# TOPOLOGICAL GEOMETRODYNAMICS
## Construction of S-matrix

**Matti Pitkänen**

**http://www.helsinki.fi/~matpitka/**

**matpitka@rock.helsinki.fi**

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# Basic notions and ideas

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- **Zero energy ontology** and S-matrix defines entanglement coefficients of positive and negative energy parts of zero energy states: makes sense only for hyperfinite factors of type $II_1$.
- **New view about quantum measurement theory** based on Jones inclusions $N \subset M$ with N characterizing measurement resolution. Non-commutativity.
- **Space-time picture about particle reactions** based on quantum classical correspondence.
- **Super-conformal invariance at parton level** suggests stringy formulas: partonic 2-surfaces analogous to closed strings.
- **Number theoretic universality**: S-matrix elements algebraic numbers. Number theoretic braids and possible role of zeros of Zeta.

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# Zero energy ontology

To the beginning

- States have vanishing conserved quantum numbers. Every state of universe creatable from vacuum. Initial and final state particles of ordinary description positive and negative energy components of state in zero energy ontology.

- U-matrix characterizing unitary process as part of quantum jump and describing transitions between zero energy states sense was the first guess for the S-matrix as particle physicist defines it. These states have vanishing conformal weights and other quantum numbers. U-matrix could be tensor product of almost trivial factorizing S-matrix for integrable 2-dimensional system.

- Problem:. The S-matrix describing particle physics scattering cannot correspond to U-matrix if it is tensor product of factoring S-matrices!

- Solution: S-matrix as unitary entanglement coefficients between positive and negative energy components of the state. Makes sense for hyper-finite factors of type $II_1$ :Tr(Id)=1! Quantum measurement analogous to state function reduction reduces this entanglement.

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- **Can S-matrix define also for p-adic-to-real or $p_1$-to-$p_2$ transitions?** If quantum numbers are algebraic numbers and thus universal (definable for p-adic partons as those of corresponding real parton) this might make sense(intentional actions). **Most natural option: S-matrix diagonal with respect to number field.** U-matrix between states zero energy states can have elements between different number fields. **U-matrix can describe intentional actions.**

- **Interpretation for almost triviality of U-matrix**: positive and negative energy parts of the state stable in time scale defined by temporal distance between positive and negative energy components of state. If U-matrix for p-adic-real transitions also almost trivial , **realization of intentions occurs with maximal precision.**

- **Why perceived world seems to obey positive energy ontology**? Useful sensory perceptions are consistent with positive energy ontology: not much sense to perceive universes disappearing immediately.

- **Superconductivity as a direct support of zero energy ontology**. Coherent states of Cooper pairs and charged Higgs responsible for massivation of photon and identifiable as charged wormhole contact break basic conservation laws of charge, lepton number, and energy in positive energy ontology. Not so in zero energy ontology!

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# New view about quantum measurement theory

- S-matrix characterizes zero energy state rather than transitions. Tr(Id)=1 for hyperfinite factors of type $II_1$ makes unitarity possible with finite norm !

- Quantum measurement of reaction rates reduces this time-like entanglement.

- Quantum measurement is never ideal but has finite resolution characterized in terms of Jones inclusion $N \subset M$. N represents degrees of freedom about which measurement does not provide information. Precise mathematical definition for cutoff in these degrees of freedom. The quantum space M/N corresponds to those degrees of freedom which are measured and reduction of entanglement occurs in these degrees of freedom.

- Quantum measurement replaces system with a system with new S-matrix. Looks problematic. Unitary process can regenerate the entanglement.

- Quantum criticality and fractality of TGD universe suggest that the S-matrix could be fractal and in some sense invariant under this replacement.

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# Quantum S-matrix

- Problem: S-matrix in M does not correspond as such to the transition probabilities in finite measurement resolution.
- Reduction of S-matrix in M to S-matrix in M/N defined in quantum state space generated by quantum Clifford algebra M/N with N-valued matrix elements. Replacement of complex number based QM with N-based non-commutative QM.
- Reduction of S-matrix in M to quantum S-matrix in M/N with N-valued non-commuting elements. N-unitarity a well defined concept.
- Transition probabilities defined by S-matrix as traces of the N-valued commuting hermitian operators defined by moduli squared of S-matrix.
- N-valued transition probability operators have spectrum. Interpretation in terms of N degrees of freedom over which average is taken. Fuzziness.

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# Geometric view about particle reaction in zero energy ontology

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- **Partonic 2-surfaces acting as vertices** are generated from vacuum. From each of them emanate some number of 3-D lightlike surfaces which end up to the boundaries of future/past lightcone depending on the sign of the energy (incoming/outgoing). **Illustration.**

- Each 3-D lightlike 3-surface belongs a 4-D space-time sheet representing particle by quantum classical correspondence. The ends of these 4-D ends space-time sheets intersect only along the common partonic 2-surfaces serving as vertices.

- **S-matrix represents unitary entanglement coefficients** between positive and negative energy partons at the opposite ends of the complex (Tr(Id)=1!). S-matrix should be constructible using only data at partonic 2-surfaces.

- Connes tensor product gives powerful constraints on S-matrix. Crossing symmetry for action of elements of N to states. S-matrix also superconfornmal invariant.

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# S-matrix as generalization of braiding S-matrices

- **Original dream**: S-matrix could be constructed from braiding S-matrix by allowing also branching of braids. Not quite correct: **replication** of braids at vertices correct interpretation.

- Possible to assign braiding S-matrices with incoming and outgoing particles and also to particle exchanges. The integral over positions of end points gives rise to propagator.

- **Number theoretic realization of braid** as a set of finite number of points on $X^2$ common to real and p-adic space-time sheets.

- Time evolution of partonic 2-surface in preferred coordinates defines the braiding evolution. Slicing by lightcones in rest system of partonic 3-surface defines the slicing to partonic 2-surfaces.

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# Generalized Feynman diagrams

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- Lines of ordinary Feynman diagrams replaced with light-like partonic 3-surfaces. Internal lines and particle exchanges. Assign with each line braiding S-matrix.

- Incoming and outgoing particles characterized by the positions for tips of future/past light-cones whose boundaries contain the partonic 2-surfaces: tips correspond to arguments of N-point function. Unitary S-matrix for each choice of points of $M^4$ . $M^4$ Fourier transform of this unitary S-matrix is also unitary.

- Vertices partonic 2-surfaces at which parton lines meet along their ends. At vertices incoming and outgoing particles define tensor powers of hyper-finite factor of type $II_1$ giving back HFF of type $II_1$! Vertices unitary isomorphisms between these HFFs. This is a crucial point! S-matrix non-trivial and unitary.

- Analogs of string diagrams correspond to the propagation of particle along several routes simultaneously, not to particle reactions! Double slit experiment.

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- For each reaction and given choice of arguments of N-point function there is a minimal diagram defined by the maximum of Kähler function. No summation over Feynman diagrams.

- Path integral replaced with a functional integral around the maximum. Quantum criticality: radiative corrections vanish and the functional integral can be carried out exactly as in integrable theories.

- Non-trivial RG evolution from the dependence of spectrum of modified Dirac operator on p-adic prime p.

- The integral over the end points of internal lines connecting vertices gives propagators as Fourier transforms of braiding S-matrices.

- Perturbative phase: maximum of Kähler function approximately constant and disappears totally from S-matrix elements. In non-perturbative phase situation different. Gauge coupligns proportional to Kähler coupling strength if super-algebra generators vanish at maxima of Kähler function.

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# Possible connection with quantum computation and biology

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- At vertices number theoretical braids replicate. This is a new element. Interpreted as copying of classical and quantum information carried by braids. Quantum information is not copied exactly.

- Particle exchanges have interpretation as communication of information.

- Internal and outgoing lines have interpretation as topological quantum computations.

- TGD based model for topological quantum computation led to the proposal that DNA/RNA is topological quantum computer. One of the number theoretical models for genetic code led to the proposal that each codon is characterized by an integer interpreted as the number of strands of a braid associated with it. DNA replication would be braid replication at deeper level.

- Topological quantum computation could take pla ll

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# Relationship with string models

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- Stringy picture for vertices rather than Feynman diagrams. Partonic 2-surfaces analogous to world sheets of Euclidian closed strings. Fermions and super-canonical and super Kac-Moody generators conformal fields.

- Parton level allows N=4 super-conformal symmetries. Almost topological QFT.

- N-point functions of the conformal field theory defined by C-S action for the induced Kähler gauge potential and corresponding modified Dirac action. N-point functions should define partonic vertices by analogs of stringy formulas. Vertices only!

- How to obtain propagators? 4-D space-time dynamics generates correlations between partons. $CP_2$ type extremals connecting partonic 2-surfaces as correlates for particle exchanges between partons. Classical non-determinism (lightlike randomness giving rise to Virasoro conditions!) makes possible the notion of virtual particle.

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- **Stringy formula** for amplitudes involving integration of arguments $z_i$ of N-point function $G(z_1,..z_M)$ over circle using vertex operator construction. Number theoretic universality forces to replace integral with sum.

- **Vertex operator construction** brings in **artificial target space** as space defined by the Cartan algebra of Kac-Moody and super-canonical algebras. This could mean a close **relationship with string theories**.

- Question: What almost topological QFT property implies? Could **only 3-point functions** remain as in **topological N=4 string model**? At least in QFT like perturbative phase.

- Conclusion: **almost topological QFT would give vertices**.

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# p-Adicization of S-matrix by algebraic continuation

- **S-matrix elements should be algebraic numbers** at least in p-adic-real and p-adic-p-adic transitions. If number theoretic universality is accepted this holds true quite generally.

- **Localization at maxima of Kähler function** and vanishing of loop corrections (quantum criticality) gives hopes about number theoretic universality at the level of configuration space. Cancellation of Gaussian and metric determinants.

- **Objection**: vanishing of radiative corrections not consistent with experimental facts! Dynamical character of h and its appearance in metric of H allows in principle to interpret Kähler function as expansion in powers of ratio of $M^4$ and $CP_2$ Planck constants. p-Adic coupling constant evolution discretizes RG evolution for color and ew coupling constants.

- The 1-D integrals at partonic 2-surfaces defining stringy amplitudes are problem. **Could integrals be replaced with discrete sums over a finite set of points**. These points are naturally rational/algebraic points of imbedding space common to reals and extension of p-adics considered and naturally define braids.

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# Zeros of Riemann zeta and number theoretical braids

- **Hypothesis**: Zeros of $\zeta$ are number theoretically universal in the sense that zeros are algebraic numbers, and zeta and the factors $1/(1+p^s)$ in the product representation of $\zeta$ are algebraic numbers, that is, s, $\zeta$ (s), and $p^s$ are algebraic numbers for any prime and zero of $\zeta$ .

- **Hypothesis**: super-canonical conformal weights $\Delta$ correspond to linear combinations of zeros of Riemann Zeta or of their imaginary parts. Follows naturally from the first hypothesis.

- **Conjugation of conformal weights interpreted as phase conjugation**: positive energy particle traveling to geometric future in general not equivalent with negative energy particle traveling to geometric past.

- Question inspired by quantum classical correspondence: Could the number theoretic braid contained in intersection of real and p-adic partonic 3-surfaces correspond naturally to a fixed value of $\Delta$ . Could the strands of braid with given $\Delta$ be mapped naturally to point z of a geodesic sphere of $CP_2$ by Zeta: $z= \zeta ( \Delta)$ ?

- This question could be inspired by the observation that a family of R-matrices (Yang-Baxter equation) is parameterized by points of $CP_2$ . $CP_2$ in the role of heavenly sphere representing super-canonical

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- **This is the case** if the dependence of Hamiltonians of $\delta M^4_{+/-} \times CP_2$ on suitably scaled lightlike radial coordinate r of $\delta M^4_{+/-}$ involves conformal weight depending on $CP_2$ point z:

  $r^{\Delta(s)}$ , $\Delta(s) = \zeta^{-1}(z)$,

  $z = \xi^1/\xi^2$ coordinate for geodesic sphere of $CP_2$. $\xi^1$ and $\xi^2$ transform linearly under U(2) subgroup of SU(3). Heavenly sphere would be quite literally sphere!

- **Different branches of $\zeta^{-1}(z)$ labelled by zeros of zeta**. Can be glued together at values of r which form fractal hierarchies [$r_n = \exp(n2\pi/\mathrm{Im}(\Delta_1 - \Delta_2))$].

- Points with fixed $\Delta = \Sigma\, n_k s_k$ or $\Delta = 1/2 + i\,\Sigma\, n_k y_k$ would correspond to algebraic values of $r^{\Delta(s)}$ for rational values of r. For given value of $\Delta$ several *rational* values of r, define the strands of braid.

- **Slicing of partonic 3-surface** to 2-surfaces by lightcones defines number theoretical braiding (actually tangle: strands can turn back).

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# Do zeros of $\zeta$ correspond to transitions changing the value of Planck constant?

- Weakest form form criticality for transition changing the value of $M^4$ Planck constant is that the points of number theoretic braid correspond to orbifold point in $CP_2$ degrees of freedom. $\Delta$-conserving time evolution of partonic 2-surface can lead it to a sector with different covering of $M^4$ by $CP_2$ points via a 2-surface with $CP_2$ projection consisting of orbifold point.

- The transitions could occur if the discrete set of points appearing in S-matrix element corresponds to orbifold points of $CP_2$ remaining invariant under the group G characterizing the canonical Jones inclusion. These groups leave the points $z= \xi^1/\xi^2 \in [0,\infty] \cup \infty$ of heavenly sphere invariant.

- $z= \xi^1/\xi^2=0$ if $\Delta$ is zero of Riemann $\zeta$. Zeros of $\zeta$ would define the critical conformal weights for which leakage between different sectors of imbedding space is possible!
  Zeros of zeta have been associated with critical systems!

- One application could be quantum critical high Tc super-conductivity. At the boundary of large hbar super-conductor Cooper pairs would have conformal

# Connection between number theoretic braids and Jones inclusions?

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- The finite set of algebraic points in intersection of real and p-adic partonic 2-surfaces could be interpreted as braid (or tangle). Braiding S-matrices assignable to the legs of S-matrix. In vertex these braids would collide. Branching of braids possible in partonic vertex where negative and positive energy space-time sheets meet.

- Also Jones inclusions $N \subset M$ represented in terms of infinite hierarchy of braids and Temperley-Lieb algebras. Braids define hierarchy of approximations for hyperfinite factors and inclusion of subsequent finite braids defines finite-dimensional approximation for the inclusion of factors. At limit of infinite braid the ratio for dimensions of algebras associated with N and N-1-strand -→ fractal dimension $B_n = 4\cos^2(\pi/n)$ for M/N.

- Question: Is there a connection between the braids defined by intersections of partonic 2-surfaces in different number fields and braid hierarchy defining Jones inclusion? Could sub-Clifford algebras of CH and their inclusions have number theoretic braids as space-time correlates.

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# How number theoretic braids emerge from Jones inclusions?

- Number theoretic braids would result when induced spinor fields anticommute only in a discrete subset of points of number theoretic string at partonic 2-surface.
- M→M/N reduction implies that the number of spinor modes becomes finite.
- Complex coordinates z associated with geodesic spheres of $CP_2$ and lightcone boundary become N-valued and non-commutative and commute only at points of braid.
- Coordinates z appear in the generalized eigenvalues for the modes of induced spinor field so that also induced spinor field anticommutes only at these points.
- Physical states coherent states for z and eigenmodes of the complex coordinates. Eigenvalues expressible in terms of zeros of zeta.

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# S-matrix in zero energy ontology

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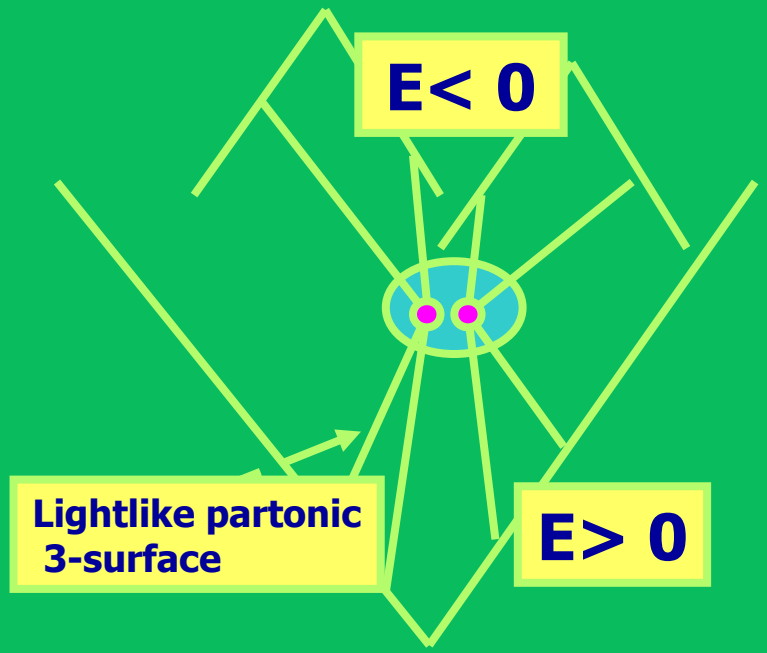


Zero energy state

- Partonic 2-surface $X^2$ =intersection of incoming lightlike partonic 4-surfaces (!). Note that their interiors do not intersect! Necessary for realizing quantum classical correspondence.

S-matrix unitary entanglement matrix: $SS^{\Sigma}$ =Id, Tr(Id)=1.

# Number theoretic braid

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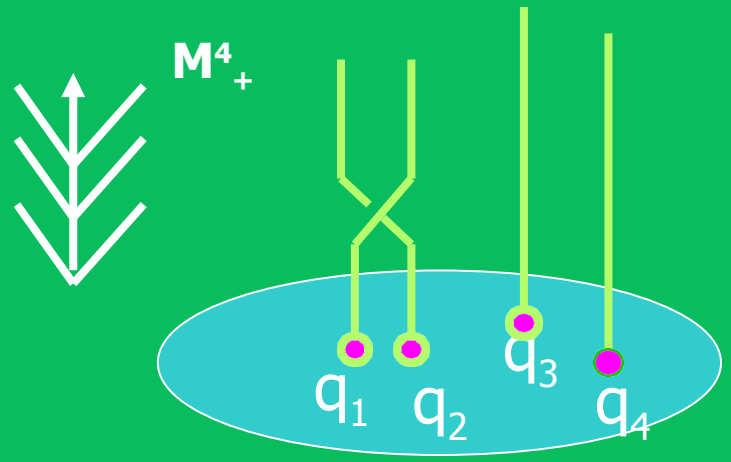
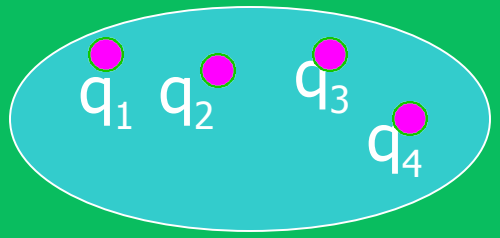


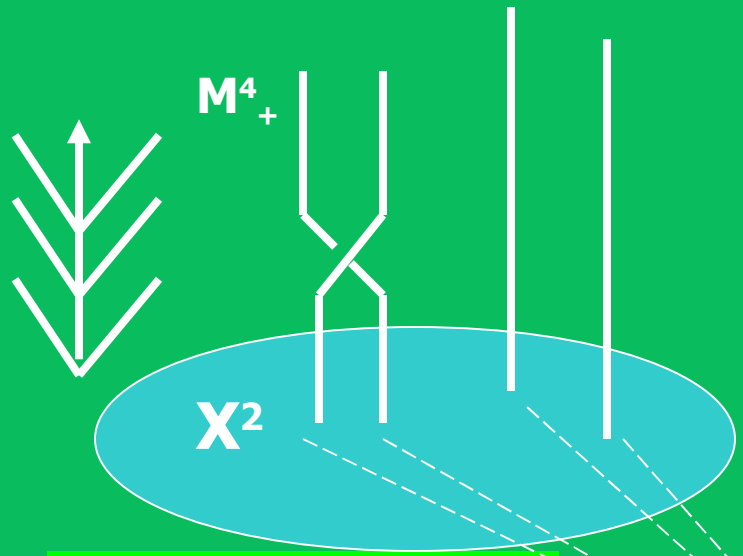

Real parton



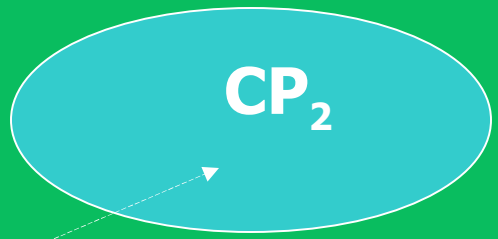

p-Adic parton

- Punctures $q_i$ common rational (algebraic) points of real and p-adic partonic surfaces.
- Points p-Adically arbitrary near to $q_i$ at infinite distance from $q_i$ in real sense.
- The foliation by future lightcones $M^4_+$ defines number theoretic braiding.

# Do zeros of Riemann ζ define number theoretical braidings?




**Number theoretical braid**: Rational points (or those in algebraic extension of rationals common to real and p-adic space-time sheet define the strandsof braid. Foliation by lightcones of $M^4_+$ defines braiding.




**Radial conformal weight**

$\Delta = \Sigma\, n_k s_k$

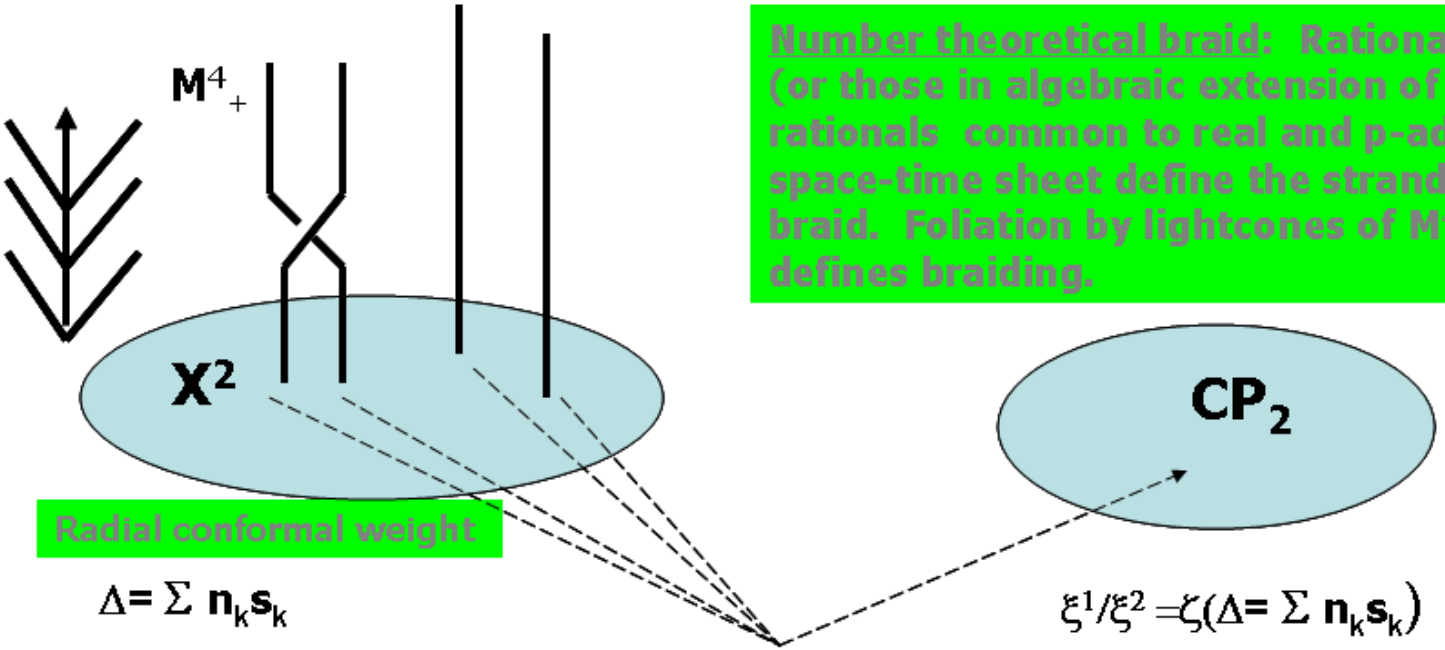
$\xi^1 / \xi^2 = \zeta\,(\Delta = \Sigma\, n_k s_k)$

**Conformal confinement**: $\Sigma_i \Delta_i$ real, sum over partons associated with given lightcone.

**Assumptions needed**:

a) Number theoretic universality of Riemann ζ . $p^{s_k}$ algebraic number for any zero $s_k$ of ζ and any prime p.

b) The Hamiltonians at $\delta M^4_+ \times CP_2$ are of form $r^{\Delta(s)}$, where $\Delta(s) = \zeta^{-1}(\xi^1/\xi^2)$ is radial conformal weight, $\xi^1$ and $\xi^2$ complex coordinates of $CP_2$ transforming linearly under SU(2) ⊂ SU(3) and r is suitably scaled lightlike radial coordinate of future lightcone boundary.

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