The Big Puzzle

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How do we start composing a jigsaw puzzle? It is certainly helpful if we see the picture of the puzzle when fully composed. If not, we may find it easiest and logical to search out the scheme of the picture from the corners with a wish that the parts will fit with each other when completed. In the big puzzle of physics, we are about to fit the highly tuned parts together to see whether they match, and what the total picture looks like – have we created a monster or a beauty, or something in between?

Antique philosophers tried to outline the total picture from fundamental principles. The limits of such an approach were met in a couple of hundred years and the efforts ceased for more than a thousand years. A fresh start in the late middle ages and early modern period turned the approach upside down by the groundbreaking works of Isaac Newton and his contemporaries. Mechanics and motion became linked to celestial structures and, at least as important, the power of mathematics as a tool for the description of physical phenomena became convincingly demonstrated.

Newton's work fixed the basic approach to mechanics and the related hypotheses for the next two hundred years and, in a less visible form, still today. Electromagnetism in the 1800s required its own postulates, and necessitated a re-evaluation of the Newtonian basis. A further diversification and challenge for the theories was brought by the 20th century's development of advanced instruments to observe at the extremes; microscopic structures, cosmological distances, and velocities approaching the velocity of light.

Primary pieces of the puzzle

Since antiquity, physics has been seen as a doctrine of matter and motion. Complemented with astronomy, physics is supposed to cover the descriptions of matter, motion, and space – and make the observable phenomena understandable. The antique description of matter was abstract; at a metaphysical level matter was described either by continuity and condensation of abstract *apeiron (Anaximander)* or *nous (Anaxagoras)* as the basic substances, or by separate, invisible and indivisible atoms *(Leucippus, Democritus, Epicurus)*. At a practical level matter was described in qualitative terms as combinations of earth, water, air, and fire *(Empedocles, Aristotle)*. Empirical studies of atoms became possible first in the late 19th century, and in more detail, in the 20th century.

In antiquity, the Earth was the solid basis and reference at rest. In the 1500s, Galileo Galilei noticed that any observer in uniform motion may regard his state as the state of rest. The Galilean relativity was inherited in Newton's laws of motion and further, after a redefinition of the concepts of time and distance, into Einsteinian relativity.

The present "corners" of the puzzle come from quantum mechanics for the structure of matter and its interactions with electromagnetic radiation, from electromagnetism for electrical and electronic systems, special and general relativity as refinements of classical mechanics and celestial mechanics, and from Friedman–Lemaître–Robertson–Walker (FLRW) cosmology, primarily as an extension of general relativity, Fig. 1.

The corner pieces of our puzzle

Each corner in our puzzle in Fig. 1 comprises assumptions in common and assumptions specific to the corner. Special relativity is well anchored to electromagnetism via the compatibility of Maxwell's equations [1] and observations on the velocity of light. General relativity and the FLRW cosmology have a broad boundary in common, simply because the latter is primarily a derivative of the first. One of the cornerstones of quantum mechanics is the Planck equation [2] that Max Planck saw as an independent or parallel equation with Maxwell's equations. Quantum mechanics is linked to classical mechanics via the Schrödinger equation [3] and to FLRW cosmology via Planck's equation that is needed in the interpretation of the dilution of radiation power in expanding space. The wave–particle duality in quantum mechanics complicates the definition of mass that in classical mechanics is linked to the inertial property, and in special relativity to the energy property.

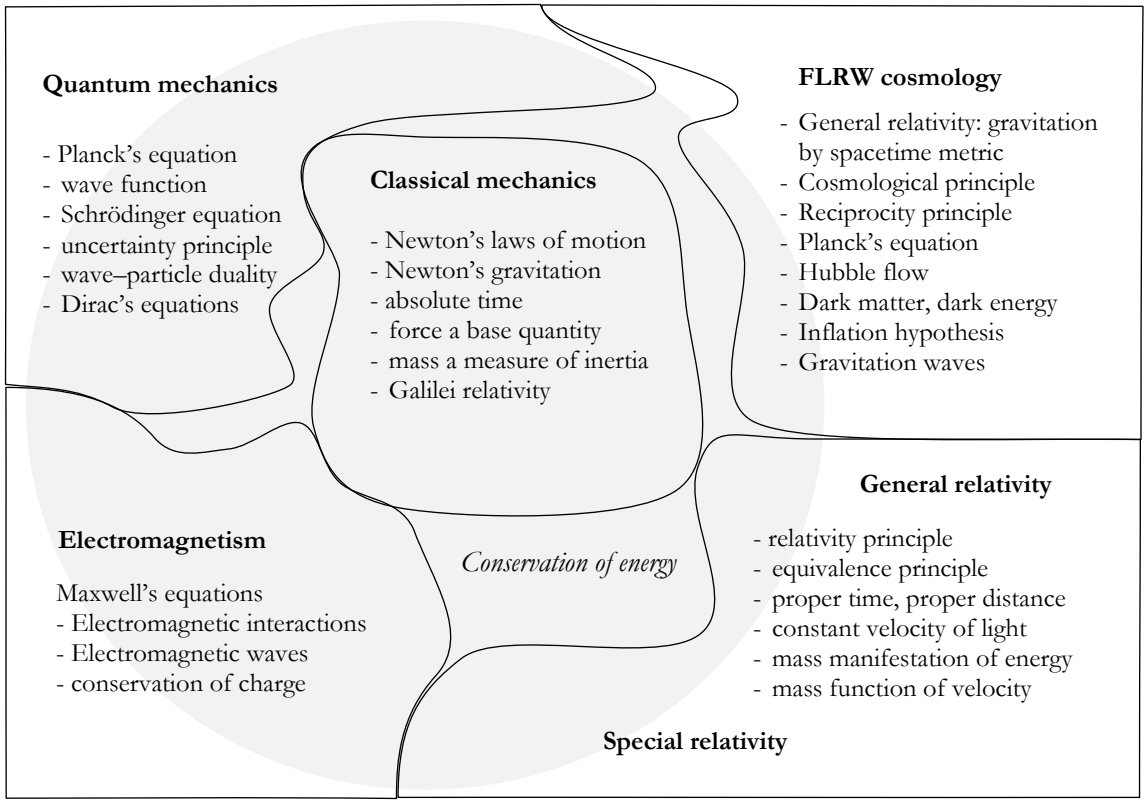


Figure 1. The puzzle. The roots of modern science are in classical mechanics and its derivatives like celestial mechanics, analytical mechanics, statistical mechanics, and thermodynamics. Diversification of physics into specific theory structures is illustrated as new pieces in the corners occupied by, electromagnetism, special and general relativity, quantum mechanics, and FLRW cosmology – each with their postulates – either new or derivatives from their classical counterparts, some adopted as empirical facts, some with a profound metaphysical basis [4]. Conservation of energy as an underlying law of nature applies in most parts of the puzzle; however, its application in relativistic systems is cumbersome and practically excluded in FLRW cosmology.

In the late 19th century the concept of energy and the conservation of energy were widely realized as underlying general principles that unified different parts of known physics. The roots of the energy principle, which is generally credited to Hermann Helmholtz [5], can be seen extending back to Aristotelian *entelecheia* [6] describing the actualization of potentiality and, e.g., in Gottfried Leibniz's equality of the cause and the effect [7].

Application of the conservation of energy as a unifying principle in our modern puzzle is complicated by the concepts of proper time and proper distance in the theory of relativity – it is also complicated by the interpretation of Planck's equation as an inherent property of radiation that leads to disappearance of the energy of radiation propagating in expanding FLRW space.

Re-evaluation of the pieces in our puzzle

In scientific evolution, the selections made, are based on the information available at the time of the selection. – Is there any chance for re-evaluation of postulates based on the information obtained after the choices or based on a more holistic view obtained by combining findings in different areas?

Linkage between Planck's equation and Maxwell's equations

In order to eliminate the ultraviolet catastrophe in Rayleigh and Jeans solution for the black body radiation, Max Planck assumed that the radiation in a black body cavity is controlled by monochromatic oscillators or resonators as the emitters and absorbers on the walls. He linked the frequency of individual oscillators to the energy available and thereby to the temperature and temperature distribution of the black body. In spite of his

serious attempts, however, Max Planck did not find support to his equation from Maxwell's equations that he highly respected – so he presented the equation as an *ad hoc* equation.

The trick in finding the linkage between Maxwell's equations and Planck's equation, $E=hf$, is in regarding Planck's atomic point-like oscillators as dipoles in the fourth dimension [8,9]. During the emission of one cycle, $\Delta T=1/f$, a point emitter moves distance $\Delta s=c\Delta T=c/f=\lambda$ in the fourth dimension, interpreted as a space-like dimension rather than the time-like dimension of special relativity.

In the standard solution of Maxwell's equations, the average energy flow from a dipole is

$$\left\langle \frac{dE}{dt} \right\rangle = P = c\int_{sphre} \frac{\Pi_0^2 \mu_0 \omega^4}{32\pi^2 r^2 c^2} \sin^2\theta \, d\theta = \frac{\Pi_0^2 \chi \mu_0 \omega^4}{32\pi^2 r^2 c} \int_{sphre} \sin^2\theta \, d\theta \tag{1}$$

where $\Pi_0 = Ne\chi_0$ is the peak value of the dipole momentum, e is the unit charge carried by an electron, N is the number of electrons, and χ_0 is the length of the dipole. We choose using the magnetic constant $\mu_0 = 1/\varepsilon_0 c^2$ instead of the electric constant ε_0. By further observing that $\omega = 2\pi f = 2\pi c/\lambda$, the total energy flow in one cycle of radiation can be obtained by dividing (1) by the frequency f as

$$E_\lambda = \frac{P}{f} = \frac{N^2 e^2 \chi_0^2 \mu_0 16\pi^4 f^4}{32\pi^2 r^2 c f} \frac{2}{3} 4\pi r^2 = N^2 \left(\frac{\chi_0}{\lambda}\right)^2 \frac{2}{3}\left(2\pi^3 e^2 \mu_0 c\right) f = N^2 A \cdot 2\pi^3 e^2 \mu_0 c \cdot f \tag{2}$$

For a one-wavelength dipole $(\chi_0/\lambda)=1$; for a dipole in the fourth dimension all space directions are on the normal plane of the dipole – so we may assume that the geometrical factor A of our antenna is close to unity. Making $A = 1.1049$, and $N=1$ (for one electron transition) equation (2) reduces to Planck's equation

$$E_\lambda = 1.1049 \cdot 2\pi^3 e^2 \mu_0 c \cdot f = h \cdot f = h_0 c \cdot f = \frac{h_0}{\lambda} c^2 \tag{3}$$

where $h = 1.1049 \cdot 2 \cdot \pi^3 e^2 \mu_0 c = 5.997 \cdot 10^{-34}$ [kgm/s^2] is the Planck constant. In the last two forms, the velocity of light, c, as a hidden factor in the Planck constant is removed, which reveals the intrinsic Planck constant $h_0 = h/c$, with the dimension of mass-distance [kg·m]. The last form of (3) is of special interest because, as a step towards unified expressions of energy, it is formally equal to the rest energy of mass $m_\lambda = h_0/\lambda$

$$E_\lambda = \frac{h_0}{\lambda} c^2 = m_\lambda c^2 \tag{4}$$

which is equal to the electromagnetic mass interpretation deduced by Henry Poincaré from Poynting's equation [10]. Applying the Planck constant in (3), the fine structure constant a obtains a form as a pure numerical factor

$$a \equiv \frac{e^2 \mu_0 c}{2h} = \frac{e^2 \mu_0}{2h_0} = \frac{e^2 \mu_0}{2 \cdot 1.1049 \cdot 2\pi^3 e^2 \mu_0} = \frac{1}{1.1049 \cdot 4\pi^3} \simeq \frac{1}{137.0360} \tag{5}$$

Importantly, Planck's equation should be understood as an expression for the energy conversion in the emission and absorption of electromagnetic radiation, *not as an intrinsic property of radiation propagating in space*. Following the conservation of energy, the conserved quantity is the mass equivalence of a cycle of radiation, which conserves the energy but dilutes the energy density in expanding space.

Interim balance:	hypothesis skipped:	- Planck's equation
	new hypothesis:	- dynamic interpretation of the time-like dimension

Unified expression of energy

Obviously, expression (4), showing the energy emitted into a cycle of radiation by a single electron transition reveals the close connection between mass and wavelength. Let's describe a cycle of electromagnetic radiation as an energy object with the momentum in the direction of propagation, which is expressed by introducing equation (4) in the form

$$E_\lambda = c \cdot |\mathbf{p}| = c \cdot |m_\lambda \mathbf{c}| = c \frac{h_0}{\lambda} \cdot |\mathbf{c}| \tag{6}$$

We found the physical interpretation of Planck's equation by interpreting the imaginary fourth dimension, the Einsteinian time-like dimension, as a hypothetical direction in which space moves at the velocity of light, c.

Adopting the idea of the hidden imaginary motion and by writing the rest energy of mass m into the form of an energy object moving at c in the direction of the imaginary fourth dimension

$$E_{m(rest)} = c \cdot |\mathrm{i}\,\mathbf{p}| = c \cdot |m\,\mathrm{i}\,\mathbf{c}| = c \frac{h_0}{\lambda_m} \cdot |\mathrm{i}\,\mathbf{c}| = c \cdot mc \tag{7}$$

which also shows the wavelength equivalence of mass m as the Compton wavelength $\lambda_m = h_0/m$. Adding momentum $\mathbf{p_r}$ in a space direction, the total momentum and the total energy appears as

$$E_{m(tot)} = c \cdot |\mathbf{p}_{tot}| = c \cdot |\mathrm{i}\,\mathbf{p}_{rest} + \mathbf{p}_r| = c\sqrt{(mc)^2 + p_r} = c \cdot (mc + \Delta mc) \tag{8}$$

Obviously, the total energy of a mass object can be expressed in terms of c and the complex momentum composed of an imaginary component and a real component, Fig. 2.

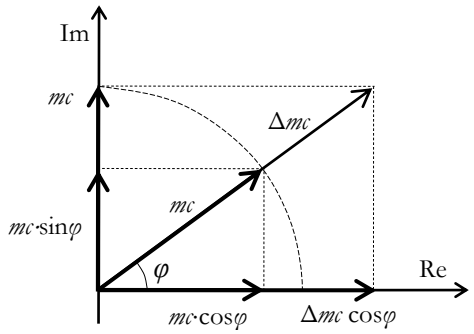


Figure 2. Total momentum $p = (m+\Delta m)c$ is built up from component mc originating from the rest momentum and component Δmc needed in obtaining the state of motion. If we conserve the velocity of light c, the velocity in space appears as the real component of the "turned" imaginary rest velocity $v = c\cdot\cos\varphi$, or $v = \beta c$, where $\beta = \sqrt{1-(v/c)^2}$.

The momentum in space creates an orthogonal component to i $\mathbf{p}_{rest}$ and turns the total momentum $|\mathbf{p}_{tot}| = |mc + \Delta mc|$ into an angle φ relative to the real axis. For honoring the constancy of the velocity light, we must assume that the increase of the total momentum has been obtained by mass contribution Δm needed to put the object into motion in space at velocity $v = c\cdot\cos\varphi$, or $v = c\sqrt{1-\beta^2}$.

Applying the intrinsic Planck constant h_0 and the electric constant μ_0 for Coulomb energy we get

$$E_c = N^2 \frac{e^2 \mu_0}{4\pi r} c^2 = N^2 a \frac{h_0}{2\pi r} c^2 = m_c c^2 \tag{9}$$

which means that acceleration of charged particles in electric field can be interpreted as the release of "mass substance m_c" from the Coulomb energy to the object accelerated.

Characteristic emission and absorption frequencies

Once the part $mc\cdot\cos\varphi$ of the rest momentum contributes to the momentum in space, the rest momentum in the imaginary direction is reduced, respectively

$$\mathrm{Im}\{mc_\varphi\} = mc \cdot \sin\varphi = mc\sqrt{1-\beta^2} \tag{10}$$

The momentum in space appears as

$$\mathrm{Re}\{mc_{\varphi(tot)}\} = (m + \Delta m)c \cdot \cos\varphi = mc \cdot \cos\varphi + \Delta mc \cdot \cos\varphi \tag{11}$$

As understood after Niels Bohr's semi-classical solution of the hydrogen atom in 1913, the characteristic emission and absorption frequencies of atomic objects are directly proportional to the rest energy or rest momen-

tum of the electron, and the transition between the quantum states $\Delta(n,m,l)$ determining the transition in the emission/absorption. In our dynamic approach it means that the frequencies are functions of velocity:

$$f_{\Delta(n.m,l)\beta} \propto m_{rest(\beta)}c \cdot F\left[\Delta(n,m,l)\right] = m_{rest(0)}c\sqrt{1-\beta^2} \cdot F\left[\Delta(n,m,l)\right] = \frac{h_0}{\lambda_{m(0)}}c\sqrt{1-\beta^2} \cdot F\left[\Delta(n,m,l)\right] \qquad (12)$$

I.e., atomic clocks in motion run slower due to the reduced rest energy – not because time would be different as taught by special relativity.

Interim balance:	hypotheses skipped:	- increase of mass is a consequence of motion - time dilation?
	new hypotheses:	- energy, momentum, and mass are described as complex quantities

Inertial work – and Mach's principle

In our analysis of the components of the total momentum of an object in motion we found that the mass input from the accelerating system contributed to the momentum in space by $\Delta mc \cdot \cos\varphi$ (11). What is the role of the imaginary component $\Delta mc \cdot \sin\varphi$ that looks like it were lost – or could it be related to the inertia? Philosophically, as expressed by *Mach's principle*, inertia is related to the presence of all other mass in space. For analyzing the interaction between a local mass object and the rest of space, let's have a look at Richard Feynman's ideas.

In his lectures on gravitation in the 1960s, Richard Feynman stated [11]:

"If now we compare the total gravitational energy $E_g = GM^2_{tot}/R$ to the total rest energy of the universe, $E_{rest} = M_{tot}c^2$, lo and behold, we get the amazing result that $GM^2_{tot}/R = M_{tot}c^2$, so that the total energy of the universe is zero. — It is exciting to think that it costs nothing to create a new particle, since we can create it at the center of the universe where it will have a negative gravitational energy equal to $M_{tot}c^2$. — Why this should be so is one of the great mysteries — and therefore one of the important questions of physics. After all, what would be the use of studying physics if the mysteries were not the most important things to investigate."

In the lectures he also pondered the possibility of a describing space as the 3-surface of a 4-sphere [12]:

"...One intriguing suggestion is that the universe has a structure analogous to that of a spherical surface. If we move in any direction on such a surface, we never meet a boundary or end, yet the surface is bounded and finite. It might be that our three-dimensional space is such a thing, a tridimensional surface of a four sphere. The arrangement and distribution of galaxies in the world that we see would then be something analogous to a distribution of spots on a spherical ball."

Let's combine Feynman's *great mystery* and *intriguing suggestion* in a dynamic framework [7] (close to what was proposed by Georges Lemaître in the 1920s [13] after Einstein's suggestion of spherically closed static space [14] in 1917). Once we integrate the gravitational energy of all mass in homogeneous space described as the closed 3-surface of a 4-sphere, we get

$$E_{g(m)} = -m\frac{GM''}{R_4} \quad \text{and for} \quad M_\Sigma = \sum_{space} m \quad \text{as} \quad E_{g(tot)} = -M_\Sigma \frac{GM''}{R_4} \qquad (13)$$

where $M'' = 0.776 \cdot M_\Sigma$ is the mass equivalence of the total mass at the center of the 4-sphere as seen by a test mass m anywhere in spherically closed space, Fig. 3. The zero-energy balance of the total rest energy and the total gravitational energy can be expressed as

$$E_{tot} = E_{rest(tot)} + E_{g(tot)} = M_\Sigma c^2 - M_\Sigma \frac{GM''}{R_4} = 0 \qquad (14)$$

As a confirmation of the zero-energy balance of the rest energy and the gravitational energy, we get c = 300 000 km/s by applying the current estimate of the average mass density in space. The dynamic interpretation of Feynman's zero-energy balance means that space expands or contracts at velocity c in the direction of the 4-radius. In the spirit of Aristotelian *entelecheia* or Leibnizian *vis viva – vis mortua* the rest energy of matter has been obtained against release of gravitational energy in a contraction phase and is now paid back to gravitation in the ongoing expansion phase. The expression of energy in space appears as an excitation of local rest energy against the gravitational energy due to the rest of space.

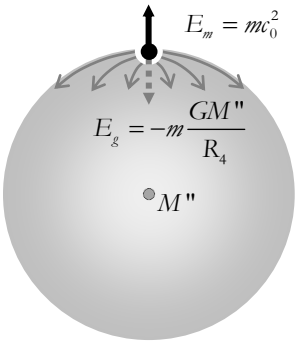


Figure 3. In spherically closed space the gravitational energy of mass m is calculated by integrating the gravitational potential due to all other mass

$$E_g = -\frac{2}{\pi}\frac{GmM_\Sigma}{R_4}\int_0^\pi \frac{\sin^2\theta}{\theta}\,d\theta = -\frac{GmM_\Sigma}{R_4}\,0.776 = -m\frac{GM''}{R_4}$$

The resulting gravitational energy is equal to the gravitational energy due to mass equivalent $M'' = 0{,}776 \cdot M_{total}$ in the center of the 4-sphere.
The dynamic balance occurs when the 4-velocity of space is

$$c_0 = \pm\sqrt{\frac{GM''}{R_4}}$$

The expansion velocity of space in the fourth dimension determines the velocity of light in space.

Any motion in spherically closed space is central motion relative to the 4-center of the structure. A short calculation shows that an object moving at velocity c in space moves like in a "satellite orbit", which means that the momentum in the local imaginary direction is cancelled by the gravitation of all the mass in space.

The imaginary component of the kinetic energy $\mathrm{Im}\{E_k\} = \mathrm{Im}\{c \cdot \Delta m \cdot c\}$ – is the inertial work (via central force) done against the gravitation of the mass in the rest of space – a quantitative expression of the Mach's principle! *Inertia is not a property of mass, but a manifestation of the energy balance in space.*

The dynamic solution means that the velocity of light decelerates with the expansion of space with the increasing 4-radius. At the present state of the expansion it decreases as $\Delta c/c \approx -3.6 \cdot 10^{-11}$ /year which, in principle, would be detectable – however, the frequency of atomic clocks as well as the rates other physical processes are proportional to the rest energy and, consequently, to the velocity of light.

Interim balance:	hypotheses skipped:	- the constancy of the velocity of light (with time)
		- inertia is a property of mass
		- mass is a form of energy
	new hypotheses:	- a zero-energy balance of motion and gravitation in spherically closed space
		- mass is a wavelike substance for the expression of energy

Local structures in zero-energy space

In the dynamic solution of Feynman's *great mystery*, the primary energy buildup was described as the contraction and expansion of spherically closed homogeneous space producing the rest energy of matter. For motion in space and the buildup of local mass centers and material structures we need motion in space directions. In homogeneous space, due to the spherical symmetry, the gravitational energy appears in the fourth dimension only (in the direction of the 4-radius). Buildup of any mass center means breakage of the symmetry and a related buildup of a real component to the complex gravitational energy. Conservation of the total zero-energy balance requires bending of local space in the vicinity of the mass center. The velocity of free fall and the corresponding momentum is now obtained against a reduction of the velocity of space in the local fourth dimension in curved space – which also means reduction in the local velocity of light, Figure 4. In the locally curved space the imaginary gravitational energy is

$$E''_{g(\psi)} = E_{g(0)} - \frac{GM}{R} = E_{g(0)}\left(1 - \frac{MR_4}{M''R}\right) = E_{g(0)}\left(1-\delta\right) \tag{15}$$

where R is the distance to the local mass center M, and the rest energy is

$$E_{rest(\psi)} = c_0\left|\mathbf{p}_\psi\right| = c_0 mc = c_0 mc_0\left(1-\delta\right), \quad \text{where } c = c_0 \cdot \cos\psi = c_0\left(1-\delta\right) \tag{16}$$

where c_0 is the velocity of light in non-curved space and c is the velocity of light in local space. Instead of getting generated by a mass input, the kinetic energy in free fall is obtained against the release of rest energy, which means that we need to abandon the equivalence principle! An interesting consequence is that celestial mechanics based on the zero-energy balance shows stable circular and elliptic orbits down to the critical radius of black holes.

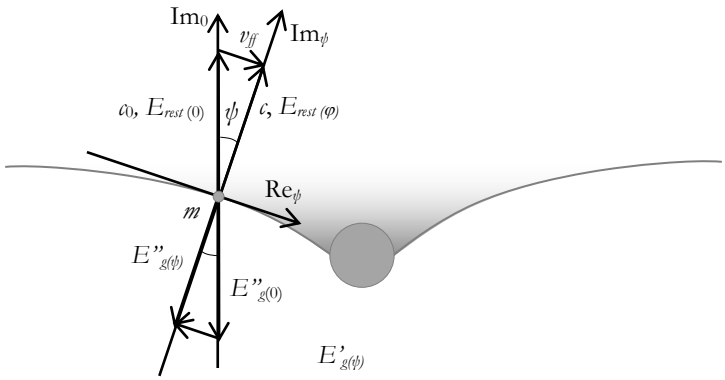


Figure 4. Bending of space in the vicinity of mass centers converts part of the velocity in the fourth dimension into velocity in space. The imaginary velocity of homogeneous space, c_0, is divided into orthogonal components: the local imaginary velocity of space, c, and the velocity of free fall v_{ff} in the direction of the tilted local space.

Buildup of mass centers occurs in several steps forming a system of nested gravitational frames – and by combining the effects of local motions, a system of nested energy frames. The rest energy of a mass m in a local energy frame can now be expressed as

$$E_{rest} = c_0 mc = c_0 m_0 c_0 \prod_{i=1}^{n} \left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{17}$$

which relates the local rest energy, via all the parent frames (like an accelerator frame, the Earth frame, the Solar frame, the Milky Way frame, etc.) to the rest energy at the state of rest in hypothetical homogeneous space.

The philosophical message of the zero-energy analysis is that relativity is a direct consequence of the conservation of the zero energy balance in space. Instead of expressing relativity in terms of distorted coordinate quantities, relativity is now expressed in terms of locally available rest energy.

Substitution of (17) for the rest energy of an electron in Balmer's equation gives the dependence of the clock frequencies on the motions and gravitational states of a clock. In a local frame like the Earth gravitational frame we get

$$f_{\delta,\beta} = f_{0,0}\left(1-\delta\right)\sqrt{1-\beta^2} \tag{18}$$

where $f_{0,0}$ is the frequency of the clock beyond the gravitational interaction of the Earth and at rest relative to the Earth. The corresponding equation for the dilated time in the framework of general relativity (Schwarzschild space) is

$$t_{\delta,\beta} = t_{0,0}\sqrt{1-2\delta-\beta^2} \tag{19}$$

that in the near Earth circumstances differs from (18) only in the 18th decimal.

Interim balance:	hypotheses skipped:	- relativity principle
		- equivalence principle
		- constancy of the velocity of light (within space)
		- proper time and proper distance
	new hypotheses:	- total energy is conserved in all interactions within space
		- time and distance are universal coordinate quantities

Cosmology and atomic structures under zero-energy postulates

We are about to fix the jigsaw puzzle by replacing the separate postulates in our corner pieces by the postulate of spherically closed space with the energies of motion and gravitation in a zero-balance. We have reconsidered the postulates behind special and general relativity and eliminated Planck's hypothesis by deriving Planck's equation from Maxwell's equations. We still need to check how these replacements affect the remaining parts of the puzzle – how they affect the predictions of cosmological observables and the formalism of quantum mechanics.

Cosmological observables

The local geometry of the zero-energy space is related to the local geometry of spacetime in the general theory of relativity. Predictions for the perihelion advance, the Shapiro delay, and the bending of light are essentially the same [7]. The prediction for the angular size [15,16] of objects in FLRW cosmology is subject to reciprocity [17] derived from special relativity, which makes the predicted angular size of non-expanding objects increase at redshifts exceeding $z > 2$. Local gravitational systems in the FLRW space do not expand with the expansion of space [18]. In zero-energy space [7] however, gravitationally bound local systems expand in direct proportion to the expansion of space, which together with an optical distance that is equal to the increase the 4-radius during the propagation of light leads to Euclidean appearance of galactic space [19], Fig. 5.

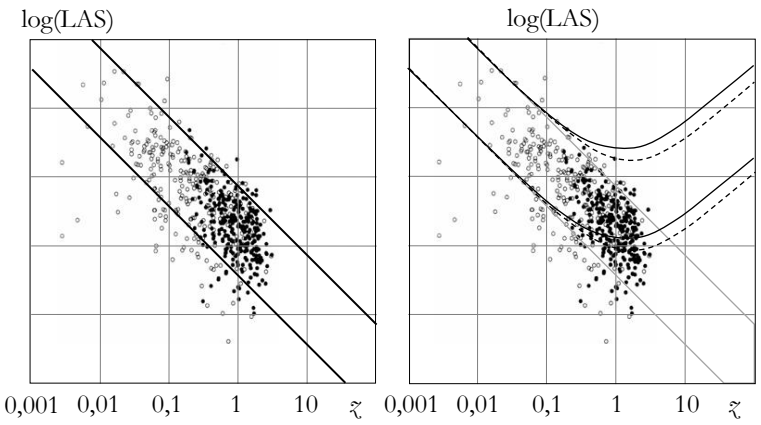


Figure 5. Dataset [14] of the observed Largest Angular Size (LAS) of quasars and galaxies in the redshift range $0.001 < z < 3$. Open circles are galaxies, filled circles are quasars. In (a) observations are compared with the Euclidean prediction in zero-energy space. In (b) observations are compared with the FLRW prediction with $\Omega_m=0$ and $\Omega_\Lambda = 0$ (solid curves), and $\Omega_m= 0.27$ and $\Omega_\Lambda= 0.73$ (dashed curves). As shown by the curves in (b) the density parameter in the FLRW cosmology have only minor effect on the angular sizes. The Euclidean prediction of the zero-energy (a) space prediction gives excellent match with observations.

In spherically closed space the prediction for apparent magnitude applicable to the *K*-corrected supernova observations obtains a simple, parameter free form [7]

$$m = M + 5\log\frac{R_4}{D_0} + 2.5\log\left[z^2\left(1+z\right)\right] \tag{20}$$

replacing the FLRW prediction [20]

$$m = M + 5\log\frac{R_H}{D_0} + 5\log\left[\left(1+z\right)\int_0^z \frac{1}{\sqrt{\left(1+z\right)^2\left(1+\Omega_m z\right) - z\left(2+z\right)\Omega_\Lambda}}\,dz\right] \tag{21}$$

Fig. 6 compares the predictions of (20) and (21) with observations [21]. It should be noted that the perfect fit of (20) with the observations means that space expands with decelerating rate due to the work expansion does against the gravitation of the system. There is no place for dark energy in zero-energy space.

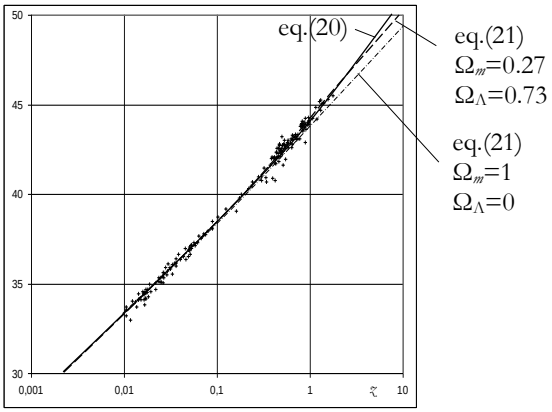


Figure 6. Magnitude observations of Ia supernovae and the predictions of the FLRW cosmology and the zero-energy space. The figure shows the distance modulus $\mu = m - M$, vs. redshift for Riess et al.'s "high confidence" dataset and the data from the Hubble Space Telescope. The optimum fit for the standard cosmology prediction is obtained with density parameters $\Omega_m=0.27$ and $\Omega_\Lambda=0.73$, shown by the dashed curve, the FLRW prediction with the "conventional" density parameters $\Omega_m=1$ and $\Omega_\Lambda=0$ shows slightly smaller values for the distance modulus. The zero-energy prediction is shown, by the solid curve. The zero-enrgy prediction does not have density parameters or any other additional parameters.

Quantum mechanics

Mass in zero-energy space obtains the role of a wave-like substance for the expression of energy. Mass objects are described as resonant mass wave structures, generally in spherical symmetry. In the complex function presentation, symmetry in three space directions appears as a sum function in the imaginary direction, e.g. the sum momentum of the opposite waves in a one-dimensional resonator is not cancelled but it appears as momentum or wave in the imaginary direction like the rest momentum of any mass object [7].

Let's see what happens, e.g., to a 1-dimensional resonator like a laser moving at velocity v in the direction of its axis in space. First, the frequency of the laser is reduced by the velocity as $f = f_0\sqrt{1-\beta^2}$. When observed in the parent frame the opposite waves in the resonator are subject to opposite Doppler shifts, which create a difference between opposite momentums, thus resulting in a net momentum in the direction of velocity v, Fig. 7. The net momentum can be interpreted either as the de Broglie wave propagating at velocity c, or more naturally, as a wave with wave number $k_\beta = k_0/\sqrt{1-\beta^2}$ propagating at velocity v in parallel with the moving resonator. The latter interpretation is of special interest as an explanation of the double slit experiment, Fig. 8.

Electronic states in atoms appear as energy minima of states fulfilling the mass wave resonance conditions.

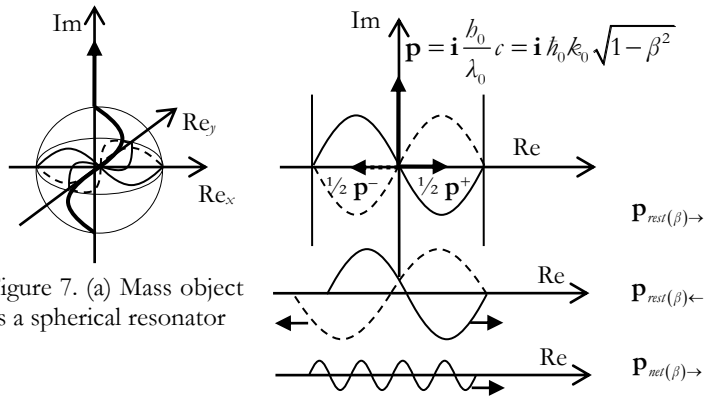


Figure 7. (a) Mass object as a spherical resonator

Figure 7. (b) Buildup of the momentum wave as the sum of Doppler shifted front and back waves.

$$\mathbf{p}_{rest(\beta)\rightarrow} = \tfrac{1}{2}\cdot\hbar_0 k_{rest(0)}\frac{\sqrt{1-\beta^2}}{1-\beta}c\,\hat{\mathbf{r}}$$

$$\mathbf{p}_{rest(\beta)\leftarrow} = -\tfrac{1}{2}\cdot\hbar_0 k_{rest(0)}\frac{\sqrt{1-\beta^2}}{1+\beta}c\,\hat{\mathbf{r}}$$

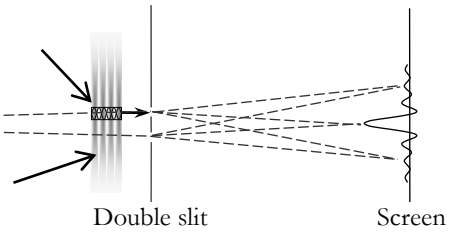
$$\mathbf{p}_{net(\beta)\rightarrow} = \hbar_0\frac{k_{rest(0)}}{\sqrt{1-\beta^2}}\beta c\,\hat{\mathbf{r}} = \frac{m_0 v}{\sqrt{1-\beta^2}}\hat{\mathbf{r}}$$

Figure 8. The double slit experiment

The rest momentum of the object $\mathbf{p}_{internal} = \hbar_0 k_{rest(0)} c\sqrt{1-\beta^2}\,\hat{\mathbf{r}}$

Source:

Momentum of the object in the frame of the source and the double-slit $\mathbf{p}_{external} = \hbar_0\frac{k_{rest(0)}}{\sqrt{1-\beta^2}}\beta c\;\hat{\mathbf{r}}$



Conclusions

If we are to keep the structures of existing theory, it would be hard to eliminate or change even a single postulate. Most probably, further development of the existing theories leads to even more postulates as can be seen in the recent development in cosmology. An option for fewer postulates and simpler theory structures can be found in an energy system approach, which, in principle, is based on the same insight as that behind Copernicus/Newton's success; the study of the wholeness to be modeled as a system, which allows the use of overarching conservation laws.

Keeping in mind that the purpose of scientific models is to make nature understandable, alternatives for the unintelligible relativistic spacetime construction and the somewhat artificial wave function would be warmly welcomed. For human conception, the base questions are What?, Where?, and When?. For the answer we need the quantity for substance, and the universal coordinate quantities for distance and time – just as reflected by the base SI units kilogram, meter, and second.

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