All-loop singularities of scattering amplitudes in massless planar theories

Stefan Stanojevic

Brown University

Jun 12, 2018

arXiv:1805.11617 (Igor Prlina, Marcus Spradlin, SS)

Landau Singularities

Stefan Stanojevic

Consider a Feynman-parametrized Feynman integral,

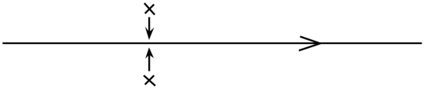
$$\int \prod_{r=1}^{L} d^D l_r \int_{\alpha_i \geq 0} d^\nu \alpha \; \delta\left(1 - \sum_{i=1}^{\nu} \alpha_i\right) \frac{\mathcal{N}(l_r^\mu, p_i^\mu, \ldots)}{\mathcal{D}^\nu}$$

Integrated expression will develop singularities when a set of Landau equations is satisfied,

$$\sum_{i \in \text{loop}} \alpha_i q_i^\mu = 0 \text{ for each loop, and}$$

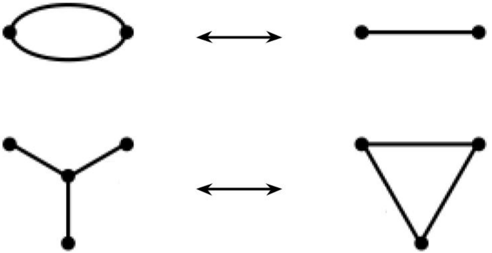
$$\alpha_i (q_i^2 - m_i^2) = 0 \text{ for each } i$$

corresponding to a pinching of integration contour by 'colliding poles' of the integrand,



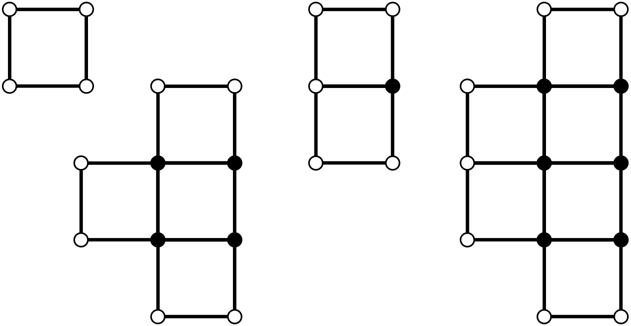
Graph Operations

The content of (massless) Landau equations is preserved by electrical circuit - inspired graph moves



Graph Reduction

Using the theorem on n - terminal $Y - \Delta$ reduction (Gitler, 1991), planar Landau graphs of arbitrary complexity are reduced to 'ziggurat' graphs



Conclusions

- The first-type Landau singularities of an n-particle scattering amplitude in any massless planar field theory are a subset of those of the n-particle ziggurat graph
- In the special case of planar $\mathcal{N} = 4$ super Yang-Mills theory, technology that can verify whether singularities are spurious exists (amplituhedron, on-shell diagrams)
- We find that perturbative amplitudes in planar $\mathcal{N} = 4$ super Yang-Mills theory exhibit singularities on all possible first-type singularity loci

Thank You!