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# Entanglement entropy in conformal quantum mechanics

in collaboration with M. Arzano and D. Frattulillo  
Based on [1]

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 Università degli studi di Napoli "Federico II"

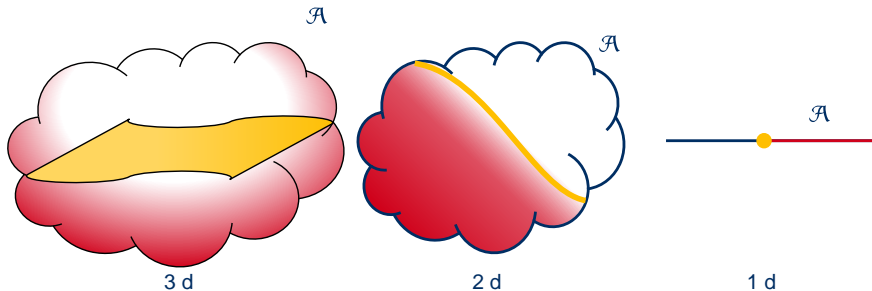
 COST CA18108 Fourth Annual Conference - Rijeka (HR)

R^zdp@~<ZSb^

R^ k Gy zPC C^z- ^LY\ C^z C^zdp%σ- ^ <P-q <ZCpS C zPCI -- ^z-\ <bpqY zSb^s 4Cz..CC^  
@LqCs bHHqC@b\ S^sSc - ^@b-zSc - LfC^ qLb^ bHse- <CZ\ C 9:

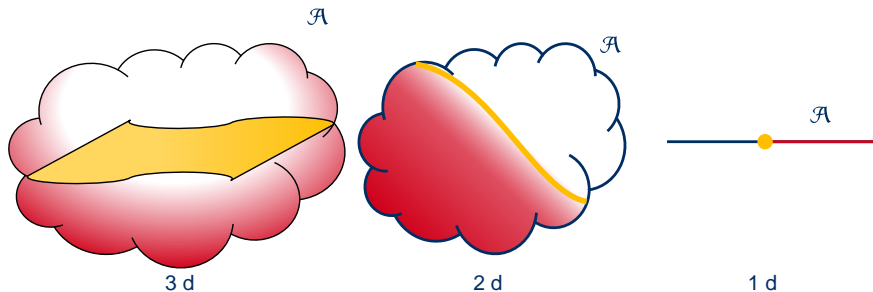
R^zdp@~<zSb^

R^ k Gy zPC C^z-^LYA C^z C^zdp%<- ^ <P-q <zCqS CzPCI -- ^z-\ <bopCf zSb^s 4Cz..CC^  
@CLqCs bHHqC@b\ S^sSc-^@b-zScC- LSc^ qLSb^ bHse-<CzS C q:



$R^z p @ \sim z S^A$

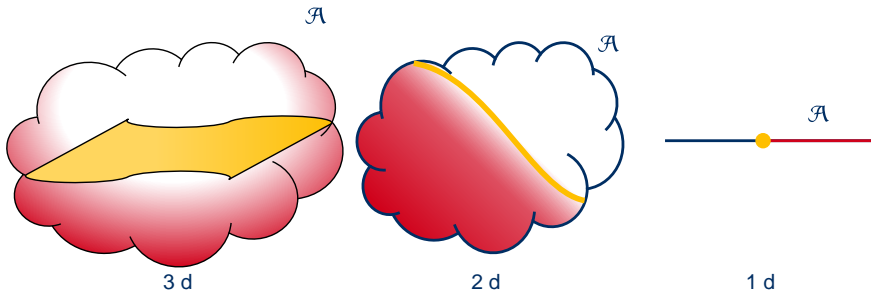
$R^k G_y z P C^z \sim \wedge L Y C C^z C^z p e \% \sim \wedge \langle P - q \rangle \langle C q S C z P C I \sim \wedge z \sim \rangle \langle b o p p \rangle z S^A s 4 C z . . C C^A$   
 $@ C L q C s b H H q C C @ \backslash S^s s a C - \wedge @ b - z s s a C - L S f C^A q C L S^A b H s e - \langle C C S C q :$



$z P C z q \langle C b f C q z P C @ C L q C s b H H q C C @ \backslash Y b \langle Y S C @ b^A - q C L S^A \dots P S P S s^A b z - \langle \langle C s s S A Y C z b z P C$   
 $b 4 s C q f C q q S - Y s S^s - q @ \sim \langle C @ @ C^A s s \% \lambda - z q f x$

$R^z p @ \sim z S b ^ \wedge$

$R^k G y z P C C^z \wedge L Y \wedge C^z C^z p e \% \sim \wedge \langle P - q \rangle \langle z C q S C z P C I \sim \wedge z \sim \rangle \langle b o p p C \rangle z S b ^ \wedge s 4 C z . . C C ^ \wedge$   
 $@ C L q C s b H H q C C @ \backslash S ^ s s a C - \wedge @ b \sim z s s a C - L S f C ^ q C L S b ^ b H s e \sim \langle C C S \rangle C q :$



$z P C z q \langle C b f C q z P C @ C L q C s b H H q C C @ \backslash Y b \langle Y S C @ b ^ \wedge - q C L S b ^ \wedge \dots P S P S s ^ \wedge b z \sim \langle \langle C s s S \rangle Y C z b z P C$   
 $b 4 s C q f C q q S \sim z s S ^ \wedge - q @ \sim \langle C @ @ C ^ \wedge s s \% \lambda \rangle - z q f x$   
 $z P C C^z \wedge L Y \wedge C^z C^z p e \% s s z P C , b ^ \wedge ] C \sim \wedge \wedge C^z p e \% s s b \sim S z C @ z b x$

„ P-z - \ RLbS^L zb z- YW- 4b~zm



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entanglement entropy between time domains in Minkowski space-time covered by orbits of different generators of time evolution

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goal

entanglement entropy between time domains in Minkowski space-time covered by orbits of different generators of time evolution

who



# „ P-z - \ RLbS^L zb z- YW- 4b~zm

**goal**

entanglement entropy between time domains in Minkowski space-time covered by orbits of different generators of time evolution

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generators coinciding with conformal Killing vectors tangent to worldlines of Milne and diamond observers at constant radius

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**methods**

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entanglement entropy between time domains in Minkowski space-time covered by orbits of different generators of time evolution

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**methods**

correspondence between radial conformal symmetries in Minkowski space-time and time evolution in conformal quantum mechanics (CQM)

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**methods**

correspondence between radial conformal symmetries in Minkowski space-time and time evolution in conformal quantum mechanics (CQM)

**how**

within CQM we identify states which have a thermofield double structure associated to these generators of time evolution

;  $b^{\wedge}Hbq\ \ -Yq\ @S\ YV\ S^{\wedge}L\ fC\ <zbq\ S^{\wedge}\ [ \ S^{\wedge}Vb..s\ V\ S\ se\ -\ <CQ\ S\ C$

[  $S^{\wedge}Vb..s\ V\ S\ \ C\ zq\ S^{\wedge}\ q\ @S\ Y\ <b\ b\ q\ @S^{\wedge}\ -z\ C\ S$

$$s^2 = z^2 + q^2 + s^2 + s^2$$

fcg

;  $b^{\wedge}Hbq \lambda - Yq \text{ @S YV SXS}^{\wedge}L fC\text{-zbpS}^{\wedge} [ S^{\wedge}Vb..sV\text{S}se\text{-} \langle CQSA C$

[  $S^{\wedge}Vb..sV\text{S} \setminus Czq\text{S}^{\wedge} S^{\wedge} q \text{ @S Y} \langle b bq \text{ @S}^{\wedge} - zCs$

$$@s^2 = @z^2 + @q^2 + q^2 @^2 + sS^2 @^2$$

fcg

-  $fC\text{-zbp} \text{ " C} \text{ @ S} - \langle b^{\wedge}Hbq \lambda - YV SXS^{\wedge}L fC\text{-zbp} \text{ S} \text{ H}$

L L / L

;  $b^{\wedge}Hbq \lambda - Yq \text{ @S YV SXS}^{\wedge}L fC\text{-zbpS}^{\wedge} [ S^{\wedge}Vb..sV\text{Sse-} \langle CQSA C$

[  $S^{\wedge}Vb..sV\text{S} \setminus Czq\text{S}^{\wedge} S^{\wedge} q \text{ @S Y} \langle b\text{bq} \text{ @S}^{\wedge} - zCs$

$$s^2 = z^2 + q^2 + s^2 \quad fcg$$

-  $fC\text{-zbp} \text{ " } C \text{ @ } S\text{-} \langle b^{\wedge}Hbq \lambda - YV SXS^{\wedge}L fC\text{-zbp} S \text{ H}$

$$L \quad L \quad / \quad L \quad E) = (z; q) \quad f|g$$



;  $b^{\wedge}Hbq \backslash - Yq \text{ @S YV SXS^L fC-zbqs S^ [ S^Vb..sV\se- <CQS C$

$$[ S^Vb..sV\ Czf\ S^ q \text{ @S Y } \langle b b q \text{ @S } - zCs$$

$$s^2 = z^2 + q^2 \quad @^2 + s^2 @^2 \quad \text{fcg}$$

$$- fC-zbq \text{ " C@ S - } \langle b^{\wedge}Hbq \backslash - YV SXS^L fC-zbq SH$$

$$L L / L E) = (z; q) \quad \text{f|g}$$

Hbq [ S^Vb..sV\se- <CQS C - Yq \text{ @S Y } \langle b^{\wedge}Hbq \backslash - YV SXS^L fC-zbqs - qC \langle Y s s S C @ q :

;  $b^{\mu}H_{\mu\nu} - Y_{\nu} \partial_{\mu} S = Y_{\nu} S_{,\mu} - f C_{\nu\lambda\mu} S^{,\lambda}$  [  $S^{\prime\prime} V_0 \dots s^{\prime\prime} S^{\prime} s e - \langle C C S \rangle C$

$$[ S^{\prime\prime} V_0 \dots s^{\prime\prime} S^{\prime} C_{\nu\lambda\mu} S^{,\lambda} \partial_{\mu} S - Y_{\nu} \partial_{\mu} S - f C_{\nu\lambda\mu} S^{,\lambda} - z C_s$$

$$\partial S^2 = \partial z^2 + \partial q^2 + q^2 \partial^2 + S S^2 \partial^2 \quad f c g$$

$$- f C_{\nu\lambda\mu} S^{,\lambda} \partial_{\mu} S - \langle b^{\mu} H_{\mu\nu} \rangle - Y_{\nu} S_{,\mu} - f C_{\nu\lambda\mu} S^{,\lambda}$$

$$L L / L E) = (z; q) \quad f | g$$

$$H_{\mu\nu} [ S^{\prime\prime} V_0 \dots s^{\prime\prime} S^{\prime} s e - \langle C C S \rangle C - Y_{\nu} \partial_{\mu} S - Y_{\nu} \partial_{\mu} S - f C_{\nu\lambda\mu} S^{,\lambda} - q C - Y_{\nu} S_{,\mu} \partial^{\mu} S ] :$$

$$= - V_0 + 4 \int_0 + \langle d_0 \rangle \quad f \{ g$$

;  $b^{\wedge}Hbq \lambda - Yq \text{ @S YV SWS}^{\wedge}L fC\text{-}z bq s^{\wedge} [ S^{\wedge}Vb..sV\text{S}se\text{-} <CQ\text{S} C$

$$[ S^{\wedge}Vb..sV\text{S} \setminus Czq\text{S} S^{\wedge} q \text{ @S Y} <b bq\text{S}^{\wedge}\text{-} zCs$$

$$\text{@s}^2 = \text{@z}^2 + \text{@q}^2 + q^2 \text{@}^2 + \text{S}^{\wedge}2 \text{@}^2 \quad \text{fcg}$$

$$\text{- } fC\text{-}z bq \text{ " } C\text{@} \text{ S} \text{- } <b^{\wedge}Hbq \lambda \text{-} YV SWS^{\wedge}L fC\text{-}z bq \text{ S}H$$

$$L \quad L \quad /L \quad E) = (z; q) \quad \text{f|g}$$

Hbq [  $S^{\wedge}Vb..sV\text{S}se\text{-} <CQ\text{S} C \text{-} Yq \text{ @S Y} <b^{\wedge}Hbq \lambda \text{-} YV SWS^{\wedge}L fC\text{-}z bq s \text{-} qC \text{ <Y} \text{ss} \text{S} C\text{@} \text{q}:$

$$= - \underline{V_0} + 4 \underline{?_0} + \underline{<d_0} \quad \text{f\{g}$$

$$V_0 = \underline{seC\text{S} Y <b^{\wedge}Hbq \lambda \text{-} Yzq \text{ ^} sHbq \lambda \text{-} zSb^{\wedge}s}$$

;  $b^{\wedge}Hbq\downarrow - Yq\ @S YV S\ S^{\wedge}L fC\z b\ q\ S^{\wedge} [ S^{\wedge}Vb\ .. s\ V\ S\ se- <CQ\ S\ C$

$$[ S^{\wedge}Vb\ .. s\ V\ S\ \ C\ z\ q\ S^{\wedge} q\ @S Y\ \ b\ b\ q\ S^{\wedge} - z\ C\ S$$

$$\omega^2 = \omega_z^2 + \omega_q^2 + q^2 \omega^2 + S^2 \omega^2$$

fcg

$$- fC\z b\ q\ " C\ @\ S\ -\ \ b^{\wedge}Hbq\downarrow - YV S\ S^{\wedge}L fC\z b\ q\ S\ H$$

$$L\ L\ /L\ E) = (z; q)$$

f|g

$$Hbq [ S^{\wedge}Vb\ .. s\ V\ S\ se- <CQ\ S\ C - Yq\ @S Y\ \ b^{\wedge}Hbq\downarrow - YV S\ S^{\wedge}L fC\z b\ q\ S - q\ C\ \ Y\ s\ S\ C\ @\ q:$$

$$= - V_0 + 4 \text{?}_0 + < d_0$$

f{g

$$V_0 = \underline{se\ C\ S\ Y\ \ b^{\wedge}Hbq\downarrow - Yz\ q\ \ ^{\wedge}S\ Hbq\downarrow - z\ S\ ^{\wedge}S}$$

$$\text{?}_0 = \underline{\ @S\ z\ S\ ^{\wedge}S}$$

;  $b^{\mu}H_{\mu\nu} - Y_{\nu} \partial_{\mu} S$   $Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu} [ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} se - \langle CQ \rangle S C$

$$[ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} \langle Cq \rangle S^{\mu} \partial_{\mu} S Y \langle b_{\nu} q \rangle S^{\mu} - z C S$$

$$\partial S^2 = \partial z^2 + \partial q^2 + q^2 \partial^2 + S^2 \partial^2$$

fcg

$$- f_{CZ} b_{\nu} \dots C \partial S - \langle b^{\mu} H_{\mu\nu} \rangle - Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu}$$

$$L L / L E) = (z; q)$$

f|g

$H_{\mu\nu} [ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} se - \langle CQ \rangle S C - Y_{\nu} \partial_{\mu} S Y \langle b^{\mu} H_{\mu\nu} \rangle - Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu} - q C \langle Y S S \rangle C \partial q :$

$$= - V_0 + 4 ?_0 + \langle d_0$$

f{g

$$V_0 = \underline{se C S Y \langle b^{\mu} H_{\mu\nu} \rangle - Y z q^{\mu} s^{\nu} H_{\mu\nu} - z S^{\mu} s^{\nu}}$$

$$?_0 = \underline{\partial S z S^{\mu} s^{\nu}}$$

$$d_0 = \underline{z q^{\mu} s^{\nu} z S^{\mu} s^{\nu}}$$

;  $b^{\mu}H_{\mu\nu} - Y_{\nu} \partial_{\mu} S$   $Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu} [ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} se - \langle CQ \rangle S C$

$$[ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} \langle Cq \rangle S^{\mu} \partial_{\mu} S Y \langle b_{\nu} q \rangle S^{\mu} - z C S$$

$$\partial S^2 = \partial z^2 + \partial q^2 + q^2 \partial^2 + S S^2 \partial^2$$

f c g

$$- f_{CZ} b_{\nu} \dots C \partial S - \langle b^{\mu} H_{\mu\nu} \rangle - Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu}$$

$$L L / L E) = (z; q)$$

f | g

$H_{\mu\nu} [ S^{\nu} \partial_{\mu} \dots s_{\nu} S^{\mu} se - \langle CQ \rangle S C - Y_{\nu} \partial_{\mu} S Y \langle b^{\mu} H_{\mu\nu} \rangle - Y^{\nu} S_{;\mu}^{\mu} L f_{CZ} b_{\nu} S^{\mu} - q C \langle Y S S \rangle C \partial q :$

$$= - V_0 + 4 ?_0 + \langle d_0$$

f { g

$$V_0 = se C S Y \langle b^{\mu} H_{\mu\nu} \rangle - Y_{\nu} \partial_{\mu} S^{\mu} H_{\mu\nu} - z S^{\mu} S^{\nu}$$

$$\langle Y S C z P C S I (2; R) X S C - Y L C q$$

$$?_0 = \partial S^{\mu} z S^{\nu} S^{\mu}$$

$$[d_0; ?_0] = d_0; [V_0; ?_0] = V_0;$$

f J g

$$d_0 = z q^{\mu} S^{\nu} z S^{\mu} S^{\nu}$$

$$[?_0; d_0] = 2 ?_0$$

;  $Y_{ss} \leftarrow z^b \partial^a b \eta_{q\lambda} @S Y \leftarrow b^a \eta_{bq\lambda} - YV S^{\lambda} L fC \leftarrow z b q s$

„  $C \dots \eta_{\lambda b} \leftarrow s b \sim q - z z^C \leftarrow z^b \partial^a b^{\lambda} :$

;  $Y_{ss} \ll z \hat{S} b H q @ S Y \ll b^{\wedge} H b q \setminus - Y V S Y S^{\wedge} L f C \ll z b q s$

„ C .. S Y H b < ~ s b ~ q - z z C^{\wedge} z \hat{S} b^{\wedge} b^{\wedge} :

$\phi z - z \hat{S}^{\wedge} s$

$$p_0 = \frac{1}{2} d_0 + \frac{V_0}{2}$$

flg



;  $Y_{ss} \leftarrow z \hat{S} b H q @ S Y \leftarrow b^{\wedge} H b q \setminus - Y V S Y S^{\wedge} L f C \leftarrow z b q s$

„ C ..  $S Y H b \leftarrow s b \sim q - z z C^{\wedge} z \hat{S} b^{\wedge} b^{\wedge}$  :

$\phi z - z \hat{S}^{\wedge} s$

$$p_0 = \frac{1}{2} d_0 + \frac{V_0}{2}$$

fl g

$@ S z \hat{S}^{\wedge} s$

?<sub>0</sub>

fv g

;  $Y_{ss} \ll z^{\Delta} b^{\Delta} Hq @S Y \ll b^{\Delta} Hq \setminus - YV S^{\Delta} L fC \ll z b q s$

„  $C \dots SY H b \ll s b \sim q - z z^{\Delta} z^{\Delta} b^{\Delta} :$

$\phi z - z^{\Delta}$

$$p_0 = \frac{1}{2} d_0 + \frac{V_0}{2}$$

flg

$@SY z^{\Delta}$

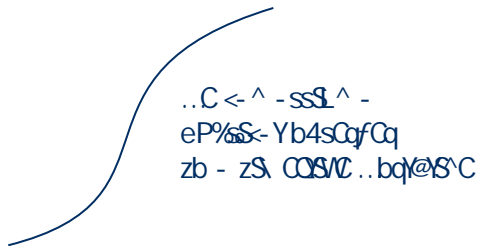
$?_0$

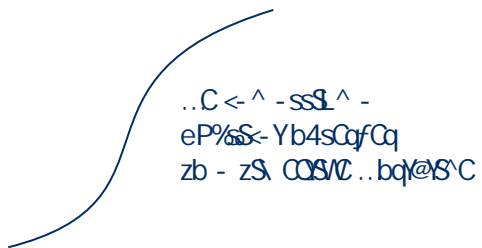
fvq

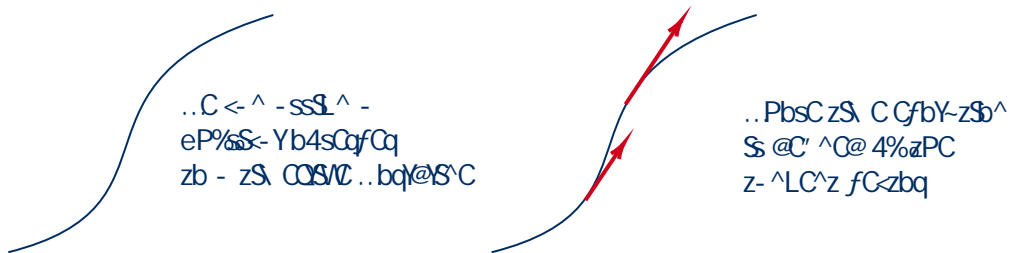
$\ll b \setminus 4S^{\Delta} - z^{\Delta} b^{\Delta} Hq \setminus ^{\Delta} SY z^{\Delta} s - ^{\Delta} @ se C \setminus S Y \ll b^{\Delta} Hq \setminus - Yz q \setminus ^{\Delta} Hq \setminus - z^{\Delta} s$

$$r_0 = \frac{1}{2} d_0 - \frac{V_0}{2}$$

fug







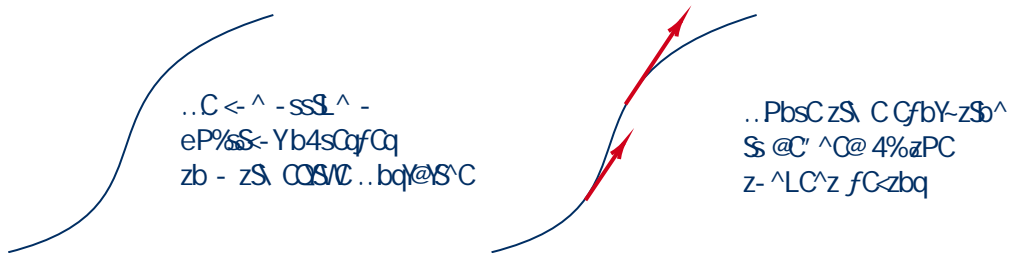
$$\begin{aligned} & \dots C \ll \wedge - s s \wedge - \\ & e P \% s - Y b 4 s C q f C q \\ & z b - z s \cos \wedge \dots b q \wedge s \wedge C \end{aligned}$$

$$\begin{aligned} & \dots P b s C z s \ C G f b Y - z s \wedge \\ & S @ C' \wedge C @ 4 \% z P C \\ & z - \wedge L C \wedge z f C - z b q \end{aligned}$$

$$\begin{aligned} & \dots C \dots S Y H b \ll \sim s b \wedge \quad \underline{sz - z s} \quad b 4 s C q f C q s \\ & = - z^2 + 4 z + < @_z \end{aligned}$$

fDg

$$L C \wedge C q - z b q b H \ll b \wedge H b q \setminus - Y z q \wedge s H b q \setminus - z s \wedge s b H z P C q C - Y f z s \ C q \ Y \wedge C$$

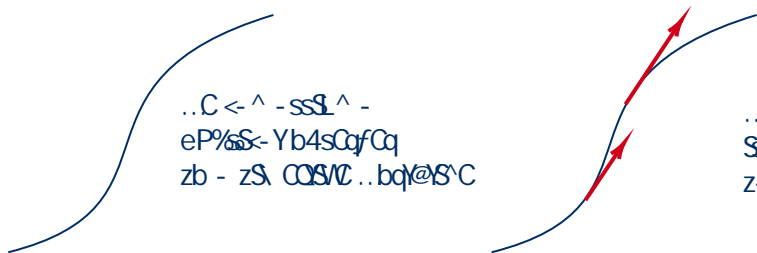


$$\begin{aligned}
 & ..C .. S Y H b < \sim s b ^ \mathbf{sz-zs} b 4 s C q f C q s \\
 & = - z^2 + 4 z + < @_z
 \end{aligned}$$

fDg

$$L C ^ C q z b q b H < b ^ H b q \setminus - Y z q ^ s H b q \setminus - z S b ^ s b H z P C q C - Y f z S C g Y ^ C$$

$$?_0 z S C O S V C S ^ s s @ z P C H z \sim q C - ^ @ e - s z Y S L P z Q b ^ C$$



..C < ^ - s s s ^ -  
eP% s - Y b 4 s C q f C q  
z b - z s C O S V C .. b q Y @ S ^ C

..P b s C z s C C G f b Y - z s b ^  
S @ C ^ C @ 4 % z P C  
z - ^ L C ^ z f C - z b q

$$..C .. S Y H b < \sim s b ^ \underline{sz-zs} b 4 s C q f C q s$$

$$= - z^2 + 4 z + < @_z$$

fDg

$$L C ^ C q - z b q b H < b ^ H b q \setminus - Y z q ^ s H b q \setminus - z s b ^ s b H z P C q C - Y f z s C q Y ^ C$$

$$?_0 z s C O S V C S ^ s s @ C z P C H z \sim q C - ^ @ e - s z Y S L P z Q b ^ C$$

$$r_0 z s C O S V C S ^ s s @ C z P C < - \sim s - Y @ s \setminus b ^ @$$

$$= \frac{1}{2} \left[ \frac{S^2 C}{\cos^2 C} \right]$$

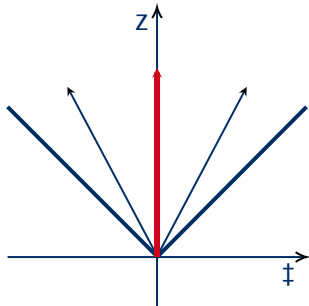


$$= \gamma_0 [ \frac{S^2 C}{\cos C} ]$$

$$\frac{\gamma_0}{S} \gamma S @$$

$$= \gamma_0 [ \sin^2 \theta - \cos^2 \theta ]$$

$$\frac{\gamma_0}{2} \gamma_{\mu\nu} S^\mu S^\nu$$

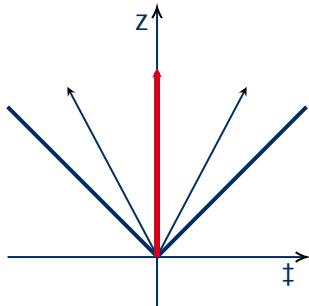


$$L^2 \gamma_{\mu\nu} S^\mu S^\nu = \frac{1}{2} \gamma_{\mu\nu} S^\mu S^\nu$$

$$= \tau_0 [ \sin C \cos C ]$$

$$= r_0 [ -s - Y @ S \setminus b^@ ]$$

$$\tau_0 \int S @$$



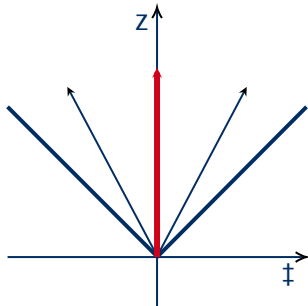
$$LC^A C_f z C_s z S C C_f b Y - z S^A b H - [ S^A C b 4 s C_f C_f C_f ] S^A z P C [ S^A C z S C$$

$$= \tau_0 [ \sin C \cos C ]$$

$$= r_0 [ -s - Y @ S \setminus b^@ ]$$

$$\tau_0 \int S @$$

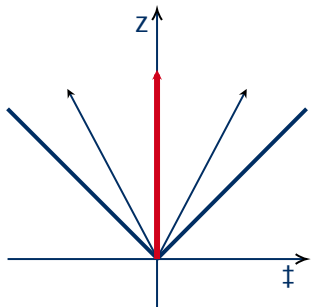
$$r_0 \int S @$$



LC^Cq zCs zS C Cfby-zS^ bH- [ S^C b4sCqfCq  
S^ zPC [ S^C zS C

$$= \tau_0 [ \text{S}^{\wedge} C \text{se} \text{--} \langle \text{OZS} \rangle C$$

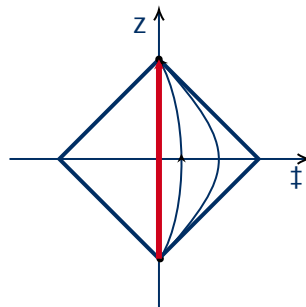
$$\tau_0 \int S @$$



LC^Cq\_f zCs zS C Cfby-zS^ bH- [ S^C b4sCqfCq  
S^ zPC [ S^C zS C

$$= r_0 \langle \text{--} s \text{--} Y @ S \setminus b^ @$$

$$r_0 \int S @$$



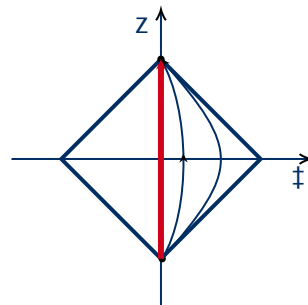
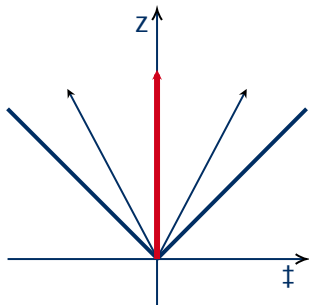
LC^Cq\_f zCs zS C Cfby-zS^ bH- @S \ b^ @  
b4sCqfCq S^ zPC @S \ b^ @ zS C

$$= \tau_0 [ \frac{S^2 C}{s^2} \frac{e^{-\cos S} C}{s^2} ]$$

$$= r_0 [ \frac{S^2 C}{s^2} \frac{e^{-\cos S} C}{s^2} ]$$

$$\tau_0 \int S @$$

$$r_0 \int S @$$



$LC^A C_f z C_s z S C C_f b y - z S^A b H - [ S^A C b 4 s C_f C_q$   
 $S^A z P C [ S^A C z S C$

$LC^A C_f z C_s z S C C_f b y - z S^A b H - @ S \setminus b^A @$   
 $b 4 s C_f C_q S^A z P C @ S \setminus b^A @ z S C$

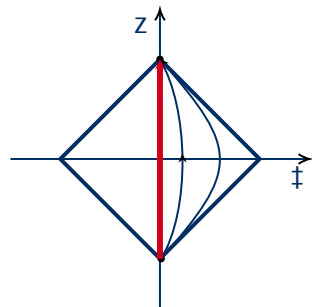
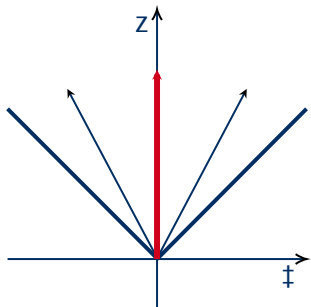
$\rho - ^A r X(2; R) z q^A s H b q \setminus - z S^A \setminus - e e S^L r (z^A) S^z b ? (z) :$

$$= r_0 [ \frac{S^2 C}{s} - \frac{C^2 S}{s} ]$$

$$= r_0 [ \frac{S^2}{s} - \frac{C^2}{s} ]$$

$$\frac{r_0}{s} \int S @$$

$$\frac{r_0}{s} \int S @$$



$LC^2 C_f z C_s z S C C_f b y - z S^2 b H - [ S^2 C b 4 s C_f C_f C_f ]$   
 $S^2 z P C [ S^2 C z S C ]$

$LC^2 C_f z C_s z S C C_f b y - z S^2 b H - @ S \setminus b^2 @$   
 $b 4 s C_f C_f C_f S^2 z P C @ S \setminus b^2 @ z S C ]$

$$g - ^r X(2; R) z q^2 \wedge s H b q \setminus - z S^2 \setminus - e e S^2 L r(z^j) S^2 z b ?(z) : z^j = \frac{(z)}{z +} f_g$$

$$k = -z^2 - 4z + c_2$$

$$= -z^2 + 4z + c_2$$



$$k_{--}^{\hat{z}-\backslash} \setminus C^P-\hat{S}-Y \llcorner \hat{z} C^q-p-qz$$

$$= -z^2 + 4z + \dots @_z ; b^{\hat{H}bq} - Yk_{--}^{\hat{z}-\backslash} [ C^P-\hat{S}S$$

f; k [ g

$$k_{\mu\nu} = -\partial_\mu \partial_\nu \log|z| \quad \text{in } \mathbb{C}P^1 \text{ with metric } ds^2 = 4|z|^{-2} dz d\bar{z}$$

$$= -z^2 + 4z + c \quad ; \quad b^{\mu\nu} \partial_\mu \partial_\nu \log|z| = \frac{1}{z^2} \quad \text{in } \mathbb{C}P^1 \text{ with metric } ds^2 = 4|z|^{-2} dz d\bar{z}$$

$$k \sim \partial_z \sim \partial_{\bar{z}} \quad \setminus \quad C\mathbb{P}^1 \simeq S^2 \simeq \mathbb{R}P^2 \simeq \mathbb{C}P^1$$

$$= -z^2 + 4z + c \quad ; \quad b^{\mu\nu} \partial_{\mu} \partial_{\nu} \left[ \frac{1}{z} \right] \quad S = -V + 4\pi + c \quad \text{fc}$$

$$V = S V_0 \quad ; \quad S_0 > 0 = S d_0 \quad \text{XSCZPCsl(2;R) XSC-YLCAq 9:}$$

$$k \sim z^{-1} \setminus \mathbb{C}P^1 \setminus S^1 \hookrightarrow \mathbb{C} \setminus \mathbb{R} \cong \mathbb{C} \setminus \mathbb{R}$$

$$= -z^2 + 4z + c \partial_z \quad ; \quad b^{\mu\nu} \partial_\mu \partial_\nu \sim z^{-1} \setminus \mathbb{C}P^1 \setminus S^1 \quad \mathbf{S} = -V + 4\epsilon + c \partial_z \quad \text{fc} \mathbb{C}$$

$$V = S V_0 \partial_z = S \partial_z \partial_t = S \partial_t \partial_z \in \text{sl}(2; \mathbb{R}) \quad \mathbb{X} \mathbb{C} \setminus \mathbb{R} \mathbb{C} \setminus \mathbb{R} \quad \mathbb{R}$$

$$= p_0 \quad ; \quad \mathbf{p} = \frac{1}{2} \mathbf{v} + 0$$

$k \sim z^{-1} \setminus \mathbb{C}P^1 \setminus S^1 \hookrightarrow \mathbb{C}P^1 \setminus S^1$

$$= -z^2 + 4z + c \partial_z \quad ; \quad b^{\mu\nu} \partial_\mu \partial_\nu \sim z^{-1} \setminus \mathbb{C}P^1 \setminus S^1 \quad S = -V + 4\epsilon + c \partial_z \quad f \partial_z$$

$$V = SV_0 \partial_z = S \partial_z \partial_z = S d_0 \langle \text{IsCzPCsl}(2;R) \rangle \setminus \mathbb{C}P^1 \setminus S^1 \quad \mathfrak{g}$$

$$= p_0 \quad ; \quad k \partial_z \quad \mathbf{p} = \frac{1}{2} \frac{V}{z} + 0$$

$$= ?_0 \quad ; \quad k \partial_z \quad ?$$



$$k = -z^{-1} \partial_z - Y \partial_Y - z \partial_x - \partial_t$$

$$= -z^2 + 4z + c \partial_z \quad ; \quad b^{\mu\nu} \partial_\mu \partial_\nu - Y k - z^{-1} [C^{\mu\nu} \partial_\mu \partial_\nu] \quad \mathbf{S} = -V + 4\partial_t + c \partial_x \quad \text{fc} \mathbb{C} \mathbb{R}$$

$$V = S V_0 \partial_t = S \partial_t \partial_0 = S d_0 \langle \text{bsCzPCsl}(2; \mathbb{R}) \text{XSC-YLC} \partial_t \mathbb{R} \rangle$$

$$= p_0 \quad ; \quad k \partial_t \quad \mathbf{p} = \frac{1}{2} \frac{V}{z} + 0$$

$$= ?_0 \quad ; \quad k \partial_t \quad ?$$

$$= r_0 \quad ; \quad k \partial_t \quad \mathbf{r} = \frac{1}{2} \frac{V}{z} - 0$$

Q Pb... @ .. C sz - @ % z S C C f b Y - z S ^ b H sz - z S b 4 s C o f C o s S ^ e b o z S ^ s b H [ S ^ V b .. s V S se - < C z S C - s S ^ L ; k [ m

y S C GfbY-zSb^ S^ [ S^Vb..sV\$se- <COS\ C ~sS^L ; k [



$y \ S \ C \ G \ b \ Y \ z \ S \ b \wedge \ S \wedge \ [ \ S \wedge \ b \dots \ s \wedge \ S \ se \ - \ < \ C \ O \ S \ C \ \sim \ s \wedge \ L \ ; \ k \ [$

$$X_0 = p; \quad X = r \ S; \quad C^2 = p^2 + p \ X \ X_+$$

fccg

$y \ S \ C \ G \ b \ Y \ - \ z \ b \ ^ \ S \ ^ \ [ \ S \ ^ \ V \ b \ . \ . \ s \ V \ S \ s \ e \ - \ < \ C \ O \ S \ C \ \sim \ s \ ^ \ L \ ; \ k \ [$

$$X_0 = p; \quad X = r \ S; \quad C^2 = p^2 + p \ X \ X_+$$

fccg

$p \ P \ - \ s \ @ \ S \ < \ q \ z \ C \ s \ e \ C \ z \ q \ - \ ^ \ @ \ ^ \ b \ q \ - \ Y \ S \ C \ @ \ C \ S \ C \ ^ \ f \ C \ - \ z \ b \ q \ s \ j \ ^ \ i$

$y \ S \ C \ G \ f \ b \ Y \ - \ z \ S \ b \ ^ \ S \ ^ \ [ \ S \ ^ \ V \ b \ . \ . \ s \ V \ S \ s \ e \ - \ < \ C \ O \ S \ C \ \sim \ s \ S \ ^ \ L \ ; \ k \ ]$

$$X_0 = p; \quad X = r \quad \mathcal{S}; \quad C^2 = p^2 + p \quad X \quad X_+$$

fccg

$$p \ P \ - \ s \ @ \ S \ < \ q \ z \ C \ s \ e \ C \ z \ q \ - \ ^ \ @ \ ^ \ b \ q \ - \ Y \ S \ C \ @ \ C \ S \ C \ ^ \ f \ C \ z \ b \ q \ s \ j \ ^ \ i$$

$$p \ j \ ^ \ i = q \ j \ ^ \ i \quad \dots \ S \ P \quad q = q + \wedge; \quad \wedge = 0; 1; \dots; \quad q > 0$$

$$X \ j \ ^ \ i = \frac{p}{q(q-1)} \quad q(q-1) j \ ^ \ i \quad 1/i$$

$$h \ j \ ^ \ i = \wedge \ ^ \ i$$

$$C^2 j \ ^ \ i = q(q-1) j \ ^ \ i$$

$y \ S \ C \ G \ f \ b \ Y \ - \ z \ S \ b \ ^ \ S \ ^ \ [ \ S \ ^ \ V \ b \ . \ . \ s \ V \ S \ s \ e \ - \ < \ C \ O \ S \ C \ \sim \ s \ ^ \ L \ ; \ k \ ]$

$$X_0 = p; \quad X = r \quad \mathcal{S}; \quad C^2 = p^2 + p \quad X \quad X_+$$
fccg

$p \ P \ - \ s \ @ \ S \ < \ q \ z \ C \ s \ e \ C \ z \ q \ - \ ^ \ @ \ ^ \ b \ q \ - \ Y \ S \ C \ @ \ C \ S \ C \ ^ \ f \ C \ - \ z \ b \ q \ s \ j \ ^ \ i$

$$p \ j \ ^ \ i = q \ j \ ^ \ i \quad \dots \ S \ P \quad q = q + \wedge; \quad \wedge = 0; 1; \dots; \quad q > 0$$

$$X \ j \ ^ \ i = \frac{p}{q(q-1)} \quad q(q-1) j \ ^ \ i \quad 1/i$$

$$h \ j \ ^ \ i = \wedge \wedge$$

$$C^2 \ j \ ^ \ i = q(q-1) j \ ^ \ i$$

$$\leftarrow \wedge \ C \ b \ H \ 4 \ - \ s \ s \ j \ ^ \ i \ ! \ j \ z \ i \ \dots \ P \ C \ q \ C$$

$$0 \ j \ z \ i = \ S \ @ \ _ \ @ \ j \ z \ i$$
fc|g

$\infty$   
 $\approx$   
 $\cdot \nabla$

$$O_{jz} = S_{@z}^{@} jz$$

$$?_{jz} = S z \frac{@}{@z} + \varphi_{jz}$$

$$V_{jz} = S z^2 \frac{@}{@z} + 2z\varphi_{jz}$$

$$\dots C S C z \varphi = 1 - \wedge @ b 4 z - S' \varrho > | :$$

$$\begin{aligned}
 \infty & \\
 \approx & \quad 0 jz i = S_{az}^{\otimes} jz i \\
 \cdot \nabla & \quad ? jz i = S z \frac{\otimes}{az} + \varphi jz i \quad \dots C S C z \varphi = 1 - \wedge @ b 4 z - S' g > | : \\
 & \quad V jz i = S z^2 \frac{\otimes}{az} + 2 z \varphi jz i
 \end{aligned}$$

$$(\wedge + 1) h z j^{\wedge} i = h z j p j^{\wedge} i E ) \quad \boxed{jz i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0 i} \quad fc\{g$$

$$\begin{aligned} \infty & \\ \approx & \quad 0 \, jz_i = S_{\text{az}}^{\text{a}} \, jz_i \\ ? & \quad jz_i = S \, z \frac{\text{a}}{\text{az}} + \varphi \, jz_i \quad \dots C S C \varphi = 1 - \text{^@b4z-S' g>l :} \\ \cdot \nabla & \quad V \, jz_i = S \, z^2 \frac{\text{a}}{\text{az}} + 2z\varphi \, jz_i \end{aligned}$$

$$(\wedge + 1) \, hzj^{\wedge} i = hzj p j^{\wedge} i \, E) \quad \boxed{jz_i = \frac{1}{4} \frac{- + S}{- S} + 1^2 \, C \frac{a+it}{a-it} X_+ j^{\wedge} = 0i} \quad \text{fc}\{g$$

$$zPC S^{\wedge} C q e p @ \sim \langle z = \quad hz_1 / z_2 i = \frac{2}{4(z_1 \quad z_2)^2} \quad \text{fc}\{g$$

$$\begin{aligned}
 \infty & \\
 \approx & \quad 0 jz i = S_{az}^{\otimes} jz i \\
 ? & \quad jz i = S z \frac{\otimes}{az} + \varphi jz i \quad \dots C S C \varphi = 1 - \wedge @ b 4 z - S' \varrho > | : \\
 \cdot \vee & \quad V jz i = S z^2 \frac{\otimes}{az} + 2 z \varphi jz i
 \end{aligned}$$

$$(\wedge + 1) \hbar z j^{\wedge} i = \hbar z j p j^{\wedge} i E \quad \boxed{jz i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0 i} \quad fc\{g$$

$$zPC S^{\wedge} C q e p @ - < z = \hbar z_1 / z_2 i = \frac{2}{4(z_1 - z_2)^2} \quad fcJg$$

$\setminus - z < PC s zPC z . b @ b S' z H^{\wedge} < z b^{\wedge} b H - \setminus - s s Y C s s < - Y q " C X @ S' [ S' V b . . s V S s e - < C Q S C$   
 $C f - Y - z C @ - Y b^{\wedge} L zPC .. b q @ S' C b H - ^ S' C q S Y b 4 s C q f C q s S z S' L - z zPC b q S' \varrho > u :$



$$\begin{aligned} \infty \\ \approx \\ \cdot \nabla \end{aligned} \quad \begin{aligned} 0 jz i &= S_{az}^{\otimes} jz i \\ ? jz i &= S z \frac{\otimes}{az} + \varphi jz i \\ V jz i &= S z^2 \frac{\otimes}{az} + 2z\varphi jz i \end{aligned} \quad \dots C S C \varphi = 1 - \wedge @ b 4 z - S' \varrho > | :$$

$$(\wedge + 1) h z j^{\wedge} i = h z j p j^{\wedge} i E ) \quad \boxed{jz i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0 i} \quad fc\{g$$

$$z P C S^{\wedge} C q e p @ - < z = \quad h z_1 / z_2 i = \frac{2}{4(z_1 - z_2)^2} \quad fc\}g$$

\ - z < P C s z P C z . . b @ b S' z H ^ < z S b ^ b H - \ - s s Y C s s < - Y q " C Y @ S' [ S' V b . . s V S s e - < C Q S C C f - Y - z C @ - V b ^ L z P C . . b q i @ S' C b H - ^ S' C o p S Y b 4 s C o f C q s S z S' L - z z P C b o f L S' \varrho > u :

$$z = z P C S' C o p S Y z S C$$

$$\begin{aligned} \infty \\ \approx \\ \cdot \end{aligned} \quad \begin{aligned} 0 jz i &= S_{az}^{\otimes} jz i \\ ? jz i &= S z \frac{\otimes}{az} + \varphi jz i \quad \dots C S C \varphi = 1 - \wedge @ b 4 z - S' \varrho > | : \\ V jz i &= S z^2 \frac{\otimes}{az} + 2 z \varphi jz i \end{aligned}$$

$$(\wedge + 1) h z j^{\wedge} i = h z j p j^{\wedge} i E) \quad \boxed{jz i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0 i} \quad fc\{g$$

$$z P C S^{\wedge} C q e p @ - < z = \quad h z_1 / z_2 i = \frac{2}{4(z_1 - z_2)^2} \quad fcJg$$

\ - z < P C s z P C z . . b @ b S' z H ^ < z S b ^ b H - \ - s s Y C s s < - Y q " C Y @ S' [ S' V b . . s V S s e - < C Q S C C f - Y - z C @ - V b ^ L z P C . . b q i @ S' C b H - ^ S' C o p S Y b 4 s C o f C q s S z S' L - z z P C b o f L S' \varrho > u :

$$z = z P C S' C o p S Y z S C$$

$$jz i = z P C s z - z C b H - ^ S' C o p S Y s z - z S < b 4 s C o f C q - V b ^ L z P C z S C - \dagger S$$

$$\begin{aligned}
 \infty & \\
 \approx & \quad 0 \ jzi = S_{\partial z}^{\partial} \ jzi \\
 ? & \quad jzi = S \ z \frac{\partial}{\partial z} + \varphi \ jzi \quad \dots C S C \varphi = 1 - \wedge @ b4z - S' \ \varrho > | : \\
 \cdot \nabla & \quad V \ jzi = S \ z^2 \frac{\partial}{\partial z} + 2z\varphi \ jzi
 \end{aligned}$$

$$(\wedge + 1) \ hzj^{\wedge} i = \ hzj^{\rho} j^{\wedge} i \ E) \quad \boxed{jzi = \frac{1}{4} \frac{- + S}{- S} + 1 \quad C \frac{a+it}{a-it} X_+ \ j^{\wedge} = 0i} \quad fc\{g$$

$$zPC \ S^{\wedge} Cq \ eqp @ \ - < z = \quad hz_1/z_2 i = \frac{2}{4(z_1 \quad z_2)^2} \quad fcJg$$

$\setminus - z < PCs \ zPC \ z. \ b @ bS^{\wedge} z \ H^{\wedge} < zS^{\wedge} \ bH - \setminus - ss \ VCss \ s < - Y \ q" \ C \ @ \ S' \ [ \ S' \ Vb. \ s \ V \ S \ se - < CQ \ S \ C$   
 $Cf - Y - zC @ - \ Vb^{\wedge} L \ zPC \ .. \ bq \ @ \ S' \ C \ bH - \wedge \ S' \ Cq \ S \ Y \ b4s \ Cq \ f \ Cq \ s \ S \ z \ S' \ L - z \ zPC \ bq \ S' \ \varrho > u:$

$$z = zPC \ S^{\wedge} Cq \ S \ Y \ z \ S \ C$$

$$jzi = zPC \ sz - zC \ bH - \wedge \ S' \ Cq \ S \ Y \ sz - zS < \ b4s \ Cq \ f \ Cq - \ Vb^{\wedge} L \ zPC \ zS \ C - \dagger S$$

$$\begin{aligned}
 \infty & \\
 \approx & \quad 0 \, jz_i = S_{\text{az}}^{\text{a}} jz_i \\
 ? & \quad jz_i = S z_{\text{az}}^{\text{a}} + \varphi_j z_i \quad \dots C S C \varphi = 1 - \text{^@b4z-S` 9>| :} \\
 \cdot \nabla & \quad V jz_i = S z_{\text{az}}^2 + 2z\varphi_j z_i
 \end{aligned}$$

$$(\wedge + 1) \, hz j^{\wedge i} = hz j p j^{\wedge i} E \quad \boxed{jz_i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0i} \quad fc\{g$$

$$zPC S^{\wedge} C q e p @ \sim \langle z = \quad hz_1/z_2 i = \frac{2}{4(z_1 \quad z_2)^2} \quad fcJg$$

\ - z < PC s z PC z . . b @ b s ^ z H ^ < z s ^ b H - \ - s s C s s < - Y q " C Y @ S ^ [ S ^ V b . . s V S s e - < C Q S C  
C f - Y - z C @ - V b ^ L z PC . . b q @ S ^ C b H - ^ S ^ C o p S Y b 4 s C o f C q s S z S ^ L - z z PC b o f L S ^ 9 > u :

$$z = zPC S^{\wedge} C o p S Y z S C$$

$$jz_i = zPC s z - z C b H - ^ S ^ C o p S Y s z - z S < b 4 s C o f C q - V b ^ L z PC z S C - \dagger S$$

$$hz_1/z_2 i = hz = 0jC \quad s(z_1 \quad z_2)^0 jz = 0i$$

$$\begin{aligned} \infty \\ \approx \\ \cdot \end{aligned} \quad \begin{aligned} 0 jz i &= S_{az}^{\otimes} jz i \\ ? jz i &= S z \frac{\otimes}{az} + \varphi jz i \quad \dots C S C \varphi = 1 - \wedge @ b 4 z - S' \vartheta > | : \\ V jz i &= S z^2 \frac{\otimes}{az} + 2 z \varphi jz i \end{aligned}$$

$$(\wedge + 1) h z j^{\wedge} i = h z j p j^{\wedge} i E) \quad \boxed{jz i = \frac{1}{4} \frac{- + S}{- S} + 1^2 C \frac{a+it}{a-it} X_+ j^{\wedge} = 0 i} \quad fc\{g$$

$$z P C S^{\wedge} C q e p @ \sim z = h z_1 j z_2 i = \frac{2}{4(z_1 z_2)^2} \quad fc\}g$$

\ - z < P C s z P C z . . b @ b S' z H ^ < z S b ^ b H - \ - s s Y C s s < - Y q " C Y @ S' [ S' V b . . s V S s e - < C Q S C C f - Y - z C @ - V b ^ L z P C . . b q @ S' C b H - ^ S' C o p S Y b 4 s C o f C q s S z S' L - z z P C b o f L S' \vartheta > u :

$$z = z P C S' C o p S Y z S C$$

$$jz i = z P C s z - z C b H - ^ S' C o p S Y s z - z S < b 4 s C o f C q - V b ^ L z P C z S C - \dagger S$$

$$h z_1 j z_2 i = h z = 0 j C^{S(z_1 z_2)} j z = 0 i E) \quad j z = 0 i = C X_+ j^{\wedge} = 0 i \quad S' C o p S Y f \leftarrow \sim \setminus$$

↻  $sl(2; \mathbb{R})$  -  $\mathcal{Y}_b \circ \mathcal{G} \mathcal{Y}_S \circ \mathcal{C} @ 4\% \circ b \sim e \mathcal{Y} \circ \mathcal{P} \circ \mathcal{Q} \setminus b^{\wedge} \mathcal{S} \circ b \mathcal{S} \mathcal{Y} \circ z b \circ \mathcal{P} \circ \mathcal{E}$ )  $j^{\wedge} = 0_i = j^0_i \chi \quad j^0_i \rho$

↻  $sl(2;R) = \{j^0, j^1, j^2\}$   $j^0 = 0i = j^0i_x \quad j^0i_p$

$$j^z = 0i = \sum_{\hat{\alpha}} (1)^{\hat{\alpha}} j^{\hat{\alpha}}i_x \quad j^{\hat{\alpha}}i_p = \sum_{\hat{\alpha}} C^{\hat{\alpha}} j^{\hat{\alpha}}i_x \quad j^{\hat{\alpha}}i_p \quad \text{fcl g}$$

$sl(2; \mathbb{R})$  -  $j^z = 0_i = \sum_{\alpha} (1)^{\alpha} j^{\alpha}_i$   $j^z = 0_p = \sum_{\alpha} C^{\alpha} j^{\alpha}_p$  fcl g

$L_0 = R$



↻  $sl(2; \mathbb{R})$  -  $\mathcal{L}_0 = \mathcal{R}$   $j^t = 0i = j^0i_x \quad j^0i_p$

$$j^z = 0i = \sum_{\alpha} (1)^{\alpha} j^{\alpha}i_x \quad j^{\alpha}i_p = \sum_{\alpha} C^{\alpha} S_{X_0} j^{\alpha}i_x \quad j^{\alpha}i_p \quad \text{fcl g}$$

$L_0 = \mathcal{R}$

$j^t = 0i = i^P_{\alpha} e^{\alpha} S_{X_0} j^{\alpha}i_x \quad j^{\alpha}i_p$

$$sl(2; \mathbb{R}) = \langle H, P, D \rangle$$

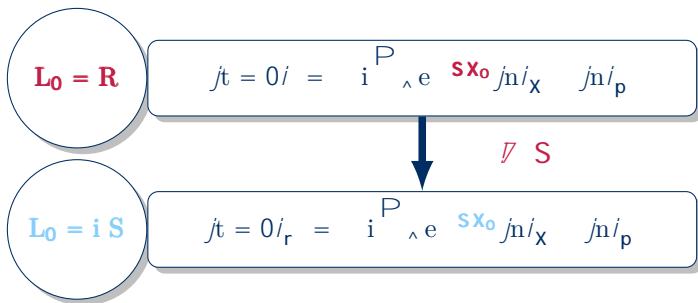
$$j^z = 0i = \sum_{\alpha} (1)^{\alpha} j^{\alpha} i_X \quad j^{\alpha} i_p = \sum_{\alpha} C^{\alpha} j^{\alpha} i_X \quad j^{\alpha} i_p$$

$$L_0 = R \quad j^z = 0i = i^P \sum_{\alpha} e^{\alpha} j^{\alpha} i_X \quad j^{\alpha} i_p$$

$$L_0 = i S$$

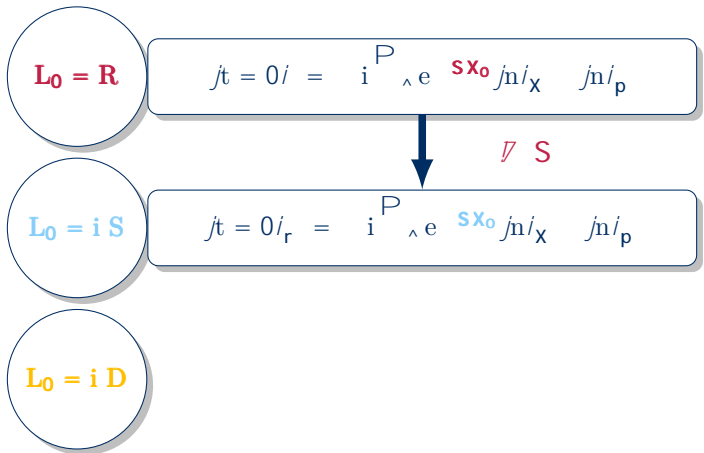
$\mathfrak{sl}(2; \mathbb{R})$  -  $\mathfrak{so}(2, 1)$   $\cong$   $\mathfrak{so}(1, 2)$   $\cong$   $\mathfrak{so}(3)$   $\cong$   $\mathfrak{su}(2)$   $\cong$   $\mathfrak{so}(4)$   $\cong$   $\mathfrak{so}(1, 3)$   $\cong$   $\mathfrak{so}(3, 1)$   $\cong$   $\mathfrak{so}(4, 1)$   $\cong$   $\mathfrak{so}(5)$

$$j^z = 0i = \sum_{\alpha} (1)^\alpha j^\alpha i_x \quad j^\alpha i_p = \sum_{\alpha} C^{S X_0} j^\alpha i_x \quad j^\alpha i_p \quad \text{fcl g}$$



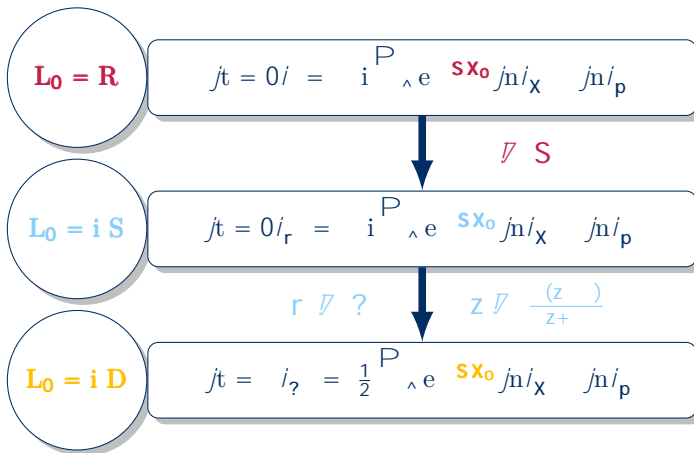
sl(2;R) -  $j^{\hat{z}} = 0i = j^0i_x \quad j^0i_p$

$$j^z = 0i = \times (1)^{\wedge} j^{\wedge} i_x \quad j^{\wedge} i_p = S \times C^{Sx_0} j^{\wedge} i_x \quad j^{\wedge} i_p \quad \text{fcl g}$$



$\mathfrak{sl}(2; \mathbb{R})$  -  $\mathfrak{so}(4)$  -  $\mathfrak{so}(2, 2)$  -  $\mathfrak{so}(1, 3)$  -  $\mathfrak{so}(1, 2)$  -  $\mathfrak{so}(1, 1)$  -  $\mathfrak{so}(0, 2)$  -  $\mathfrak{so}(0, 1)$  -  $\mathfrak{so}(0, 0)$

$$j_z = 0i = \sum_{\alpha} (1)^{\alpha} j^{\alpha}_X \quad j^{\alpha}_P = \sum_{\alpha} C^{\alpha} S X_0 j^{\alpha}_X \quad j^{\alpha}_P \quad \text{fcl g}$$



$y P C \backslash b'' C \textcircled{a} \textcircled{b} \sim 4 Y C s z - z C$

$$j z = 0 i_r f j z = i_? g s z - z C \textcircled{+} P S \textcircled{+} S s - s z q \sim z \sim q C s \backslash S \textcircled{-} q z b z P - z b H$$

$$- z P C \backslash b'' C \textcircled{a} \textcircled{b} \sim 4 Y C s z - z C H b q \textcircled{<} b \sim e Y \textcircled{+} P - q \textcircled{)} b \wedge S \textcircled{-} b s \textcircled{<} S \textcircled{-} z b q s$$

$$j y G? i = \frac{1}{\tilde{S}(\ )} \sum_{\wedge=0}^{\times} C^{B_n/2} j^\wedge i_x j^\wedge i_p \quad P S \textcircled{+} P \textcircled{+} C \wedge z - \wedge L Y \textcircled{+}$$

$y \text{ PCq} \setminus b'' \text{ C} \setminus @ \text{ @b} \sim 4 \text{ C sz} - z \text{ C}$

$$jz = 0 \quad i_r \quad f/jz = i_? \quad g \text{ sz} - z \text{ C} \setminus \text{PS} \setminus \text{S} \setminus \text{s} - \text{szq} \sim \text{z} \sim \text{q} \text{ C} \setminus \text{S} \setminus \text{S} \setminus \text{q} \text{ zb} \text{ zP} - z \text{ bH}$$

$$- z \text{ PCq} \setminus b'' \text{ C} \setminus @ \text{ @b} \sim 4 \text{ C sz} - z \text{ C} \text{ Hbq} \setminus \text{b} \sim \text{e} \text{ C} \setminus \text{P} - \text{q} \setminus \text{b} \wedge \text{S} \setminus \text{bs} \setminus \text{S} \setminus \text{z} \text{ bqs}$$

$$jy \text{ G? } i = \frac{1}{\xi(\cdot)} \sum_{\wedge=0}^{\times} C^{B_n/2} j^\wedge i_x \quad j^\wedge i_p \quad \text{PSLP} \setminus \text{C} \setminus \text{z} - \wedge \text{LYC} \setminus$$

$$zq \setminus \text{S} \setminus \text{L} \text{ bf} \text{ Cq} \text{ zPC} \setminus \text{C} \setminus \text{L} \text{ qCs} \text{ bH} \setminus \text{C} \setminus \text{C} \setminus \text{b} \setminus \text{bH} \text{ b} \wedge \text{C} \setminus \text{b} \text{ e} \setminus \text{b} \text{ HzPC} \text{ s} \setminus \text{z} \setminus \text{C} \setminus \text{..C} \text{ b4z} - \text{S} \setminus - z \text{ PCq} \setminus - \text{Y}$$

$$\setminus \text{C} \setminus \text{S} \setminus \text{z} \setminus \text{a} \setminus - z \text{ qf}$$

$$y \text{ q} \setminus f/jy \text{ G? } i \text{ hy} \text{ G? } jg = \frac{C}{\xi(\cdot)} \quad \text{..SP} \text{ z} \setminus \text{e} \text{ Cq} \text{ z} \sim \text{q} \text{C} \quad y = \frac{1}{\text{fcvg}}$$

h?2`KQ}2H/ /Qm#H2 bi i2

ji=0i<sub>a</sub> Uj= i V bi i2 2t?B#Bib bi`m+im`2 bBKBH`iQ i? i Q  
 i?2`KQ}2H/ /Qm#H2 bi i2 7Q` +QmTH2/ ? `KQMB+ Qb+B

$$jh6j = \frac{1}{\sqrt{}} \sum_{M \neq 0}^{X} 2^{-1/2} j M_G j M_- ?B;?Hv 2Mi M;H2/$$

i` +BM; Qp2` i?2 /2;`22b Q7 7`22/QK Q7 QM2 +QTv Q7 i  
 /2MbBiv K i`Bt

$$h`dj h6.jh h6.jg = \frac{2}{\sqrt{}} \frac{H}{i} rBi? i2KT2` im`-2 h URe$$

$$ji=0i_a = \frac{P}{B} M^2 B_0 G j M_G j M_- 4 \quad H = B_0 G a / B KQM/$$



h?2`KQ}2H/ /Qm#H2 bi i2

ji=0i\_a Uj= i V bi i2 2t?B#Bib bi`m+im`2 bBKBH`iQ i? i Q  
 i?2`KQ}2H/ /Qm#H2 bi i2 7Q` +QmTH2/ ? `KQMB+ Qb+B

$$jh6j = \frac{1}{\sqrt{2}} \sum_{M=0}^{M=2} \langle j M_G j M_- | ?B;?Hv 2Mi M;H2/$$

i` +BM; Qp2` i?2 /2;`22b Q7 7`22/QK Q7 QM2 +QTV Q7 i  
 /2MbBiv K i`Bt

$$h`dj h6.jh h6.jg = \frac{2}{\sqrt{2}} \langle rBi? i2KT2` im`-2 h \quad URe$$

$$ji=0i_a = \frac{1}{\sqrt{2}} \langle M^2 B_0 G \rangle M_G j M_- \quad H = B_0 G a /B KQM/$$

$$ji= i_ = \frac{1}{\sqrt{2}} \langle M^2 B_0 G \rangle M_G j M_- \quad H = B_0 G . JBHM2$$

h?2`KQ}2H/ /Qm#H2 bi i2

ji=0i\_a Uj= i V bi i2 2t?B#Bib bi`m+im`2 bBKBH`iQ i? i Q  
 i?2`KQ}2H/ /Qm#H2 bi i2 7Q` +QmTH2/ ? `KQMB+ Qb+B

$$jh6j = \frac{1}{\sqrt{)} } \sum_{M \neq 0}^{X} 2^{-1M^2} j M_G j M_- ?B;?Hv 2Mi M;H2/$$

i` +BM; Qp2` i?2 /2;`22b Q7 7`22/QK Q7 QM2 +QTV Q7 i  
 /2MbBiv K i`Bt

$$h`dj h6.jh h6.jg = \frac{2}{\sqrt{)} } \frac{H}{rBi? i2KT2` im`-2} h \quad URe$$

$$ji=0i_a = \frac{P}{M^2} B_0 G j M_G j M_- 4 \quad H = B_0 G a /B KQM/$$

$$ji= i . = \frac{1}{2} \frac{P}{M^2} B_0 G j M_G j M_- 4 \quad H = B_0 G . JBHM2$$

h?2`KQ}2H/ /Qm#H2 bi i2

ji=0i\_a j\_i = i V bi i2 2t?B#Bib bi`m+im`2 bBKBH` iQ i? i Q  
i?2`KQ}2H/ /Qm#H2 bi i2 7Q` +QmTH2/ ? `KQMB+ Qb+B

$$jh6j = \frac{1}{\sqrt{}} \cdot X^1 \cdot 2^{1/2} j M_G j M_- ?B;?Hv 2Mi M;H2/$$

i` +BM; Qp2` i?2 /2;`22b Q7 7`22/QK Q7 QM2 +QTv Q7 i  
/2MbBiv K i`Bt

$$h`dj h6.jh h6.jg = \frac{2 H}{\sqrt{}} rBi? i2KT2` im`1/2 h URe$$

$$ji=0i_a = \frac{P}{M^2} B_0 G j M_G j M_- 4 H = B_0 G a /B KQM/$$

$$ji= i . = \frac{1}{2} \frac{P}{M^2} B_0 G j M_G j M_- 4 H = B_0 G . JBHM2$$

irQ b2ib Q7 /2;`22b Q7 7`22/QK b #2HQM;BM; iQ i?2 /QK  
2pQHmiBQM M/ i?2B` +QKTH2K2Mib

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQMvL+2 nK mM Mi 2Mi; Q  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi 2Mi; Q`  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_{i=0} = \sum_{M} (1)^M M_G j_{M_-}$$

URd

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2MQMvL+2mK mMmiBMi;`Q`  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_i=0_i = \sum_{M} (1)^M M_G j_{M-} \quad MQM MQ`K HBb #H25Rd$$

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi 2Mi;`Q  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_i=0_i = \sum_{M} (1)^M M_G j_{M_-} \quad MQM MQ`K HBb #H25Rd$$

`2MQ`K HBb iE

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi 2Mi;`Q  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_i=0_i = \sum_{M} (1)^M M_G j_{M_-} \quad MQM MQ`K HBb #H25Rd$$

`2MQ`K HBb iE

1 bm+? i?i≠ B



1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi 2Mi;`Q  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_i=0_i = \sum_{M} (1)^M M_G j_{M_-} \quad MQM MQ`K HBb #H25Rd$$

`2MQ`K HBb iE

1 bm+? i?i≠ B 4 \_G

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi 2Mi;`Q`  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_{i=0} = \sum_{M} (1)^M M_G j_{M_-} \quad MQM MQ`K HBb #H 25R d$$

`2MQ`K HBb iE

1 bm+? i?j i= B 4    \_G 4    aj i= B = h`f G H Qg

1 Mi M; H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M; H2K2M Q Mv L+2 m K m M Mi 2Mi; Q`  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_{i=0} = \sum_{M} (1)^M M_G j_{M\_} \quad MQM MQ`K HBb \#H25Rd$$

`2MQ`K HBb iE

1 bm+? i?j i= B 4    \_G 4    a\_{j i= B} = h`f G H Q Q`! 0    a\_{j i=0}

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K nMMi 2Mi;` Q`  
 `2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_{i=0i} = \sum_{M} (1)^M M_G j_{M\_} \quad MQM MQ`K HBb \#H25Rd$$

`2MQ`K HBb iE

1 bm+? i?ji= B 4 \_G 4 a\_{j=i B} = h`f G H Q Q! 0 a\_{j=i0i}

$$a_{j=i0i} = HQ;+ + Q M \text{D}(\ )$$

1 Mi M;H2K2Mi 2Mi`QTv Q7 iBK2 /QK BMb

q2 + M [m MiB7v i?Bb 2Mi M;H2K2 MQ MvL+2 m K mM Mi BMi;`Q`  
`2/m+2/ /2MbBiv K i`Bt bbQ+B i2/ iQ i?2 BM2`i

$$j_{i=0} = \sum_{M} (1)^M M_G j M \quad MQM MQ`K HBb #H25Rd$$

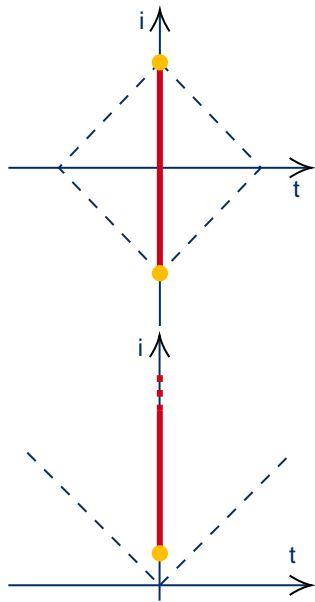
2MQ`K HBb iE

1 bm+? i?ji= B 4    \_G 4    aj\_i=B = h`f G H Q q! 0    aj\_i=0

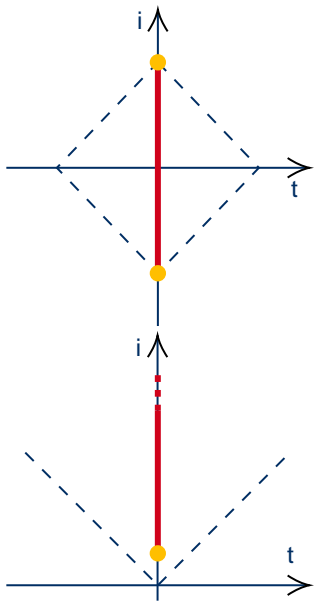
$$aj_{i=0} = HQ;+ + Q M D(i)$$

i?Bb 2Mi M;H2K2Mi 2Mi`QTv 0+ M@#B K22Mb BbQim 2H M H C  
2Mi M;H2K2Mi 2Mi`QTv Q7 [m MimK }2H/ +`Qbb I

# \* Q M + H m b B Q M b



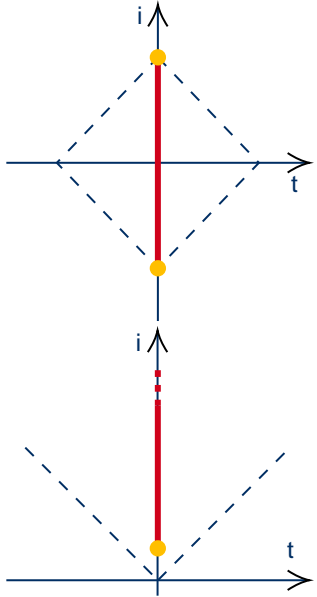
# \* Q M + H m b B Q M b



+Q` `2bTQM/2M+2 #2ir22M` /B H +QM  
 JBMFQrbFB bT +2@iBK2 M/ iBK2 2p

\*QM7Q`K H` /B H EBHHBM; p2M Q Cb K H Zm MimK J2+? MBM M;H2K2Mi 2Mi`QTv272`2M+2b" +FmT bHB/ oooo oooooo oooooo

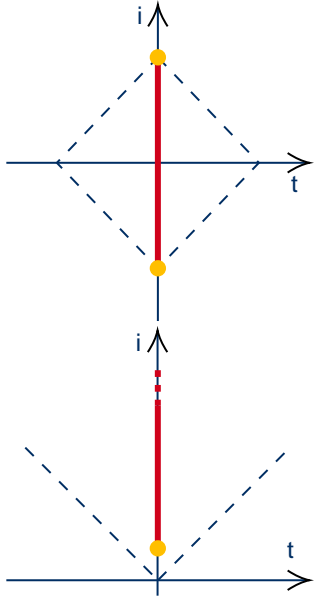
# \* Q M + H m b B Q M b



+Q``2bTQM/2M+2 #2ir22M` /B H +QM  
 JBMFQrbFB bT +2@iBK2 M/ iBK2 2p  
 r2 +QMbB/2` b2ib Q7 bi i2b BM \*ZJ b  
 ;2M2` iQ`b a M/ .



# \* Q M + H m b B Q M b

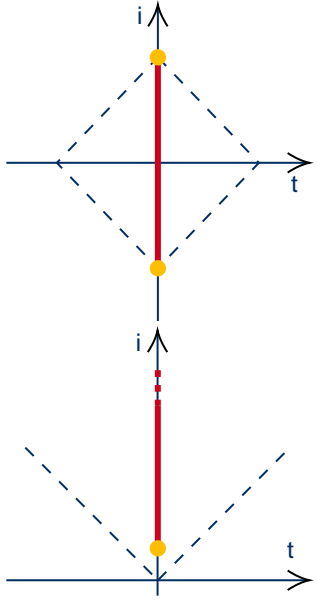


+Q` `2bTQM/2M+2 #2ir22M` /B H +QM  
 JBMFQrbFB bT +2@iBK2 M/ iBK2 2p

r2 +QMbB/2` b2ib Q7 bi i2b BM \*ZJ b  
 ;2M2` iQ`b a M/ .

bm+? bi i2b 2t?B#Bi i?2 bi`m+im`2 Q  
 BM i2`Kb Q7 2t+Bi iBQMb Q7 a M/ .

# \* Q M + H m b B Q M b



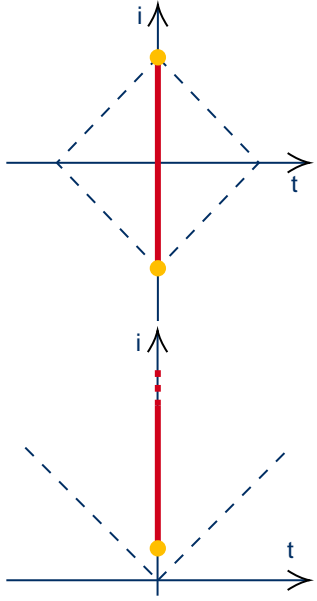
+Q` `2bTQM/2M+2 #2ir22M` /B H +QM  
 JBMFQrbFB bT +2@iBK2 M/ iBK2 2p

r2 +QMbB/2` b2ib Q7 bi i2b BM \*ZJ b  
 ;2M2` iQ`b a M/ .

bm+? bi i2b 2t?B#Bi i?2 bi`m+im`2 Q  
 BM i2`Kb Q7 2t+Bi iBQMb Q7 a M/ .

r2 [m MiB}2/ i?2 2Mi M;H2K2Mi Q7 bm  
 i?2 oQM L2mK MM 2Mi`QTv Q7 i?2 bb  
 /2MbBiv K i`Bt

# \* Q M + H m b B Q M b



+Q` `2bTQM/2M+2 #2ir22M` /B H +QM  
 JBMFQrbFB bT +2@iBK2 M/ iBK2 2p

r2 +QMbB/2` b2ib Q7 bi i2b BM \*ZJ b  
 ;2M2` iQ`b a M/ .

bm+? bi i2b 2t?B#Bi i?2 bi`m+im`2 Q  
 BM i2`Kb Q7 2t+Bi iBQMb Q7 a M/ .

r2 [m MiB}2/ i?2 2Mi M;H2K2Mi Q7 bm  
 i?2 oQM L2mK MM 2Mi`QTv Q7 i?2 bb  
 /2MbBiv K i`Bt

i?2 `2bmHi /Bp2`;2b HQ; `Bi?KB+ HH  
 `2;mH iQ` Bb b2Mi iQ x2`Q b 2tT2+i2

#QmM/ **TvQB Mi @ HBF2**

# \_272`2M+2b

- (R) JB+?2H2 `x MQ- H2bb M/` .ö HBb2- M/ó01M2IMB;H2K2Mi2MB`QTV +QM7Q`K H [m MimK K2+? MBMb Mb2öKykjVX `sBp, kjyeXRkkNR (?2T@
- (k) >X \* bBMB M/ JX6-1Mi`M;H2K2Mi 2Mi`QTV BM 7`22 [mAMi,mQX}S PVB; UkyyNV- TX 8y9yydX .PA, RyXRy33fRd8R@3RRjf9kf8yf8y9yydX `
- (j) >X \* bBMB M/ JX6-1Mi`M;H2K2Mi 2Mi`QTV 7QAMP,2SM @bXT G2`i2X eN TTX Red RdRX .PA, RyXRyRefDXT?vbH2i#XkyRyXyNXy89X `sBp,
- (9) oBiiQ`BQ /2 H7 `Q- aX 6m#B M6\*QM7QXK6H`A`Mp`XB M+2 BM ZmAMi,n LmQpQ \*BKX j9 URNdeV- TX 8eNX .PA, RyXRyydf"6ykd38eeeX
- (8) \_X C +FBr M/ aXó@QM7Q`K H "HQ+Fb 7Q`i?2 9@SQB Mi 6mM+iBQM J2+? M BAMBôS?vbX \_2pX . 3e UkyRkVX (1``imK, S?vbX\_2pX. 3e- y .PA, RyXRRyjfS?vb\_2p.X3eXy98yRdX `sBp, Rky8Xy99j (?2T@i?)
- (e) . "QQx2óZm MimK }2H/ i?2Q`v BM UyY RM, /Bk2QTB QMMbQ`M H QT UkyydV- TX dkNX
- (d) \*H m/BQ \*? QM6\*QM7Q`K H [m MimK K2+? MB`mbHbiQ22AM, S?vbX G2iiX " dyR UkyRRV- TTX 8yj 8ydX .PA, RyXRyRefDXT?vbH2i#Xky
- (3) S b[m H2 \* H #`2b2 M/ CQ61MBM;H2K2Mi 2Mi`QTV M/ [m MiANk,}Q ai iX J2+?X y9ye Ukyy9V- SyeykX .PA, RyXRy33fRd9k@89e3fkyy ?2T@i?fy9y8R8kX

\*QM7Q`K H ` /B H EBHHBM; p2M0 Q`K H Zm MimK J2+? MBb M;H2K2Mi 2Mi`QTv272`2M+2b" +FmT bHB/  
oooo ooooo ooo ooooooooo

\_272`2MA2b

(N) JmFmM/\_ M; K MB M/ h / b?B >QHQ;M T?B+ 1Mi M;H2K2Mi 2Mi`QTv272`2M+2b" +FmT bHB/  
aT`BM;2`- kyRdX .PA, RyXRyydfNd3@j@jRN@8k8dj@yX `sBp, Re

h ? M F v Q m 5



\*QM7Q`K H B Mp `B M+2

\*QMbB/2` i?2 KQbi ;2M2` H b+ H `K bbH2bb }2H/ G ; M

$$L = \frac{1}{2} @ @ ; \frac{2/}{1/2} \quad \text{UR3}$$

B Mp `B M+2 mM/2` i?2 7mHH +QM7Q`K H ;

$$\geq = \underline{i` MbH} iBQMb \quad [;> .]= B; \{E .]= B; \{E .; >]= 2 B.$$

$$. = \underline{/BH} iBQMb$$

$$E = \underline{bT2+B H +QM7Q`K H i` M b 7 Q 2 K i B Q M b} \quad C_{6h}^2 = \frac{1}{2} (> E+ E >) .^2 * bBKb` \quad \text{URNV}$$

i?2b2 QT2` iQ`b H2 p2 i?2 +iBQM B Mp `B Mi M/ `2

$$= \underline{>} + \underline{\#} . + \underline{+E} \quad \text{Uky}$$

+ M #2 mb2/ iQ bim/v i?2 2pQHmiBQM Q7 i?2



\* H b b B } + i B Q M Q 7 ` / B H + Q M 7 Q ` K H E B H H

; # M / + / 2 i 2 ` K B M 2 i ? 2 + m b H + + Q ` / B M ; i Q 7 4 + ( j - 9 ) ,  
< 0 2 H H B T i B + i ` M b 7 Q ` K i B Q M b U ` Q i i B Q M b V

$$-o = \frac{1}{2} S_0 + \frac{E_0}{2} \quad \text{UkR}$$

> 0 ? v T 2 ` # Q H B + i ` M b 7 Q ` K i B Q M b U G Q ` 2 M i x # Q Q b i b

$$.o \quad M / o a = \frac{1}{2} S_0 \quad \frac{E_0}{2} \quad \text{Ukk}$$

= 0 T ` # Q H B + i ` M b 7 Q ` K i B Q M b U M r E H H ` Q i i B Q M b V ,

# J Q ` 2 Q Msl(2, R) G B 2 H ; 2 # `

$$sl(2; R) G B 2 H ; 2 # ` + M # 2 ` 2 H B x 2 / B M i 2 ` K b Q 7 i r Q b 2 i b ( QT 2 ` i Q ` y ; G _$$

$$G = \frac{1}{2} y_G G + y_{-} + 1 ; G = y_G y_{-} M / G = G _ Ukjv$$

$$i ? B b b ? Q r b i ? i i ? 2 ; ` Q m M / b i i 2 Q 7 i ? 2 _ @ Q T 2 ` i Q ` ?$$

$$j M = 0 i = j 0 i G j 0 i _ ; Uk9$$

$$M / i ? i i j ? = 2 0 i b i i 2 + M # 2 r ` B i i 2 M b$$

$$j i = 0 i = 2 y_G y_{-} j 0 i G j 0 i _ = \sum_M^X ( - 1 )^M j M G j M _ = \sum_M^X B 2^B G j M G j M _ ; Uk8$$

# JQ`2 QM i?2 BM2`iB H p +mmK

$$>j 1i = 1j 1i b iBb7v i?2 +QM/BiBQM b$$

$$1 1^0 = (1 1^0) M / \frac{Z_{+1}}{0} / 1j 1i h 1j = 1 \quad \text{Uke}$$

$$r2 + M r`j`Bi2b (9)$$

$$j i = 2^B >j i = 0 i = \frac{Z_1}{0} / 1 \frac{p-1}{2} 2^B 1j i \quad \text{Ukd}$$

$$M / Q \# i B M i?2 Q p 2`j`Hi T M j`i r 2 2 M$$

$$h j 1i = \frac{p-1}{2} 2^{B 1 i} \quad \text{Uk3}$$

i?2 bi ji 2 b`2 bBKBH` BM bTB`Bi iQ i?2 K QTKi?Mii Q M 2 B;M M C  
 BM Z6h BM i2`Kb Q7 r?B+? i?2 +iBQM Q M i?2 H/ Q m a`KiQ

$$(t) j 0i = \frac{Z}{(2)^3} \frac{\beta T}{2 1 T} 2^{BT} j T ; r?2`2 T T^p = 2 1 T (2)^3 (3) (T T) \quad \text{UkN}$$

= Sr

$$\langle b \setminus e - \langle z \rangle S \langle z \rangle b \wedge e \text{ qpebs} - Y$$

$$X_0 = Sr; \quad X_+ = S(\dots p); \quad X_- = S(\dots + p)$$

f{CG

$$jzi = \frac{2}{(z + \bar{z})^2} C_{t+}^t X_+ j^\wedge = 0i$$

f{cg

$$\langle C \setminus C^\wedge sz - zC - s \text{ sb} \langle S z \rangle @ z b - \wedge b \text{ 4s} C \text{ qf} C \text{ q} \dots P \text{ bs} C z \setminus C C \text{ f} b \text{ Y} - z \text{ b}^\wedge S @ C^\wedge @ 4\% = Sr$$

$$S^\wedge \setminus S @ E) h_{1j} j_{2i} = 16 S^\wedge^2 \frac{1}{2} \frac{2}{2} \quad \setminus S \quad 16 S^\wedge P^2 \frac{1}{2} \frac{2}{2}$$

$$\setminus S \setminus - \text{es} zPC; k [ @ C \setminus \text{q} \text{e} z \text{ b}^\wedge bH = Sr S^\wedge z b zPC z \setminus C C \text{ f} b \text{ Y} - z \text{ b}^\wedge bH - @ S \setminus b^\wedge @$$

$$b \text{ 4s} C \text{ qf} C \text{ q}$$

$$yPC f - \langle \sim \setminus S \text{ e} C \text{ q} \setminus C \text{ f} C @ 4 C \setminus L S^\wedge - zPC \setminus - Y 4 - zP \dots \setminus P \quad y = \frac{1}{2}$$

= S?

$$\langle b | e^{-\langle S | \langle z | \mathcal{S} | z \rangle} | e \rangle$$

$$X_0 = S? ; X_+ = S \ 0; X_- = S \frac{V}{2}$$

f{|g

$$|jz\rangle = \frac{2}{2Z^2} C^{-X_+} |j\rangle = 0$$

f{|g

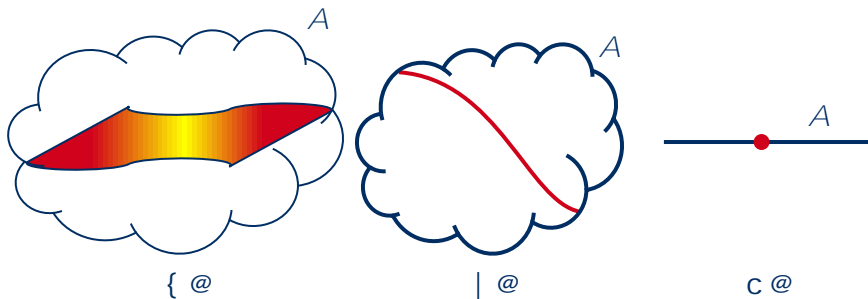
$$\langle S | C^{\wedge} s z - z C - s s b \langle S | z \langle z | \mathcal{S} | z \rangle - \langle b | 4 s C q f C q \dots P b s C z \mathcal{S} | C C f b Y - z \mathcal{S} | \mathcal{S} | \langle C' | \wedge C \rangle @ 4 \% = S?$$

$$S? \nabla S @ E) h_{1j2i} = 16 s s^2 \frac{1}{2} \frac{2}{2} \nabla S / 16 s s^2 \frac{1}{2} \frac{2}{2}$$

$$\nabla S \setminus - e s z P C; k [ @ C \langle \mathcal{S} | z \rangle b H = S? S' z b z P C z \mathcal{S} | C C f b Y - z \mathcal{S} | b H - [ S' C b 4 s C q f C q$$

$$y P C f - \langle \sim \setminus \mathcal{S} e C q \langle S' C \rangle @ 4 C S' L S' - z P C q \setminus - Y 4 - z P \dots \mathcal{S} P \quad y = \frac{1}{2}$$

$B^z - \Lambda \gamma \backslash C^z C^z \rho e \%_0$



„ C... ^z z b < \ e - z C z P C ^z - \Lambda \gamma \backslash C^z C^z \rho e \%\_0 D. 4 C z . . C ^ z . b q L S ^ s .. P C q z P C  
C^z - \Lambda \gamma \backslash s ~ q H < C f Biri g S < \ e q S @ b H S < b ^ ^ C z C @ e b S ^ z s

S^ k G y z P C W b . . ^ q S - \zeta S \underline{z}:

$$r_A / \frac{q_C(@A)}{2}$$

$$\frac{e_{bS^z} q_C(@A)}{Biri}$$

$$r_A / \gamma_L -$$

$$f\{Jg$$

.. P C q C , q\_C (@A) S z P C - q\_C b H z P C 4 b - ^ @ q % b H z P C q L S ^ f C sig - ^ @ S - } , < - z O'