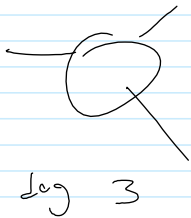
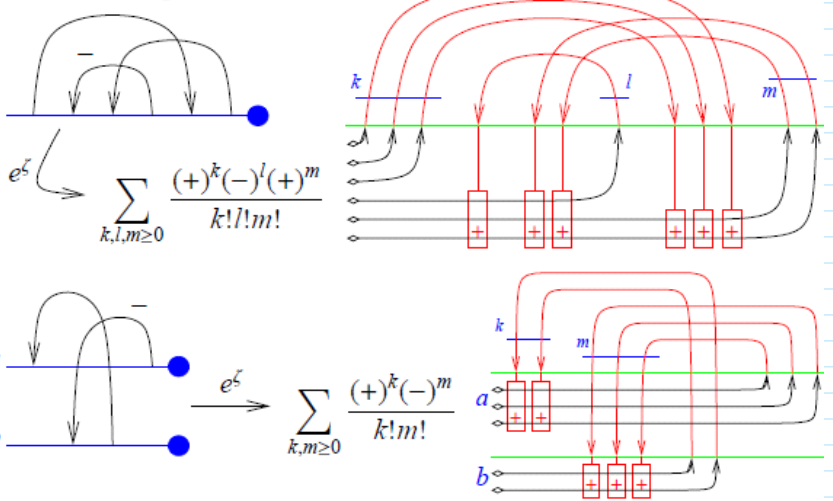
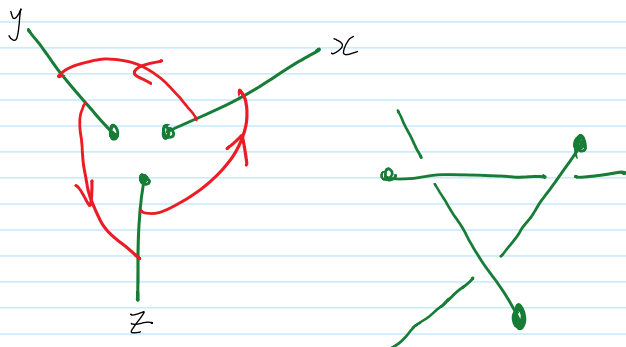


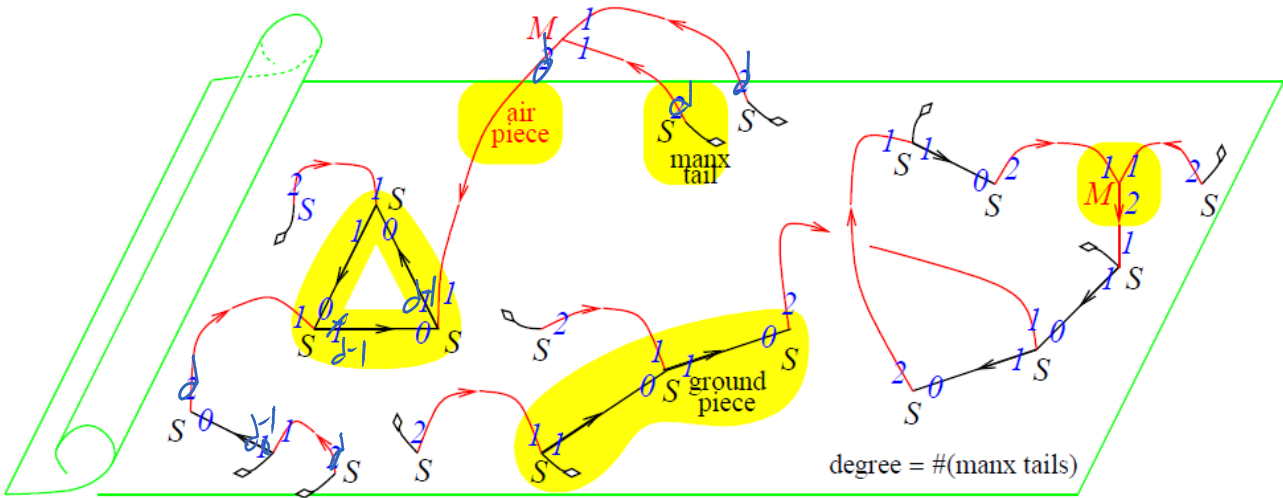
Theorem 1 (with Cattaneo (credit, no blame)). In the ribbon case, $e^{\mathcal{L}}$ can be computed as follows:



Infra-red matters!



In higher d , $dC \rightarrow d+2$.



G

$O(E)$: order edge w/ sign
action of $S(E)$. $O(H)$ orienting the set of half-edges

$D(E)$: directed edges $\rightarrow + \leftarrow = 0$

even $O(E)$ / odd $O(V) \otimes D(E)$

$O(E) \otimes O(V) \otimes D(E) =$
 $= O(C_0) \otimes O(C_1) \quad \square, \triangle$
 $= O(H_0) \otimes O(H_1)$

only for graphs all of whose components are wheels ($|H_i|=1$): $O(H_i) = O(H_0) \otimes D(W)$

$= D(W)$

$D(E) = O(H) \otimes O(V) \otimes D(V)$
in 3-valent graphs

Euler's Plan $0 \rightarrow C_1 \rightarrow C_0 \rightarrow 0 \rightarrow 0 \rightarrow H_1 \rightarrow H_0 \rightarrow 0$

$O(C_1) \otimes O(C_0) \cong O(H_1) \otimes O(H_0)$
 $C_0 \cong V \quad O(C_1) \cong O(E) \otimes D(E)$

$D(W)$ orienting the cycle / flip = -1

\mathbb{Z}^2 $D(V) \cong O(V) \otimes D(E)$ $\sum_{D \in O(E)} |D|$

\mathbb{Z}^2 $D(V) =$ in a 3-valent diagram, orient each vertex / as