# Kerr-Schild Gravity as "New Physics" Beyond the Standard Model

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**Based on: *"Illusion of the Weakness of Gravity..."* arXiv:1701.01025 and**
**A.B., *Gravitating Lepton Bag Model* , JETP, v.148 (8), 228 (2015),**
**A.B., *Stability of the Lepton Bag Model ...*, JETP, v.148(11), 937 (2015), arXiv:1706.02979,**
***A.B., Source of the Kerr-Newman solution ...* Phys.Lett. B754, 99 (2016), arXiv:1602.04215.**

**It is known that Standard Model is not ultimate and has to be generalized to a "New Physics" beyond the Standard Model.**

**The main problem is consistency with gravity.**

**Also, extra dimensions and superpartners haven't been experimentally confirmed.**

**Kerr solution (1963) – radical change of structure relative to Schwarzschild Black Hole.**
**Schwarzschild geometry which is essential only at "gravitational radius"**

$$R_g = 2Gm. \tag{1}$$

**Ultra-rotating Kerr geometry,** $a = J/m >> m,$ **loses BH horizons and creates naked singular ring, which deforms space TOPOLOGICALLY at Compton distance:**

$$a = \hbar/2mc. \tag{2}$$

**B. Carter (1968): Kerr-Newman solution has gyromagnetic ratio $g = 2$, as the *Dirac electron.***

**This could shed light on interplay gravity and quantum theory and deserves to be studied!** ***50 Years to the problem of source of KN solution:*** AB, ***Phys. Lett. B 754 (2016) 99.***

**Kerr-Newman electron:** ***W. Israel (1970); Debney, Kerr and Schild (1969); AB (1974); D.Ivanenko & AB (1975); C. López (1984); V. Hamity (1976); ... .***

**PROBLEM of the SOURCE OF KN SOLUTION: two-sheeted topology, which find later interpretation as *Einstein-Rosen bridge.***

**Horizons disappear opening the HOLE in space of the *COMPTON RADIUS* – Size of hole in on 20 orders more than Planck scale!**

**QUANTUM THEORY CANNOT WORK IN SUCH SPACE-TIME.**

**Conceptual changes:**

**NO: Gravity is the most weak interaction.**

**NO: Quantization of gravity.**

**NO: Modified gravity.**

**NO: Information paradox.**

**NO: Extra dimensions.**

**NO: Planck scale as fundamental scale.**

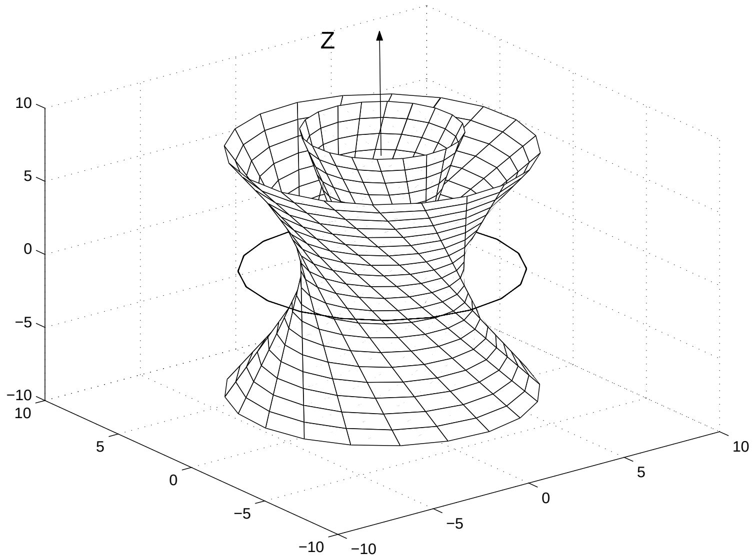
**NO: Spinning gravity is not weak $\Rightarrow$ Compton scale.**

**NEW CONCEPT: Conflict between Gravity and Quantum theory is shifted from Planck to Compton scale!**

**Kerr-Newman metric** $g_{\mu\nu} = \eta^{\mu\nu} + 2Hk^\mu k^\nu$,
**and vector potential**

$$A^\mu = -ek^\mu/(r + ia\cos\theta)$$

**are fixed by direction of frame-dragging** $k^\mu$ **.**




**For** $a = J/m >> m$, **singular ring creates HOLE in space = Einstein-Rosen bridge (AB 2002, 2012, Gibbons and Volkov 2017).**

**New view: Gravity must be considered as background for work of Quantum theory – it must not be quantized!**

**What to do?**

**2. *Supersymmetry regularizes Kerr space-time!* SUSY was not confirmed in the form of "superpartners", but it finds natural application as a supersymmetric field model.**

**BAG MODEL – *nonperturbative solution* based on supersymmetric Higgs model of symmetry breaking.**

**Supersymmetric vacuum state inside the bag is regular and flat space *suitable for work of quantum theory*, AB 2017.**

## 50 years to problem of source of the Kerr-Newman solution.

- **Bubble or solitonic source:** H.Keres 1967 , B.Carter 1968, W.Israel 1970, M.Gürses & F.Gürsay 1975, A.Krasinski 1978, C.López 1985, I.Dymnikova 2006, AB 2010 etc.
- **String-like source:** AB 1974, Ivanenko & AB 1975
- **Einstein-Rosen bridge:** AB 2002,2012, Gibbons & Volkov 2017.
- **Bag models:** AB 2015-2017. BAG models unite the solitonic and string-like models.

**Bags are soft and flexible.**
**Shape of the rotating bag is *fixed unambiguously by gravity* as oblate disk with circular string on its edge.**

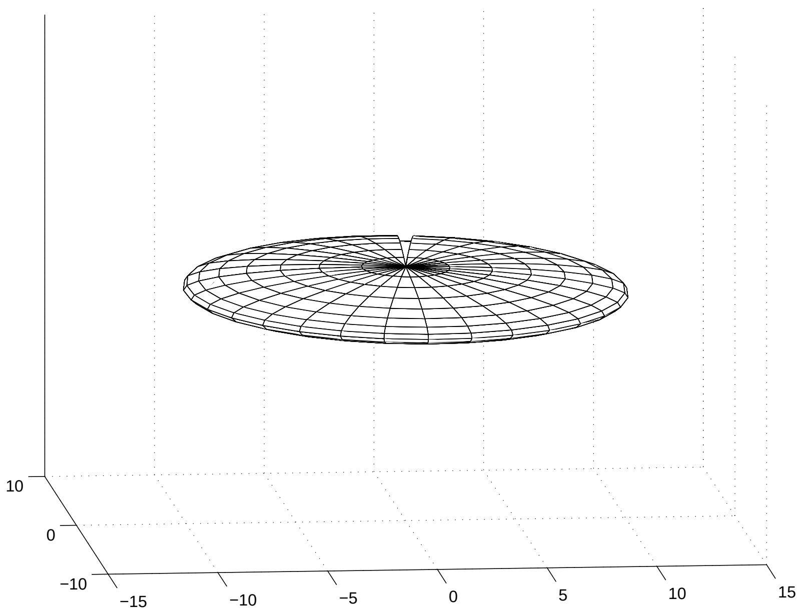



Figure 1: **Superconducting bag-like core of the KN solution.**

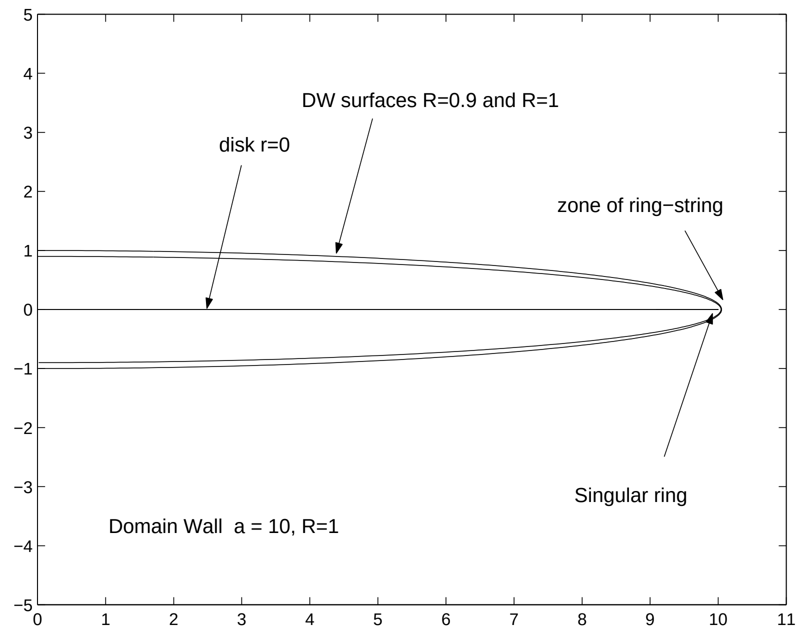



Figure 2: **Profile of bag boundary.**

## Matching external Kerr-Newman solution with FLAT CORE (López 1985).

$$g^{(KN)}_{\mu\nu} = \eta_{\mu\nu} + 2H_{(KN)}k_\mu k_\nu, \quad \textbf{where} \quad H_{(KN)} = \frac{mr - e^2/2}{r^2 + a^2\cos^2\theta} \quad \textbf{and}$$

**r is oblate spheroidal coordinate.**

**We have $H_{(KN)} = 0$ at $r = R = e^2/2m$, and $g^{(KN)}_{\mu\nu} = \eta_{\mu\nu}$. Bag takes ellipsoidal form. String is placed on the sharp rim of the Bag.**

**SUPERCONDUCTIVITY: Supersymmetric BAG is built of Landau-Ginzburg field model = Higgs model.**
**LG model is used in Nielsen-Olesen (NO) dual string model, soliton models and in the MIT and SLAC bag models.**

$$\mathcal{L}_{NO} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{2}(\mathcal{D}_\mu\Phi)(\mathcal{D}^\mu H)^* - V(|H|).$$

***The usual quartic potential $V = g(H\bar{H} - \sigma^2)^2$ is inappropriate because it leads to superconductivity in outer space.*** **( NO vortex in superconductor, MIT Bag as "cavity in superconductor").**
***Superconducting bag is formed by superpotential $W$ and requires supersymmetric LG model.*** **( A.B. *JETP* 2015, 2016; *Phys.Lett.B* 2016).**

**Phase of the Oscillating Higgs field $H(x) = |H|e^{i\chi(x)}$ interacts in the core of particle with WILSON LOOP of the vector potential $A^\mu$:**

$$\mathcal{D}_\nu\mathcal{D}^\nu H = \partial_{H^*}V, \tag{3}$$

$$\nabla_\nu\nabla^\nu A_\mu = I_\mu = \frac{1}{2}e|H|^2(\chi_{,\mu} + eA_\mu). \tag{4}$$

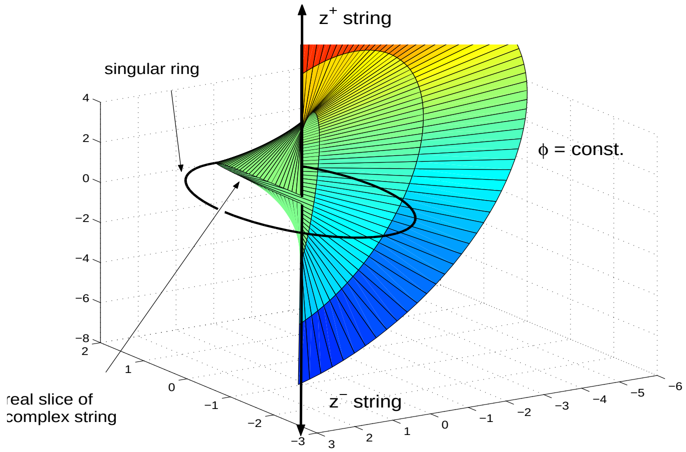



Figure 3: The Kerr congruence and vector potential are dragged by Kerr singular ring, forming a closed Wilson loop.

**At the rim of disk,** $r = e^2/2m, \cos\theta = 0,$ **KN potential is** $A_\mu dx^\mu = A_\mu^{max} dx^\mu = -\frac{2m}{e}(dr - dt - ad\phi).$

**Inside superconducting core** $I_\mu = 0,$ **and from** $\chi,_\mu + eA_\mu = 0$ **and** $eA_t = 2m, \ eA_\varphi = 2ma,$ **we obtain** $\chi = -2mt - 2ma\varphi,$ **which leads to important consequences:**

**(i) closed flux of the vector potential** $\oint eA_\varphi d\varphi = -4\pi ma$ **forms a *quantum Wilson loop* leading to quantized angular momentum,** $J = ma = n\hbar/2, \ n = 1, 2, 3, ...$

**(ii) phase of the Higgs** $\chi$ **oscillates with frequency** $\omega = 2m$ **similar to solitonic models of oscillons and Q-balls (G.Rosen 1968, Coleman 1985).**

## SUPERSYMMETRIC scheme of phase transition.

**Triplet of the chiral fields $\Phi^{(i)} = \{H, Z, \Sigma\}$, where $H$ is the Higgs field.**

**Lagrangian $\mathcal{L} = -\frac{1}{4}\sum_{i=1}^{3} F^{(i)}_{\mu\nu} F^{(i)\mu\nu} - \frac{1}{2}\sum_{i=1}^{3}(\mathcal{D}^{(i)}_{\mu}\Phi^{(i)})(\mathcal{D}^{(i)\mu}\Phi^{(i)})^{*} - V$, covariant derivatives $\mathcal{D}^{(i)}_{\mu} = \nabla_{\mu} + ieA^{(i)}_{\mu}$.**

**Superpotential (suggested by J. Morris, 1996)**

$$W = \Phi^{(2)}(\Phi^{(3)}\bar{\Phi}^{(3)} - \eta^{2}) + (\Phi^{(2)} + \mu)\Phi^{(1)}\bar{\Phi}^{(1)}, \tag{5}$$

**determines the potential**

$$V(r) = \sum_{i} |\partial_{i} W|^{2}, \tag{6}$$

**where $\mathcal{H} \equiv \Phi^{(1)}$ is taken as Higgs field.**

**Vacuum states $V_{(vac)} = 0$ are determined by the conditions $\partial_{i} W = 0$. The model yields two vacuum states:**

**(I) the supersymmetric false-vacuum state inside: $|H| = \eta;\ Z = -\mu;\ \Sigma = 0,$**

**(II) the vacuum state outside: $|H| = 0;\ Z = 0;\ \Sigma = \eta.$**

**Higgs field $H$ forms inside the bag the supersymmetric and superconducting vacuum state.**

**Einstein-Maxwell eqs. are trivially satisfied inside and outside the bag.**

**BPS-saturated DOMAIN WALL SOLUTION . AB, JETP, v.148, 937(2015), arXiv:1706.02979, AB, Phys.Lett. B754, 99(2016), arXiv:1602.04215.**

**Supersymmety and Bogomolnyi bound. Hamiltonian:**

$$H^{(ch)} = T_0^{\ 0(ch)} = \frac{1}{2}\sum_{i=1}^{3} \ [\sum_{\mu=0}^{3} |\mathcal{D}_\mu^{(i)}\Phi^i|^2 + |\partial_i W|^2].$$

**Kerr's coordinate system** $x + iy = (r + ia)e^{i\phi}\sin\theta, \quad z = r\cos\theta, \quad t = \rho - r.$ **Vector potential**

$$A_\mu dx^\mu = -Re \ [(\frac{e}{r + ia\cos\theta})](dr - dt - a\sin^2\theta d\phi). \tag{7}$$

**Terms** $A_\phi d\phi$ **and** $A_t dt$ **drop out of the Hamiltonian due the constraints**

$$\mathcal{D}_t^{(1)}\Phi^1 = 0, \quad \mathcal{D}_\phi^{(1)}\Phi^1 = 0, \tag{8}$$

**consistent with (i) and (ii). The rest is reduced to integral over variable** $r$.

$$H^{(ch)} = T_0^{\ 0(ch)} = \frac{1}{2}\sum_{i=1}^{3} \ [|\mathcal{D}_r^{(i)}\Phi^i|^2 + |\partial_i W|^2], \tag{9}$$

**Then we use the TRICK suggested by Cvetiĉ & Rey for planar Dom Wall, which WORKS! and allows to transform Hamiltonian to Bogomolnyi form**

$$H^{(ch)} = T_0^{\ 0(ch)} = \frac{1}{2}\sum_{i=1}^{3}\ [|\mathcal{D}_r^{(i)}\Phi^i - e^{i\chi_i}\partial_i\bar{W}|^2 + 2Re\ e^{-i\chi_i}\partial_i\bar{W}\mathcal{D}_r^{(i)}\Phi^i] \qquad (10)$$

**The angles $\chi_i$ are determined by phase of the oscillating Higgs field**

$$\Phi(x) \equiv \Phi^1(x) = |\Phi^1(r)|e^{i\chi(t,\phi)}. \qquad (11)$$

**It yields $\chi_1 = 2\chi(t,\phi),\ \chi_2 = \chi_3 = 0$, and We obtain the Bogomolnyi equations**

$$\mathcal{D}_r^{(i)}\Phi^i = \partial W/\partial\Phi^i, \quad \mathcal{D}_r^{(i)}\bar{\Phi}^i = \partial\bar{W}/\partial\bar{\Phi}^i. \qquad (12)$$

**Hamiltonian turns into full differential ($\mathcal{D}_r \to \partial_r$ due structure of $W$)**

$$H^{(ch-r)} = Re\ (\partial W/\partial\Phi^i)\partial_r\Phi^i = \partial W/\partial r. \qquad (13)$$

**Using the Kerr coordinate system, and $\Delta W = W(R+\delta) - W(R-\delta) = -\mu\eta^2$, we obtain**

$$\delta M_{bag} = 2\pi\Delta W\int_{-1}^{1} dX(R^2 + a^2X^2) = 4\pi(R^2 + \frac{1}{3}a^2)\Delta W. \qquad (14)$$

**BPS-saturated solution $\Rightarrow$ Stability.**

**STRINGY STRUCTURES IN THE BAG MODELS: Bags are soft and elastic. Rotating bags are deformed in string-like flux-tubes.** ( **K. Johnson and C. B. Thorn, PRD 13, 1934 (1976); Chodos et al. PRD 9, 3471 (1974).** )

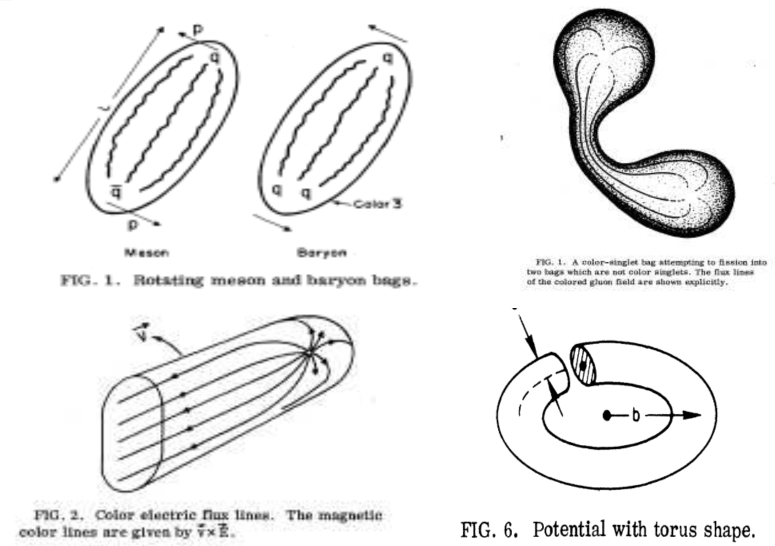



Figure 4: **Bags form flux-tube strings.**

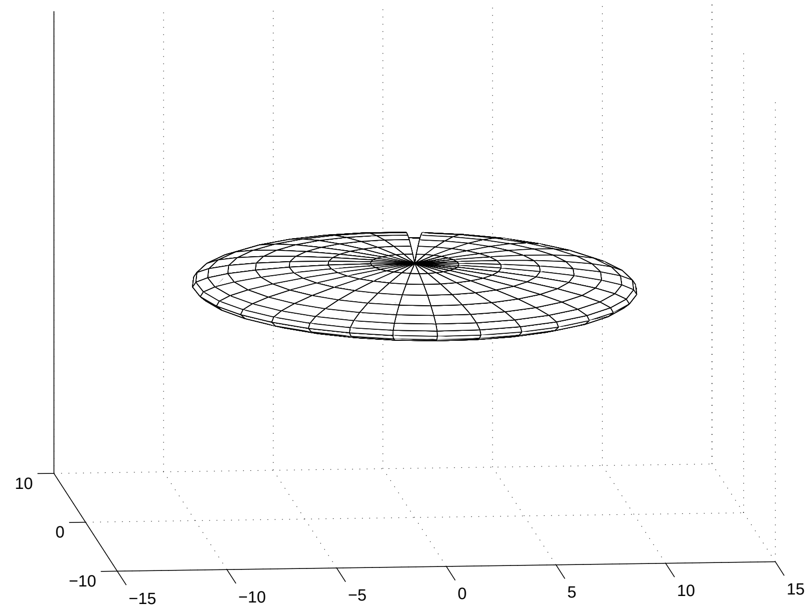
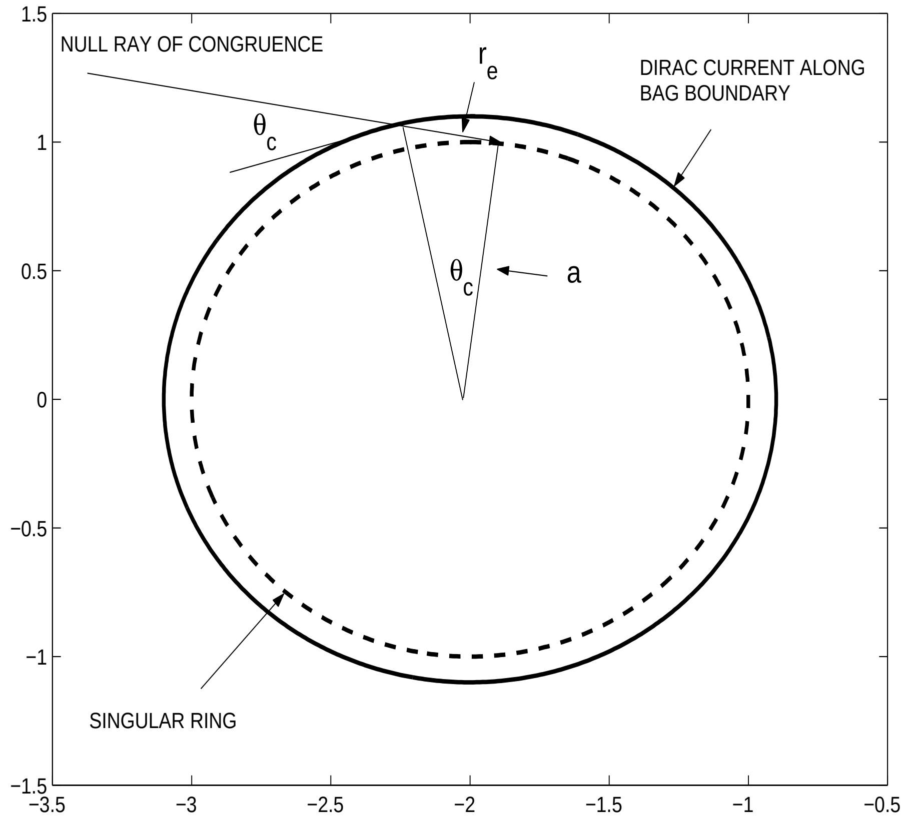



Figure 5: **Disk-like shape of Kerr's Bag.**

**Kerr-Newman bag takes oblate ellipsoidal shape, with the LIGHTLIKE circular string on the sharp edge of the Bag.**

**The Kerr singular ring as a "gravitational waveguide" for traveling EM waves (pp-waves),** (A.B. 1974. A.B.& Ivanenko 1975.)

**External observer perceives lightlike string as a point** (Punsly 1985 , Arcos & Pereira, 2006, A.B. 2009.) **Lightlike string forms worldline – not worldsheet.**




**Kinematic analysis of the Kerr-Newman string shows that there is a lapse** $\tan\theta_c = r_e/a$, **and therefore, the string differs slightly from lightlike.**
**The lightlike "left" mode is indeed completed by a weak "right" mode.**

**The surface current splits into the "left" and "right" components**

$$\Box A_\mu = J^-_\mu + J^+_\mu = e[|H^+|^2(\chi^+,_\mu + eA^+_\mu) + |H^-|^2(\chi^-,_\mu - eA^-_\mu)].$$

**The "left" and "right" null coordinates $\chi^- = t - \sigma$ and $\chi^+ = t + \sigma$, are phases of the oscillating Higgs fields $H^+$ and $H^-$ ($\sigma = a\phi \in [0, 2\pi]$).)**
**For fixed time – the orientifold symmetry – a closed but folded string.**

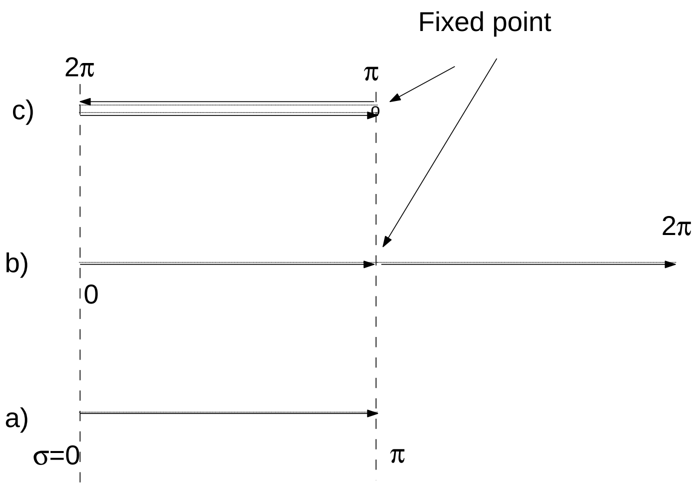



Figure 6: **Formation of the planar orientifold.**

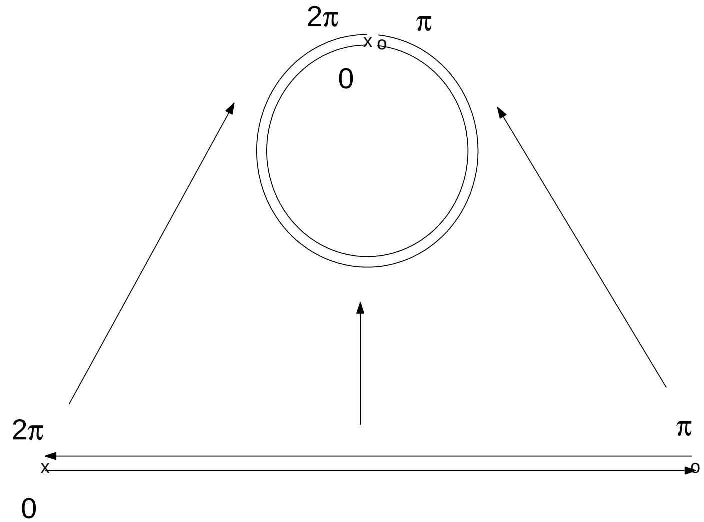
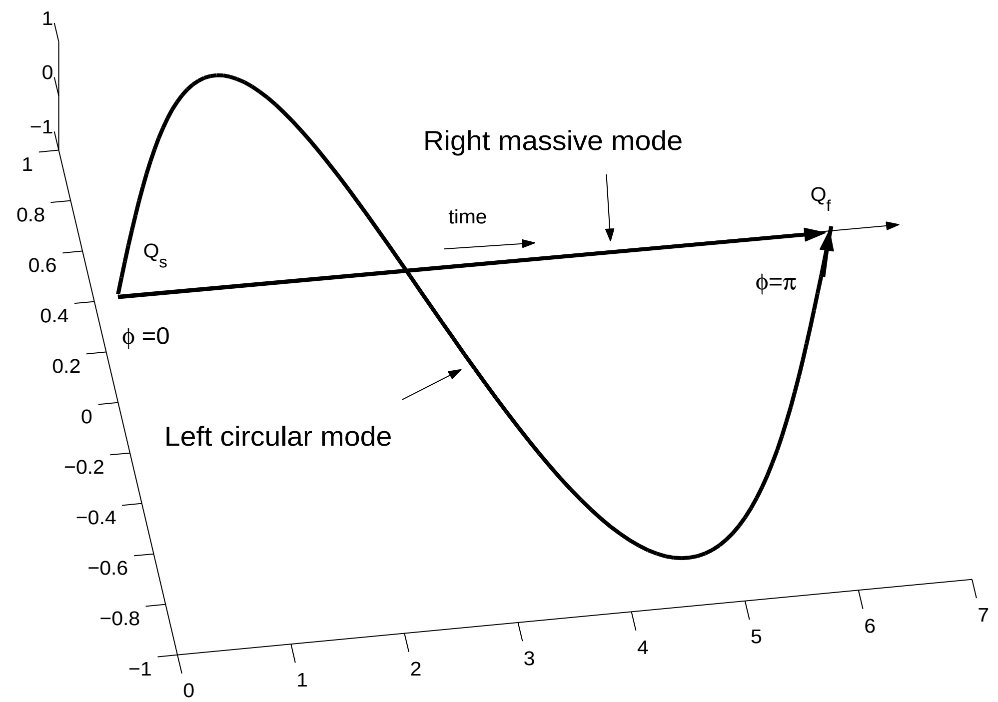



Figure 7: **Mapping of the planar orientifold on the static Kerr's circle.**

**Relativistic rotation breaks orientifold symmetry.**

**Phase of the "left" Higgs field is oriented clockwise, along direction of rotation, while phase of the "right" Higgs field is oriented counterclockwise, against direction of rotation – the right null direction becomes timelike: the right mode acquires mass.**



**Wave EM excitations:** $A_\mu = Re \frac{\psi(Y,\tau)}{r+ia\cos\theta} k_\mu - \frac{1}{2}(\chi d\bar{Y} + \bar{\chi} dY).$

**For stationary Kerr-Newman solution $\psi = -e$, which corresponds to a constant cut-off parameter $R$. String propagates in the almost lightlike direction $\sim k^\mu$, and parametrized by $\phi$.**

**In the excited solutions $\psi = \psi(Y,\tau)$, where $Y = e^{i\phi} \tan\frac{\theta}{2}, \quad \tau = t - r - ia\cos\theta$.**

**Potential is accompanied by additional terms which break alignment $A^\mu \sim k^\mu$. Negative half-waves $A^\mu \sim -k^\mu$, have opposite time-direction.**

**For $\psi < 0$ we can set $r < 0$ and pass to negative sheet which retains time-ordering of the Wilson loop $\oint T A^\mu(t)$.**

**SUPER-BAG – nonperturbative analog to Wess-Zumino SuperQED model. Super-QED forms a bridge to perturbative QED of the electron!**

**Supersymmetric perturbation theory is developed as a direct extension of the ordinary perturbation theory.**

$\Phi^i$ **become chiral fields in the component form** $\Phi_i(y) = A_i(y^\mu) + \sqrt{2}\theta\psi_i(y^\mu) + \theta\theta F_i(y^\mu)$.

**Kinetic term super-QED has two chiral fields** $\Phi_+$ **and** $\Phi_-$,

$$\mathcal{L}_{kinQED} = \frac{1}{4} Re \int d^4x\, d^2\theta\, W^a W_a + \int d^4x\, d^4\theta\, (\Phi_+^+ e^{eV} \Phi_+ + \Phi_-^+ e^{-eV} \Phi_-), \qquad (15)$$

**and potential term is formed as the sum of the chiral and anti-chiral parts** $W + W^+$.

**The Feynman rules are stated in terms of superfield vertices and propagators with miraculous cancellations between component diagrams. (Wess and Bagger "Supersymmetry and Supergravity".)**

**GENERALIZATION: Nonperturbative Super-QED field model is constructed as unification of the kinetic part of super-QED with potential of the bosonic super-Bag. In notations $\Phi_+ = \Phi$, $\Phi_- = \bar{\Phi}$, and $\Phi_1 = \Sigma$, $\Phi_2 = \bar{\Sigma}$, and $\Phi_0 = Z$, superpotential takes the form $W(\Phi_i) = \Phi_0(\Phi_1\Phi_2 - \eta^2) + (\Phi_0 + \mu)\Phi_+\Phi_-$.**
**Nonperturbative Super-QED bag model of dressed electron is matched with QED and principles of the SM. It shows that the Compton zone of the consistent with gravity dressed electron must have the form a superconducting disk, built from supersymmetric vacuum state of the Higgs field. It contains the light-like string on perimeter of the bag and circulating pole. The known zitterbewegung of the Dirac electron acquires natural explanation as consequence of the traveling wave solutions.**

***KERR THEOREM: Geodesic and Shear-free congruences are obtained as analytic solutions of the equation*** $F(T^a) = 0$ , ***where*** $F$ ***is a holomorphic function of the projective twistor coordinates in CP***$^3$, $T^a = \{Y, \quad \zeta - Yv, \quad u + Y\bar{\zeta}\}$.

$Y^+ = \phi_1/\phi_0$, **is equivalent to Weyl spinor** $\phi_\alpha$ **and** $Y^-$, **to** $\bar{\chi}^{\dot{\alpha}}$.

**TWISTOR ⇔ SPINOR relation is origin of the consistent Dirac field.**

**FERMIONIC SECTOR DIRAC EQUATION splits in the Weyl representation into two equations**

$$\sigma^\mu_{\alpha\dot{\alpha}} i\partial_\mu \bar{\chi}^{\dot{\alpha}} = m\phi_\alpha, \quad \bar{\sigma}^{\mu\dot{\alpha}\alpha} i\partial_\mu \phi_\alpha = m\bar{\chi}^{\dot{\alpha}}, \tag{16}$$

**the "left-handed" and "right-handed" electron fields, Weyl spinors.**

**Two antipodally conjugate solutions of the Kerr theorem** $Y^+ = -1/\bar{Y}^-$ **determine two Weyl spinor fields** $\phi^\alpha$ **and** $\bar{\chi}_{\dot{\alpha}}$, **corresponding to antipodal congruences** $Y^+ = \phi_1/\phi_0 \quad , \quad Y^- = \bar{\chi}^{\dot{1}}/\bar{\chi}^{\dot{0}}$

**For** $Y^+$ **we have**

$$\phi_\alpha = \begin{pmatrix} e^{-i\phi/2}\cos\frac{\theta}{2} \\ e^{i\phi/2}\sin\frac{\theta}{2} \end{pmatrix}, \tag{17}$$

**and for** $Y^- = -1/\bar{Y}^+$,

$$\bar{\chi}^{\dot{\alpha}} = \begin{pmatrix} -e^{-i\phi/2}\sin\frac{\theta}{2} \\ e^{i\phi/2}\cos\frac{\theta}{2} \end{pmatrix}. \tag{18}$$

**CONCLUSION:**

- **Spinning Kerr's gravity creates in space Einstein-Rosen bridge – the vortex-like hole of the Compton radius.**
- **Spinning Gravity changes present concept as weak interaction, because it shifts fundamental scale of interaction from Planck to Compton lengths.**
- **Gravity acquires priority before Quantum theory as the Space-Time theory, necessary for effective work of Quantum theory.**
- **Gravity must not be quantized, but it must be regulated for normal work of quantum theory.**
- **Regularization of the Spinning Gravity is achieved by Supersymmetry, by use of the superconducting Bag model based on the Supersymmetric Landau-Ginzburg field model = Wess-Zumino SuperQED model = Supersymmetric Higgs model.**
- **Bag models are soft and deformable, and create specific string model without extra dimensions.**

**THANK YOU VERY MUCH FOR YOUR ATTENTION!**