rotation and angles of rotation are independent from the underlying coordinate system and directly readable
- there is no need to to take care about the sequencing of the rotary axes.

(28) Determining nuclear spin

„Each nucleus has an intrinsic angular momentum which interacts with angular momenta of electrons or other nuclei. It is measured in units of the Planck constant and, according to quantum mechanics, can take only integral or half-integral values. Three methods of determining nuclear spin are:

- Hyperfine structure of spectra
The interaction of the magnetic moments of the electrons and the nucleus may separate in energy the states of the atom corresponding to various relative orientations of these two magnetic moments. ...

- Zeeman spectra
The magnetic moment associated with nuclear spin can interact with an external magnetic field. ...

- Band spectra
Intensity variations of alternate lines in the band spectra of diatomic molecules with identical nuclei yield nuclear spin. ...“, (BeH) p. 19.

(29) Gauge invariance

If a theory is invariant under transformations by a symmetry group one obtains a conservation law and quantum numbers. Gauge symmetries are local symmetries that act differently at each space-time point. They automatically determine the interaction between particles by introducing bosons that mediate the interaction.

(30) The Standard Model of Elementary Particles (SMEP)

The Standard Model of Elementary Particles (SMEP) is about three decoupled, not complete, but consistently defined physical theories, (GiJ). The common denominator of those three theories is the *quantum mechanics,* which is based on an axiomatic structure in a Hilbert space framework, (NeJ). The SMEP is concerned with gauges theory and variational principles. The gauge invariance is the main principle in current SMEP theory. Each of the three observed or assumed „forces“, the weak & strong forces of particle interactions, and the electromagnetic interactions are related to a specific gauge group. Conceptually, the SMEP starts with a set of fermions, e.g. the electron in quantum electrodynamics.

(31) Scattering processes

„Scattering processes are an important theoretical tool to explore microscopic interaction effects. The interpretation of the considered experiments resulted into the large number of propagated elementary particles of the SMEP, because on the short range energy level there was the need for two additional „strong and weak“ EP interaction interpretations. The current supposition is that there are three related quantum field theories, the QED, the QCD, and the QFD“, (WaA) p. 189.

(32) The three gauge groups U(1), SU(2), SU(3) of the SMEP

The U(1) symmetry, i.e. the complex unit circle numbers, (where probability of the wave function is conserved) describes the electromagnetic interaction with one boson (photon) and one quantum number (charge Q).

The group SU(2) of complex, unitary (2x2) matrices with determinant 1 describes the weak force interaction with 3 bosons W(+), W(-), Z. The charged particles W(+), W(-) have resemblance to positrons and electrons, and the neutral Z particle corresponds to the photon, (UnA3) S. 191. It describes the „how“ of the beta-decay process. This is the (about 15 minutes) decay of a neutron into a proton, an electron, and an antineutrino. Unfortunately, this (weak interaction process) theory does not say anything about the „why“ accompanied by related physical laws.

The group SU(3) of complex, unitary matrices describes the strong force interaction with 8 gluon bosons. This means that each of the observed Nature „force“ phenomena are related to a specific gauge group.

(33) Gauge symmetry break down

For gauge invariances the fundamental equations are symmetric, but e.g., the ground state wave function breaks the symmetry. When a gauge symmetry is broken the gauge bosons are able to acquire an effective mass, even though gauge symmetry does not allow a boson mass in the fundamental equations.

(34) The principle of transfer causality in classical mechanics and SMEP

Classical mechanics is concerned with kinematics and dynamics. Classical kinematics deals with the different forms of the movement of bodies in a space-time environment. Classical dynamics should explain the reasons of the connection of those different form of movements. The common denominator of all dynamical models in physics is the principle of transfer causality, ("*Prinzip der Übertragungs-Kausalität*", or, *Impetusprinzip)*, (WoM).

In the SMEP "*the principle of transfer causality*" leads to the invention of two types of quantum elements, the fermions and the bosons. Correspondingly there are three decoupled electromagnetic, weak and strong interaction models of the SMEP equipped with related decoupled fermion and boson groups and accompanied with related groups of arbitrary (free) parameters w/o any physical meaning. In the GRT "*the principle of transfer causality*" is addressed by the principle that "*the boundary of the boundary of a manifold is zero*", ((CiI) p. 49.

(35) Different numbers of scales in the classical-macro-micro worlds

In classical mechanics one deals with the three scales, „distance", „time", and „mass"; in non-relativistic quantum theory and classical relativity one deals with two scales, „distance", and „time"; in relativistic quantum theory one deals with only one scale, the „distance", (DeP) p. 551.

(36) Scale dependent/decoupling physics requiring renormalization groups

The down (complexity) causality thinking results into a degrease of the number of scales, while the number of «nature constants» increases. The effect of the required auxiliary scales, cutoffs, etc. on the physics is encoded into the renormalization group equation. The "case" if there is no related (G-invariant) renormalization realisation (example ground state energy) is called "symmetry break down", (DeP1) p. 1119 ff.

(37) A mathematical microscope being well-localized in physical spaces

Wavelet analysis can be used as a mathematical microscope, looking at the details that are added if one goes from a scale "a" to a scale "a+da", where " da " is infinitesimally small. The mathematical microscope wavelet tool 'unfolds' a function over the one-dimensional space R into a function over the two-dimensional half-plane of "positions" and "details". This two-dimensional parameter space may also be called the position-scale half-plane.   The wavelet theory is established in the Fourier Hilbert space framework. In order to apply the Calderón inverse formula in a Hilbert scale framework it requires the so-called admissibility condition defining a wavelet. "*A wavelet synthesis can be performed locally as opposed to the Fourier transform which is inherently nonlocal due to the space-filling nature of the trigonometric functions. .... The wavelet transform unfolds any signal (e.g. in time) or any field (e.g., in three-dimensional space) into both space (or time) and scale (or time scale), and possible directions (for dimensions higher than one). ... „Decomposing a vector field into orthogonal wavelets, scale-dependent distributions can be quantified at different length scales and in different directions and hence longitudinal or transverse contributions can be determined. In the case of an imposed magnetic field the constructions in the directions perpendicular or parallel to it can be dinstinguished*", (FaM1). *„In practice the Fourier transform may be thought of as embedded into the wavelet transform, because it is, to first approximation, possible to compute the Fourier spectrum of a signal by summing its wavelet coefficients over all positions scale by scale. ... In practice the wavelet should also be well-localized in both physical and Fourier spaces*", (FaM).

(38) The full group of Lorentz transformations

„The full group of Lorentz transformations is the group of transformations that leaves the Minkowski metric invariant. But in the space of all possible Lorentz transformations there is no continuous path that starts out at the Identity, and so are the pure Lorentz boosts, but one cannot reach Parity by pure boosts or pure rotations or combinations of the two. So the real Lorentz group splits up into at least two disconnected components: the Lorentz transformations that one can reach via continuous path from the Identity (the „restricted" Lorentz transformations), and the Lorentz transformations that one can reach via continuous path from Parity. And there is another split, namely the split between the Lorentz transformations that include Time Reversal and the ones that do not. So the Lorentz group has at least disconnected components. In fact it has exactly four disconnected components. …. The classical real Klein Gordon field is a real scalar field whose field values are invariant under the restricted Lorentz transformations. The restricted Lorentz transformations are the ones that are continuously connected to the Identity. They include spatial rotations and Lorentz boosts. They include neither P nor T nor PT. The law of evolution on the Klein Gordon field, the Klein Gordon equation is invariant under the restricted Lorentz tranformations", (CaC) p. 636.

(39) The three related sub-groups of the Lorentz group

There are three related sub-groups of the Lorentz group, (A) the orthochronous Lorentz group (containing „1" and the space inversion); (B) the proper Lorentz group (containing the „1" and the space-time inversion; it is associated to the group of complex matrices of determinant one, which is denoted by), which is important in describing the tranformation properties of spinors), and (C) the orthochorous Lorentz group (containing the space inversion and the time inversion).

(40) The complex Lorentz group

The complex Lorentz group is associated with SU(2) x SU(2). It is the set of all pairs of 2x2-matrices of determinant one accompanied by a multiplication law. While two (real) Lorentz transformations need to be connected to one another by an appropriately defined continuous curve of Lorentz transformations (the Lie group concept), there are two pairs of components of the complex Lorentz group, which are both already connected by definition accompanied by a related multiplication law, (BrK0) p. 48.

(41) The PCT Theorem

The complex Lorentz group SU(2) x SU(2) plays a key role in the proof of the PCT theorem, where PCT stands for P = space inversion; T = time inversion; C = charge conjugation, (StR). This theorem is one of the rarely physical theorem, which is mathematically proven like the Noether theorem.

(42) The Coulomb problem and SU(2)xSU(2)

The complex Lorentz group SU(2) x SU(2) is the hidden symmetry group of the Coulomb problem, (RoH) p. 172.

(43) The Yang-Mills mass gap

The classical Yang-Mills theory is the generalization of the Maxwell theory of electromagnetism where the chromo-electromagnetic field itself carries charges. As a classical field theory it has solutions which travel at the speed of light so that its quantum version should describe massless particles (gluons). However, the postulated phenomenon of color confinement permits only bound states of gluons, forming massive particles. This is the mass gap.

(44) A mathematical curiousity in the electroweak theory

„In the standard model the weak and the electromagnetic interactions are unified in what is called electroweak theory, where there is a special symmetry related to W(+), W(-), Z, and the photon, according to the groups SU(2)xU(1) or, more correctly, U(2). The group might be expressed as SU(2)/U(1)/Z(2), where

the „Z(2)" means „factor out by a Z(2) subgroup". However, there is more than one such subgroup, so this notation is „Z(2)" not fully explicit. The notation „U(2)" automatically picks out the correct one. (I am grateful to Florence Tsou for this observation.) It seems that the reason that the electroweak symmetry group is not conventionally referred to as „U(2)" is that this does not easily extend to the symmetry of the full standard model, which also incorporates the strong symmetry group SU(2), the full group being a version SU(3)xSU(2)xU(1)/Z(6)", (PeR4) p. 641, 654.

(45) Quantum fluctuations, the Casimir and the Lamb shift phenomena

The existence of quantum fluctuations dynamics in a „world" without a time arrow and without entropy has been verified by the Casimir and the Lamb shift effects.

(46) The supergravity phase after "Big Bang"

According to the "Big-Bang Theory" in the early universe pressures and temperature prevented the permanent establishment of elementary particles. None of the invented elementary particles of the SMEP were able to form stable objects until the universe had cooled beyond the so-called „supergravity phase".

(47) SMEP and the inflation phase after "Big Bang"

The SMEP does not provide any explanation where the related elementary „particles" were built from during the inflation phase of the current big bang story and why their mass have their specific values.

(48) The Higgs effect (or mechanism)

The Higgs effect (or mechanism) builds on an extended from global to local U(1) transformations symmetry group of the underlying Lagrangian. It explains the mass of the gauge W- and Z- (weak interaction) bosons of the weak "nuclear-force". The Higgs boson is supposed to be a heavy elementary particle (with non-zero rest mass of about 125 GeV with spin 0).

„The Higgs mechanism helps in two ways. First, gauge fields can acquire mass by the symmetry breaking. Second, the undesirable Goldstone bosons (which arise in the symmetry-breaking process) can be usually gauged away", (BlD) 10.3. This degeneracy of the physical vacuum (as a result of a "spontaneous" breakdown of symmetry) permits … nonzero vacuum expectation values (or "vacuons"), (HiP).

The Higgs field is supposed to fill the whole universe interacting with each particle, which "moves" through it by a kind of frictional resistance, i.e., which has kinetic energy. This means that the Higgs mechanism requires a Higgs field with not vanishing amplitudes in the ground state. The mechanism is therefore incompatible with the SMEP.

(49) The standard model is not the final theory

„Theoretical physicists are convinced that the standard model is not the final theory. There are a number of phenomena which find no explanation in the context of the standard model and must be added in an ad hoc manner. For example, the Higgs mechanism, th mysterious field which gives mass to all other particles, does not follow in any sense from the standard model. The apparent asymmetry between matter and anti-matter is not explained by the standard model. Neutrino masses do not naturally arise in the context of the standard model. There is clearly physics, a deeper theory, beyond the standard model", (SaR) p. 82.

(50) The free electron (Fermi gas) model in solid state physics

"According to the „free electron model" the valence electrons of the constituent atoms become conduction electrons and move about freely through the colume of the metal. Even in metals for which the free electron model works best, the charge distribution of the conduction electrons reflects the strong electrostatic potential of the ion cores. The utility of the free electron model is greatest for properties that depend essentially on the kinetic properties of the conduction electrons. The free electron model of metals gives good insight into the heat capacity, thermal conductivity, electrical conductivity, magentic susceptibility", (KiC) p. 163.

(51) Free-electron theory and an infinite resistance of insulators

„The success of Bohr's early and pioneering ideas on the atom was always a rather narrow one and the same applies to Ptolemy's epicycles. Our present vantage point gives an accurate description of all phenomena which these more primitive theories can describe. The same is not true any longer of the so-called free-electron theory, which gives a marvelously accurate picture of many, if not most, properties of metals, semiconductors, and insulators. In particular, it explains the fact, never properly understood on the basis of the "real theory," that insulators show a specific resistance to electricity which may be 10exp(26) times greater than that of metals. In fact, there is no experimental evidence to show that the resistance is not infinite under the conditions under which the free-electron theory would lead us to expect an infinite resistance. Nevertheless, we are convinced that the free-electron theory is a crude approximation which should be replaced, in the description of all phenomena concerning solids, by a more accurate picture. If viewed from our real vantage point, the situation presented by the free-electron theory is irritating but is not likely to forebode any inconsistencies which are unsurmountable for us. The free-electron theory raises doubts as to how much we should trust numerical agreement between theory and experiment as evidence for the correctness of the theory. We are used to such doubts", (WiE).

(52) The physics of superconducting state

„The electrical resistivity of many metals and alloys drops suddenly to zero when the specimen is cooled to a sufficiently low temperature, often a temperature in the liquid helium range", (KiC) p. 259. ... *„The Meissner effect shows that a bulk superconductor behaves as if the magnetic field B inside the specimen vanishes"*, (KiC) p. 262. ... *„The result B=0 cannot be derived from the characterization of a superconductor as a medium of zero resistivity"*. However, from Ohm's law one may concluded that *„the flux through the metal cannot change on cooling through the transition. The Meissner effect suggests that perfect diamagnetism is an essential property of the superconducting state"*, (KiC) p. 263. ... *„An energy gap is a characteristic, but not universal, feature of the superconductivity state. The gap is accounted for by the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity. The energy gap of superconductors is of entirely different origin and nature than the energy gap of insulators. In an insulator the energy gap is caused by the electron-lattice interaction. This interaction ties the electrons to the lattice. In a superconductor the important interaction is the electron-electron interaction which orders the electrons in **k**-space with respect to the Fermi gas of electrons"*, (KiC) p. 266. ... *„The basis of a quantum theory of superonductivity was laid by the classic 1957 papers of Bardeen, Cooper, and Schrieffer"*, (KiC) p. 277. ... *„The flux quantum is called fluxoid or fluxon"*, (KIC) p. 281. ... *„There is no difference in the mechanism of superconductivity in type I and type II superconductors. Both types have similar thermal properties at the superconductor-normal transition in zero magnetic field. But the Meissner effect is entirely different"*, (Kic) p. 283.

(53) The BCS theory and Cooper pairs

„Ausganspunkt der von Bardeen, Cooper, and Schrieffer gegebenen mikroskopischen Theorie ist das Vorhandensein von Cooper-Paaren. Diese Quasiteilchen haben, ohne daß ein Suprastrom fließt, den Schwerpunktimpuls Null bzw. bei Vorliegen eines Suprastromes den einheitlichen Schwerpunktimpuls >0. Nach der Heisenbergschen Unschärferelation ist ihre räumliche Lage im Supraleiter völlig unbestimmt oder anders ausgedrückt, ihre Wellenfunktion ist über den gesamten Supraleiter ausgedehnt", (WeC) S. 563.

(54) The London dispersion forces

The term "van der Waals force" is used to describe any dipole-dipole interactions in atom/molecules. Since hydrogen bonds involve interactions between permanent dipoles, they can be considered as a type of van der Waals force (and would fall under the category of Keesom interactions). The strength of van der Waals forces varies, with dipole-dipole interactions typically being stronger than covalent or ionic bonds. *"London dispersion forces"* are a specific type of intermolecular force present in nonpolar molecules. They are the weakest of all molecular forces. Molecules like noble gases (e.g., He, Ar), diatomic molecules (e.g., H2), and nonpolar organic molecules experience these forces, Wikipedia.

(55) Current matter and force particles of the universe

„All known particles in the universe can be divided into two groups: particles of spin ½, which make up the matter in the universe, and particles of spin 0, 1, and 2, which give rise to forces between matter particles. The matter particles obey what is called Pauli's exclusion principle", (HaS1) pp. 69/70.

„The neutron is observed to change spontaneously into a proton, an electron, and a neutrino. This process is so rare that we can often ignore it. Neutron decay takes on the average some thousand seconds for a free neutron, whereas within a nucleus the characteristic time between nucleon-nucleon collisions is only 10 exp(-21) second", (BeH) p. 29.

„The word „neutrino" has been used to represent any assumed product of decay which has half-integer spin, no charge, and neglegible mass. Whether these particles are all identical with neutrinos of beta-decay is so far conjecture", (BeH) p. 32.

„Charge neutrality is one of the fundamental property of plasma, the fourth state of matter: it is about the shielding of the electric (Coulomb) potential applied to the plasma. When a probe is inserted into a plasma and positive (negative) potential is applied, the probe attracts (repulses) electrons and the plasma tends to shield the electric disturbance", (MiK).

(56) Relativity theory & quantum theory describe two different universes

„Obviously, the two theories, the relativity theory and the quantum theory, describe two different universes. The doubters in this little fairy tale asked, why there flowed out exactlty the right quantity of gas from the Ur-hole ensuring that the sun can continue to burn evently. ...There are computer simulations of universes with different constants of Nature. ...There is perhaps a superordinated reason, which is not discovered yet. There are different conceivable explanations to this point:

- pure conincidence
- a creator has built that universe
- superordinated laws establish the constants of Nature
- there are multiple universes.

The fourth option is a special case of the third one", (GaG3) S. 107/108.

(57) The phenomenon of plasma matter

About 95% of the universe is about the phenomenon „vacuum". The same proportion applies to the emptyness between a proton and an electron. The remaining 5% of universe's vacuum consists roughly of 5% matter, of 25% sophisticated „*dark matter*", and of 70% sophisticated „*dark energy*". Nearly all (about 99%) of the 5% matter in the universe is in "plasma state". A presumed physical concept of „*dark matter*" „explains" the phenomenon of the spiral shapes in the universe. A presumed physical concept of „*dark energy*" explains the phenomenon of the cosmic microwave background.

(58) Microwave radiation pressure to plasma (ponderomotive force)

Light waves exert radiation pressure which is usually very weak and hard to detect. ... When high-powered microwaves or laser beams are used to heat or confine plasmas the radiation pressure can reach several hundred thousand atmospheres! When applied to plasma, this force is coupled to the particles in a somewhat subtle way and is called the ponderomotive force. Many nonlinear phenomena have a simple explanation in terms of the ponderomotive force, (BrK14) p. 19

(59) The Landau damping phenomenon

The Landau damping phenomenon is a characteristic of collisionless plasma dynamics (i.e. there is no mechanical particle interactions); it is governed by the Coulomb potential.

(60) The Debye length

The Debye length is an important physical parameter for the description of a plasma. It provides a measure of the distance over which the influence of the electric field of an individual charged particle (or of a surface at some nonzero potential) is felt by the other charged particles inside the plasma. The charged particles arrange themselves in such a way as to effectively shield any electrostatic fields within a distance of the order of the Debye length. ... It is convenient to define a Debey sphere as a sphere inside the plasma of radius equal to the Debye length, (BiJ) p. 8.

(61) Two incompatible math. models of the Landau damping phenomenon

„There are actually two kinds of the plasma Landau damping phenomenon: linear Landau damping, and nonlinear Landau damping. Both kinds are independent of dissipative collisional mechanisms. If a particle is caught in the potential well of a wave, the phenomenon is called „trapping". Particles can indeed gain or lose energy in trapping. However, trapping does not lie within the purview of the linear theory. .... Trapping is not in the linear theory. When a wave grows to a larger amplitude, collisonless damping with trapping occur. One then finds that the wave does not decay monotonically; rather the amplitutes fluctuates during the decay as the trapped particles bounce back and forth in the potential wells. This is nonlinear Landau damping. .. Since the linear Landau damping is derived from a linear theory, ... the nonlinear Landau damping must arise from a different physical effect. The question is: Can untrapped electrons moving close to the phase velocity of the wave exchange energy with the wave?", (ChF) p. 248-249.

(62) Hermann Weyl's „Purely Infinitesimal Geometry"

"*A general concept,* the whole *(here the continuum), has to be presupposed in order to give meaning to an individual determination, the particular, or the part (here the point). On the other hand,* the whole*, the general concept (the continuum) is constituted in a process of common generation by particulars (the parts).*

This conceptual figure came close to those procedures that had been called „impredicative" by Russell and Poincaré and that had been blamed as being responsible for contradictions of the type of Russell's antinomy", (ScE6). ", (GaG3) S. 107/108.

(63) General relativity made up of fields on fields

"*General relativity is the discovery that spacetime and the gravitational field are the same entity. What we call „spacetime" is itself a physical object, in many respects similar to the electromagnetic field. We can say that GR is the discovery that there is no spacetime at all. What Newton called „space", and Minkowski called „spacetime", is unmasked: it is nothing but a dynamic object – the gravitational field – in a regime in which we neglect its dynamics. ...., the universe is not made up of fields on spacetime; it is made up of fields on fields*", (RoC).

(64) The boundary of the boundary principle and geometrodynamics

Einstein's "general relativity" or "geometric theory of gravitation" or "geometrodynamics", has two central ideas:

(1) Spacetime geometry "tells" mass-energy how to move; and
(2) mass-energy "tells" spacetime geometry how to curve.

ad (1): We have just seen that the way spacetime tells mass-energy how to move, is automatically obtained from the Einstein field equations by using the identity of Riemannian geometry, known as the

Bianchi identity, which tells us that the covariant divergence of the Einstein tensor is zero.

In other words, Einstein geometrodynamics has the important and beautiful property that the equations of motion are a direct mathematical consequence of the Bianchi identities.

ad (2): According to an idea of extreme simplicity of the laws at the foundations of physics, what one of us has called „the principle of austerity“ or „law without law at the basis of physics“, in geometrodynamics it is possible to derive the dynamical equations for matter and fields from the extremely simple but central identity of algebraic topology: the principle that the boundary of the boundary of a manifold is zero“, (CiI) p. 49

(65) The prize for a physical “purely geometrodynamics” interpretation

„The prize being paid for a physical “purely geometrodynamics” interpretation is

1. *giving up the fundamental principle of nature, the least action principle*
2. *requiring so-called Einstein spaces*
   a. *gravitation models without sources*
   b. *not identical with SRT-Minkowski space equipped with an indefinite inner product,*“ (TrH1).

(66) First appearance of manifolds in mathematical physics

Of course there are several semantical links of the manifold concept to physics, which could be pursued even in the 19th century. Riemann had already started to discuss such links on at least two levels. The final part and culmination of his Habilitations talk gave a sketch how in a subtle interplay between mathematical arguments and the evaluation of physical/empirical insights he proposed to come to a refined understanding of physical space. The essential bridge was an improved understanding of the microstructure of matter and its binding forces that should be, according to Riemann, as directly translated into differential geometric structures on manifolds as possible. But he also left the possibility open for further consideration that perhaps some time even a discrete structure of matter has to be taken into account, as it might very well be that the concepts of rigid body and light ray lose their meaning in the small. Still, so Riemann argued by reference to astronomical measurements, the acceptance of a Euclidean space structure was well adapted to the physical knowledge of the time, (ScE6).

(67) Manifolds

The terminology of "multiple extended quantities" was introduced by B. Riemann, synonymly to a "continuous manifold". The history of manifolds is the attempt to build a mathematical structure to model the whole (the continuum) and the particular (the part) to put its combination into relationship to describe motion, action etc. It is conceptually based on two essential attributes: "continuity" and "multiple extension". Based on the concept of a manifold developing a mathematical framework which symbolically explores the "relationship between the part and the whole" for the case of the continuum lead to the concepts of of co-variant derivatives, affine connexion and Lie algebra.

(68) The "*Evolution Problem in General Relativity* & physical "*black holes*"

The mathematical framework of the General Relativity Theory (GRT) does not allow the derivation of the laws of gravitational radiation as dynamic developments of initial data sets, (ChD). The "*Evolution Problem in General Relativity*", i.e., the full solution of the radiation problem in vacuum for arbitrary asymptotically flat inital data sets, (KlS1), is about a not well-posed, (LoA1), nonlinear hyperbolic partial differential equation system on Riemann manifolds equipped with the Einstein metric accompanied by mathematical singularities and related physical "*black holes*", (PeR) p. 444.

(69) The Cosmological Microwave Background Radiation and Big Bang models

The CMBR provides us with the most important evidence supporting the Big Bang model. Big Bang models are on the basis of general relativity and follow from a number of assumptions, (LaM) p. 7:

- homogeneity of space applies. Thus it is assumed that all points of space are equivalent and the properties associated with each point are the same

- isotropy of space applies. This means that there is no privileged direction in space

- the matter in the universe can be described very simple in terms of what is called a perfect fluid. In this case its properties are completely given by its density and its pressure

- the laws of physics are the same everywhere.

(70) Gödel's new type of cosmological solutions of the gravity field equations

All cosmological solutions with non-vanishing density of matter known at present have the common property that, in a certain sense, they contain an „absolute" time coordinate, owing to the fact that there exists a one-parametric system of three-spaces everywhere orthogonal on the world lines of matter. It is easily seen that the non-existence of such a system of three-spaces is equivalent with a rotation of matter relatively to the compass of inertia. In this paper I am proposing a solution (with a cosmological term) which exhibits such a rotation. This solution, or rather the four-dimensional space S which it defines, has the further properties

1. S is homogeneous
2. .... so that any two world lines of matter are equidistant
3. S has rotational symmetry
4. ... That is, a positive direction of time can consistently be introduced in the whole solution
5. It is not possible to assign a time coordinate to each space-time point in such a way that the coordinate always increases, if one moves in a positive time-like direction; ...
6. ... it is theoretically possible in these worlds to travel into the past, or otherwise influence the past
7. There exist no three-spaces which are everywhere space-like and intersect each world line of matter in one point
8. ... an absolute time does not exist, even if it is not required to agree in direction with the times of all possible observers (where absolute means: definable without reference to individual objects, such as e.g. a particular galactic system).

Matter everywhere rotates relatively to the compass of inertia with the angular velocity constant depending from the mean density of matter and Newton's gravitational constant, (BrK14) p. 35.

(71) The most advanced mathematics of "galactic dynamics"

The most advanced mathematics of "galactic dynamics" is about collisionsless Boltzmann and Poisson equations accompanied by the probability of a given star to be found in unit phase-space volume near the phase-space position , (BiJ) p. 555.

(72) The "*Unfinished Revolution*" in physics

The mathematical modelling framework of the GRT (manifolds and all that) is incompatible to the mathematical framework of the SMEP. The scope of the "*Unfinished Revolution*" in physics regarding the two discoveries, the relativity and the quantum, is described by Smolin's "*five unsolved problems in the theoretical physics*", (SmL1).

(73) The extraordinarily special Big Bang story

„In order to produce an universe resembling the one in which we live, the Creator would have to aim for an absurdly tiny volume of the phase space of possible universes – about 10exp(10)exp(123) – of the entire volume, for the situation under consideration“, (PeR) p. 444.

„The chaotic inflation state of the early universe does not match to the second law of thermodynamics as this law requires a permanent increase of the entropy of the universe over time, while the cosmos started with an incredible low probability, but also with an incredible high ordered state“, (PeR1) pp. 122 ff.

„It (the expanding universe) starts with high-entropy singularity which, it seems, could have been an initial state for our actual universe, and, indeed, would be a far more probable initial state (i.e. of much larger entropy) than the Big Bang that actually occurred. The black holes that congeal together in the final stage of our envisaged collapse would, when time-reversed to an expanding universe, provide us with the image of an initial singularity consisting of multiply bifurcating white holes! A white hole is the time-reverse of a black hole, and I have indicated the sort of situation that this provides us with in Fig. 2,45. It is the total absence of such white-hole singularities that singles out our Big Bang as being so extraordinarily special“, (PeR1) p. 125.

(74) "*It can be shown by the means of the wave equation of light (which can be immediately extended to n dimension) that only the space of an odd number of dimensions is the extinction of a candle followed by complete darkness about the candle (within a radius that increases as rapidly as light travels). This, at least, shows up an important inner difference regarding the propagation of effects between even and odd number of dimensions. Those particularly simple and harmonious laws which Maxwell had developed for the electromagnetic field in empty space are invariant with respect to an arbitrary change of the standard unit length at every point, provided the world is four-dimension. This principle of "gauge invariance" holds for no other number of dimensions*", (WeH) p. 136 ff.

(75) The Courant conjecture

"*Distortion-free families of progressive, spherical wave of higher levels only exist if and only if the Huygens' principle is valid; families of spherical, progressive families only can exist for space-time dimensions n=2 and n=4, and only if the differential equation is equivalent to the wave equation",* (CoR) p. 763

(76) A Heuristic Approach to General Relativity

The article "A Heuristic Approach to General Relativity", (DeH), explains all known tests of Einstein's general relativity theory with variable speed of light, (UnA1) p. 142.

(77) The Mach principle

"*Einstein associated with Mach's name two specific problems.*

*The first may be called the **absolute-space problem**, but it could equally well be called the problem of the distinguished frames of references. …*

*The second may by called the **inertial-mass problem**. This problem was first mentioned explicitly by Einstein in 1912, when he asserted that Mach had sought to explain the inertial mass of bodies through a kind of interaction with all masses of the universe*", (BaJ), (UnA1) p. 65.

(78) Mach's distribution of masses througthout the universe

"*Mach conjectured that distant celestial objects must also be responsible for masses having gravitational properties. … according to Mach's hypothesis the acceleration of a falling apple would not only be determined by Newton's (supposedly) universal gravitational constant, but also by the distribution of masses throughout the universe! … In contrast, for example, electrical charges have nothing to do with inertia, while mass is „heavy" and „inert" at the same time*", (UnA1) pp. 65/66.

(79) Einstein's lost key: a variable speed of light

"*Nothing forces us to assume that ... clocks have to be seen as running at the same speed*", (UnA1) p. 12. ... *The formula for gravitational potential he had developed in his variable speed of light article implied that the graviational constant itself could be calculated from the mass distribution of the universe*", (UnA1) p. 15. ... *Dicke later became famous for his role in the discovery of the cosmic microwave background, and only bad luck prevented him from winning the Nobel Prize. Dicke, who studied Ernst Mach, saw the power of Einstein's formula - and improved it in one crucial respect*" (UnA1) p. 16.

(80) Differentiable Riemann manifolds

The key ingredients of Einstein's field equations are Riemann's differentiable manifolds (whereby the differentiability condition is w/o any physical meaning) in combination with the concept of affine connexion (enabled by the differentiability condition) to build the metric g based (Riemann manifold) metric space (M,g).

(81) Inflations and time bomb solutions of Einstein's field equations

Einstein's field equations are hyperbolic and allow so called „*time bomb solutions*" which spreads along bi-characteristic or characteristic hyper surfaces. Actual quantum theories are talking about „inflations", which blew up the germ of the universe in the very first state. The inflation field due to these concepts are not smooth, but containing fluctuation quanta. The action of those fluctuations create traces into a large area of space.

(82) Schrödinger's forgotten cosmological hypothesis

„Schrödinger suspected that all the potentials in the universe might just add up to the square of the speed of light c, (UnA1) p. 120*:*

„This remarkable relationship states that the (negative) potential of all masses at the point of observation, calculated with the gravitational constant valid at the observation point, must be equal to half the square of the speed of light*".*

„Thus only a a vanishingly small fraction of the inertial effect observed on Earth and in the solar system can originate from their interaction with the masses of the Milky Way*".*

He was the first to suspect the coincidence between the gravitational potential constant divided by the square of the speed of light and the ratio between the radius of the universe and the total mass of the universe", (UnA1) p. 118.

(83) Dirac's two „large number hypotheses"

"*Dirac had discovered the coincidence between the size of the proton and the size of the universe. Dirac also noticed the approximately same ratio number (about 10exp(40) as the ratio between the electrical force and the gravitational force between the proton and the electron in a hydrogen atom and the ratio of the visible horizon of the universe and the radius of the proton, (UnA2) p. 73. This is what is called Dirac's first „large number hypothesis.*

Dirac's second „large number hypothesis" is based on the coincidence of the ratio between the square of the latter ratio (i.e., the ratio of visible horizon of the universe and the radius of the proton) and the ratio of all masses in the universe and the mass of the proton", (UnA1) p. 156, (UnA2) p. 82.

"*Why are coincidences such as Dirac's considered exotic? Assuming that the number of hydrogen atoms in the universe is proportional to the square of ist size indeed appears grotesque: as if the amount of matter in the universe had to do with its surface, rather than with its volume*", (UnA) p. 156.