Masses and fields in Microdynamics: a possible foundation for dynamic gravity

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Abstract

The quest for a complete theory of microphysics is probably near the top of the agenda in fundamental physics today. We survey existing modifications of quantum mechanics to assess their potential. In the following we present recent results on the dynamic nature of electric charge. The theoretical model, valid at all length scales, relates mass oscillations to static electric and gravity fields. The same concept is used, with substantially lower frequencies, to compute the intensity of gravity waves within the solar system. These waves, in the range of kilohertz, can in principle be detected.

1 In search of new foundations

A few years ago physicists thought that all the fundamental puzzles of their field were essentially solved. The experiments in high energy physics, designed to test the standard model, gave agreement between theoretical predictions and experimental findings to the n-th decimal, all the fundamental interactions seemed to be known, the full variety of atomic behaviour explained; and the whole history of our Universe appeared to be at the brink of final disclosure. The first cracks in this monumental edifice of quantum field theory and general relativity appeared on the level of atoms and, independently, on the level of galaxies. On the level of atoms it was the remarkable success of experimental methods in condensed matter physics. These methods, most prominently the scanning tunnelling microscope, allowed to study the behaviour of atoms in real time and real space. Henceforth, chemical processes could not only be mathematically described, they could actually be observed. Implicitly, this made a reinterpretation of quantum mechanics necessary. Because if I can study the behaviour of a single atom (which is by now routinely done), how can this experiment be the result of statistics? And if this atom is real, in what sense precisely is the atom not, which we treat in quantum mechanics? Exactly the same question can be asked in experiments with single photons or electrons. Also these experiments are by now routine in many laboratories around the world. The experimental situation allows only one answer: quantum mechanics is an algorithm and essentially incomplete. But then we may immediately ask: Is there a complete theory, and is there a reality behind the mathematical objects in quantum mechanics? Since quantum mechanics is the basis for quantum field theory, these questions are important for the whole of microphysics. Also, in principle, for high energy
physics. So what, we may ask, is the reality behind a neutrino, a quark, a Higgs boson?

On the level of galaxies the standard model is based on the experimental fact of an isotropic background radiation in the range of 160 GHz. This radiation is equal to the radiation of a black body with $T = 2.726$ K. It is thought to originate from the birth of our Universe in the "big bang", some 10 to 20 billion years ago. On closer scrutiny this model encountered several obstacles. The cosmic background radiation, for example, is constant in all directions. The fact is problematic, because the early universe could not be completely homogeneous. To reconcile facts with the theory, one either has to assume a varying velocity of light (in contrast with special relativity), or a peculiar way, how the universe initially expanded. Today, the most serious objection against its validity is motion of galactic mass. According to model calculations the observations can only be accounted for, if more than 90 percent of a galaxy’s mass is unobservable. But this, in turn, contradicts the calculations of the upper limit of baryon mass in the big bang model. One either has to resort to ad hoc hypotheses about the qualities of this "dark matter", or concede, that the big bang model is flawed. But if it is fundamentally flawed, then the cosmic radiation background must have other origins. And this, then, could be the point of departure of a completely different theory about our Universe.

2 Alternative formulations

The problems sketched have only surfaced in the last ten to twenty years of the Twentieth century. Limiting our discussion to theories amending or extending quantum mechanics, these fall essentially into two categories: (i) Theories aimed at reconciling the microscopic with the macroscopic domain. (ii) Theories aimed at recovering a physical reality behind the mathematical formulations.

It is a constitutional feature of the theories type (i) that they accept the existing formulations. The aim is therefore not so much an extension of our knowledge, than limiting the application of existing mathematical expressions. In this sense, they provide a subset of the unrestricted original frameworks. Examples of this type are: The consistent histories approach due to Griffiths, Hartle, andOmnes; the Ghirardi-Rimini-Weber model; or the many-world concept. None of these models develops a new physical reality beyond quantum mechanics, which could in principle be measured. In this sense, none of the models is suitable to answer the principal question: What is the physical reality of an atom, photon, electron?

The same deficiency probably afflicts all theories based on classical mechanics. Because the main addition, in quantum mechanics, is the uncertainty principle. Mathematically this is expressed by non-commuting variables. Since this condition inhibits any observation of systems with a higher degree of precision, it is theoretically necessary to postulate some hidden variables, which describe fundamental reality. Mechanics is not developed beyond point-like objects and density distributions. In particular the notion of a phase is not a mechanical concept. But as phases play a major role in field physics - and thus, generally, in microphysics - their omission is a severe, probably decisive, limitation. This is true before and apart from any analysis of the actual models used in quantum mechanics. In this sense Bohm’s theory, if it is interpreted as a theory of real particles with real
trajectories, pays the price that also the non-local connections, inherent in quantum mechanics, must be real. Even though it is therefore a theory of type (ii), it cannot be consistently formulated as such.

Another theory of type (ii), stochastic electrodynamics \[10\], focuses on electrodynamics and photons. Classical electrodynamics in this concept is extended by a zero-point field which carries the statistical uncertainty inherent in quantum mechanics. Even though there has recently been new interest in the theory, it is for all practical purposes restricted to photons. It thus has nothing to say, so far, about atoms, or electrons.

The most recent theory type (ii), microdynamics \[11, 12, 13, 14\], focuses on wave properties of matter. These waves are thought to be real. It could be shown that electrodynamics and quantum mechanics are limiting cases of the same general model of matter in microphysics. In this theory the reality behind quantum mechanics is the reality of fields and densities. Contrary to other theories, microdynamics also allows to develop a dynamic model of atoms \[15\].

In the initial concept, the model of hydrogen required an ad-hoc hypothesis: the existence of fields inside the atom, which are due to density oscillations of the proton. In this sense the density oscillations were postulated in addition to the electrostatic charge of the proton. It was only realized recently, that these oscillations may play a far more fundamental role and in fact be related to the very existence of electric charge. A line of research, we shall pursue in the rest of this paper. As shall be seen shortly, the concept can even be used to bridge the gap between electrodynamics and gravitation in microphysics. It thus appears to be at the bottom of what could well become a completely new field: gravity dynamics.

3 The nature of charge

Since the discovery of the electron by J. J. Thomson \[16\] the concept of electric charge has remained nearly unchanged. Apart from Lorentz’ extended electron \[17\], or Abraham’s electromagnetic electron \[18\], the charge of an electron remained a point like entity, in one way or another related to electron mass \[19, 20\]. In atomic nuclei we think of charge as a smeared out region of space, which is structured by the elementary constituents of nuclear particles, the quarks \[21\].

But experiments on the quantum hall effect \[22, 23\], performed around 1980, suggested the existence of "fractional charge" of electrons. Although this effect has later been explained on the basis of standard theory \[24\], its implications are worth a more thorough analysis. Because it cannot be excluded that the same feature, fractional or even continuous charge, will show up in other experiments, especially since experimental practice more and more focuses on the properties of single particles. And in this case the conventional picture, which is based on discrete and unchangeable charge of particles, may soon prove too narrow a frame of reference. It seems therefore justified, at this point, to analyse the very nature of charge itself. A nature, which would reveal itself as an answer to the question: What is charge?

With this problem in mind, we reanalyse the fundamental equations of intrinsic particle properties \[12\]. The consequences of this analysis are developed in two directions. First, we determine the interface between mechanic and electromagnetic
properties of matter, where we find that only one fundamental constant describes it: Planck’s constant $\hbar$. And second, we compute the fields of interaction within a hydrogen atom, where we detect oscillations of the proton density of mass as their source. Finally, the implications of our results in view of unifying gravity and quantum theory are discussed and a new model of gravity waves derived, which is open to experimental tests.

4 The origin of dynamic charge

The intrinsic vector field $\mathbf{E}(\mathbf{r}, t)$, the momentum density $\mathbf{p}(\mathbf{r}, t)$, and the scalar field $\phi(\mathbf{r}, t)$ of a particle are described by (see [12], Eq. (18)):

$$\mathbf{E}(\mathbf{r}, t) = -\nabla \frac{1}{\bar{\sigma}} \phi(\mathbf{r}, t) + \frac{1}{\bar{\sigma}} \frac{\partial}{\partial t} \mathbf{p}(\mathbf{r}, t)$$

(1)

Here $\bar{\sigma}$ is a dimensional constant introduced for reasons of consistency. Rewriting the equation with the help of the definitions:

$$\beta := \frac{1}{\bar{\sigma}} \quad \beta \phi(\mathbf{r}, t) := \phi(\mathbf{r}, t)$$

(2)

we obtain the classical equation for the electric field, where in place of a vector potential $\mathbf{A}(\mathbf{r}, t)$ we have the momentum density $\mathbf{p}(\mathbf{r}, t)$. This similarity, as already noticed, bears on the Lorentz gauge as an expression of the energy principle ([12] Eqs. (26) - (28)).

$$\mathbf{E}(\mathbf{r}, t) = -\nabla \phi(\mathbf{r}, t) + \beta \frac{\partial}{\partial t} \mathbf{p}(\mathbf{r}, t)$$

(3)

Note that $\beta$ describes the interface between dynamic and electromagnetic properties of the particle. Taking the gradient of (3) and using the continuity equation for $\mathbf{p}(\mathbf{r}, t)$:

$$\nabla \mathbf{p}(\mathbf{r}, t) + \frac{\partial}{\partial t} \rho(\mathbf{r}, t) = 0$$

(4)

where $\rho(\mathbf{r}, t)$ is the density of mass, we get the Poisson equation with an additional term. And if we include the source equation for the electric field $\mathbf{E}(\mathbf{r}, t)$:

$$\nabla \mathbf{E}(\mathbf{r}, t) = \sigma(\mathbf{r}, t)$$

(5)

$\sigma(\mathbf{r}, t)$ being the density of charge, $\epsilon$ set to 1 for convenience, we end up with the modified Poisson equation:

$$\Delta \phi(\mathbf{r}, t) = -\underbrace{\sigma(\mathbf{r}, t)}_{\text{static charge}} - \underbrace{\beta \frac{\partial^2}{\partial t^2} \rho(\mathbf{r}, t)}_{\text{dynamic charge}}$$

(6)
The first term in (6) is the classical term in electrostatics. The second term does not have a classical analogue, it is an essentially novel source of the scalar field $\phi$, its novelty is due to the fact, that no dynamic interpretation of the vector potential $A(r,t)$ exists, whereas, in the current framework, $p(r,t)$ has a dynamic meaning: that of momentum density.

To appreciate the importance of the new term, think of an aggregation of mass in a state of oscillation. In this case the second derivative of $\rho$ is a periodic function, which is, by virtue of Eq. (6), equal to periodic charge. Then this dynamic charge gives rise to a periodic scalar field $\phi$. This field appears as a field of charge in periodic oscillations: hence its name, dynamic charge. We demonstrate the implications of Eq. (6) on an easy example: the radial oscillations of a proton. The treatment is confined to monopole oscillations, although the results can easily be generalised to any multipole. Let a proton’s radius be a function of time, so that $r_p = r_p(t)$ will be:

$$r_p(t) = R_p + d \cdot \sin \omega_H t$$  \hspace{1cm} (7)

Here $R_p$ is the original radius, $d$ the oscillation amplitude, and $\omega_H$ its frequency. Then the volume of the proton $V_p$ and, consequently, its density of mass $\rho_p$ depend on time. In first order approximation we get:

$$\rho_p(t) = \frac{3M_p}{4\pi} (R_p + d \sin \omega_H t)^{-3} \approx \rho_0 (1 - x \sin \omega_H t) \quad x := \frac{3d}{R_p}$$  \hspace{1cm} (8)

The Poisson equation for the dynamic contribution to proton charge then reads:

$$\Delta \phi(r,t) = -\beta x \rho_0 \omega_H^2 \sin \omega_H t$$  \hspace{1cm} (9)

Integrating over the volume of the proton we find for the dynamic charge of the oscillating proton the expression:

$$q_D(t) = \int_{V_p} d^3 r \beta x \rho_0 \omega_H^2 \sin \omega_H t = \beta x M_p \omega_H^2 \sin \omega_H t$$  \hspace{1cm} (10)

This charge gives rise to a periodic field within the hydrogen atom, as already analysed in some detail and in a slightly different context [15]. We shall turn to the calculation of a hydrogen’s fields of interaction in the following sections. But in order to fully appreciate the meaning of the dynamic aspect it is necessary to digress at this point and to turn to the discussion of electromagnetic units.

## 5 Natural electromagnetic units

By virtue of the Poisson equation (6) dynamic charge must be dimensionally equal to static charge, which for a proton is $+ e$. But since it is, in the current framework, based on dynamic variables, the choice of $\beta$ also defines the interface between dynamic and electromagnetic units. From (8) we get, dimensionally:
\[ [\epsilon] = [\beta][M_\rho \omega_H^2] \Rightarrow [\beta] = \left[ \frac{\epsilon}{M_\rho \omega_H^2} \right] \] (11)

The unit of \( \beta \) is therefore, in SI units:

\[ [\beta] = C \cdot \frac{s^2}{kg} = C \cdot \frac{m^2}{J} \quad [SI] \] (12)

We define now the *natural system of electromagnetic units* by setting \( \beta \) equal to 1. Thus:

\[ [\beta] := 1 \Rightarrow [C] = \frac{J}{m^2} \] (13)

The unit of charge \( C \) is then energy per unit area of a surface. Why, it could be asked, should this definition make sense? Because, would be the answer, it is the only suitable definition, if electrostatic interactions are accomplished by photons. Suppose a \( \delta^3(r - r') \) like region around \( r' \) is the origin of photons interacting with another \( \delta^3(r - r'') \) like region around \( r'' \). Then \( r' \) is the location of charge. Due to the geometry of the problem the interaction energy will decrease with the square of \( |r' - r''| \). What remains constant, and thus characterises the charge at \( r' \), is only the interaction energy per surface unit. Thus the definition, which applies to all \( r^{-2} \) like interactions, also, in principle, to gravity.

Returning to the question of natural units, we find that all the other electromagnetic units follow straightforward from the fundamental equations [12]. However, if we analyse the units in Lorentz’ force equation, we observe, at first glance, an inconsistency.

\[ \mathbf{F}_L = q (\mathbf{E} + \mathbf{u} \times \mathbf{B}) \] (14)

The unit on the left, Newton, is not equal to the unit on the right. As a first step to solve the problem we include the dielectric constant \( \epsilon^{-1} \) in the equation, since this is the conventional definition of the electric field \( \mathbf{E} \). Then we have:

\[ [\mathbf{F}_L] = \frac{Nm}{m^2} \left( \frac{m^4 N}{N m^3} + \frac{m N s}{s m^4} \right) = N + N \cdot \frac{N}{m^4} \] (15)

Interestingly, now the second term, which describes the magnetic forces, is wrong in the same manner, the first term was before we included the dielectric units. It seems thus, that the dimensional problem can be solved by a constant \( \eta \), which is dimensionally equal to \( \epsilon \), and by rewriting the force equation [14] in the following manner:

\[ \mathbf{F}_L = \frac{q}{\eta} (\mathbf{E} + \mathbf{u} \times \mathbf{B}) \quad [\eta] = Nm^{-4} = Cm^{-3} = [\sigma] \] (16)
The modification of (14) has an implicit meaning, which is worth being emphasised. It is common knowledge in special relativity, that electric and magnetic fields are only different aspects of a situation. They are part of a common field tensor $F_{\mu\nu}$ and transform into each other by Lorentz transformations. From this point of view the treatment of electric and magnetic fields in the SI, where we end up with two different constants ($\varepsilon, \mu$), seems to go against the requirement of simplicity. On the other hand, the approach in quantum field theory, where one employs in general only a dimensionless constant at the interface to electrodynamics, the fine-structure constant $\alpha$, is over the mark. Because the information, whether we deal with the electromagnetic or the mechanic aspect of a situation, is lost. The natural system, although not completely free of difficulties, as seen further down, seems a suitable compromise. Different aspects of the intrinsic properties, and which are generally electromagnetic, are not distinguished, no scaling is necessary between $p, E$ and $B$. The only constant necessary is at the interface to mechanic properties, which is $\eta$. This also holds for the fields of radiation, which we can describe by:

$$\phi_{\text{Rad}}(r, t) = \frac{1}{8\pi \eta} \left( E^2 + c^2 B^2 \right)$$

(17)

Note that in the natural system the usage, or the omission, of $\eta$ ultimately determines, whether a variable is to be interpreted as an electromagnetic or a mechanic property. Forces and energies are mechanic, whereas momentum density is not. The numerical value of $\eta$ has to be determined by explicit calculations. This will be done in the next sections. Comparing with existing systems we note three distinct advantages: (i) The system reflects the dynamic origin of fields, and it is based on only three fundamental units: m, kg, s. A separate definition of the current is therefore obsolete. (ii) There is a clear cut interface between mechanics (forces, energies), and electrodynamics (fields of motion). (iii) The system provides a common framework for macroscopic and microscopic processes.

6 Interactions in hydrogen

Returning to proton oscillations, let us first restate the main differences between a free electron and an electron in a hydrogen atom [15]: (i) The frequency of the hydrogen system is constant $\omega_H$, as is the frequency of the electron wave. It is thought to arise from the oscillation properties of a proton. (ii) Due to this feature the wave equation of momentum density $p(r, t)$ is not homogeneous, but inhomogeneous:

$$\Delta p(r, t) - \frac{1}{u^2} \frac{\partial^2}{\partial t^2} p(r, t) = f(t)\delta^3(r)$$

(18)

for a proton at $r = 0$ of the coordinate system. The source term is related to nuclear oscillations. We do not solve (18) directly, but use the energy principle to simplify the problem. From a free electron it is known that the total intrinsic energy density, the sum of a kinetic component $\phi_K$ and a field component $\phi_{EM}$ is a constant of motion [12]:

$$\phi_K(r) + \phi_{EM}(r) = \rho_0 u^2$$

(19)
where \( u \) is the velocity of the electron and \( \rho_0 \) its density amplitude. We adopt this notion of energy conservation also for the hydrogen electron, we only modify it to account for the spherical setup:

\[
\phi_K (r) + \phi_{EM}(r) = \frac{\rho_0}{r^2} u^2
\]

(20)

The radial velocity of the electron has discrete levels. Due to the boundary values problem at the atomic radius, it depends on the principal quantum number \( n \). From the treatment of hydrogen we recall for \( u_n \) and \( \rho_0 \) the results [13]:

\[
u_n = \frac{\omega_H R_H}{2\pi n} \quad \rho_0 = \frac{M_e}{2\pi R_H}
\]

(21)

where \( R_H \) is the radius of the hydrogen atom and \( M_e \) the mass of an electron. Since \( \rho_0 \) includes the kinetic as well as the field components of electron "mass", e.g. in Eq. (20), we can define a momentum density \( p_0(r, t) \), which equally includes both components. As the velocity \( u_n = u_n(t) \) of the electron wave in hydrogen is periodic, the momentum density \( p_0(r, t) \) is given by:

\[
u_n(t) = u_n \cos \omega_H t \quad \Rightarrow \quad p_0(r, t) = \frac{\rho_0 u_n}{r^2} \cos \omega_H t e^r
\]

(22)

The combination of kinetic and field components in the variables has a physical background: it bears on the result that photons change both components of an electron wave [12]. With these definitions we can use the relation between the electric field and the change of momentum, although now this equation refers to both components:

\[
E_0(r, t) = \frac{\partial}{\partial t} p_0(r, t) = -\frac{\rho_0 u_n}{r^2} \omega_H \sin \omega_H t e^r
\]

(23)

Note that charge, by definition, is included in the electric field itself. Integrating the dynamic charge of a proton from Eq. (10) and accounting for flow conservation in our spherical setup, the field of a proton will be:

\[
E_0(r, t) = \frac{q_d}{r^2} = \frac{M_p \omega_H^2 x}{r^2} \sin \omega_H t e^r
\]

(24)

Apart from a phase factor the two expressions must be equal. Recalling the values of \( u_n \) and \( \rho_0 \) from (21), the amplitude \( x \) of proton oscillation can be computed. We obtain:

\[
x = \frac{3d}{R_p} = \frac{M_e}{(2\pi)^2 M_p} \cdot \frac{1}{n}
\]

(25)

In the highest state of excitation, which for the dynamic model is \( n = 1 \), the amplitude is less than \( 10^{-5} \) times the proton radius: Oscillations are therefore
comparatively small. This result indicates that the scale of energies within the proton is much higher than within the electron, say. The result is therefore well in keeping with existing nuclear models. For higher \( n \), and thus lower excitation energy, the amplitude becomes smaller and vanishes for \( n \to \infty \).

It is helpful to consider the different energy components within the hydrogen atom at a single state, say \( n = 1 \), to understand, how the electron is actually bound to the proton. The energy of the electron consists of two components.

\[
\phi_K(r, t) = \frac{\rho_0 u_1^2}{r^2} \sin^2 k_1 r \cos^2 \omega_H t
\]  

(26)

is the kinetic component of electron energy (\( k_1 \) is now the wavevector of the wave). As in the free case, the kinetic component is accompanied by an intrinsic field, which accounts for the energy principle (i.e. the requirement, that total energy density at a given point is a constant of motion). Thus:

\[
\phi_{EM}(r, t) = \frac{\rho_0 u_1^2}{r^2} \cos^2 k_1 r \cos^2 \omega_H t
\]  

(27)

is the field component. The two components together make up for the energy of the electron. Integrating over the volume of the atom and a single period \( \tau \) of the oscillation, we obtain:

\[
W_{el} = \frac{1}{\tau} \int_0^\tau dt \int_{V_H} d^3r (\phi_K(r, t) + \phi_{EM}(r, t)) = \frac{1}{2} M_e u_1^2
\]  

(28)

This is the energy of the electron in the hydrogen atom. \( W_{el} \) is equal to 13.6 eV.

The binding energy of the electron is the energy difference between a free electron of velocity \( u_1 \) and an electron in a hydrogen atom at the same velocity. Since the energy of the free electron \( W_{free} \) is:

\[
W_{free} = \hbar \omega_H = M_e u_1^2
\]  

(29)

the energy difference \( \Delta W \) or the binding energy comes to:

\[
\Delta W = W_{free} - W_{el} = \frac{1}{2} M_e u_1^2
\]  

(30)

This value is also equal to 13.6 eV. It is, furthermore, the energy contained in the photon field \( \phi_{Rad}(r, t) \) of the proton’s radiation

\[
W_{Rad} = \Delta W = \frac{1}{\tau} \int_0^\tau dt \int_{V_H} d^3r \phi_{Rad}(r, t) = \frac{1}{2} M_e u_1^2
\]  

(31)

This energy has to be gained by the electron in order to be freed from its bond, it is the ionization energy of hydrogen. However, in the dynamic picture the electron is not thought to move as a point particle in the static field of a central proton charge, the electron is, in this model, a dynamic and oscillating structure, which emits and absorbs energy constantly via the photon field of the central proton. In a very limited sense, the picture is still a statistical one, since the computation of energies involves the average over a full period.
## 7 The meaning of \( \eta \)

The last problem, we have to solve, is the determination of \( \eta \), the coupling constant between electromagnetic and mechanic variables. To this end we compute the energy of the radiation field \( W_{\text{Rad}} \), using Eqs. (17), (24), and (25). From (17) and (24) we obtain:

\[
\phi_{\text{Rad}}(r, t) = \frac{1}{8\pi \eta} \cdot 1 \cdot \frac{M_p^2 \omega_H^4 x^2}{r^4} \sin^2 \omega_H t
\]

Integrating over one period and the volume of the atom this gives:

\[
W_{\text{Rad}} = \frac{1}{\tau} \int_0^\tau dt \int_{R_p}^{R_H} 4\pi r^2 dr \phi_{\text{Rad}}(r, t) \approx -\frac{1}{4\eta} \cdot \frac{M_p^2 \omega_H^4 x^2}{R_p}
\]

provided \( R_p \), the radius of the proton is much smaller than the radius of the atom. With the help of (25), and remembering that \( W_{\text{Rad}} \) for \( n = 1 \) equals half the electron’s free energy \( \hbar \omega_H \), this finally leads to:

\[
W_{\text{Rad}} = \frac{1}{4\eta} \cdot \frac{M_p^2 \omega_H^4 x^2}{R_p} = \frac{1}{2} \hbar \omega_H
\]

\[
\eta = \frac{M_p^2 \nu_H^3}{2\hbar R_p} = \frac{1.78 \times 10^{20}}{R_p}
\]

since the frequency \( \nu_H \) of the hydrogen atom equals \( 6.57 \times 10^{15} \) Hz. Then \( \eta \) can be calculated in terms of the proton radius \( R_p \). This radius has to be inferred from experimental data, the currently most likely parametrisation being (26):

\[
\rho_p(r) = \frac{1}{1 + e^{(r - 1.07)/0.55}}
\]

radii in fm. If the radius of a proton is defined as the radius, where the density \( \rho_{p,0} \) has decreased to \( \rho_{p,0}/e \), with \( e \) the Euler number, then the value is between 1.3 and 1.4 fm. Computing \( 4\pi \) the inverse of \( \eta \), we get, numerically:

\[
\frac{4\pi}{\eta} = 0.92 \times 10^{-34} \quad (R_p = 1.3 \text{ fm})
\]
\[
= 0.99 \times 10^{-34} \quad (R_p = 1.4 \text{ fm})
\]
\[
= 1.06 \times 10^{-34} \quad (R_p = 1.5 \text{ fm})
\]

Numerically, this value is equal to the numerical value of Planck’s constant \( \hbar \) (27):

\[
\hbar_{\text{UIP}} = 1.0546 \times 10^{-34}
\]
Given the conceptual difference in computing the radius the agreement seems remarkable. Note that this is a genuine derivation of $\hbar$, because nuclear forces and radii fall completely outside the scope of the theory in its present form. If measurements of $R_p$ were any different, then we would be faced, at this point, with a meaningless numerical value. Reversing the argument it can be said, that the correct value - or rather the meaningful value - is a strong argument for the correctness of our theoretical assumptions. For the following, we redefine the symbol $\hbar$:

$$\hbar := 1.0546 \times 10^{-34}[N^{-1}m^4]$$

(39)

Then we can rewrite the equations for $\mathbf{F}$, the Lorentz force, for $\mathbf{L}$, angular momentum related to this force, and $\phi_{Rad}$, the radiation energy density of a photon in a very suggestive form:

$$\mathbf{F} = \hbar q \left( \frac{\mathbf{E}}{4\pi} + \mathbf{u} \times \frac{\mathbf{B}}{4\pi} \right)$$

$$\mathbf{L} = \hbar q \mathbf{r} \times \left( \frac{\mathbf{E}}{4\pi} + \mathbf{u} \times \frac{\mathbf{B}}{4\pi} \right)$$

(40)

$$\phi_{Rad} = \frac{\hbar}{2} \left[ \left( \frac{\mathbf{E}}{4\pi} \right)^2 + c^2 \left( \frac{\mathbf{B}}{4\pi} \right)^2 \right]$$

(41)

Every calculation of mechanic properties involves a multiplication by $\hbar$. Since $\hbar$ is a scaling constant, the term "quantization", commonly used in this context, is misleading. Furthermore, it is completely irrelevant, whether we compute an integral property (the force in (40)), or a density ($\phi_{Rad}$ in (41)), a force density can also be obtained by replacing charge $q$ by a density value). What is, in a sense, discontinuous, is only the mass contained in the shell of the atom. But this mass depends, as does the amplitude of $\phi_{Rad}(r,t)$, on the mass of the atomic nucleus. Thus the only discontinuity left on the fundamental level, is the mass of atomic nuclei. That the energy spectrum of atoms is discrete, is a trivial observation in view of boundary conditions and finite radii.

All our calculations so far focus on single atoms. To get the values of mechanic variables in SI units used in macrophysics, we have to include the scaling between the atomic domain and the domain of everyday measurements. Without proof, we assume this value to be $N_A$, Avogadro’s number. The scale can be made plausible from solid state physics, where statistics on the properties of single electrons generally involve a number of $N_A$ particles in a volume of unit dimensions $[m^3]$. And a dimensionless constant does not show up in any dimensional analysis.

### 8 Dynamic gravity fields

The dynamic fields of mass in motion, and the interpretation of charge as a dynamic feature of mass has far-reaching consequences. In general relativity the connection between electrodynamics and gravity is obtained only via the energy stress tensor $T_{ab}$, according to Einstein’s equation [29].
Here $T_{ab}$ is related in a complicated manner to the electromagnetic fields at a given position. $G_{ab}$ describes the curvature of spacetime at the same position, which in turn is related to gravity. There is no direct way, in Einstein’s theory, from the electromagnetic to the gravitational properties of matter. Indirect routes have been explored in the past [30, 31, 32, 33], focusing on the notion of black holes and a length scale considerably below the atomic domain. To date, the only connection between microphysics and gravity is thought to exist in extreme environments, like the first few seconds after the big bang or the vicinity of a black hole. The interpretation of electric charge as a dynamic feature of mass, elaborated in the previous sections, allows a connection in standard situations. For the first time we may ask, whether the gravitational aspect of matter (= its mass) and the electromagnetic aspect (= its charge) are only different scales of the same physical feature: its oscillations.

Oscillations couple strongly to the environment of matter, therefore transport, dissipation and radiation effects should in principle alter the picture in a dynamic way. The fundamental question, in any such theory, is exactly the opposite one posed in static concepts. Static theories have difficulties with the question: How do things change? Dynamic theories, on the other hand, must answer the following one: How can things remain stable?

An answer to this puzzle could lie in the frequency, thus the time scale involved. It is well known that biological organisms utilise mainly electromagnetic or chemical interactions, the time scale for the life of these organisms is in the range of days to years. The frequencies involved in the interactions are around $10^{14}$ to $10^{15}$ Hz. The frequency is also the main parameter for the amplitude of the field of dynamic charge. From Eq. (24) we get:

$$|E| = \frac{qD}{r^2} \approx \frac{M\omega^2}{r^2}$$

The coupling between mass and gravity is much weaker than between charge and its electrostatic field. We have two ways, in principle, to estimate the difference: either we set mass and charge equal to 1 and compute the fields. Then the ratio between gravity and electrostatics is $\epsilon_0 G \approx 10^{-22}$. For the frequency of the dynamic gravity field we get consequently:

$$\omega_G \approx 10^{-11}\omega_E$$

Or we compute the ratio of the fields from the static equations, accounting for physical units by a constant $k_u$, which shall be purely dimensional. Then we have:

$$|E| = \frac{e}{4\pi\epsilon_0 r^2} := \frac{M\omega^2_E}{r^2} \quad |G| = \frac{GM}{r^2} := \frac{M\omega^2_G}{r^2} \quad \omega_G = \sqrt{\frac{4\pi\epsilon_0 GM}{e}} \omega_E$$

At present, we have no way to remove this ambiguity about the exact numerical value. Consequently, the scale $\eta$ between the two frequencies will be:
\[ \omega_G = \eta \cdot \omega_E \quad 10^{-14} \leq \eta \leq 10^{-11} \] (46)

Here \( \omega_E \) is the characteristic electromagnetic frequency, \( \omega_G \) its gravitational counterpart. The hypothesis can in principle be tested. If \( \nu_G \), the frequency of gravity radiation, is about \( \eta \) times the frequency of proton oscillation, we get:

\[ \nu_G \approx 10\text{Hz} - 10\text{kHz} \] (47)

The frequency is in the same range as the theoretical results based on general relativity \[34\]. Also the implications are the same: if fields of this frequency range exist in space, we would attribute these fields to stellar gravity. However, since there is no difference between electromagnetic waves and gravitational waves, apart from their frequency, we would also attribute electromagnetic waves in this range to gravity. To estimate the intensity of this, hypothetical, field, we use Eq. (23):

\[ G_S(r, t) = \frac{\partial}{\partial t} p_E(r, t) \] (48)

Here \( G_S \) is the solar gravity field. The momentum density and its derivative can be inferred from centrifugal acceleration.

\[ \frac{\partial}{\partial t} p_E(r, t) = \rho_E a_C \mathbf{e}_r, \quad \rho_E = \frac{3M_E}{4\pi R_E^3}, \quad a_C = \omega_E^2 R_O \] (49)

where \( R_O \) is the earth’s orbital radius and where we have assumed isotropic distribution of terrestrial mass. Then Eq. (22) leads to:

\[ \phi_G(r = R_O) = \frac{\hbar}{2} \left( \frac{G_S}{4\pi} \right)^2 = \frac{\hbar}{2} \left( \frac{3M_E R_O}{4R_E^3 \hbar} \right)^2 \] (50)

Note the occurrence of Planck’s constant also in this equation, although all masses and distances are astronomical. The intensity of the field, if calculated from (50), is very small. To give it in common measures, we compute the flow of gravitational energy through a surface element at the earth’s position. In SI units we get:

\[ J_G(R_O) = \phi_G(R_O) \cdot N_A \cdot c \approx 70\text{mW/m}^2 \] (51)

Compared to radiation in the near visible range - the solar radiation amounts to over 300 Watt/m\(^2\) \[35\] - the value seems rather small. But considering, that also radiation in the visible range could have an impact on terrestrial motion, the intensity of the gravity waves could be, in fact, much higher. Concerning the detectors of gravity waves, by now in operation at several locations around the world \[34\], the hypothesis involves a conjecture: not, that gravity waves have not been detected so far, because their intensity is so small, but because they are so ubiquitous. The
background noise, all experimental groups report as a major obstacle, could be the main experimental feature of gravity waves. If this is the case, then an unambiguous detection is not possible on earth. To that end, electromagnetic radiation in space is the only possible source for analysis.

Coming back to the question, how the solar system in a dynamic theory of gravity could be stable, we find that the frequency scale between gravity and electricity is very different. If the typical lifetime of a primitive organism based on chemical interactions is in the range of days, then the typical lifetime of an organism based on gravity would be in the range of billion years. This value is in the same order of magnitude as current estimates in cosmology about the typical lifetime of a small yellow star like our sun.

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