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Mini Review

Weyl conformal symmetry for gravitation and cosmology

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The novel paradigm of universal conformal symmetry has been found to explain accelerating Hubble expansion, centripetal lensing by dark galactic halos, and observed excessive galactic rotational velocities, without dark matter. Both general relativity and the Higgs scalar field model are modified by the postulate of universal conformal (local Weyl scaling) symmetry. Conformal gravity and the conformal Higgs model complement each other and together have been found to require reconsideration of the accepted Λ CDM paradigm. The theory is consistent with the recently confirmed dependence of galactic total radial acceleration solely on classical baryonic acceleration but does not support the existence of a massive Higgs particle, replacing Higgs mass by dark energy. The recently observed LHC 125GeV particle is attributed to a compound W_2 diboson whose mass confirms a basic parameter of the Higgs model. The logic of these conclusions is reviewed here.

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Introduction

The consensus Λ CDM paradigm for cosmology assumes unobserved cold dark matter to account for observed deviations from gravitation predicted by general relativity. A cosmological constant Λ of unknown origin is assumed to account for observed cosmic Hubble expansion. The proposed alternative paradigm imposes Weyl conformal symmetry [1,2] on Einstein's general relativity [3-7] to define conformal gravity (CG), and on the Higgs scalar field [8,9] to define the conformal Higgs model (CHM).

The CHM acquires a gravitational effect, found to account for currently accelerating cosmic Hubble expansion [8,9] and to justify the existence of dark gravitational halos as large spherical regions emptied of primordial mass that has fallen into a central baryonic galaxy [10]. The difference in cosmic acceleration inside and outside the halo determines the nonclassical CG acceleration parameter γ. This accounts for observed gravitational lensing by centripetal deflection of photon geodesics [11].

Requiring CG and the CHM to be mutually complementary and compatible requires several adjustments of the independent theories [10,11]. In particular, gauge and conformal symmetries are both dynamically broken, requiring the introduction of a hybrid metric tensor that depends on both Schwarzschild's potential function $B(r)$ [3] and Friedmann's scale factor $a(t)$ [12] in time-dependent spherical geometry. The hybrid metric eliminates primordial cosmic curvature.

Substantial empirical support for this proposed break with convention is provided by recent applications of the CHM to Hubble expansion [8,9], in the context of depleted dark galactic halos [10] and of CG to anomalous rotation velocities for 138 galaxies [13-18].

The conformal model theories

Higgs $V(\Phi^\dagger\Phi) = -(w^2 - \lambda\Phi^\dagger\Phi)\Phi^\dagger\Phi$ depends on two assumed constants W^2 and λ [19,20]. Nonzero W^2 and λ are not determined by standard theory. The conformal Higgs model (CHM) introduces a gravitational term confirmed by observed Hubble expansion [8,9]. The CHM supports the Higgs mechanism, spontaneous SU(2) symmetry-breaking, which also breaks conformal symmetry [9]. This invalidates the conformal equivalence of the two distinct metrics that define functions $a(t)$ and $B(r)$ [6], requiring a common hybrid metric.

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Variation of Ricci scalar R on a cosmic time scale implies a very small but universal source density for the Z_μ neutral gauge field. Dressing of the Higgs field by Z_μ determines parameter W^2 and dressing by diboson W_2 determines λ [8,21]. These two parameters and Ricci scalar R imply finite Φ amplitude and broken gauge and conformal symmetry.

The Lagrangian density L_g of conformal gravity theory, constructed from the conformal Weyl tensor [1,3,6], determines source-free Schwarzschild gravitational potential $B(r) = -2\beta / r + \alpha + \gamma r - \kappa r^2$, valid outside a spherically symmetric mass/energy source density [3,4]. This adds two constants of integration to the classical external potential: nonclassical radial acceleration γ and halo cutoff parameter K [10]. For a test particle in a stable exterior circular orbit with velocity v the centripetal acceleration is $a = v^2(r)/r = \frac{1}{2}B'(r)c^2$.

Baryonic Tully-Fisher and radial acceleration relations

Static spherical geometry defines Schwarzschild's potential $B(r)$. For a test particle in a stable exterior circular orbit with velocity v the centripetal acceleration is $a = v^2(r)/r = \frac{1}{2}B'(r)c^2$ Newtonian $B(r) = 1 - 2\beta / r$, were $\beta = GM / c^2$, so that $a_N = \beta c^2 / r^2 = GM / r^2$.

CG adds nonclassical Δa to a_N so that orbital velocity squared is the sum of $v^2(a_N; r)$ and $v^2(\Delta a; r)$, which cross with equal and opposite slope at some $r = r_{TF}$ if $2\kappa r / \gamma$ can be neglected. This defines a flat range of $v(r)$ centered at a stationary point r_{TF}, without constraining behavior at large r.

MOND [22-24] modifies the Newtonian force law for acceleration below an empirical scale a_0. Using $y = a_N / a_0$ as an independent variable, for assumed universal constant $a_0 \simeq 10^{-10} m/s^2$, MOND postulates an interpolation function ν(y) such that observed radial acceleration $a = f(a_N) = a_N \nu(y)$. A flat velocity range approached asymptotically requires $a^2 \to a_N a_0$ as $a_N \to 0$. For $a_N \ll a_0$, MOND $v^4 = a^2 r^2 \to GMa_0$, the empirical baryonic Tully-Fisher relation [14,25-27].

In conformal gravity (CG), centripetal acceleration $a = v^2 / r$ determines exterior orbital velocity $v^2 / c^2 = ra / c^2 = \beta / r + \frac{1}{2}\gamma r - \kappa r^2$, compared with asymptotic $ra_N / c^2 = \beta / r$. Assuming Newtonian function β_N and neglecting $2\kappa r / \gamma$, the slope of $v^2(r)$ vanishes at $r_{TF}^2 = 2\beta / \gamma$ This implies that $v^4(r_{TF}) / c^4 = (\beta / r_{TF} + \frac{1}{2}\gamma r_{TF})^2 = 2\beta\gamma$ [13, 14]. This is the Tully-Fisher relation, exact at the stationary point r_{TF} of the $v(r)$ function. Given $\beta = GM / c^2$, $v^4 = 2GM\gamma c^2$, for relatively constant $v(r)$ centered at r_{TF}.

McGaugh, et al. [28] have recently shown for 153 disk galaxies that observed radial acceleration a is effectively a universal function of the expected classical Newtonian acceleration a_N, computed for the observed baryonic distribution. The existence of such a universal correlation function $a(a_N) = a_N \nu(a_N / a_0)$ is a basic postulate of MOND [22,24]. If γ is mass-independent [29] CG implies a similar correlation function $a(a_N) = a_N + \Delta a$, where $\Delta a = \frac{1}{2}\gamma c^2$ is a universal constant [29]. For comparison with CG for the Tully-Fisher relation, CG would agree with MOND $v^4 = GMa_0$ if $a_0 = 2\gamma c^2$ [13], for mass-independent γ. CG $\gamma = 6.35 \times 10^{-28} / m$ [11] implies MOND $a_0 = 1.14 \times 10^{-10} m/s^2$.

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