AN APOLOGY FOR ADS3

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- ADS3 IS A TOY MODEL THAT CAPTURES SOME OF THE MOST PUZZLING ASPECTS OF QUANTUM GRAVITY
- THERE ARE NO GRAVITATIONAL WAVES IN PURE ADS3 GRAVITY (AND THIS IS GOOD)
- A "SQUARE ROOT" OF PURE GRAVITY EXISTS
- ADS3 POSSESSES INFINITE-DIMENSIONAL ASYMPTOTICAL ALGEBRAS THAT IN PART REDUCE DYNAMICS TO KINEMATICS
- HIGH-SPIN FIELDS PROPAGATE ZERO DEGREES OF FREEDOM BUT THEY ARE NEITHER FREE NOR EQUIVALENT TO FREE FIELDS

THE EASY PROBLEM WITH QUANTUM GRAVITY: RENORMALIZABILITY

EINSTEIN ACTION HAS A COUPLING CONSTANT WITH DIMENSION [square length] (NEWTON'S CONSTANT)

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$$S_{div} \sim G^{n-1}\log(\Lambda/\mu)\int d^4x\sqrt{-g}R^{n+1}$$

SCALAR MADE OUT OF RIEMANN TENSORS

INFINITE SET OF COUNTERTERMS

WHAT IF THEORY IS FINITE (N=8 SUPERGRAVITY?)

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WE STILL WON'T KNOW HOW THE THEORY BEHAVES AT ENERGY

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$$A_{2\to N} = \sum_{l=0}^{\infty} (GE^2)^{N/2+l} A_l$$

EXPANSION PARAMETER OF SERIES BECOMES LARGE AT PLANCKIAN ENERGIES

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QUESTIONS SUCH AS UNITARITY IN BLACK-HOLE EVAPORATION OR THE FATE OF SINGULARITIES REMAIN AS UNKNOWN AS IN THE NON-RENORMALIZABLE THEORY

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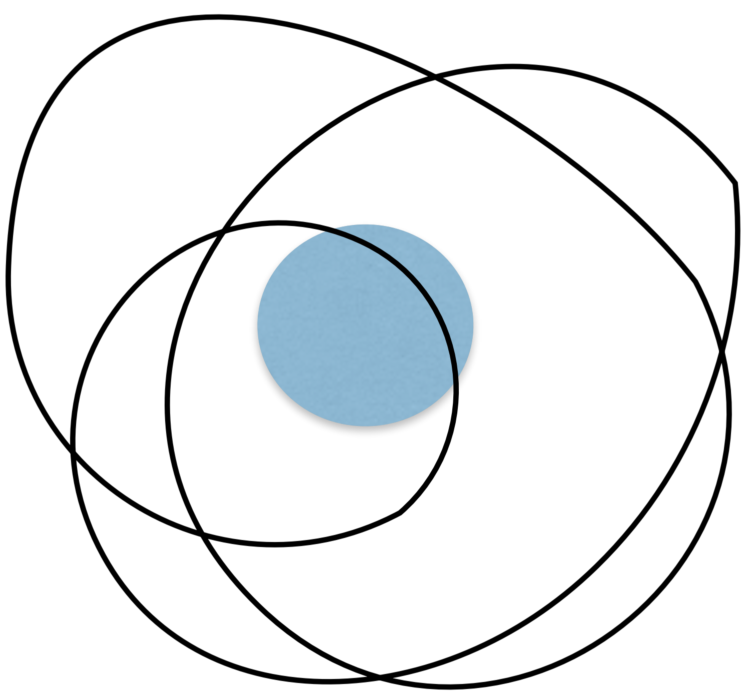

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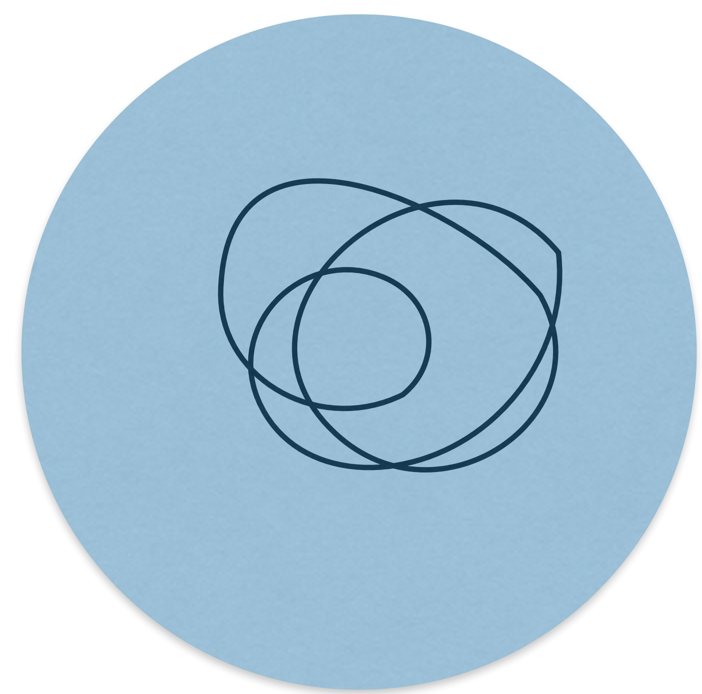

WE STILL DON'T KNOW WHAT THE THEORY DOES AT VERY HIGH ENERGY

RELATED PROBLEM: NONPERTURBATIVE OBSERVABLES

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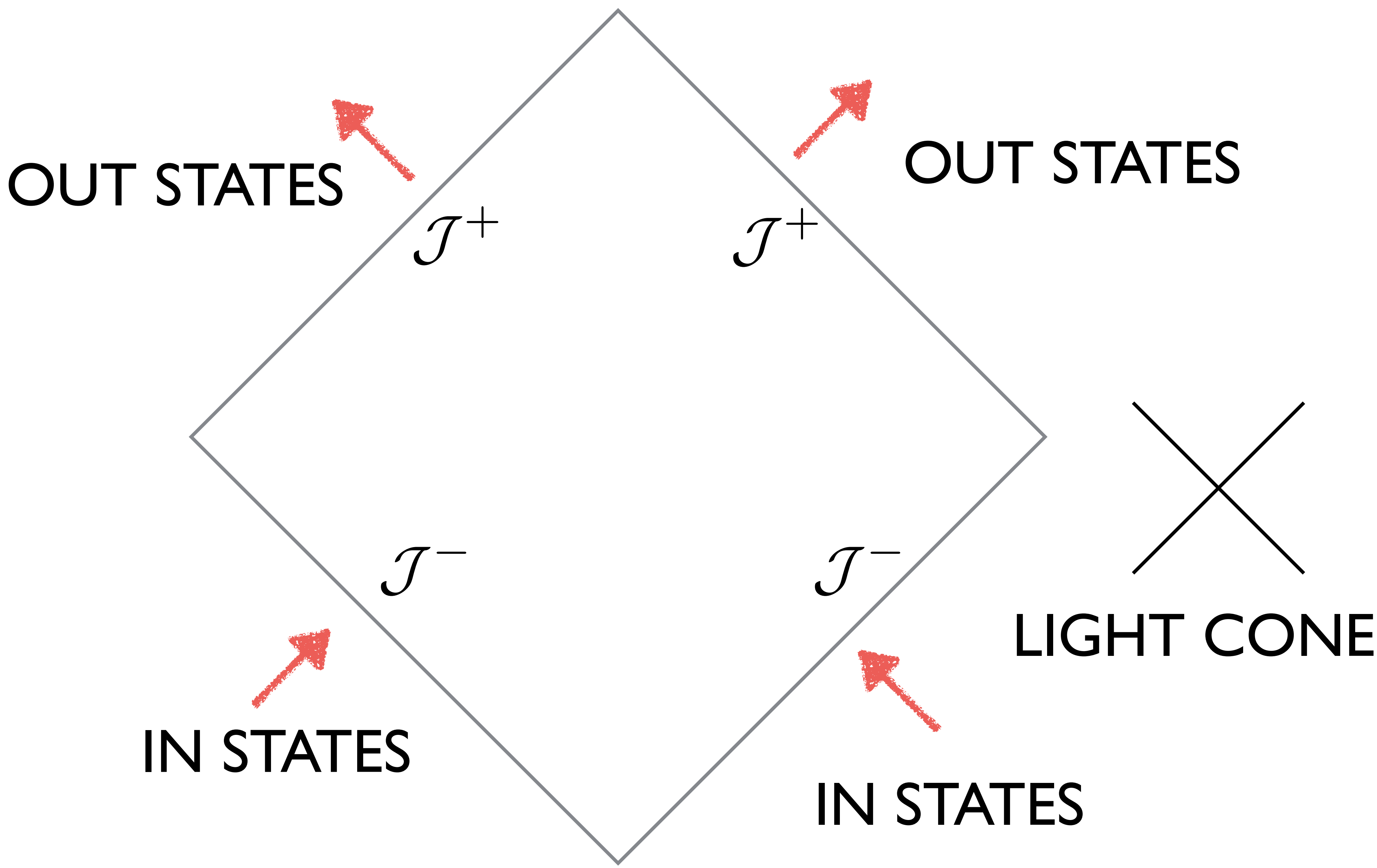
NON-PERTURBATIVELY DEFINED OBSERVABLES DEPEND ON THE ASYMPTOTIC BEHAVIOR OF SPACETIME

IN ASYMPTOTICALLY FLAT SPACETIME THE ONLY OBSERVABLE IS THE S-MATRIX



ANTI DE SITTER SPACE

SOLUTION OF EINSTEIN EQUATIONS WITH NEGATIVE COSMOLOGICAL CONSTANT (PROPAGATE SAME DEGREES OF FREEDOM AS PURE GRAVITY)

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi G T_{\mu\nu}, \qquad T_{\mu\nu} = g_{\mu\nu}(d-1)(d-2)/16\pi G L^2$$

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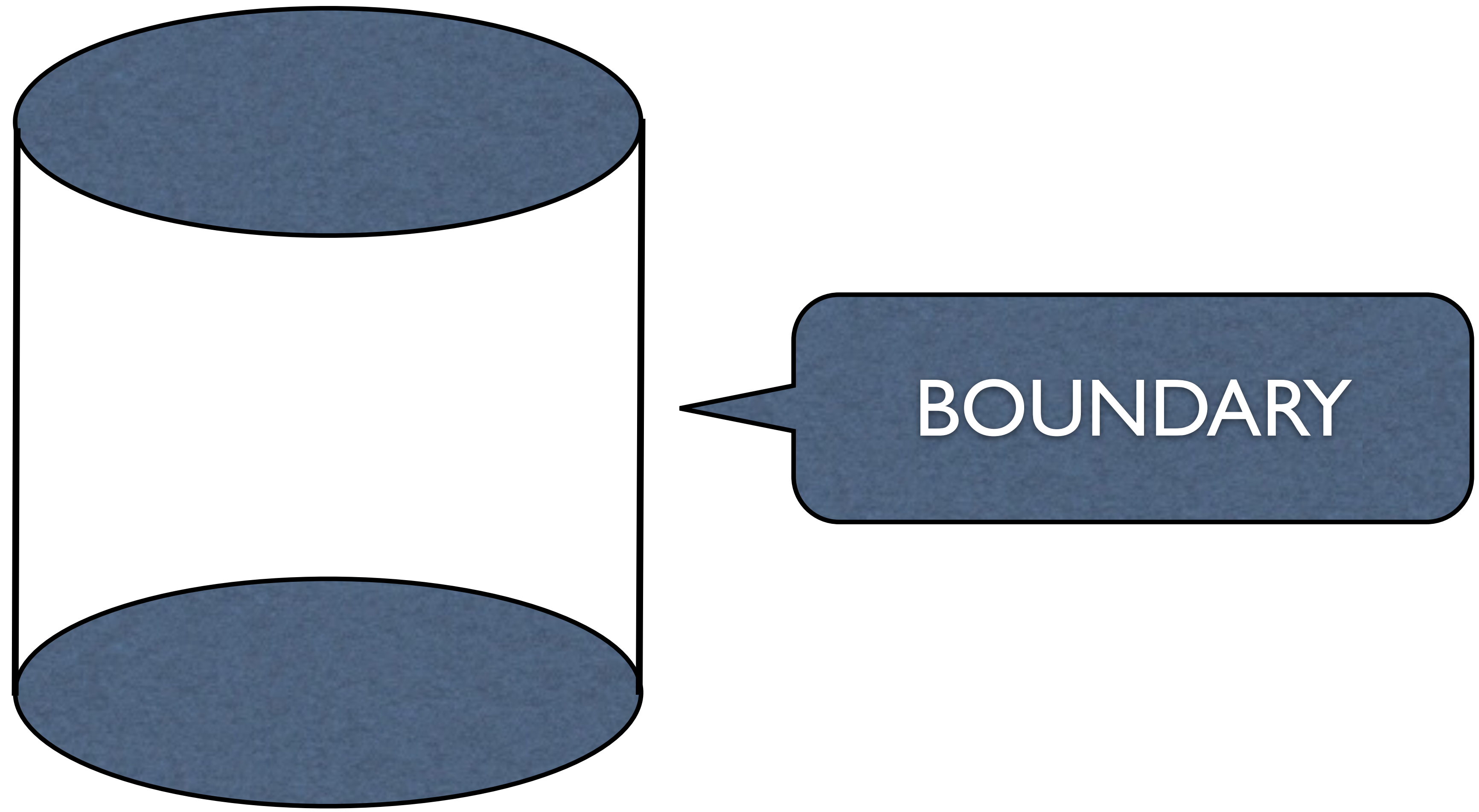
GEOMETRICALLY IT IS A d-DIMENSIONAL HYPERBOLOID IN A (2+d)-DIMENSIONAL SPACE OF SIGNATURE (2,d)

$$-(x^0)^2 - (x^{d+1})^2 + \sum_{i=1}^{d} (x^i)^2 = -L^2$$

SIMPLEST CASE: d=2
ADS3 IS CONFORMAL TO A SOLID CYLINDER



$$ds^2 = -\cosh^2\rho dt^2 + \sinh^2\rho d\phi^2 + d\rho^2$$

$$\Downarrow$$

$$ds^2 = z^{-2}(-dw_+ dw_- + dz^2) \qquad w_\pm = t \pm \phi,\ z = \exp(-\rho)$$

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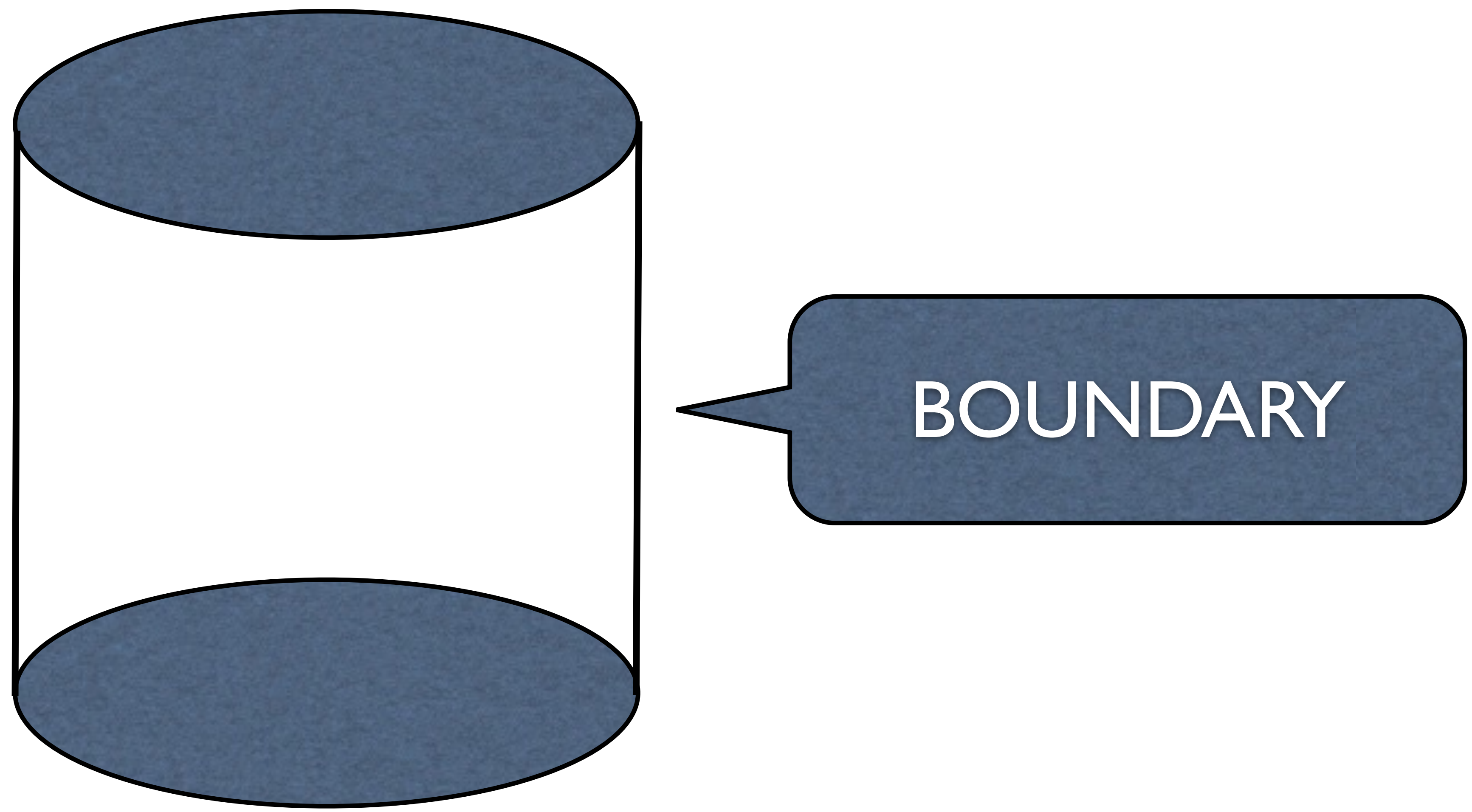

OBSERVABLES: LOCAL OPERATORS DEFINED ON THE BOUNDARY

THE ASYMPTOTICAL ADS3 METRIC IS PRESERVED BY A LARGE GROUP OF COORDINATE TRANSFORMATIONS THAT DEFINE A LARGE SYMMETRY GROUP

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$$w^\pm \to w^\pm + \epsilon^\pm(w^\pm) + \frac{1}{2} z^2 \epsilon''^\mp(w^\mp)$$

$$z \to z - \frac{1}{2} z[\epsilon'^+(w^+) + \epsilon'^-(w^-)]$$

THE ALGEBRA DEFINED BY THE CHARGES ASSOCIATED TO ASYMPTOTIC DIFFEOMORPHISM HAS A CLASSICAL CENTRAL CHARGE

$$[L_n, L_m] = (n-m)L_{n+m} + \frac{c}{12}\delta_{n,-m}m(m^2-1)$$

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$$R_{0\mu} - g_{0\mu}R + g_{0\mu}\Lambda = 0 \to -3 \text{ non-dynamical equations} = \text{constraints}$$

PURE ADS3 GRAVITY ADMITS BLACK HOLE SOLUTIONS, THE BTZ (BANADOS, TEITELBOIM, ZANELLI)

$$ds^2 = -\frac{(r^2 - R^2)^2}{r^2} dt^2 + \frac{L^2 r^2}{(r^2 - R^2)^2} dr^2 + r^2 d\phi^2, \qquad R = \sqrt{8GML}$$

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CLASSICAL GRAVITY AS CHERN-SIMONS

$$A = e/l - \omega, \qquad \tilde{A} = e/l + \omega$$

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CONSTRAINT EQUATION (GAUSS LAW)

$$F|_{\Sigma} = 0 \to A = dUU^{-1} \qquad \text{(locally)}$$

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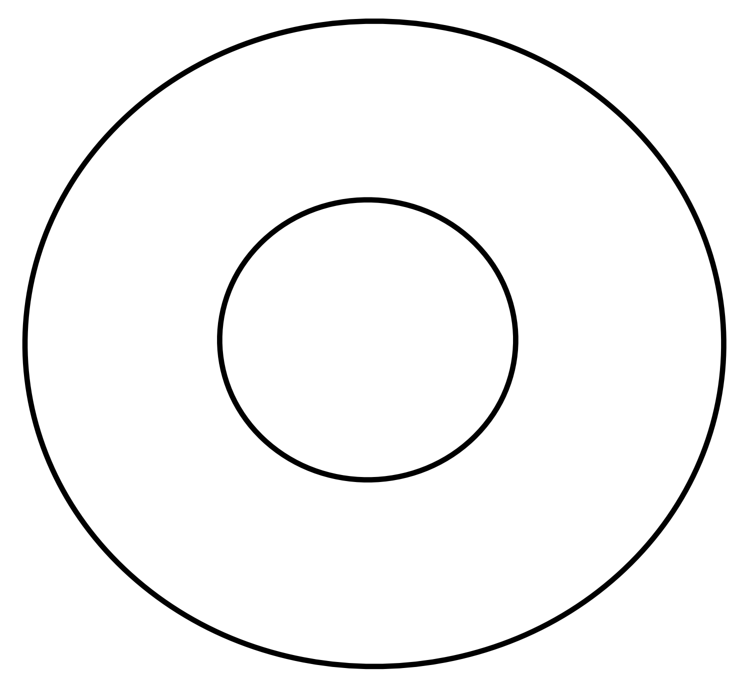

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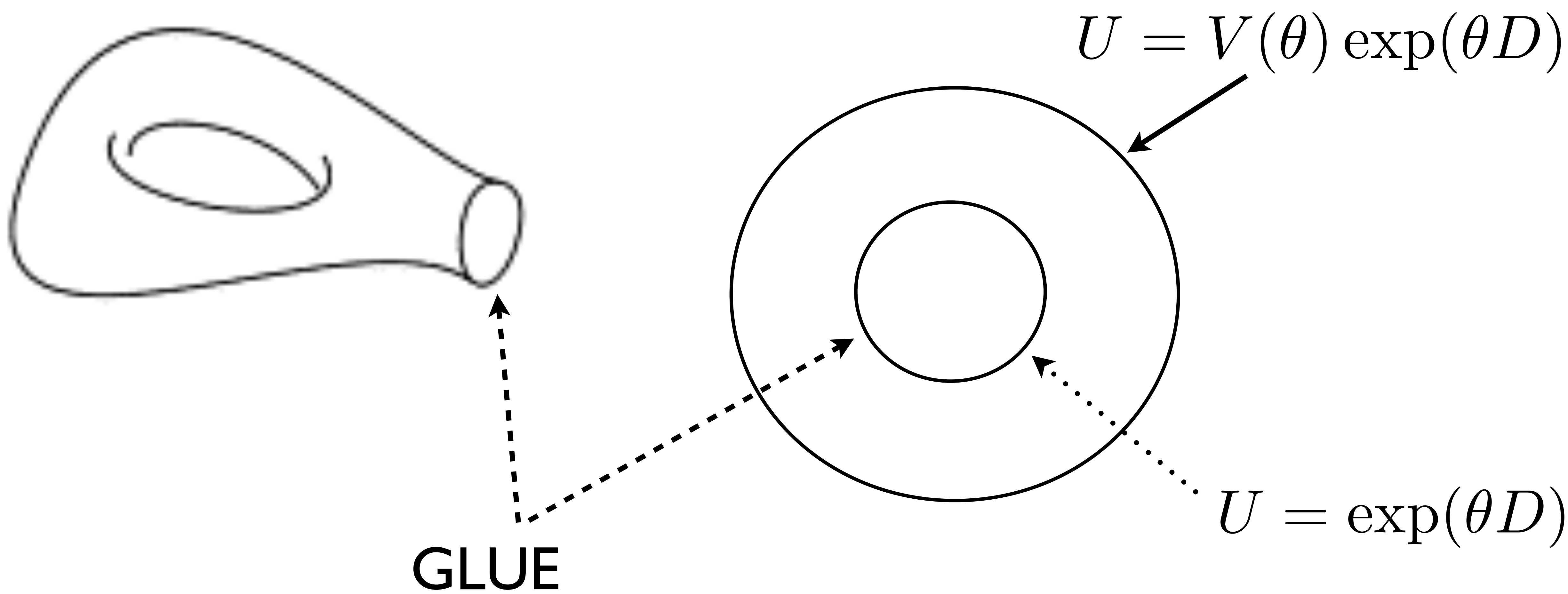

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THIS SPACE ADMITS A KAHLER STRUCTURE AND A KAHLER FORM: WE CAN QUANTIZE USING COHERENT STATES

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EXISTENCE OF THIS THEORY STILL DEBATED

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FOR GENERIC μ BAD THEORY WITH GHOSTS

AT $\mu L = 1$ GHOSTS DISAPPEAR FOR

BROWN-HENNEAUX BOUNDARY CONDITIONS

ASYMPTOTIC ALGEBRA IS ONLY ONE COPY OF VIRASORO

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BOUNDARY CONDITIONS CAN BE RELAXED TO GIVE

$$Q(\epsilon^-) \neq 0$$

BUT THEORY HAS GHOST

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INTERACTING THEORIES OF MASSLESS HIGH SPIN PARTICLES EXIST IN ADS (VASILIEV)

BOUNDARY DESCRIPTION

$$\Delta = s + (D-3)/2 \rightarrow j^{(\mu_1, \ldots, \mu_s)_T}$$

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"ANALYTIC CONTINUATION" OF SL(N,R)

$$hs[\mu] = UEA[J^a]/\{J_0^2 - \frac{1}{2}(J_-J_+ + J_+J_-) - (\mu^2 - 1)/4\}$$

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GABERDIEL-GOPAKUMAR CONJECTURE: THIS IS CFT DUAL TO ADS3 VASILIEV HIGH SPIN THEORY

TESTS: SPECTRUM OF LIGHT STATES, SYMMETRIES, DEFORMATIONS OK

GRAVITATIONAL WAVES DO NOT PROPAGATE IN ADS3,
BUT IT IS NEVERTHELESS A PRECIOUS THEORETICAL
LABORATORY FOR QUANTUM GRAVITY
BECAUSE IT POSSESSES KEY FEATURES OF 4D GRAVITY,
LIKE BLACK HOLES,
TOGETHER WITH ESPECIALLY LARGE
ASYMPTOTIC ALGEBRAS THAT PARTIALLY REDUCE
DYNAMICS TO KINEMATICS