Predictions in cosmology

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Assuming that space in certain respects may be compared to a physical fluid, and picturing a particle (an electron, say) as a whirl in this "fluid," one may imagine spin, electric charge, and matter to be inherent properties of the whirl.

Spin would be visualized as a classical, cylindrically symmetric rotation [see Paper.pdf, p. 68]. Since a cylinder is described by a circle ($x^2 + y^2 = R^2$), this rotation is essentially two-dimensional and may be said to have two degrees of freedom ($f = 2$).

Similarly, electric charge would be a kind of spherically symmetric rotation with its number of degrees of freedom (f) equaling 3 (since a sphere is three-dimensional; $x^2+y^2+z^2 = r^2$).

Finally, matter would come in the form of rest energy produced by the electric charge.

Further development of this old [p. 59: 3.19] idea leads to a new understanding of particles and forces. It results in many new and detailed predictions. Some of these predictions should be directly testable, while some may be untestable.

In the strict sense of the word, a "prediction" in physics quantifies the outcome of a future human activity, such as an astrophysical observation, a laboratory experiment, or a theoretical calculation that hasn't yet been performed. Here, the word also is used in a more loose sense, occasionally taken to mean postdiction or retrodiction. Or, it may mean prediction of how certain properties of the elementary particles or the universe will be explained in tomorrow's text books in theoretical physics.

BASIC PREDICTIONS

The classical momentum equation (the fundamental hydrodynamic equation) for a nonviscous fluid on which no external forces act is [p. 29]

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \frac{1}{2}\nabla \boldsymbol{v}^2 + \frac{1}{\rho}\nabla p = 0. \tag{1}$$

It connects a fluid's velocity ($\boldsymbol{v}$) and pressure (p) to its density (ρ). After the pressure p has been eliminated [pp. 29, 58], the equation reads

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \frac{1}{2}v_0^2\,\nabla\left(\left(\frac{\boldsymbol{v}}{v_0}\right)^2 + f\left(\frac{\rho}{\rho_0}\right)^{2/f}\right) = 0. \tag{2}$$

For a stationary ($\partial \boldsymbol{v}/\partial t = 0$) flow that is irrotational or potential ($\nabla \times \boldsymbol{v} = 0$), Eq. (2) may be integrated to yield (with $\boldsymbol{v} = 0$ for $\rho = \rho_0$),

$$\rho = \rho_0 \left(1 - \frac{1}{f}\frac{\boldsymbol{v}^2}{v_0^2}\right)^{f/2} . \tag{3}$$

Assuming that, when $f = 3$, Eq. (3) describes the electron's charge with accompanying matter (that is, rest energy or rest mass) and, when $f = 2$, its spin with accompanying magnetic moment, the equation immediately suggests that there is more to the electron than charge and spin: For $f = 1$, Eq. (3)—which now reads $\rho = \rho_0(1 - \boldsymbol{v}^2/c^2)^{1/2}$—describes an essentially one-dimensional motion, which may only be interpreted as a radial flow of space out from the particle.

Thus, Eq. (3) predicts that—in addition to charge and spin—creation of space is a fundamental property of the electron. More generally, it suggests that energy creates space. The fact that space is continuously created explains, in turn, why the universe is expanding. Further, it is readily seen that expansion causes a force that can only be identified with gravity.

QED describes an electron as a cloud of virtual photons that generate the electron's charge and mass. Therefore, Eq. (3) does not describe an existing electron. However, it is natural to assume that the electron first appeared in the form of a stationary particle, which immediately transformed into a dynamical system while preserving its mass, charge, and spin in the transformation. And, indeed, the assumption that Eq. (3) describes such a "frozen" electron leads, directly or indirectly, to many new predictions in theoretical physics:

• **Prediction 1.** The electron's mass derives from its charge. Consequently, the JBW hypothesis [p. 7] holds true. The validity of this hypothesis (which is difficult to mathematically prove) has far-reaching consequences for QED theory and the theory of elementary particles in general.

• **Prediction 2.** The rate of expansion of the universe is determined solely—and exactly—by the energy density of the universe.

• **Prediction 3.** Gravity is repulsive over very vast cosmic distances [p. 13: Eq. (5.10), p. 14: Figure 5.1].

• **Prediction 4.** Gravity is the only existing long-range force. Therefore, proposed competing forces (such as cosmic repulsion, dark energy, or quintessence) do not exist.

• **Prediction 5.** As already predicted by Paul Dirac [pp. 7–8] in 1937, gravity weakens as the universe expands; $\dot{G}/G \propto -1/t$ [p. 19]. However, the present-day change in G is much slower than Dirac originally thought.

Experimental verification. The prediction is confirmed by the observation of an apparent acceleration in the universe's expansion rate—an illusion caused by the fact that, when their light was emitted, very distant stars shone brighter than today. It should be a straightforward task to calculate the rate of decrease in G from the observed illusionary acceleration. Other observations, too, seem to confirm the prediction [pp. 76–77: I.3.2]. Because of the slow change in G, direct measurement of $\dot{G}$ is difficult.

• **Prediction 6.** Today, gravity is about 10^{40} times weaker than the electromagnetic force. When it first began to act in the universe, gravity should have been only a few orders of magnitude weaker than the electromagnetic force and, therefore, more than 10^{30} times stronger than it is today.

• **Prediction 7.** Most of the universe's mass comes in the form of black holes that were produced by the originally strong gravity. This is a direct consequence of Dirac's large-number hypothesis of 1937.

Experimental verification. The prediction was experimentally confirmed in the early 1990s by Michael Hawkins who concluded that "about 99 percent of the universe consists of tiny primordial black holes" [pp. 78–80: I.3.3].

• **Prediction 8.** The universe has a density that corresponds to $\Omega = 2$ [p. 14], which is twice its commonly assumed density.

Experimental verification. Hawkins' observations seem to support the prediction, but more microlensing observations [pp. 26, 27] are needed to confirm it.

• **Prediction 9.** The rate of expansion slows down as the universe expands; $\dot{H}/H = \dot{G}/G \propto -1/t$ [p. 19], but the decrease in the Hubble expansion rate, H, is so slow that H appears to be constant in time [p. 49].

THE D AND LEPTON PHASES

The expansion of the universe causes the photon's wavelength to increase and its energy to decrease. To compensate for the decrease in radiation energy, the law of conservation of energy causes massive particles to grow in rest energy. An expanding universe in which all massive particles and antiparticles have annihilated each other violates the law, and is forced to instantly rematerialize.

The primordial D particle is its own antiparticle and evolves according to [p. 50: last lines] $\mathrm{D} \to \tau_0^+\tau_0^- \to \gamma_\tau\gamma_\tau \to \mu_0^+\mu_0^- \to \gamma_\mu\gamma_\mu \to \mathrm{e}^+\mathrm{e}^-\ \mathrm{e}^+\mathrm{e}^- \to \gamma\gamma$, with also direct decay of the D particle possible ($\mathrm{D} \to \gamma_\tau\gamma_\tau$). During its early evolution, the universe is in an indeterminate quantum state. The massive particles (D, τ_0, μ_0, and e) of the first three phases have no kinetic energy.

The two "heavy electrons" (τ and μ) and the photon-baryon number ratio (n_γ/n_b) bear witness to the early evolution of matter from a neutral, spinless D particle via charged, spinless tauons and muons to charged, spinning electrons that pairwise annihilate each other.

A simulation of the evolution of the universe must explain the orders of magnitude (10, 10^2, and 10^9) of the ratios m_τ/m_μ, m_μ/m_e, and n_γ/n_b. Not only is such a simulation possible [p. 44: Appendix F], but it is possible without resorting to freely adjustable parameters. This remarkable fact provides in itself strong support for the model. More important, it implies that the evolution of the universe is perfectly predictable and that all particle masses (expressed in units of m_e, say), as well as the strengths of all forces, are calculable.

• **Prediction 10.** The present-day Hubble expansion rate is [p. 19] $H_0 = 56.8$ km s^{-1} Mpc^{-1}, or $1/H_0 = 17.2$ Gyr.

• **Prediction 11.** The tauon-muon mass ratio (about 16.818) is theoretically calculable. Its initial value, about 16.919 [p. 45], should be computable from first principles to any desired accuracy [pp. 44–46]. For a failed attempt, see pp. 63–65.

• **Prediction 12.** The muon-electron mass ratio (about 206.768 28) is theoretically calculable. Its initial, uncorrected value is $1/B\alpha = 205.759\ 223$ and should be computable from first principles to any desired accuracy [pp. 44–46]. For a failed attempt, see pp. 63–65.

• **Prediction 13.** The fine-structure constant α (about 1/137.035 999 08) is theoretically calculable and should be computable from first principles to any desired accuracy [pp. 44–46, 48]. For a failed attempt, see pp. 63–65.

• **Prediction 14.** The computer simulation of the first three phases of the universe suggests that the lifetime of a pair of electron pairs ($e^+ e^-\ e^+ e^-$) in phase 3 is $(1/8\pi)\alpha^{-2}$ [p. 40: Eq. (E.15)] when the lifetime of a pair of spinless muons ($\mu_0^+ \mu_0^-$) in phase 2 is 1 [p. 46] with the two lifetimes expressed in natural time units, that is, in units of t_c [pp. 40–41].

Theoretical verification. The ratio of the coefficients—predicted to be $1/8\pi$ to 1—should be calculable from standard spinor and scalar QED theory [p. 41, 48: footnote 5].

Details. When comparing the two lifetimes, it should be remembered that two phase-2 muons produce four phase-3 electrons, which means that $m_{\mu_0} = m_2 = 2m_e$ [p. 18]. Also, it should be noted in the calculations that the real photons of phase 2 lack orbital angular momentum [pp. 20–21] and, in phase 3, the electrons ($e^+ e^-$) in a pair have parallel spins.

Note. The annihilation lifetimes should relate the natural time unit to our standard time unit—the second. That is, they should yield a precise value for t_c, which is conjectured to be about 10^{-19} s [p. 41].

• **Prediction 15.** The initial photon-baryon number ratio (n_γ/n_b) is theoretically calculable. The computer simulation suggests for it a value of about 2 786 275 000 [p. 53].

THE PION PARENTHESIS

In the fourth phase transition, energy conservation causes the appearance of quarks and the strong force. The accompanying, weakly interacting Higgs and neutrinos provide a means of energy transfer between leptons and quarks. In the leptoweak and hadroweak interactions that may still be observed, particle masses and other "weak parameters" contain detailed information about the events leading up to our present, stable universe.

In the phase transition, and in the events that rapidly followed, the last phase-3 electrons evolve according to $e^+e^-\ e^+e^- \to \pi^+\pi^-\ \pi^+\pi^- \to \gamma\gamma\ \pi^+\pi^-$ and $\pi^+\pi^- \to p\bar{p} \to pe^-$ + radiation in processes governed by conservation of energy. Computer simulation of the universe suggests the details:

• **Prediction 16.** The appearance of the Higgs boson releases from the universe's nearly three billion photons the energy $4(m_\pi - m_e)c^2$ that the strong force needs to convert the originally "frozen" pions into dynamical systems of quarks and gluons [p. 39: Eq. (E.7)].

Experimental verification. The energy transfer causes a decrease, $\Delta(m_\mu/m_e) = -0.000\,2076$ [p. 34], in the measured muon-electron mass ratio.

• **Prediction 17.** The Higgs boson transferred mass (or rest energy) from the leptons to the quarks. Conservation of mass means that the Higgs mass (m_H) is directly obtained from the decrease in lepton mass. That is, $m_H(l) = -\Delta m_l$, or [p. 33: Appendix C],

$$\begin{aligned} m_H(\tau) &= 0.505 \text{ MeV}/c^2, \\ m_H(\mu) &= 106 \text{ eV}/c^2, \\ m_H(e) &= 12 \times 10^{-6} \text{ eV}/c^2 \end{aligned} \tag{4}$$

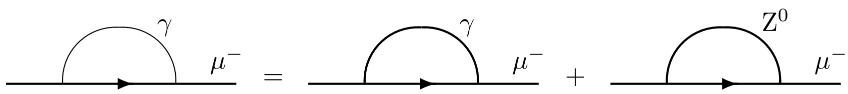
for a Higgs particle emitted by a tauon, muon, and electron, respectively.

• **Prediction 18.** The Fermi coupling constant (G_F) is calculable from Eq. (E.14).

Details. In the paper, the value of Δy given in Eq. (E.17) is obtained from Eq. (E.14). An improved theoretical treatment (yielding precise lifetimes) of the processes occuring in the "pion parenthesis" should give a precise Δy value, thus making it possible to calculate G_F from Eq. (E.14).

• **Prediction 19.** To save the last remaining pion pair from annihilation (and matter from extinction), energy conservation forces one of the pions to switch parity. The parity flipping is accomplished by the Z^0 boson.

Theoretical and experimental verification. Conservation of mass requires that the γ and Z gauge bosons together produce the same lepton mass that γ had previously produced alone:



It means that the massive (Z^0) and the massless (γ) photons must mix in such a way that no change in lepton mass occurs and that, consequently, the Z mass should be theoretically predictable (when the value of G_F is known).

• **Prediction 20.** After a brief delay, the weak parity-switching force causes the second pion to flip its parity, too.

Theoretical verification. The simulation program yields a prediction for this time delay that should be possible to theoretically confirm [p. 42].

• **Prediction 21.** The simulation program demonstrates that the delay between the two parity switchings introduces a small particle-antiparticle asymmetry—a CP violation [p. 60: 4.27].

Theoretical and experimental verification. Weak theory should explain the consequences of the CP violation. Assumingly, it is this effect that causes the "superweak force" that has long been observed in kaon decay.

• **Prediction 22.** The transformation of the pion pair into a proton pair requires an energy transfer that is carried out by three more Higgs bosons [p. 39: Eq. (E.8)].

Experimental verification. The energy transfer causes a further decrease in m_μ/m_e of three times the initial decrease. That is, a total correction of four times $-0.000\ 2076$, or $-0.000\ 830$, to the muon-electron mass ratio is attributed to Higgs mass transfer [p. 56: I.02].

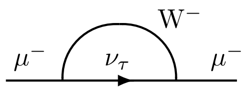
• **Prediction 23.** The three Higgs bosons transport more energy than is needed to transform the pion pair into a proton pair. The excess energy is restored to the leptons in the form of rest energy transported by neutrinos. The masses of the neutrinos are

$$\begin{aligned} m_{\nu_\tau} &= 0.065\ \text{MeV}/c^2, \\ m_{\nu_\mu} &= 38.5\ \text{eV}/c^2, \\ m_{\nu_e} &= 13 \times 10^{-6}\ \text{eV}/c^2. \end{aligned} \tag{5}$$

• **Prediction 24.** The mass brought back by the neutrinos causes an increase of 0.000 074 in the muon-electron mass ratio, yielding its final theoretical value, $m_\mu/m_e = 205.759\ 223 + 1.009\ 816 - 0.000\ 830 + 0.000\ 074 = 206.768\ 283$ [p. 56: I.02].

Experimental verification. The result matches the observed value of 206.768 282(5) and predicts a more precise value for it.

• **Prediction 25.** The purpose of the W particle is to enable a charged lepton (the muon, say) to, via the self-mass diagram



absorb the mass restored by the neutrino.

Theoretical verification. From the known strength of the weak interaction (the Fermi coupling constant G_F) and the mass of the neutrino, it should be possible to theoretically obtain the mass of the W particle and the weak mixing parameter $\sin^2\theta_W = 1 - m_W^2/m_Z^2$.

THE PROTON-ELECTRON PERIOD

With the antiproton's decay back into an electron, the universe enters a state of stable matter. Via a detailed simulation of the formation and evaporation of black holes in the young universe, it should be possible to establish a connection between cosmic time and atomic time—or global time and local time [pp. 48–49]. When the connection is known, the time variation of G is directly obtained [p. 19: Eq. (7.24)]. The variation may be too slow to be directly measurable, but it should reveal itself as an effect that makes very distant galaxies appear slightly brighter than they otherwise would.

This effect, in turn, should prove that the apparent acceleration is an illusion, and confirm prediction 10: The present-day Hubble expansion rate is H_0 = 56.8 km s^{-1} Mpc^{-1}, or $1/H_0$ = 17.2 Gyr.