LEC 9 SYMMETRIES, formally

) Feb

Huly - in progress still ~

OPPRECTIONS: Joh saked: effect of DM

on PERHELIAN OF 7?

CONTRIBUTES TO 1/r portantime

BUT not const (couse cous)

PEMINDER: ALL MY SIGNS ALE SUBJECT

TO ERROR! $p^2 = E^2 - P^2 \quad US. \quad -E^2 - P^2$ $= M^2 \qquad = -M^2$

LAST TIME: circuitous disussion of different topics

SOHW. METRIC: (1-15/r) oft2 - (1-15/r) dr2 ...

Le significance>

HOW TO ECUPY: gendesic into black hole!

... BUT WE WANTED MORE MARKINGRY:

CONS. QUANTITIES 6-> SYM.

application; Protherion of &

TODAT: DIE IN 1 DEVENDO 18012 TO GET BACK

emperaturates da cuididad debe	
SAN DEPARTMENT AND	SYMMETRY - Why?
endigen-avenuende	1. allows us to carry tooks to solve
To the second se	ordinary mechanics problems to
dan de la companya d	relativistic mechanics
NAME AND DESCRIPTION OF STREET	Geg. PERHELION of MERCURY
ANGRANAMORECTIO	
	2. SYMMETRIES ARE POWERFUL
-	5 best eq: AdS/CFT correspondence
Works and a second seco	ispnetres
	of this
-	matan
NAME OF	spacetime sym
	of this thy
	·
·~Teld	
	LAST TIME: hint of Noether's 4mm
	in curved space

= gru x x x v L(x,x) = (ds/dz)2 u 1 DL 180 IF METRIC IS INTER JXe THEN 3L/325

is T-INDEP.

BUT: $\frac{\partial L}{\partial \dot{x}^{F}} = 2g_{FV} \dot{x}^{V}$ is not invariant

FINERBY CONS.

CONSERVED &

80 WE DEFINED A HELPER VECTOR"

K(F) = Si eg (1,0,0,0)
for K(E)

then observed ; invariout.

KIMNE VECTOR

WE INTRODUCED KILLING VECTOR AS A HARK, BUT THOY'RE TELLING US COMETHING:
3r/9x = 0
→ → → = 0 → >×E ↑ = 0
"the metric is constant along thus direction"
180 metry
CONSPERSED STANLILIES;
for massive particles: $p = xm$
for wassless bortholes: can office
AFFINE PARAMETER S.T. $P = \hat{x}$
geodesic eq is 2 ^M 0 + so inv+: if z → az+b
SO A LICE PHYSICAL OVANTICY THAT IS CONSERVED IS P-KCF)

"along geodesic" C up to m 0 = 9c (b.K) x b.D (K.b) = Pr(DrKv)Pr+ PrKv(DrPr) (p.D)p" = 0 by geodesic ex (geodesic: we parallel transport x x p) = Prpv DrKv BUT THIS IS TOTALLY SYMMETRIC -> PROJECTS OUT ANTISYMMETRIC PARC OF DIKU = = PP Drkv + Drkn = DCmK2) KILLING'S EQ: DC+KN = 0 => (K.P) conserved pactually a killing freld (@ ea point)

Dr Doke = Rpor K 2nd DETAY & K of DOWN.

mento	THIS RESULT IS OF MATHEMATICAL INTEREST:
65,11.1	
	GRAPH K & DK ME CAN NOW
mones to reason the 10 decreases and consistent of Annual May, of the 200 miles of a State of Sub-Annual May (BOOTSTRAP D2K & AU HIGHER DERIVATIVES
	80 THE DATA IN A KIWING PIECD IS GIVEN BY
and a second management and a second of the second of the second of the second or a second according to the sec	Kr = A(x) 1/ K(0) + B(2) 1/ Dv K: (0) +
	6 × 1 Dereggin
	punctions of pos.
n na dia mandria dia mpika	
	K(G)" HAS I DOF IN I DIMENSIONS
renera sa kinemanani di karumanin marini Saran alguni di hakumalarin kilandi ka	DVK(0) ?
in the state of th	
	two indices -> d2 dot
o to the same shake for the administrative following (1) (1) the decision of the same shake for the same sha	BUT DUKP) =0, s.t. symmetric part vanishes
	only antisymmetric piece left
	1 2 4
r hands photosomen a sufficiency of the most of the state of the section of the section of the section of the	\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\
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The state of the s	

HOMOGENETY

ISOTROPY

80: 40tal DOF: d+ \(\frac{1}{2}d(d-1)\) = \(\frac{1}{2}d(d+1)\)

A SPACE WI A FULL SET OF KILLING VECTORS (fields) is MAXIMALLY RYMMOTRIC (Implications below).

OHEEK: 2=4, Max # KILING VEC = 10 ... ?!

L = gru x"x"

then soid: look for isomernes

34. = 0

I only four of these!

80: What are the isometries of Minkowski?

4 translations (%2xr)

\$6 rotations (valaxr-xalaxr)

und created to shumeted vot puedly ugebengents;

	of a lim comb a Kn, + b Ke, is also a Killing vector Im-dep.
P	SUT WE'RE TALKING ABOUT VECTOR FIBLOS
	alx) Kg,(x) + b(x) Km(x)
	this resulting betwee vector new
	is not nec. a dependent nos is it nec. a Killing field!
	IN FACT, FINDING KILLING VECTORS FROM A METRIC is Tricky not clear
	when to stop booking
	part of why maximizing symmetric spaces are nice.
	is satinfestation wax shw; vo
	BUT OWENS OF MINICONER AVE:

PUNUHUND: if space is maximally symmetric everywhere.

- CURVATURE is the same everywhere calculate R = 9"Rrv = Rx" = 0 one place of you're done.

Renordes everything there is
to Know about the geometry (war)
of the space!

(Given dimensionality,

(eg not tops.)

time div,...)

AROUMENT: LOC. MT. FRAME: Sm = Non Ga bout

AROUMENT: LOC. MT. FRAME: Sm = Non Ga bout

by beentz troust in this flowe.

-> Reow must be constructed from the tensors that are larentz invariant Loghi, 8%, Empo

Community opposition is a promise more on principle occording and a consequence, we	
No commence of the commence of	so e this point i'm these coords.
	R MUST be made out of g., Si, E
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ретридория деления по	BUT (HW) PR HAS VERY SPECIFIC SYMMETRIES
o de la companya de La companya de la companya de	wrt its malices!
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/	R
	Thaisun with whoch ande
	- Waishu ML Whaquaise
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TO COMMITTEE AND THE STATE AND	
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	1/W be - 1/80 hr
and the following the section of the	
	Rpow + Rpwo + Rpvon =0
J	
	UNTOUT SOUTHON:
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	116etr - Obt Jen Joh
а (техня гот от отничного безайнентя се актичист ретиской тотичности актера и	
ر المراقب المر المراقب المراقب	BUT THIS IS A TENEDRIAL EQ Leven though
NNAAN;	written in specific operals)
	both sides transform well (1 consistently)
erformárica e error na armana esta filología (el miser a electrología per esta distributos	What ahange of opocols.
و میکند و مواد از این این میکند و میکند در این میکند و	M(v) a raid 6 of 000(01)-
The Annual Market Annual Annua	

PROPORTIONOUTY CONST:

$$\Rightarrow A = \frac{R}{d(d-1)}$$

se: 10 a waxwalk shumetus above ses

"WIR some constant over apacetime

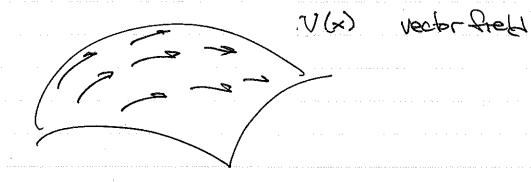
LOCAMY: WHAT MATTERS IN CLASSIFICATION I'S

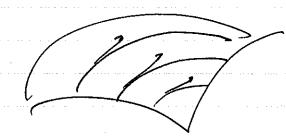
 $R \longrightarrow \pm 0.7$

	LIE DERIVAIVE
	NOTIONS OF REGNATIVE:
gamma ng kanalis (sangan) y 1915 ng kayanang milangsi (shi a pili ka kayan pin ka kababan) pili shi ya pili ka	2, PARTIME -> not covariant
	Dr covarama -> introduces connection, T,
	to "fix" non-covariance
	X.D of 9
	7
	WUD VIE THIS DEFINE T,
	BUT ON A METRE SPACE
	important for GEODERICS (Riemannian Marifeld)
	THERE IS A NATURAL CHOICE.
rum an mananannakan n-aurum manakilikukku-ilinakilikuk ilinakilikuk ilinakilikuk ilinakilikuk ilinakilikuk ili	
ayanan da galayan da Amerika da S	Both Dr. Lokes T - 9 DT
ilianteele (partiet e e e e e e e e e e e e e e e e e e	Both Dr. Lakes T -> DT Thingher ronk Tensor.
	impostant be integral curves
	SHOWS UP IT GEEN MECHANICS
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idines (d. e. nover eksterner medermer even som med de novembelska til distance ende	When we touched on this, we noted
18 a y 18 1997 y 1904 y 19	that the lie decivation of a vector
	(field) is
	x(G.Y)-Y(G.X)=[Y,x]= 7xx
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b.to DMAPENO

MORE INCUITIVE PICTURE: COMPARING NETIVE US PASSIVE





DEFINES TRAJECTORIES

dx M

dz = V (x (6))

(Realthms our identification of <u>vectors</u> w) partial derivatives)

WHAT PS THE DERIVATIVE OF A TENSOR T C & IN THE DIRECTION OF V'(x)?

FIND THE COMPARE 2 VERSIONS OF T(x):

1) PASSIVE TRANSFORM OF COORDINATES T stays "the same", it's just coord. System that's changing

$$T^{\mu\nu}(x) \longrightarrow T^{\prime}^{\mu\nu}(x')$$

Coordinates

$$\frac{9\times}{9\times} = 8 + 82 \frac{9\times}{9} \Lambda_{L}(x) + \dots$$

$$\times = \times + 82 \Lambda(x) + \dots$$

@ ACTIVE TRANSFORMATION (maybe I got these labels mixed up...)

EVAULTE TW(x) & A DIFFERENT POINT ON THE MANIFOLD, X' × + 87 V(x)

TH(x1) = TH(x) + 82 V8 = TH(x) +--

en manual	MERCHY Same POINTS 15
	TM(x1) - T/M(x1)
e mit op filt die der een derweerke feren een der Milleren, wit en entwegen voor der een de feren de feren van de een de	L.T = 82.30 87
чайн холоный няшин на продологовый уруг (В это канадаганый жана протограва на	= V8 Dx Tru - TradaV
TO THE COLOR OF TH	- Tar Dar
	DES: GIVES PREU. RESULT WHEN TO VECTOR > XVW = [V,W]
	now easy to generalize
A BOW;	
CAN REPLACE	lower index: 3x/3x', so FUP SIGN
3-30 Since the	
connection Pieces	LVTH = VYZYV + TBD+VB
ianish	1
(my ontishes)	
	from Yr(x') = (3x') h YB(x)
"The State Control of S	= (S= -82 2, Ve) To
	PROPERTIES: Lu (aT+b8) = aLvT+bLvS
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BACK TO ICOMOTRIES:

ANOTHER WAY OF IDENTIFYING ISOMETRY:

Dr gup = 0?

THE IS AWAYS TRUE FOR OUR COVARIANT DEGLUATIVE!

(metric compatibility)

LIE DERIVATIVE GIVES ALLERNATIVE -

Lugm = Vrdrgm + gradiva

(convection forms concer)

metric commutes

Lugar = W.Dgru + D(HVV)

= DCh/N) = 0 for 180W