The Higgs scalar field with no massive Higgs particle

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The postulate that all massless elementary fields have conformal Weyl local scaling symmetry has remarkable consequences for both cosmology and elementary particle physics. Conformal symmetry couples scalar and gravitational fields. Implications for the scalar field of a conformal Higgs model are considered here. The energy-momentum tensor of a conformal Higgs scalar field determines a cosmological constant. It has recently been shown that this accounts for the observed magnitude of dark energy. The gravitational field equation forces the energy density to be finite, which precludes spontaneous destabilization of the vacuum state. Scalar field fluctuations would define a Higgs tachyon rather than a massive particle, consistent with the ongoing failure to observe such a particle.

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INTRODUCTION

The standard model of spinor and gauge boson fields has higher symmetry than does Einstein gravitational theory. For massless fields with definite conformal character action integrals are invariant under local Weyl (conformal) scaling, $g_{\mu\nu}(x) \rightarrow g_{\mu\nu}(x)e^{2\alpha(x)}$. A conformal energy-momentum tensor is traceless, while the Einstein tensor is not.

Compatibility can be imposed in gravitational theory by replacing the Einstein-Hilbert field action by a formal energy-momentum tensor which is traceless, while the Einstein tensor is not. Conformal gravity accounts for anomalous galactic rotation velocities without invoking dark matter. Relativistic phenomenology at the distance scale of the solar system is preserved.

An inherent conflict between gravitational and elementary particle theory is removed if all massless elementary fields have conformal symmetry. Standard cosmology postulates uniform, isotropic geometry, described by the Robertson-Walker (RW) metric tensor. In RW geometry, conformal gravitational $L_g$ vanishes identically, but the residual gravitational effect of a conformal scalar field is consistent with Hubble expansion, dominated in the current epoch by dark energy, with negligible spatial curvature.

In electroweak theory, the Higgs mechanism introduces an SU(2) doublet scalar field $\Phi$ that generates gauge boson mass. Postulating universal conformal symmetry for massless elementary fields, these two scalar fields can be identified. Lagrangian density $L_\Phi$ for conformal scalar field $\Phi(x) \rightarrow \Phi(x)e^{-\lambda(x)}$ includes a term dependent on Ricci scalar $R = g_{\mu\nu}R^{\mu\nu}$, where $R^{\mu\nu}$ is the gravitational Ricci tensor. In uniform, isotropic geometry this determines a modified Friedmann cosmological evolution equation consistent with cosmological data back to the microwave background epoch.

Implications for the standard electroweak model are examined here. The Higgs model Lagrangian density contains $\Delta L_\Phi = (w^2 - \lambda \Phi^\dagger \Phi)\Phi^\dagger \Phi$, where $w^2$ and $\lambda$ are undetermined positive constants. Units here set $\hbar = c = 1$. Lagrangian term $\lambda(\Phi^\dagger \Phi)^2$ is conformally covariant. $w^2 \Phi^\dagger \Phi$ breaks conformal symmetry, but can be generated dynamically. Conformal symmetry requires a term $-\frac{1}{6}R\Phi^\dagger \Phi$. Empirical cosmological $R > 0$, so $-\frac{1}{6}R$ and $w^2$ have opposite signs. A consistent theory must include $(w^2 - \frac{1}{6}R)\Phi^\dagger \Phi$.

The conformal scalar field equation has exact solutions such that $\Phi^\dagger \Phi = \phi_0^2 = (w^2 - \frac{1}{6}R)/2\lambda$, if this ratio is positive and $R$ is treated as a constant. Only the magnitude of $\Phi$ is determined. For $\phi_0^2 > 0$, a modified Friedmann cosmic evolution equation has been derived and solved to determine cosmological parameters. The residual constant term in conformal energy-momentum tensor $\Theta_\Phi^{\mu\nu}$ defines a cosmological constant (dark energy) if $\phi_0^2 > 0$. Nonzero $\phi_0^2$ produces gauge boson masses.

Conformal theory identifies $w^2$ with the empirically positive cosmological constant, but does not specify the algebraic sign of parameter $\lambda$. For the Higgs mechanism, condition $\phi_0^2 = (w^2 - \frac{1}{6}R)/2\lambda > 0$ requires the sign of $\lambda$ to agree with $w^2 - \frac{1}{6}R$. The scalar field energy density determined by the coupled equations derived here is necessarily finite for any real value of $\lambda$. This precludes destabilization of the vacuum.

Fluctuations $\delta \phi \rightarrow 0$ about an exact solution of the scalar field equation satisfy $\partial_\mu \partial^\mu \delta \phi \rightarrow -4\lambda \phi_0^2 \delta \phi$. If $\lambda > 0$ this is a Klein-Gordon equation with $m^2 = 4\lambda \phi_0^2 = 2(w^2 - \frac{1}{6}R)$, which defines a Higgs boson if $R < 6w^2$. In the conformal Higgs model, empirical values of parameters $w^2$, $R$, and $\phi_0^2$ determine parameter $\lambda$. It is argued here that these parameters, now well-established from cosmological and electroweak data, imply $\lambda < 0$, consistent with an earlier formal argument.

Hence fluctuations of a conformal Higgs scalar field do not satisfy a Klein-Gordon equation. This rules out a standard Higgs particle of any real mass. Negative $m^2$ or finite pure imaginary mass, would define a tachyon, if such a particle or field could exist, and might justify an experimental search for such a tachyon.
THE MODIFIED FRIEDMANN EQUATION

In cosmological theory, a uniform, isotropic universe is described by Robertson-Walker (RW) metric
\[ ds^2 = dt^2 - a^2(t)(\frac{dr^2}{1 - kr^2} + r^2d\Omega^2), \]
if \( c = h = 1 \) and \( dw^2 = d\theta^2 + \sin^2 \theta d\phi^2 \). Gravitational field equations are determined by Ricci tensor \( R^\mu{}_{\nu} \) and scalar \( R \). The RW metric defines two independent functions \( \xi_0(t) = \frac{a}{\alpha} \) and \( \xi_1(t) = \frac{a^2}{\alpha} + \frac{k}{\alpha} \), such that \( R^{00} = 3\xi_0 \) and \( R = 6(\xi_0 + \xi_1) \). The field equations reduce to Friedmann equations for scale factor \( a(t) \) and Hubble function \( h(t) = \frac{\dot{a}}{a} \).

If the scalar field required by Higgs symmetry-breaking has conformal symmetry, its action integral \( I_a \) must depend on the Ricci scalar, implying a gravitational effect. Because conformal gravitational action integral \( I_g \) vanishes identically in RW geometry, it is consistent to assume that uniform cosmological gravity is determined by this scalar field.

Including term \( \int(u^2 - \frac{1}{3}R)\Phi \Phi^* \) in \( L \), the field equation for scalar function \( \Phi = \phi_0 \) is a global solution. Generalizing the希尔bert construction, and neglecting the cosmological time derivative of \( R \), constant \( \Phi = \phi_0 \) is a modified Friedmann equation. The modified Friedmann equation is
\[ \frac{\dot{r}}{r} = \frac{\kappa}{3} \rho - \frac{2\bar{\Lambda}}{3} \]

Variational formalism of classical field theory is easily extended to the context of general relativity. The metric functional derivative \( \frac{-1}{\sqrt{-g}g^{\mu\nu}} \) of generically determined Friedmann equations.

The gravitational field equation driven by energy-momentum tensor \( \Theta^\mu{}_{\nu} \) for uniform matter and radiation is \( X^\mu{}_{\nu} = \frac{1}{2} g^{\mu\nu}L \), if \( \delta L = \Theta^\mu{}_{\nu}g_{\mu\nu} \). The energy-momentum tensor is \( \Theta^\mu{}_{\nu} = -2X^\mu{}_{\nu} \). Varying \( g_{\mu\nu} \) for fixed scalar field solution \( \Phi \), metric functional derivative
\[ X^\mu{}_{\nu} = \frac{1}{6} R^\mu{}_{\nu} \Phi \Phi^* + \frac{1}{2} g^{\mu\nu}L \]
implies modified Einstein and Friedmann equations.

The gravitational field equation driven by energy-momentum tensor \( \Theta^\mu{}_{\nu} = -2X^\mu{}_{\nu} \) for uniform matter and radiation is \( X^\mu{}_{\nu} = \frac{1}{2} \Omega^\mu{}_{\nu} \). Since \( \Theta^\mu{}_{\nu} \) is finite, determined by fields independent of \( \Phi \), \( X^\mu{}_{\nu} \) must be finite, regardless of any parameters of the theory. This precludes spontaneous destabilization of the conformal Higgs model.

Defining \( \bar{\kappa} = -3\phi_0^2 \) and \( \bar{\Lambda} = \frac{2}{3} u^2 \), the modified Einstein equation is
\[ R^\mu{}_{\nu} - \frac{1}{4} R g^\mu{}_{\nu} + \bar{\Lambda} g^\mu{}_{\nu} = -\bar{\kappa} \Theta^\mu{}_{\nu} \]

Traceless conformal tensor \( R^\mu{}_{\nu} - \frac{1}{4} R g^\mu{}_{\nu} \) here replaces the Einstein tensor of standard theory. Cosmological constant \( \bar{\Lambda} \) is determined by Higgs parameter \( u^2 \). Non-standard parameter \( \bar{\kappa} < 0 \) is determined by the scalar field solutions. For energy density \( \rho = \Theta^0{}_{0} \), this implies \( \frac{-u^2}{3}(R^{00} - \frac{1}{4} R) = \xi_1(t) - \xi_0(t) = \frac{2}{3}(\bar{\kappa} \rho + \bar{\Lambda}) \). Hence uniform, isotropic matter and radiation determine the modified Friedmann cosmic evolution equation
\[ \xi_1(t) - \xi_0(t) = \frac{\dot{a}^2}{a^2} + \frac{k}{a^2} = \frac{2}{3}(\bar{\kappa} \rho + \bar{\Lambda}) \]

Because the trace of \( R^\mu{}_{\nu} - \frac{1}{4} R g^\mu{}_{\nu} \) is identically zero, a consistent theory must satisfy the trace condition \( g_{\mu\nu} \bar{\Lambda} g^{\mu\nu} = 4\bar{\Lambda} = -k_{\mu\nu} \Theta^\mu{}_{\nu} \). From the definition of an energy-momentum tensor, this is just the trace condition satisfied in conformal theory \( \bar{\kappa} \). \( g_{\mu\nu} (X^\mu{}_{\nu} + X^\mu{}_{\nu}) = 0 \). Vanishing trace eliminates the second Friedmann equation derived in standard theory. Although the \( u^2 \) term in \( \Delta \Phi \) breaks conformal symmetry, a detailed argument shows that the trace condition is preserved.

FITS TO COSMOLOGICAL DATA

The modified Friedmann equation determines dimensionless scale parameter \( a(t) = 1/(1 + z(t)) \), for redshift \( z(t) \), and function \( h(t) = \frac{\dot{a}}{a} \) in units of current Hubble constant \( H_0 = 70.5 \text{ km/s/Mpc} \), such that \( z = 0, a = 1, h = 1 \) at present time \( t_0 \). Distances here are in Hubble units \( c/H_0 \).

The modified Friedmann equation depends on dimensionless parameter, fitted to cosmological data for \( z \leq 50: \alpha = 3/5 \), \( \beta = -2/5 \), \( \gamma = 3/4 \), \( t_0 = 1090 \). \( z \) characterizes the cosmic microwave background, at \( t_*, \) when radiation became decoupled from matter. \( \rho_b(t_0) \) is the ratio of baryon to radiation energy densities. Empirical value \( R_b(t_0) = 688.6 \) is assumed. Scaled energy densities \( \rho_m \) and \( \rho_r \), for matter and radiation respectively, are constant. In the absence of dark matter, \( \rho_m \approx \rho_b \), the baryon density.

The parametrized modified Friedmann equation is
\[ \frac{\dot{a}^2}{a^2} - \frac{\dot{a}}{a} = -d \frac{dt}{a} = \dot{a} = a - \frac{k}{a^2} - \frac{\beta}{a^3} - \frac{\gamma}{a^4} \]

Dividing this equation by \( h^2(t) \) implies dimensionless sum rule
\[ \Omega_m(t) + \Omega_r(t) + \Omega_\Lambda(t) + \Omega_k(t) + \Omega_q(t) = 1 \]

where \( \Omega_m(t) = \frac{2 \rho_m(t)}{3 H^2(t)} < 0 \), \( \Omega_r(t) = \frac{2 \rho_r(t)}{3 H^2(t)} < 0 \), \( \Omega_\Lambda(t) = \frac{\bar{\Lambda}}{H^2(t)} > 0 \), \( \Omega_k(t) = -\frac{\bar{\kappa}}{H^2(t)} \), and \( \Omega_q(t) = \frac{\bar{\kappa}}{a^2} = -q(t) \). In contrast to the standard sum rule, \( \Omega_m \) and \( \Omega_r \) are negative, while acceleration parameter \( \Omega_q(t) \) appears explicitly.

Hubble expansion is characterized by type Ia supernovae by scaled luminosity distance \( d_L \) as a function of redshift \( z \). Here \( d_L(z) = (1 + z)d_L \), for geodesic distance \( d_L \) corresponding to \( r_s = \int dt/a(t) \), integrated from \( t_s \) to \( t_0 \). In curved space \( (k < 0) \), \( d_L = \frac{\sinh(\sqrt{-k}r_s)}{\sqrt{-k}} \). In the
standard $\Lambda CDM$ model, radiation density and curvature $\Omega_k$ can be neglected in the current epoch ($z \leq 1$). This reduces the sum rule to $\Omega_\Lambda + \Omega_m = 1$. Empirical value $\Omega_\Lambda = 0.726$ forces $\Omega_m$ to be much larger than can be accounted for by observed matter, providing a strong argument for dark matter. Mannheim [1, 11] questioned this implication, and showed that observed luminosities could be fitted equally well for $z \leq 1$ with $\Omega_m = 0$, using the standard Friedmann equation. However, sum rule $\Omega_\Lambda + \Omega_q = 1$ then requires an empirically improbable large curvature parameter $\Omega_k$. Empirical limits are $\Omega_k \approx \pm 0.013$.

This issue was examined by solving the modified Friedmann equation with parameters $k, \beta, \gamma$ set to zero. $\Omega_\Lambda$ is determined by the solution. The modified sum rule $\Omega_\Lambda + \Omega_q = 1$ then presents no problem. Computed $d(z)$ agrees with Mannheim’s empirical function for $z \leq 1$ to graphical accuracy, using parameter $\alpha = \Omega_\Lambda(t_0) = 0.732$ for $\Omega_k(t_0) = 0$. This is consistent with current empirical values $\Omega_\Lambda = 0.726 \pm 0.015, \Omega_k = -0.005 \pm 0.013$. $\Omega_m$ and $\Omega_q$ can apparently be neglected for $z \leq 1$.

$t = 0$ is defined by $h(t) = 0$ in the conformal model, which describes an initial inflationary epoch. The modified Friedmann equation was solved numerically for $0 \leq t \leq t_0$, with parameters fitted to $d(z)$ for $z \leq 1$, to shift parameter $R(z)$ [12], and to acoustic scale ratio $f_A(z)$ [12]. This determines model parameters $\alpha = 0.7171, k = -0.01249, \beta = 0.3650 \times 10^{-6}$, fixed at $\gamma = 3 \beta / 4 R_0(t_0)$, which neglects dark matter, parameter $\gamma = 0.3976 \times 10^{-8}$. There is no significant inconsistency with model-independent empirical data [4].

Defining $\zeta = \frac{1}{2} R - w^2$, the dimensionless sum rule determines $\zeta = \xi_0 + \zeta_1 - w^2 = h(t)^2(2\Omega_q + \Omega_m + \Omega_r)$. For $a \to 0$, when both $\alpha$ and $k$ can be neglected, the sum rule implies $\zeta = h(t)^2(\Omega_\Lambda + 1)$. For large $a$, $\zeta = h(t)^2(2\Omega_q)$. $\zeta > 0$ in both limits, regardless of numerical values, since $\Omega_m > 0$. The present empirical parameters imply that $\zeta$ is positive for all $\xi_0$.

Conformal symmetry is consistent with any real value of parameter $\lambda$. However, in electroweak theory Higgs symmetry-breaking requires nonvanishing conformal scalar field $\Phi$. A positive value of $\zeta$ implies

$$\lambda \phi_0^2 = -\frac{1}{2} \left( w^2 - \frac{1}{6} R \right) = -\frac{1}{2} \zeta < 0.$$  

As argued above, for $\phi_0^2 > 0$ this conflicts with existence of the hypothetical massive Higgs boson.

**Dynamical Estimate of Parameter $w^2$**

Since term $w^2 \Phi^4 \Phi$ in standard parametrized $\Delta L$ breaks conformal symmetry, it must be generated dynamically in a consistent theory [10]. As shown above, this term accounts for dark energy. Dynamically induced $w^2$ preserves the conformal trace condition [7].

The Higgs model deduces gauge boson mass from an exact solution of the parametrized scalar field equation [10]. For interacting fields, this logic can be extended to deduce nominally constant field parameters from a solution of the coupled field equations. Such a solution of nonlinear equations does not depend on linearization or on perturbation theory.

Interaction of scalar and gauge boson fields defines a quasiparticle scalar field in Landau’s sense: $\Phi$ is dressed via virtual excitation of accompanying gauge fields. The derivation summarized here considers gravitational field $g_{\mu \nu}$ interacting with scalar field $\Phi$ and $U(1)$ gauge field $B_\mu$. Solution of the coupled semiclassical field equations [12] gives an order-of-magnitude estimate of parameter $w^2$, in agreement with the empirical cosmological constant, while confirming the Higgs formula for gauge boson mass [10].

The conformal Higgs model assumes incremental Lagrangian density $\Delta L_{\Phi} = w^2 \Phi^4 \Phi - \lambda (\Phi^2 \Phi^2)^2$, with undetermined numerical parameters $w^2$ and $\lambda$. The implied scalar field equation is $\partial_\mu \partial^\mu \Phi + R \Phi = \frac{1}{\sqrt{g}} \frac{\delta \Delta L_{\Phi}}{\delta \Phi^*} = (w^2 - 2\lambda \Phi^2 \Phi) \Phi$. If $R, w^2, \lambda$ are constant, this has an exact solution $\Phi^2 = \phi_0^2 = (w^2 - \frac{1}{2} R)/2\lambda$, if this ratio is positive. For massive complex vector field $B_\mu$, parametrized $\Delta L_{B \mu}$ implies field equation $\partial_\mu B^{\mu \nu} = \frac{w^2 R}{\sqrt{-g}} \delta \Delta L_{B \mu}$. For interacting fields, both $\Delta L_{\Phi}$ and $\Delta L_{B \mu}$ can be identified with incremental Lagrangian density $\Delta L = \frac{i}{2} g_{\mu \nu} \partial_\mu (\partial_\nu \Phi)^\dagger \Phi - \frac{i}{2} g_{\mu \nu} \Phi^\dagger \partial_\nu \Phi + \frac{1}{4} g_{\mu \nu} \Phi^\dagger \Phi B_{\mu \nu}$, due to covariant derivatives, with coupling constant $g_{\mu \nu}$. Evaluated for solutions of the coupled field equations,

$$\frac{\delta \Delta L}{\delta \Phi^*} = \frac{1}{2} \frac{\delta \Delta L_{\Phi}}{\delta \Phi^*} = \frac{1}{2} \left( w^2 \Phi^4 \Phi - \lambda \Phi^2 \Phi^2 \right)$$

implies Higgs mass formula $m^2_{\Phi} = \frac{1}{2} g_{\mu \nu} \phi_0^2$. The fields are coupled by current density $J^\mu_B = ig_{\mu \nu} \Phi \partial_\nu \Phi$. For the scalar field, neglecting derivatives of $B_\mu$,

$$\frac{1}{\sqrt{-g}} \frac{\delta \Delta L_{\Phi}}{\delta \Phi^*} = \frac{1}{4} g_{\mu \nu} B_{\mu \nu}^2 - \frac{i}{2} g_{\mu \nu} (B_{\mu \nu}^* + B_{\mu \nu}) \Phi = \frac{1}{4} g_{\mu \nu} B_{\mu \nu}^2$$

implies $w^2 = \frac{1}{2} g_{\mu \nu} B_{\mu \nu}^2 B_{\mu \nu}$. For $\zeta = \frac{1}{6} R - w^2 > 0$, $\Phi^2 = \phi_0^2 = -\zeta / 2\lambda$ solves the scalar field equation if $\lambda < 0$. Ricci scalar $R(t)$ varies on a cosmological time scale, so that $\phi_0^2 = \frac{1}{2} \frac{R}{w^2 - \frac{1}{6} R} \neq 0$, for constant $w^2$ and $\lambda$. This implies small but nonvanishing real $\phi_0^2$, hence nonzero pure imaginary source current density $J^\mu_B = ig_{\mu \nu} \partial_\nu \phi_0 - ig_{\mu \nu} \frac{\dot{\phi}_0}{w} \phi_0$. Derivatives due to cosmological time dependence act as a weak perturbation of SU(2) scalar field solution $\Phi = (\Phi^+, \Phi_0) \rightarrow (0, \phi_0)$. Neglecting extremely small derivatives of the induced gauge fields (but not of $\Phi$), the gauge field equation reduces to $m^2_{B \mu} = J^\mu_B$. Implied pure imaginary $B_{\mu \nu}^2$ does not affect parameter $\lambda$. 
The coupled field equations imply \( w_B^2 = \frac{1}{2} g_B^2 |B|^2 \), proportional to \( \left( \frac{\phi_0}{\phi_1} \right)^2 \). Since observable properties depend only on \( |B|^2 \), a pure imaginary virtual field implies no obvious physical inconsistency. Gauge symmetry is broken in any case by a fixed field solution. The scalar field is dressed by the induced gauge field.

Numerical solution of the modified Friedmann equation\(^3\) \( \frac{\dot{\phi}_0}{\phi_0} = \frac{0.189}{0.088} \), at present time \( t_0 \). Given \( \phi_0 = 180 \text{GeV} \), \( \lambda = -\frac{1}{2} \phi_0^2 = 0.189 \times 10^{-88} \).

\( U(1) \) gauge field \( B_\mu \) does not affect \( \lambda \). Using \( |B|^2 = |J_B|^2/m_B^2, |J_B|^2 = g_B^2 \left( \frac{\phi_0}{\phi_1} \right)^2 \phi_0^2 \) and \( m_B^2 = \frac{1}{2} g_B^2 \phi_0^2 \), the dynamical value of \( w^2 \) due to \( B_\mu \) is \( w_B^2 = \frac{1}{2} g_B^2 |B|^2 = \left( \frac{\phi_0}{\phi_1} \right)^2 \).

From the solution of the modified Friedmann equation\(^3\), \( \frac{\phi_0}{\phi_1}(t_0) = -2.651 \) and \( w_B^2 = 7.027 \), in Hubble units, so that \( w_B = 2.651 h H_0 = 3.984 \times 10^{-33} \text{eV} \) in energy units. This can be considered only an order-of-magnitude estimate, since time dependence of the assumed constants, implied by the present theory, was not considered in fitting empirical cosmological data\(^3\). Moreover, the SU(2) gauge field has been omitted.

**NOTE ON DARK MATTER**

As stated in\(^3\), interpretation of parameter \( \Omega_m \) may require substantial revision of the standard cosmological model. Directly observed inadequacy of Newton-Einstein gravitation may imply the need for a modified theory rather than for inherently unobservable dark matter.

Mannheim has applied conformal gravity to anomalous galactic rotation\(^1\), fitting observed data for a set of galaxies covering a large range of structure and luminosity. The role played in standard \( \Lambda \text{CDM} \) by dark matter, separately parametrized for each galaxy, is taken over in conformal theory for Schwarzschild geometry by an external linear radial potential. The remarkable fit to observed data shown in\(^1\) \( \text{Sect.6.1,Fig.1} \) requires only two universal parameters for the whole set of galaxies.

As discussed by Mannheim\(^1\) \( \text{Sects.6.3,9,3} \), a significant conformal contribution to centripetal acceleration is independent of total galactic luminous mass. This implies an external cosmological source. Such an isotropic source would determine an inherently spherical halo of gravitational field surrounding any galaxy. Quantitative results for lensing and for galactic clusters should be worked out before assuming dark matter.

**CONCLUSIONS**

This paper is concerned with determining parameters \( w^2 \) and \( \lambda \) in the incremental Lagrangian density of the Higgs model, \( \Delta L_\Phi = (w^2 - \lambda \Phi^2 \Phi) \Phi \Phi \Phi. \) Fitting the modified Friedmann equation to cosmological data\(^3\) implies dark energy parameter \( \Omega_\Lambda = \frac{w^2}{1 - w^2} = 0.717 \), so that empirical \( w = \sqrt{0.717} h H_0 = 1.273 \times 10^{-33} \text{eV} \).

The modified Friedmann equation determines the time derivative of the cosmological Ricci scalar, which implies nonvanishing source current density for induced \( U(1) \) gauge field \( B_\mu \), treated here as a classical field in semiclassical coupled field equations. The resulting gauge field intensity estimates the \( U(1) \) contribution to \( w^2 \) such that \( w_B = 2.651 h H_0 = 3.984 \times 10^{-33} \text{eV} \). This order-of-magnitude agreement between computed \( w_B \) and empirical \( w \) supports the conclusion that conformal theory explains both the existence and magnitude of dark energy\(^7\).

The present argument obtains an accurate empirical value of parameter \( \lambda \) from the known dark energy parameter\(^4\), from the implied current value of Ricci scalar \( R \), and from scalar field amplitude \( \phi_0 \) determined by gauge boson masses\(^6\). The mass parameter for a fluctuation of the conformal Higgs scalar field satisfies \( m_\Phi^2 = 4 \lambda \phi_0^2 \). Empirical value \( \lambda = -0.189 \times 10^{-88} \) is negative, implying finite pure imaginary parameter \( m_\Phi \). If such a particle or field could exist or be detected, this would define a tachyon\(^8\), the quantum version of a classical particle that moves more rapidly than light. Experimental data rule out a standard massive Higgs boson with mass \( 0 \le m_H \le 108 \text{GeV} \), however, a Higgs tachyon\(^8\) might either not exist at all, or elude detection in experiments designed for a classical massive Higgs boson. The present results would only be inconsistent if experimental Higgs searches to date were capable of detecting a Higgs tachyon and failed to do so. Conformal theory clearly rules out a standard Higgs boson in the multi-GeV range.

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