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# The Gauge-Invariant Spectrum of Local Super-Symmetry as the Universe that is Observed

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**Abstract** It is demonstrated that gauge invariant states within local super-symmetry are equivalent to quantized states of global super-symmetry that are preserved by (oblivious to) super-gravitational interactions (analogous to the stationary atomic states that derive from gauge invariance in the theory of Weyl). The cosmology which emerges from this equivalence is unique and finite, and parallels observation. Specifically, mass-energy distributions occur about intersections of phase transitions that modify the shock front of global expansion, and the predicted number of galaxies approximates that determined by observation.

**Keywords** Super-gravity · Inflation events · Isotropic expansion · Gauge invariance

## 1 Introduction

Osp(1/4) pure super-gravity on $M_4$:

$$\mathcal{L} = \sqrt{-g}R + e\bar{\psi}_\mu \gamma_\nu \gamma^5 D_\sigma \psi_\rho \varepsilon^{\mu\nu\rho\sigma}$$

and the sector of those fermions that characterize the standard model can be simultaneously derived from $AdS_7XS^4$ [1]. The above Lagrangian density is based upon the super-Poincare algebra

$$[M_A, M_B\} = f_{AB}^C M_C, \tag{1}$$

where the components of the $M_A$ are

$$M_A = \{P_a, -iM_{ab}, Q_\alpha\}. \tag{2}$$

The $P_a$ generate the translation group, the $-iM_{ab}$ constitute the adjoint representation of the Lorentz group and the $Q_\alpha$ are components of the SUSY generator.

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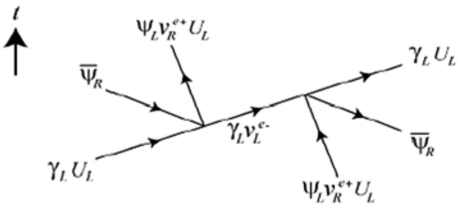

**Fig. 1** SUGRA mediated quark-lepton transitions

If the $\omega_\mu^A$ describe all connection fields:

$$\omega_\mu^A = \{e_\mu^a, \omega_\mu^{ab}, \bar{\xi}_\mu^\alpha\}, \tag{3}$$

and transform under Osp(1/4) as

$$\delta\omega_\mu^A = f_{BC}^A \varepsilon^B \omega_\mu^C, \tag{4}$$

then the Osp(1/4)-covariant derivative is

$$\nabla_\mu = \partial_\mu + M_A \omega_\mu^A = \partial_\mu + e_\mu^a P_a - i\omega_\mu^{ab} M_{ab} + \bar{\xi}_\mu^\alpha Q_\alpha, \tag{5}$$

and the Riemannian curvature tensor assumes the form

$$[\nabla_\mu, \nabla_\nu] = R_{\mu\nu}^A M_A, \tag{6}$$

where

$$R_{\mu\nu}^A = \partial_\mu \omega_\nu^A - \partial_\nu \omega_\mu^A + \omega_\nu^B \omega_\mu^C f_{BC}^A \tag{7}$$

[2].

In this context the interaction Hamiltonian for SUGRA interactions becomes

$$-\mathbf{i}(\alpha)\bar{\psi}_\mu \gamma_\nu \gamma^5 M_A \omega_\sigma^A \psi_\rho \varepsilon^{\mu\nu\rho\sigma}, \tag{8}$$

from which one obtains first-order SUGRA interactions between gravitons $\Psi$ and spin-(3/2) composites of photons and quarks (or leptons). Observe that the proposed SUGRA interactions produce amplitudes for similar (pure SUGRA) interactions that are characterized by absorptions of *composite* spin-2 particles; e.g. interactions described by SUGRA vertices

$$\gamma_L U_L + \psi_L \nu_L^{e^-} \bar{U}_R \to \gamma_L \nu_L^{e^-} + \psi_L \quad \text{and} \quad \gamma_L \nu_L^{e^-} + \psi_L \nu_R^{e^+} U_L \to \gamma_L U_L + \psi_L. \tag{9}$$

It is clear that such interactions involve net absorptions of spin-2 action $\mathcal{L}d^4x$ by the super-gravitationally interacting 4-vacuum, and it is argued that each absorption of action beyond a critical threshold results in a critical increment of mass-energy density $\mathcal{L}$ (a critical 4-curvature) that seeks the gravitational equilibrium (Friedman flatness) which is achieved by an expansion of 4-volume $d^4x$. It is argued that the proposed isotropic distribution of critical action absorptions constitutes a device which behaves like an isotropic diffraction grating. Specifically, it is argued that a *typical* SUGRA 4-curvature occurs about every critical absorption of SUGRA action in the set that collectively constitutes the proposed isotropic distribution, and that each such 4-curvature produces a typical phase transition or inflation event. The proposed model identifies these phase transitions with the gauge transformations that are intrinsic to local super-symmetry. In this context admissible phase transitions are restricted to those that produce one super-gravitationally stationary state from another.

## 2 Gauge Invariance

The connections of local super-symmetry lend themselves to gauge transformations

$$\exp(i\beta)\delta\omega^A = \exp(i\beta) f^A_{BC}\varepsilon^B\omega^C_\mu dx^\mu, \tag{10}$$

under the local SUSY group Osp(1/4), where $\beta$ represents a scale factor. The proposed model identifies the phase transitions that, according to the previous section, occur to the shock front of global expansion with the phase transformations (10). Moreover, this model imposes gauge invariance, which restricts such gauge transformations to those that preserve maximal Riemannian symmetry:

$$\exp(i\beta) f^A_{BC}\varepsilon^B\omega^C_\mu dx^\mu = \exp\{2\pi i N\} \quad N = 0, 1, 2, 3, \ldots; \tag{11}$$

i.e. to those that preserve 3-states of constant Riemannian curvature [3].

## 3 Model Calibrated in Terms of a Large Scale Boundary Condition

The proposed SUGRA spectrum can be simplified in terms of an alternative base that is indicated by observation of the large scale, provided that the scale factor $\beta$ is chosen as

$$\frac{\beta}{2\pi} \cong .434294482\ldots. \tag{12}$$

In this context, the admissible phase transitions that are described by (11) become

$$\exp\{f^A_{BC}\varepsilon^B\omega^C_\mu dx^\mu\} = 10^N \quad N = 0, 1, 2, 3, \ldots. \tag{13}$$

The selection of base 10 is founded upon the observed boundary condition that *galaxies are typically separated by a distance that is about ten times the diameter of the typical galaxy; that galactic clusters are typically separated by a distance that is about ten times the diameter of the typical cluster etc.*

The transformations of SUGRA states that are described by (10) are analogous to the gauge transformations that were proposed by Hermann Weyl [4], and the proposed constraint of gauge invariance upon such transformations is analogous to that by which Fritz London derived stationary atomic states from the theory of Weyl [5].

Adopting the proposed, naïve model, the observable universe assumes a form in which the global flatness that was traditionally observed is embellished by the prescribed phase transformations on the shock front of global expansion (Fig. 2).

It is assumed that the value $N = 0$ corresponds to a single galaxy (to the original isotropic mass-energy distribution); that the value $N = 1$ corresponds to that galaxy after it has been embellished with, and surrounded by a basic Huygens pattern of admissible phase transitions; i.e. admissible inflation events; that the value $N = 2$ corresponds to the initial configuration plus an isotropic proliferation of the initial Huygens pattern of inflation events etc. Thus it is argued that gauge invariance in the context of local super-symmetry selects a specific large-scale spectrum; i.e. selects a unique history from the continuum of histories that is admitted by conventional string theory and by the corresponding conformal field theory of super-gravity. But the question that immediately arises is whether or not the predicted galactic hierarchy parallels that which is observed.

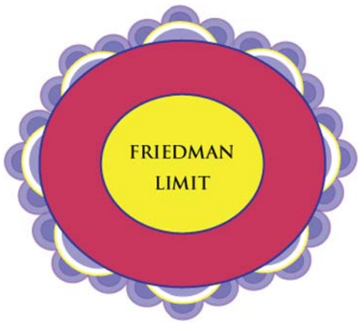


**Fig. 2** Secondary shock waves of universal expansion

## 4 Confirmations of the Predicted Structure

The large-scale that is indicated by Fig. 2 and described by the associated discussion indeed parallels large-scale observations. Specifically, the sector labeled 'Friedman limit' is revealed by observations of the immediate and intermediate past (of the region that has, from our perspective, had time to undergo complete inflation and achieve Friedman flatness). The Huygens fringe, which is purportedly constituted by isotropic phase transitions (inflation events) on the shock front of universal expansion, which are constrained by condition (13), and then by isotropic proliferations of such phase transitions is revealed by observations of the early universe (by radio surveys of regions near the event horizon).

Since the proposed phase transitions produce instantaneous, advances of the global shock front, the resulting semi-spherical shock waves which cumulatively produce the Huygens pattern that is indicated by Fig. 2, enclose 3-dimensional voids. But how can 2-dimensional, secondary and tertiary shock fronts constitute domains of mass-energy distribution? An explanation in terms of macroscopic considerations might be as follows: If two inflation events, occurring about neighboring critical absorptions of action (two semi-spherical surfaces) intersect at a point, then they share a common, 2-dimensional vector space. But if such surfaces intersect along a curve, then, generally, three linearly independent vectors are tangent to the intersecting surfaces at each point on the boundary. Because 3-space is spanned at each point of intersection and only along the boundaries that consist of such points, the proposed model restricts distributions of mass-energy to formations about such boundaries.

This naive model seems to parallel observations by radio surveys of regions that lie near the event horizon (near the edge of the observable universe). According to a semi-annual report from the Harvard-Smithsonian Center for Astrophysics, "The distribution of galaxies in the red-shift survey slice looks like a slice through suds in the kitchen sink. The galaxies are on the surfaces of bubble-like structures with diameters of 25–50 Mpc." It is further stated that "The appearance of the coma cluster at the intersection of several (semi-spherical) shells provides a clue to the relationship which we will explore more fully as the survey covers a larger and larger volume." Finally it is stated that "In a toy model with close-packed bubbles of fixed size, and with clusters located at the interstices between bubbles, the typical separation of clusters is equal" [6]. A photograph taken by one of the radio surveys to which the above discussion refers is as in Fig. 3.

One can confirm from Fig. 3 that distributions of super-clusters lie along boundaries of intersecting 'bubbles'.

A quantitative feasibility argument for the proposed model is also motivated by the sequence of cosmological scale factors that is prescribed by (13). Specifically, the scale factors that are described by (13) motivate an iterative calculation, which predicts a number of galaxies that is approximately equal to the number indicated by observation.

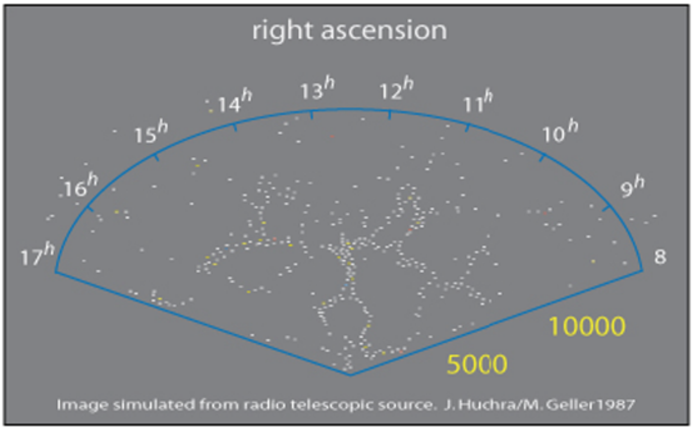


**Fig. 3** A radio-survey of regions near the event horizon

Observations of local conditions establish that the typical galaxy is about $ct_0 = 10^5$ light years (ly) in diameter, and that five galaxies populate the typical basic cluster. Based upon these boundary conditions, and upon an assumption of homogeneity, one can associate the equation $(4/3)\pi R_1^3$, describing the volume of a typical basic cluster, with the number 5.00. Thus, rounding to three digits, it is concluded that, typically, $R_1 \cong 1.06$. (According to (13), which indicates that $R_N = ct_N = ct_0 10^N$, the radius of the typical galactic cluster in light years is about $ct_1 = ct_0 10 = 10^5(10) = 10^6$ ly.) Now, continuing the initial iteration: utilizing the value $N_1 \cong 1.06$ and rounding to three digits, one determines the approximate 'radius' of the $N = 2$ state $(2(10)1.06 = 21.2)$, the $N = 3$ state $(2(10)21.2 = 424)$, the $N = 4$ state $(2(10)424 = 8480)$ and finally the $N = 5$ state $(2(10)8480 = 169600 \cong 170000)$.

Complementing this, one recalls the postulated isotropic distribution of phase transitions or inflation events, and the consequent isotropic distribution of semi-spherical 2-surfaces (and proliferations of this Huygens pattern) along the shock front of global expansion. In this segment of the early universe, the distribution of galaxies as entities that fill 3-volumes is, according to the proposed model, replaced by distributions of galaxies that populate the surfaces of semi-spherical shells. To calibrate this aspect of the postulated model, one enlists another observed boundary condition, which demonstrates for scales larger than or equal to $10^9$ ly; i.e. for scales corresponding to $N = 5$ and larger, that the number of homogeneously distributed galaxies indeed appears to populate the surfaces of semi-spherical shells, providing a structure which parallels that indicated by Fig. 3 (as indicated above, the hypothesis of isotropy and homogeneity is modified by dimensional considerations which force galactic distributions that would otherwise be isotropic to form along the boundaries of the prescribed 2-surfaces. Nevertheless, isotropy is appropriated as a counting device). In this context, the number of galaxies in the $N = 5$ state is (summing areas, described as numbers of galaxies, of opposite semi-spherical hyper-surfaces) given by

$$4\pi R_5^2 = 4(3.14)(170000)^2 \cong 3.63 \times 10^{11}. \quad (14)$$

According to the above discussion, the radius of the $N = 5$ state in light years is about $ct_5 = ct_0 10^5 = 10^{10}$ ly, which is the approximate radius of the observable universe.

## 5 Conclusion

Prior to the theory of super-strings and to the corresponding theory of super-gravity, some assumed that the observed galactic hierarchy was related to a specific early history that occurred to the universe when it was small; i.e. that the observed hierarchy was related to an isotropic pattern of phase transitions or inflation events that occurred to the early shock front of global expansion and to isotropic proliferations of this pattern. But string theory, and the corresponding theory of super-gravity indicate an infinite number of possible histories that are not distinguished by the theory; i.e. the string landscape appears to embody a fundamental uncertainty regarding the early history of the universe. It is, of course, difficult to reconcile this model with the correspondence principle.

The above discussion associates the continuum of possible histories that is conventionally admitted with a continuum of possible Huygens patterns (each a pattern of inflation events on the shock front of universal expansion; each pattern associating with a corresponding isotropic pattern of critical spin-2 action absorptions that have occurred to a super-gravitationally interacting vacuum). Implicitly then, a theory of super-gravity is formulated as a CFT that is analogous to the theory of H. Weyl, and the continuum of possible Huygens patterns that is prescribed by conventional super-gravity is compared with the continuum of electronic orbitals that is predicted by the theory of Weyl. It is recalled that F. London essentially reduced this continuum of electronic orbitals to the stationary states which correspond to actual atomic orbitals by implementing the concept of gauge invariance. Accordingly, the gauge transformations that are intrinsic to local super-symmetry are implemented, and admitted super-gravitational states are restricted to those that satisfy gauge invariance. In this context the continuum of possible histories that is conventionally prescribed is reduced to a dynamical analogue of London's stationary states: an analogue which admits a phase transition (10) if and only if it satisfies the condition (13); i.e. if and only if it transforms the physical universe from one SUGRA-invariant state to another. This formulation is advantageous because the gauge-invariant spectrum of local super-symmetry becomes a spectrum which consists of a finite number of globally super-symmetric states, which seems to address the problem of non-renormalizability which has traditionally plagued super-gravity. Moreover, when the proposed, gauge invariant spectrum of local super-symmetry is compared with the observed galactic hierarchy, the prescribed theoretical structure parallels that revealed by radio surveys and contains a number of galaxies which is approximately equal to that determined from direct observation [7].

## References

1. Aharony, O., Gubser, S. et al.: arXiv: hep-th/9905111 (1999)
2. Kaku, M.: Quantum Field Theory, pp. 692–696. Oxford University Press, Oxford (1993)
3. Misner, C., Thorne, K., Wheeler, J.A.: Gravitation, p. 721. Freeman, New York (1974)
4. Weyl, H.: Space, Time and Matter. Methuer & Co Ltd., London (1922). Chap. 4, Sect. 35
5. London, F.: Z. Phys. **42**, 375–389 (1927)
6. Huchra, J.P., Geller, M.: Semi-Annual Report: Harvard-Smithsonian Observatory, 1 July–31 December, 1987
7. Towe, J.: In: Rajantie, A., Contaldi, C., Dauncey, P., Stoica, H. (eds.) Particles, Strings and Cosmology: 13th International Symposium, pp. 445–448. AIP, London (2007)