

? relation between If and 12 coupling (eave same contin) again - 4 pt

N=4 analytic properties. tree: A=A(pol', "sil") <> [7 = () Collect.rational for (in both (i), Si; -> (i)) Sij > Collectuel stands for  $S_{ij} = (P_i + P_j)^2$ ,  $S_{ijk} = (P_i + P_j + P_k)^2 - ...$ all ivariants tocolity; X particles only poles are single poles in the sij arting from a propagator going on -chall  $\frac{1}{2} \frac{1}{1/2} \frac{1}{p} \frac{$ M41 & P2~0: M  $\frac{1}{p^2} = \frac{1}{\left(\frac{p_1 + p_2 + \dots + p_m}{2}\right)^2} \equiv \frac{1}{\varepsilon_{im}} \quad p_{\sigma} \varepsilon_{im}$ Vesidue: M((1,2,-M,P). M(-P, M+1,-N) (n-11,+1) (Mt1) (the int or the dealer of the

generally; if we have an analy th & know poles #residues - can determine the touchon · if it's well behaved (behavior of a) · technically! doing this broke force is hard-Many ronables ! Sij (4 pt : Zindep dues) · ordering is relevant; in general need to Concider all topologies >< X X many poles (factorization Shownek) if can discutangle this - goal. Mous : . start with 4pt obrok force guessing . Rediscover 4M o color ordering (termical & practical) · BCFW Reciverion : Systematic augtriction? many variables -> style complex variable

4 pts: analytic structure Souge theory reduced (Young Mille) N M=O S=1 Particles gtgt - gtgt scatterig M(10- 26- 3c+ 4d+)  $LG \quad scaling \quad M = < 12 - \frac{2}{3} [34]^2 f^{abcd} (S_{12}, S_{13})$  $\operatorname{Rell} : \quad S_{12} = \left( p_1 + p_2 \right)^2 = 2p_1 \cdot p_2$  $S_{12} + S_{13} + S_{23} = 0$ [m]=0 [f]=-ywe said  $M(1^{a-2^{b-3^{c+1}}}) = g_{1}^{abc} < \frac{<13^{3}}{<21><23>}$ tot Ag fated is a rational for of Sij tree-level ; stury; poles: when some propagator goos on flatz

5 yd P=P1+P2 3 C 2 b 2 b 3 c 1 pz p2~0 M has a simple pole residue ~ grossigteabted 1 <123 Straptics (1) <123 [43]3  $+(-000)\delta^{15}$ <125 Siz < 1/24] < 2p3] = <125[314]?. <125[42] S12 <13>[34] <2(15[13] = <125[34]<sup>2</sup> S12(5)[13] = S12(5) had fail contrast M ! out of a gubian siz like double poles. ( will have for seen !) it no scale in the pedder [fabed] =-4

Can Solve B23 = J12 JB  $=) fabol = \underline{I} fabol \left( \begin{array}{c} \underline{S}_{12} \\ \underline{S}_{12} \underline{S}_{13} \end{array} \right)$ power series in <u>Siz</u> but can't have too repative powers. trate must be at form; <125  $[347]^2 [. A_1 + A_2 + A_3 ]$  $S_{12}S_{13} + S_{12}S_{23} + S_{13}S_{57}$ SIZ Poll, SIZ-DO SZ3~- SIZ A-Az = g2 fabe fede SIZ Poll'  $A_3 - A_1 = c_2^2 \cdot c_1^2 \cdot c_2^2$ S3: A-A3= g2fifi =) [fube fall + fall + fall fbee =) [fube fall + fall + fall fbee Jocobi identity!

Lie algebras from 3mpt scattering of Magsless S=1 particles! to get consistent amplitudes: · Spin-statistics (Base sym) · correct analy prop. of upt ampl: shipe particle poles only (factorization) satisfying Jacobi relevitity totally AS for Exercise Lots rewrite what we toud!  $\frac{\langle 12^{2} \langle 34 \rangle}{\langle 12 \rangle} = \int \frac{3}{\langle 12 \rangle} \frac{\langle 12 \rangle}{\langle 12 \rangle}$ ejar MHJ 1

Some comments!

1) more terms? startis; <125 [24]  $\frac{1}{S_{12}S_{12}} \int \left(\frac{S_{13}}{S_{12}}\right)$ because accured no ease (revorm) but what if there is a lale? can add poly terms with no polos;  $+ < 125 [34]^2 \frac{1}{14} Pabed \left( \frac{512}{1^2} , \frac{513}{1^2} \right)$ no residues: can't expect to determine from tadorization. bod? no: precisely allost are axpect for an EFT. z) what about For Sile oupstation :  $\sum_{i=1}^{n} (i) = (i)$ will come back to this other talking aport color ous

Color orderin · completes ref of took for comp. (in part, from Feyn Allage. QD overs vertor Tako many vertor velocitions for coalculation 1A12 Mangano-Parke reviews (\*) · vovally Fegn diby w/ fabe tape = - [[ttatpte - ttate]] can write any n-gluon tree:  $\mathcal{H}_{n}^{\text{tree}} = g^{n-2} \geq \mathcal{H} \left( \mathcal{T}^{\alpha \in (n)} - \mathcal{T}^{\alpha \in (n)} \right) \mathcal{A}_{n}^{\text{tree}} \left( \mathcal{T}(0), - \mathcal{T}(n) \right)$ Non Cyclic Perus color ordered amplitude. each lova notion of ordering; og for  $A(l^{\alpha_1,h_1}, \dots, h)$ tr Tai. Jan (12); og for  $A(l^{\alpha_1,h_1}, \dots, h)$ tr Tai. Jan (2); og for  $A(l^{\alpha_1,h_1}, \dots, h)$ N (2); og for  $A(l^{\alpha_1,h_1}, \dots, h)$ tr Tai. Jan (2); og for  $A(l^{\alpha_1,h_1}, \dots, h)$ N (2); og for each cold ord, anyl, is galle mr.

the MHN expression quoted before are for Glor-ord ampl. <123 <23><345 ... <NI>  $\mathcal{P}^{N}(\mathcal{P}^{2},\mathcal{F},\mathcal{M})$ A (Lai - Lan) 2) before: som hawto construct by from Az

(bootstrap) by brute force sugging. Vou may wonder; this construction was blind to the lection vtx;  $\mathcal{A} = \partial f_{apc} \left[ \partial_{h} \left( k - b \right)_{b} + \cdots \right]$ +-- \ prencise shows; Dean choose ref momenta so that the contrib. of this it =0 always. [0= ilquio +..+ lous, + the fast work [] - gauge invoriance allows it to get rid of this contrib.

another way: constructed by from Az Wolt Kalw surprising? no : no new info in completely dictated by gauge invariance. but terms of the form  $<125^{2}[34]^{2}\frac{1}{N^{4}}Pabed\left(\frac{512}{N^{2}},\frac{513}{N^{2}}\right)$ are near interactions - near input that we may add i may or may not be there i only expt can Detore going on: one more practical tool' appeggymmetry. n-gluon tree ampli, is on gluon+quark ~' enberein gluings aquartes dant anter. alleady can: Lorentz constrains ampl SUSY = Oxt of Loroutz: more constraints =) relates amply of particles of diff 5. SMI