Encoding !-Tensors in Quantomatic

David Quick

Oxford Quantum Group

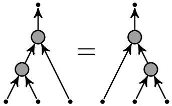
QPL
July 2015

Quantum Group
Department of Computer Science
University of Oxford

Diagrammatic Reasoning

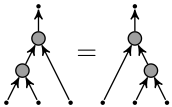
Diagrammatic Reasoning

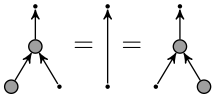
Theory:



Diagrammatic Reasoning

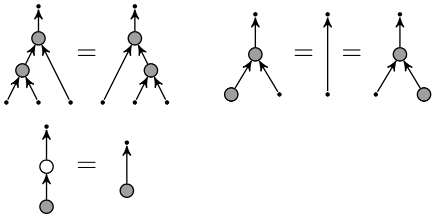
Theory:





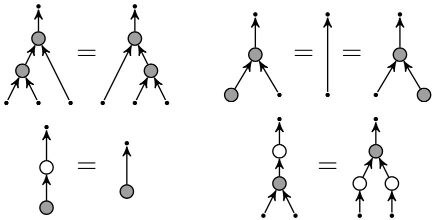
Diagrammatic Reasoning

Theory:



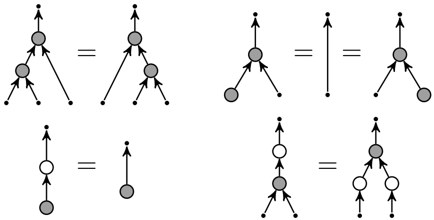
Diagrammatic Reasoning

Theory:

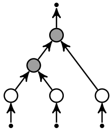


Diagrammatic Reasoning

Theory:

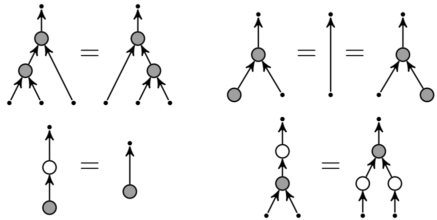


Substitution:

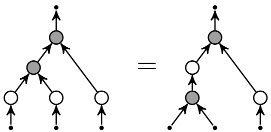


Diagrammatic Reasoning

Theory:

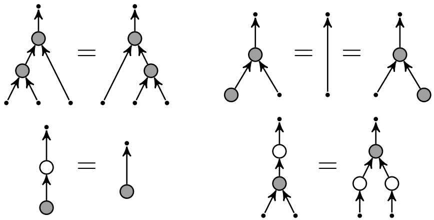


Substitution:

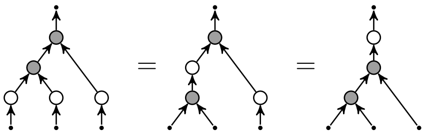


Diagrammatic Reasoning

Theory:

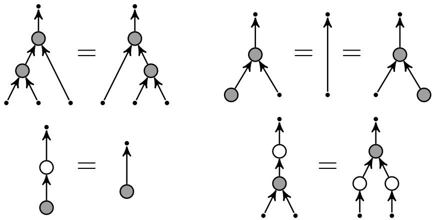


Substitution:

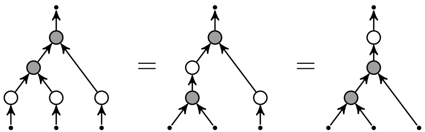


Diagrammatic Reasoning

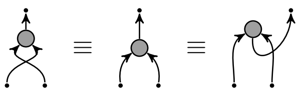
Theory:



Substitution:



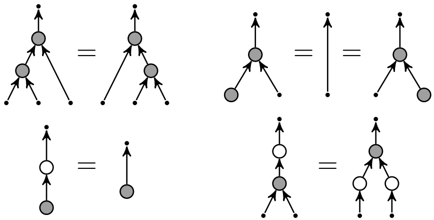
Commutative:



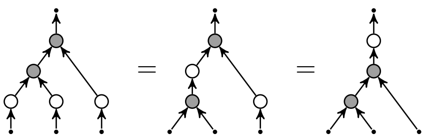
Diagrammatic Reasoning

Commutative

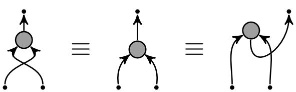
Theory:



Substitution:



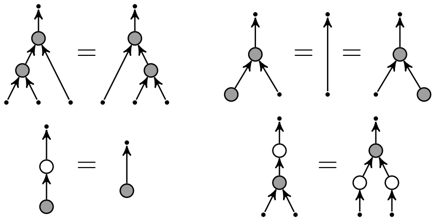
Commutative:



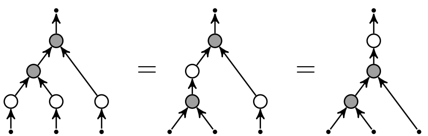
Diagrammatic Reasoning

Commutative

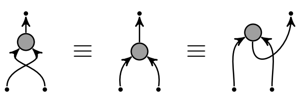
Theory:



Substitution:



Commutative:

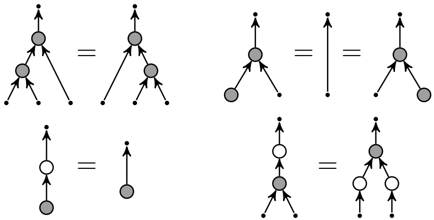


Non-Commutative

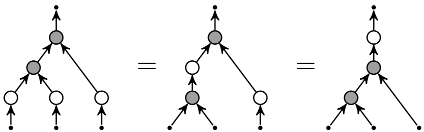
Diagrammatic Reasoning

Commutative

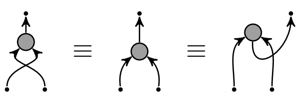
Theory:



Substitution:

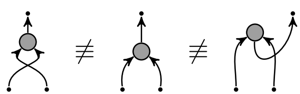


Commutative:



Non-Commutative

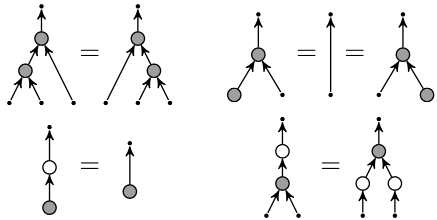
Non-commutative:



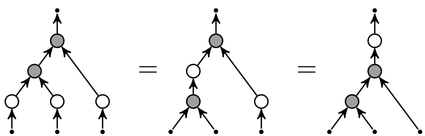
Diagrammatic Reasoning

Commutative

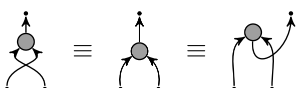
Theory:



Substitution:

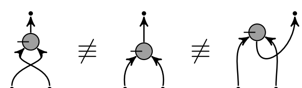


Commutative:



Non-Commutative

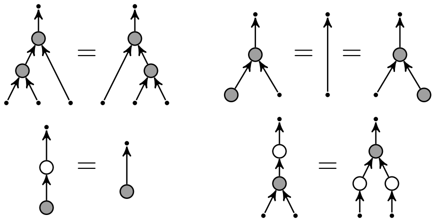
Non-commutative:



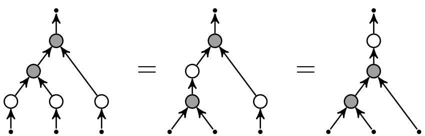
Diagrammatic Reasoning

Commutative

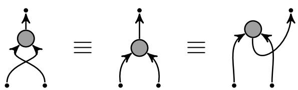
Theory:



Substitution:

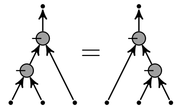


Commutative:

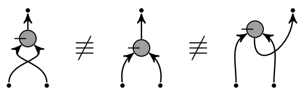


Non-Commutative

Theory:



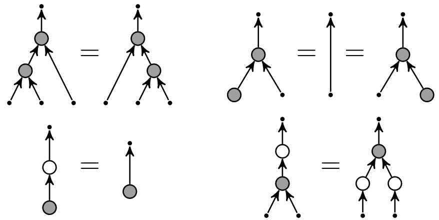
Non-commutative:



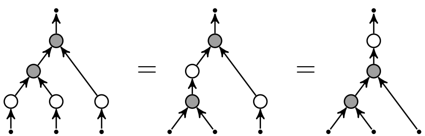
Diagrammatic Reasoning

Commutative

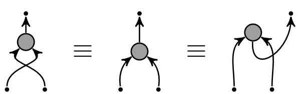
Theory:



Substitution:

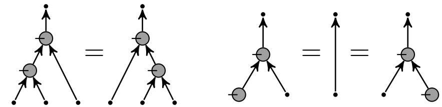


Commutative:

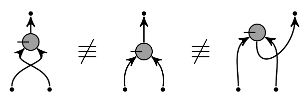


Non-Commutative

Theory:



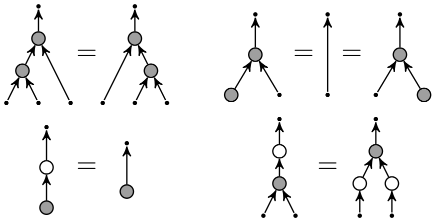
Non-commutative:



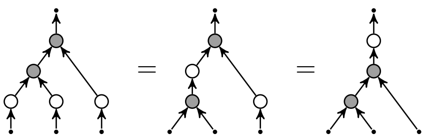
Diagrammatic Reasoning

Commutative

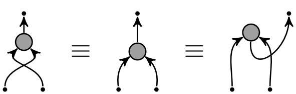
Theory:



Substitution:

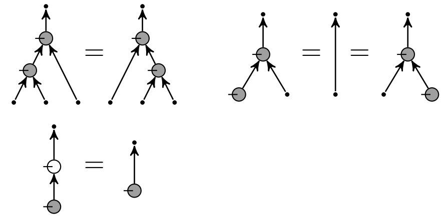


Commutative:

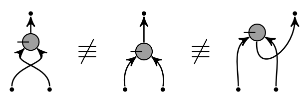


Non-Commutative

Theory:



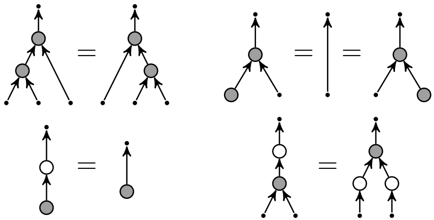
Non-commutative:



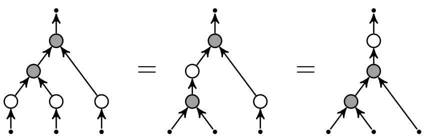
Diagrammatic Reasoning

Commutative

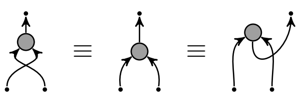
Theory:



Substitution:

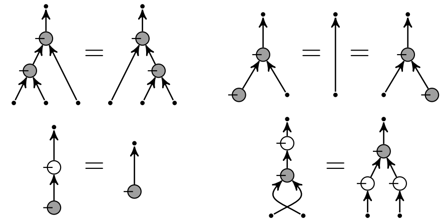


Commutative:

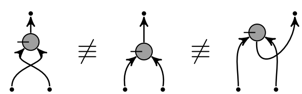


Non-Commutative

Theory:



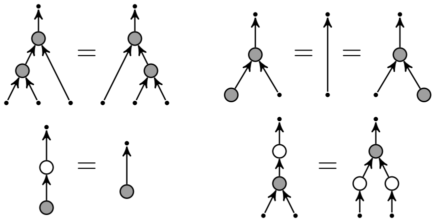
Non-commutative:



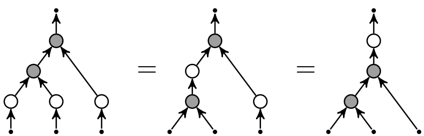
Diagrammatic Reasoning

Commutative

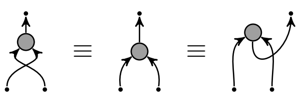
Theory:



Substitution:

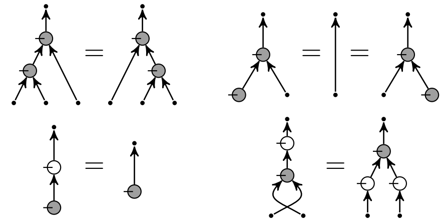


Commutative:

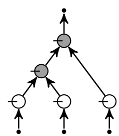


Non-Commutative

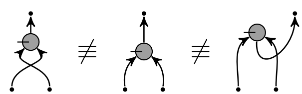
Theory:



Substitution:



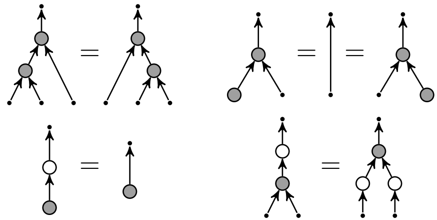
Non-commutative:



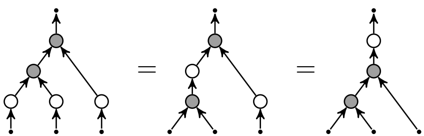
Diagrammatic Reasoning

Commutative

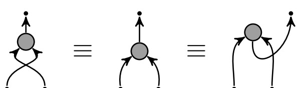
Theory:



Substitution:

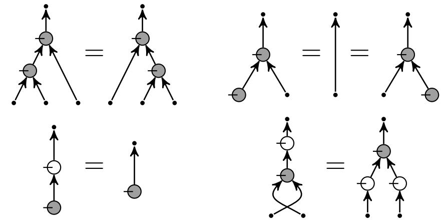


Commutative:

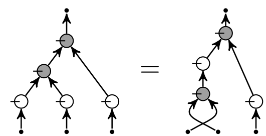


Non-Commutative

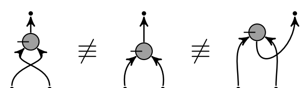
Theory:



Substitution:



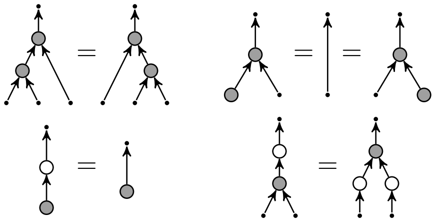
Non-commutative:



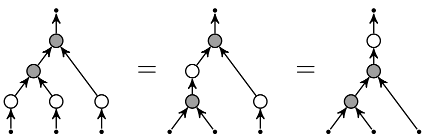
Diagrammatic Reasoning

Commutative

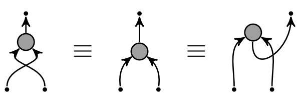
Theory:



Substitution:

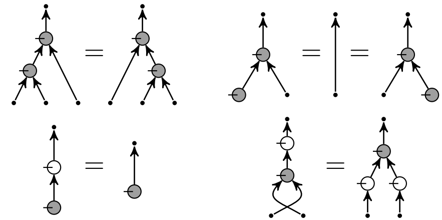


Commutative:

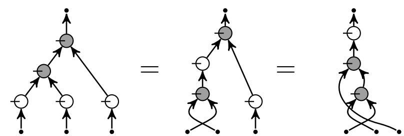


Non-Commutative

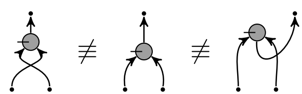
Theory:



Substitution:



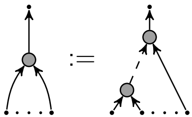
Non-commutative:



Families of (Commutative) Diagrams

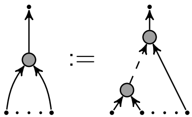
Families of (Commutative) Diagrams

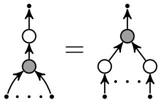
Arbitrary arity:



Families of (Commutative) Diagrams

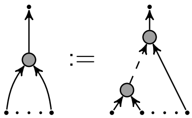
Arbitrary arity:

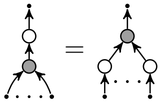




Families of (Commutative) Diagrams

Arbitrary arity:

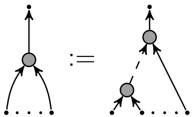


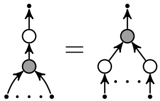


!-Boxes

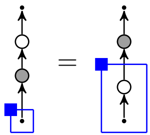
Families of (Commutative) Diagrams

Arbitrary arity:



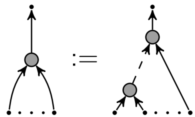


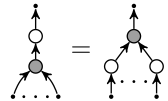
!-Boxes



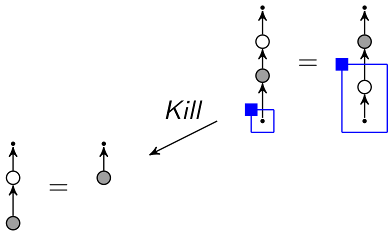
Families of (Commutative) Diagrams

Arbitrary arity:



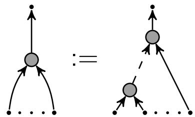


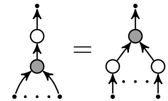
!-Boxes



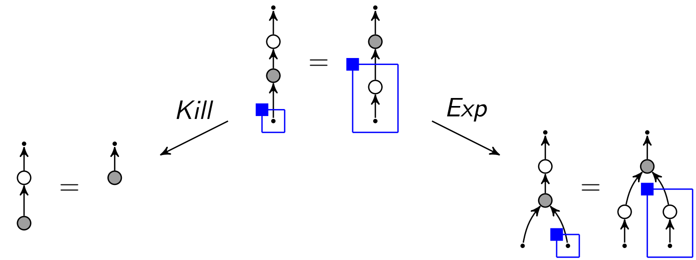
Families of (Commutative) Diagrams

Arbitrary arity:



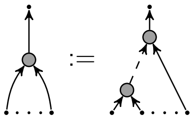


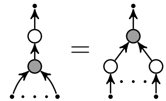
!-Boxes



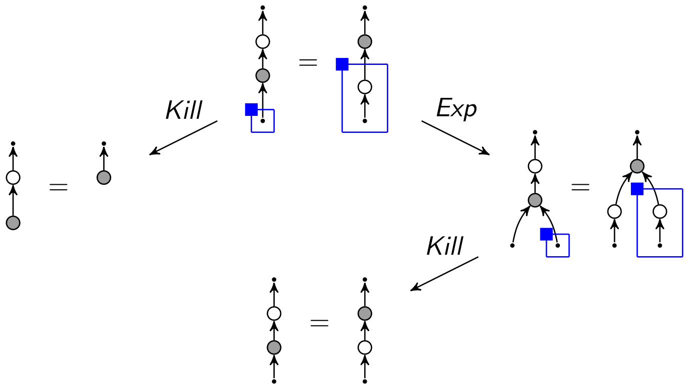
Families of (Commutative) Diagrams

Arbitrary arity:





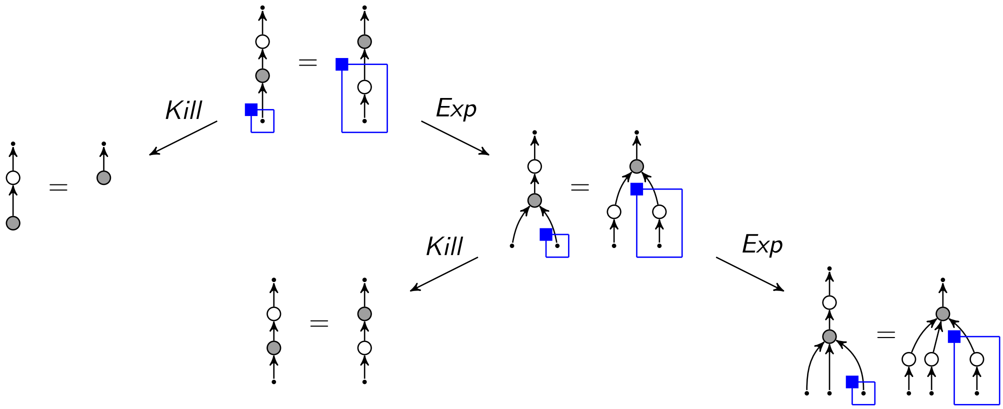
!-Boxes



Families of (Commutative) Diagrams

Arbitrary arity:

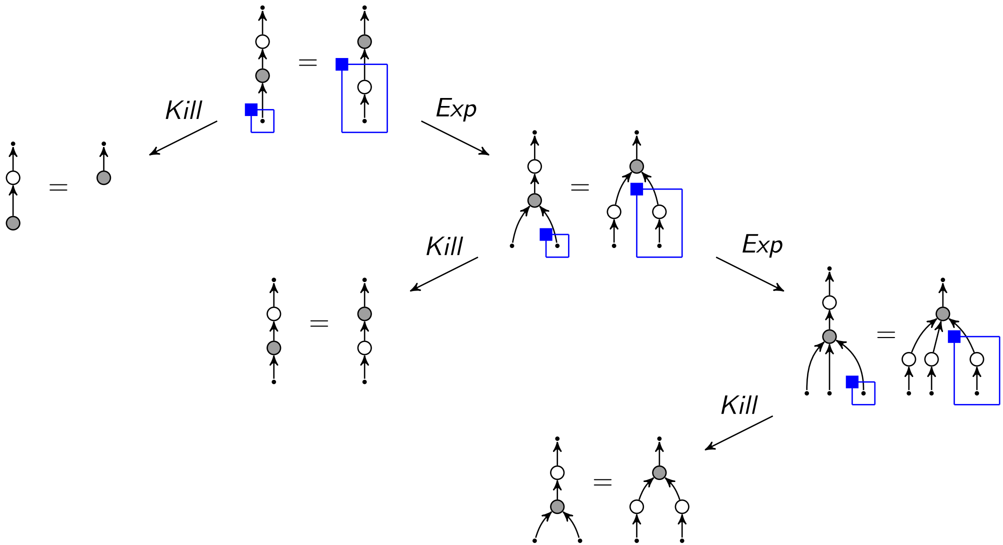
!-Boxes



Families of (Commutative) Diagrams

Arbitrary arity:

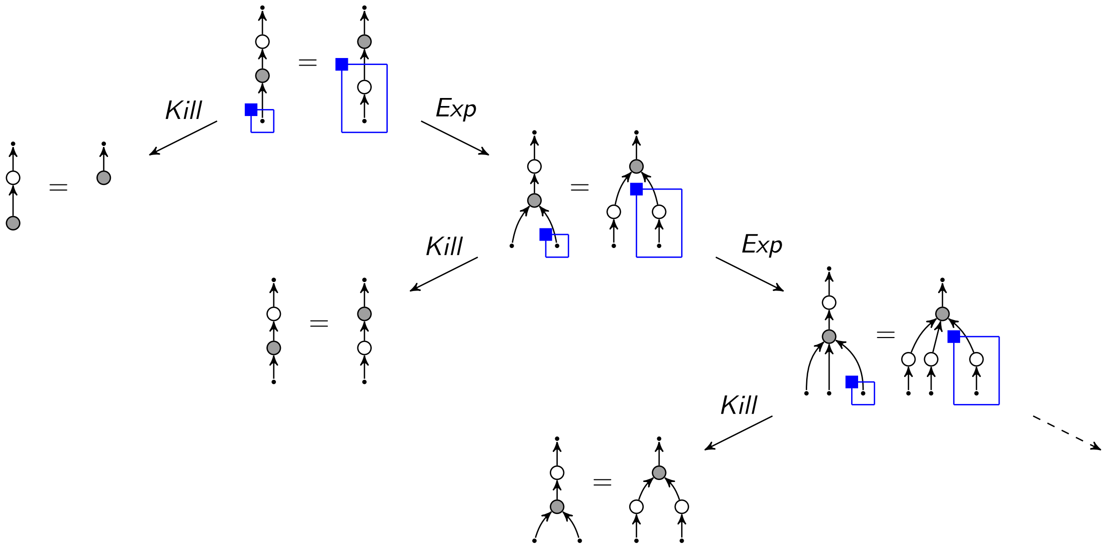
!-Boxes



Families of (Commutative) Diagrams

Arbitrary arity:

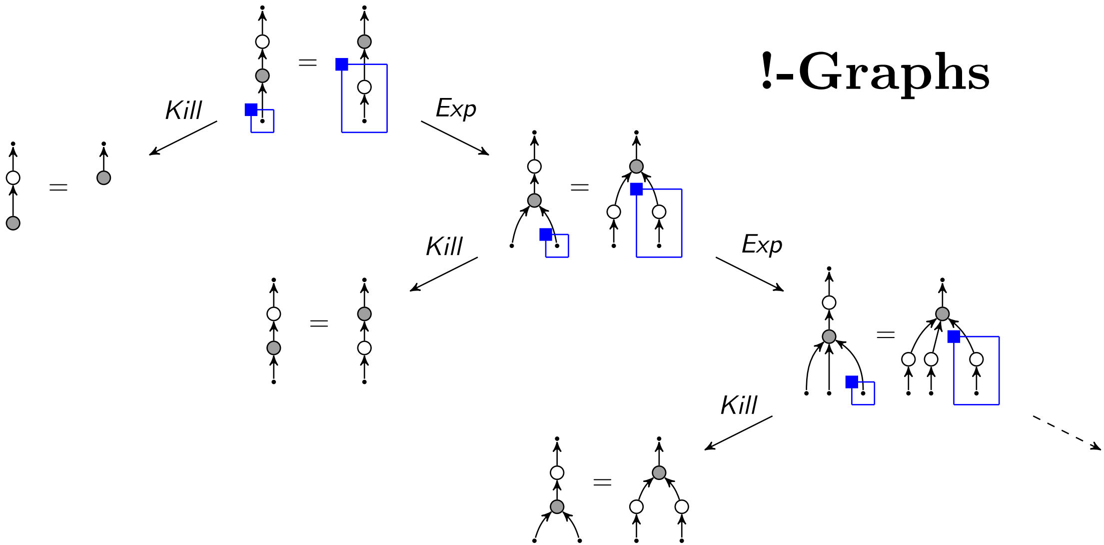
!-Boxes



Families of (Commutative) Diagrams

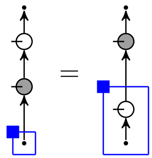
Arbitrary arity:

!-Boxes

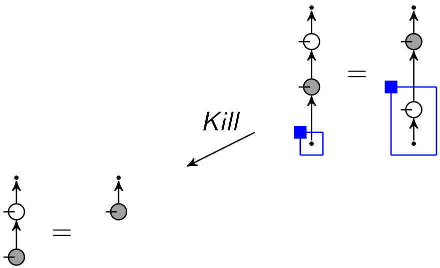


!-Graphs

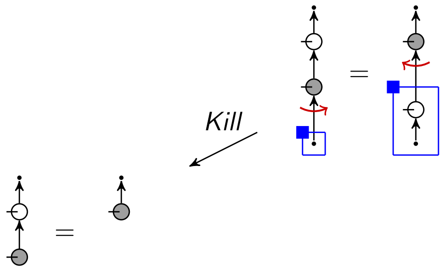
Families of (Non-Commutative) Diagrams



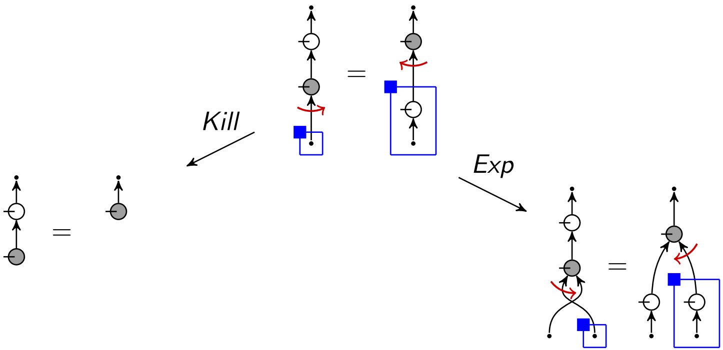
Families of (Non-Commutative) Diagrams



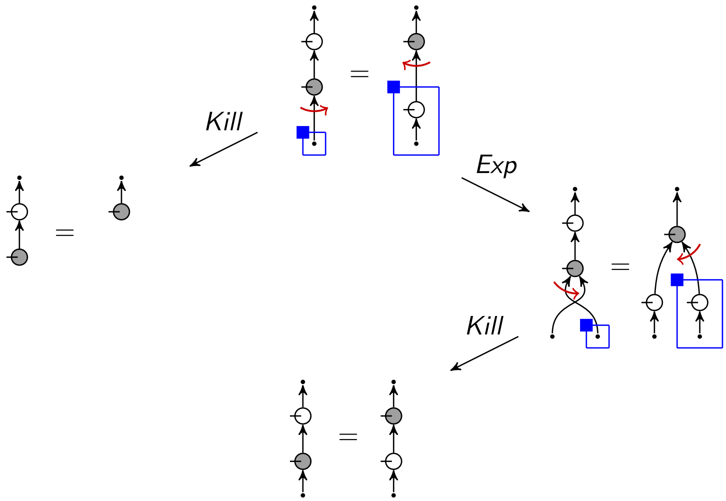
Families of (Non-Commutative) Diagrams



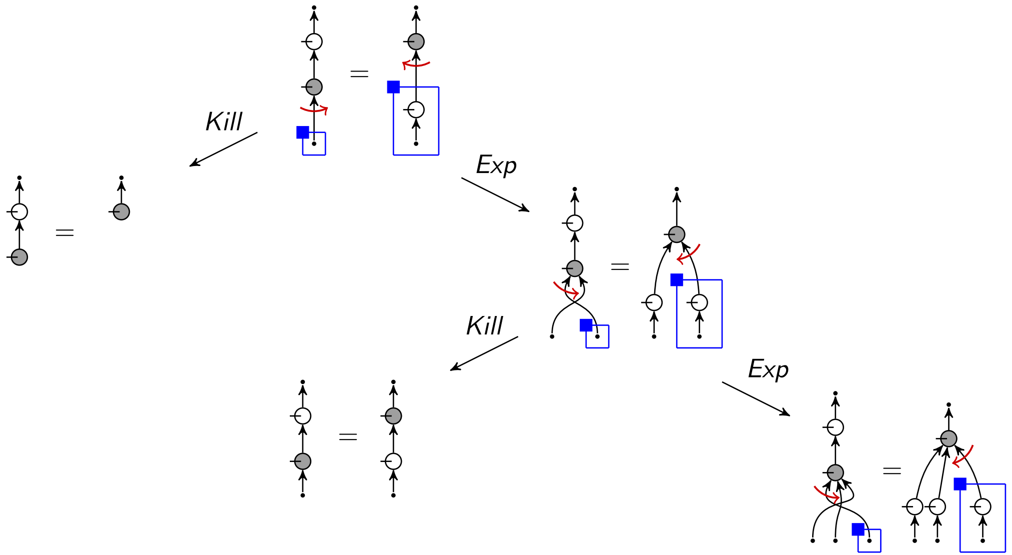
Families of (Non-Commutative) Diagrams



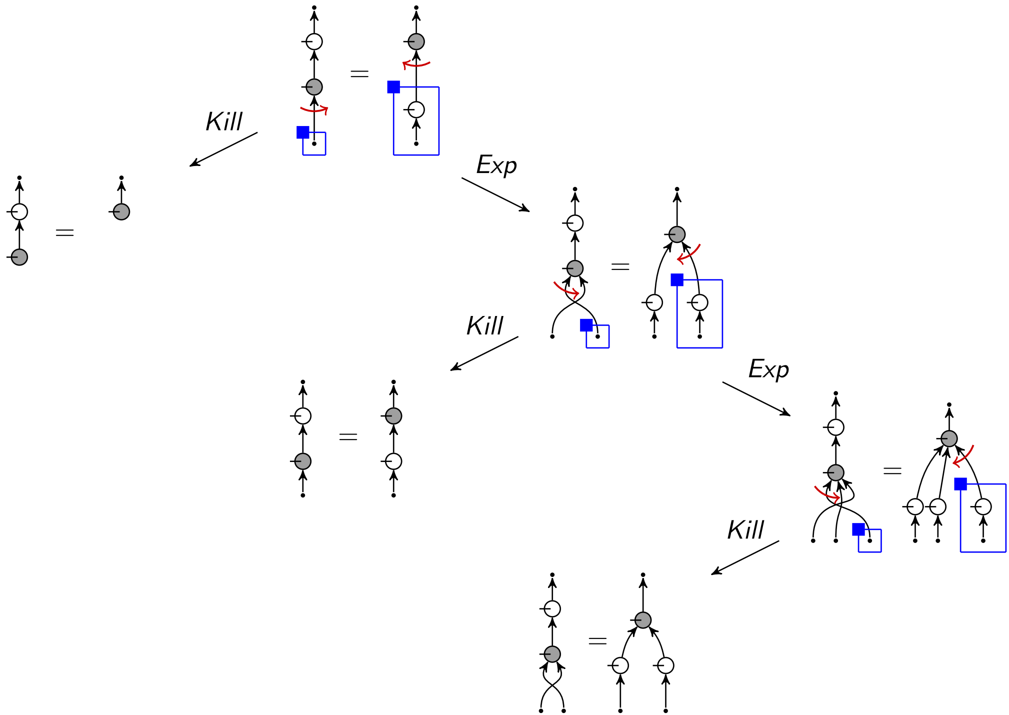
Families of (Non-Commutative) Diagrams



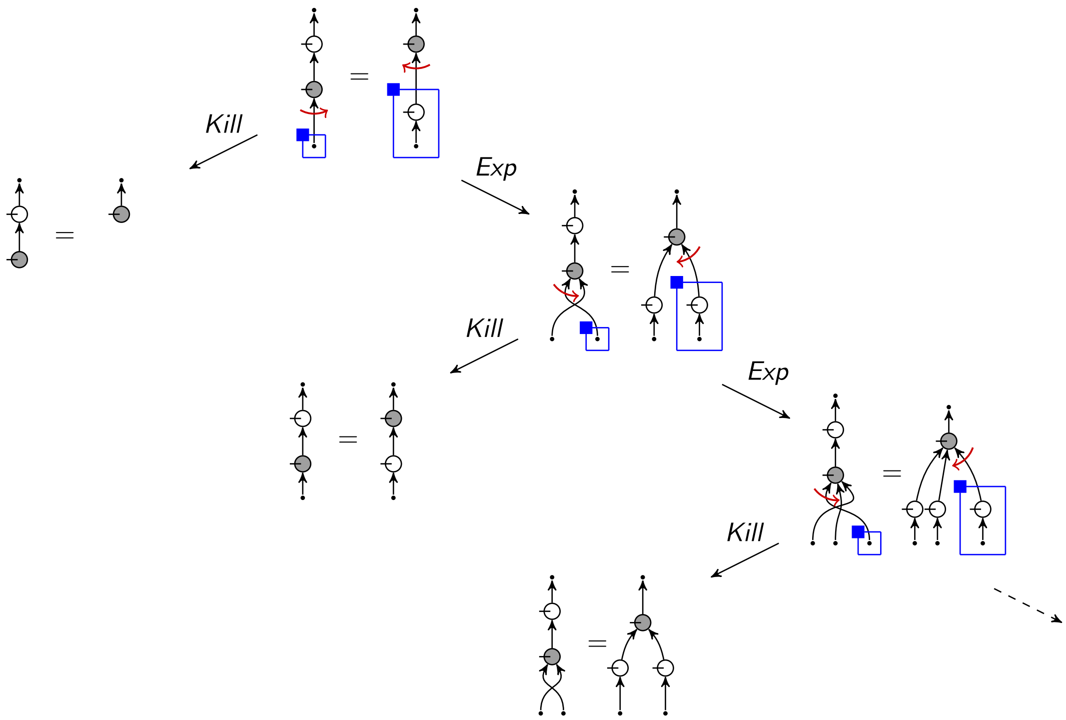
Families of (Non-Commutative) Diagrams



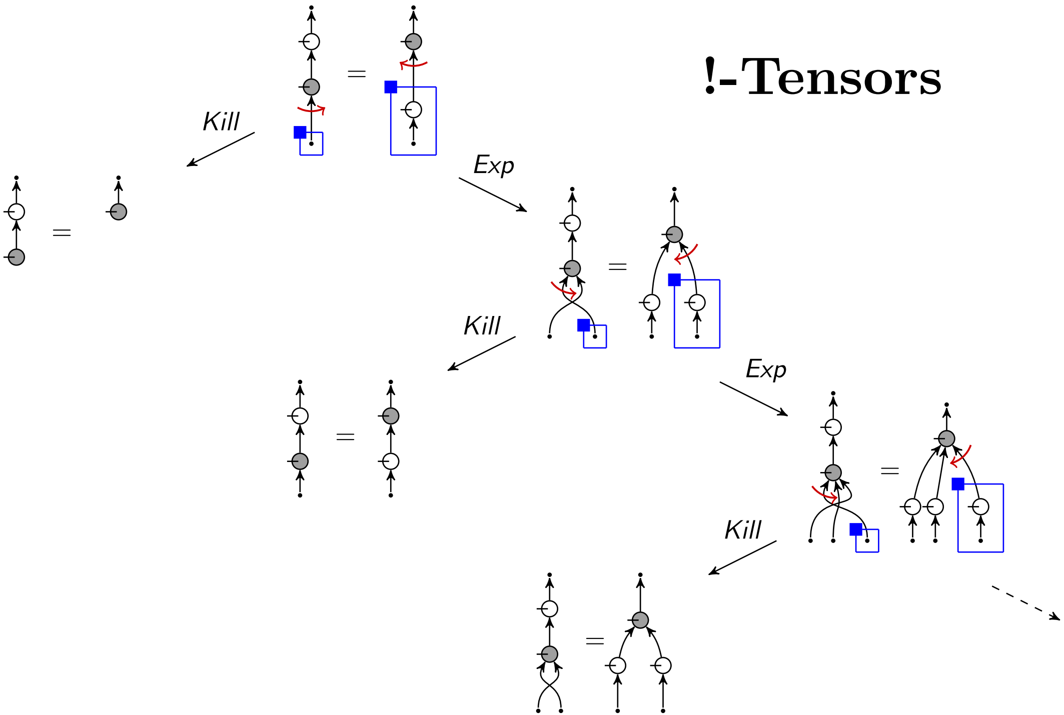
Families of (Non-Commutative) Diagrams



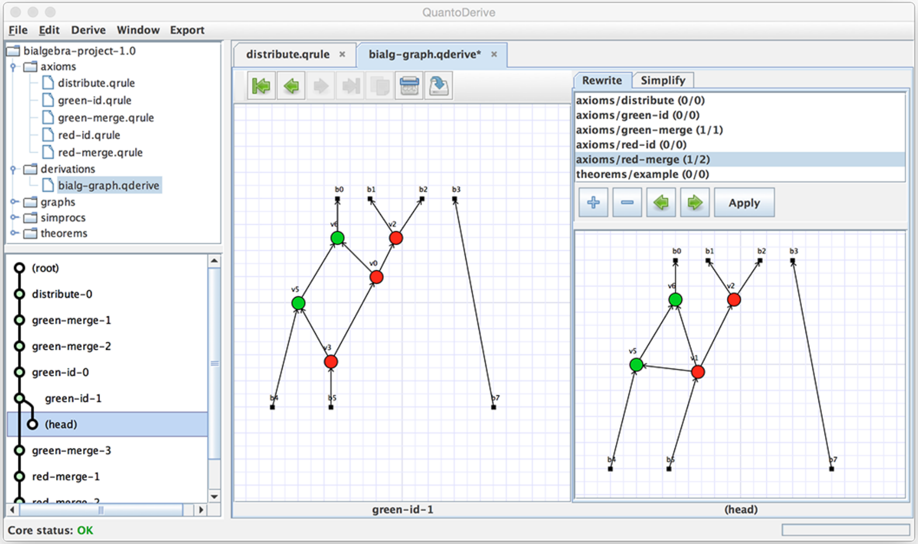
Families of (Non-Commutative) Diagrams



Families of (Non-Commutative) Diagrams



Quantomatic



Problem/Solution

!-Graphs

!-Tensors

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	

Problem/Solution

!-Graphs	!-Tensors
Requires Commutativity	Allows Non-Commutativity

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	**Not automated**

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	**Not automated**

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	**Not automated**

Solution 1: Rebuild from scratch

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	Not automated

Solution 1: Rebuild from scratch

Problem/Solution

!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	**Not automated**

Solution 1: Rebuild from scratch

Solution 2: Adapt Quantomatic

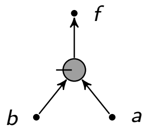
Problem/Solution

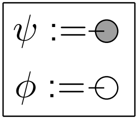
!-Graphs	**!-Tensors**
Requires Commutativity	Allows Non-Commutativity
Combinatoric	Syntactic
Automated (Quantomatic)	**Not automated**

Solution 1: Rebuild from scratch

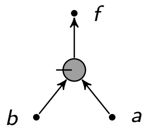
Solution 2: Adapt Quantomatic

!-Tensor Expressions

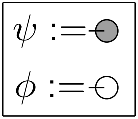




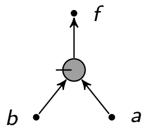
!-Tensor Expressions



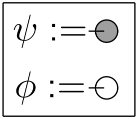
ψ



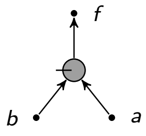
!-Tensor Expressions



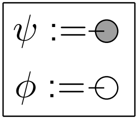
$$\psi_{fab}$$



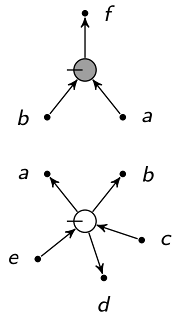
!-Tensor Expressions



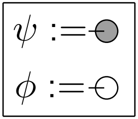
$$\psi_{\hat{f}\check{a}\check{b}}$$



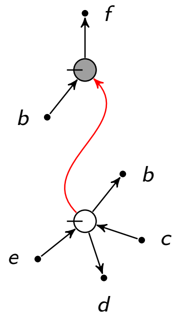
!-Tensor Expressions



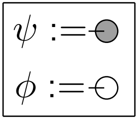
$$\psi_{\hat{f}\check{a}\check{b}} \qquad \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



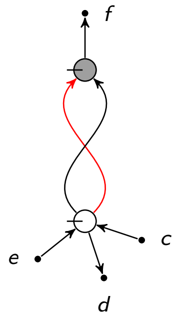
!-Tensor Expressions



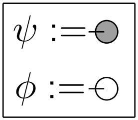
$\psi_{\hat{f}\check{a}\check{b}} \quad \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$



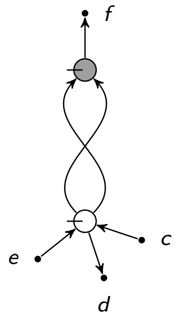
!-Tensor Expressions



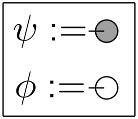
$$\psi_{\hat{f}\check{a}\check{b}} \qquad \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



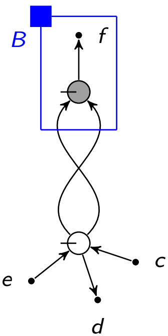
!-Tensor Expressions



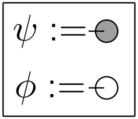
$$\psi_{\hat{f}\check{a}\check{b}} \quad \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



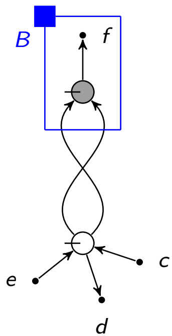
!-Tensor Expressions



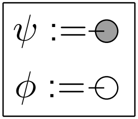
$$\psi_{\hat{f}\check{a}\check{b}} \quad \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



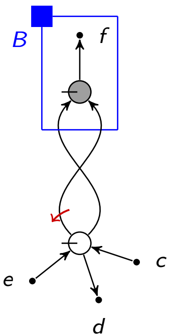
!-Tensor Expressions



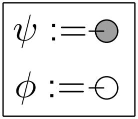
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



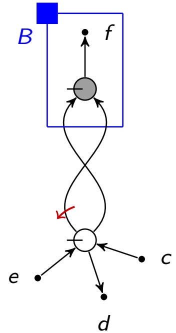
!-Tensor Expressions



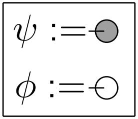
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^B \phi_{\hat{a}\hat{b}\check{c}\hat{d}\check{e}}$$



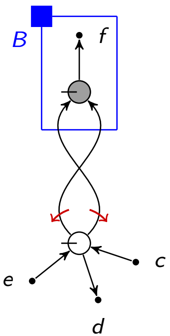
!-Tensor Expressions



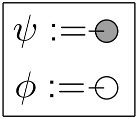
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}\hat{b}\check{c}\hat{d}\check{e}}$$



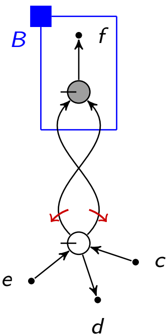
!-Tensor Expressions



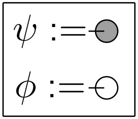
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}\hat{b}\check{c}\hat{d}\check{e}}$$



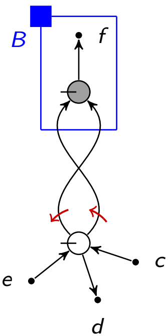
!-Tensor Expressions



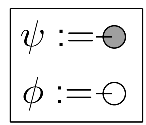
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}[\hat{b}\rangle^{B}\check{c}\hat{d}\check{e}}$$



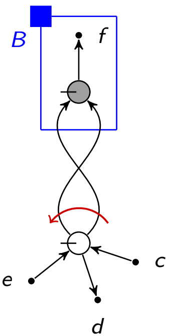
!-Tensor Expressions



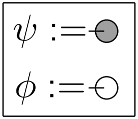
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}\langle\hat{b}]^{B}\check{c}\hat{d}\check{e}}$$



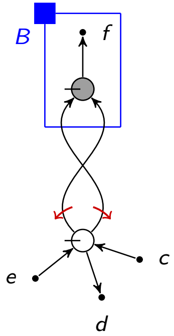
!-Tensor Expressions



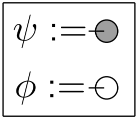
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}\hat{b}]^{B}\check{c}\hat{d}\check{e}}$$



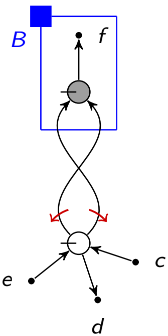
!-Tensor Expressions



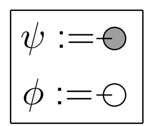
$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}[\hat{b}\rangle^{B}\check{c}\hat{d}\check{e}}$$



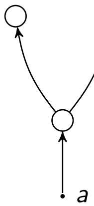
!-Tensor Expressions



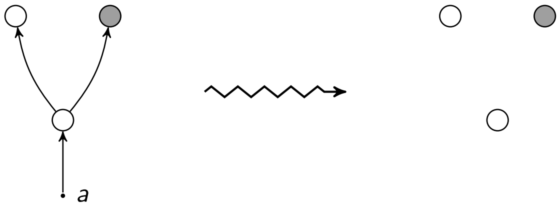
$$\overbrace{\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B}\phi_{\langle\hat{a}]^{B}[\hat{b}\rangle^{B}\check{c}\hat{d}\check{e}}}^{\text{!-Tensor Expression}}$$



!-Graphs

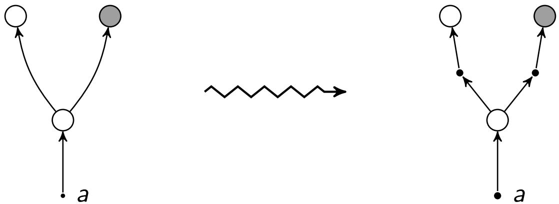


!-Graphs



Node-vertices :

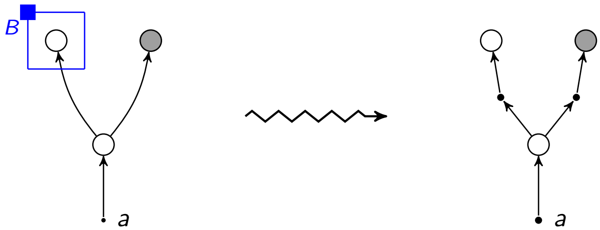
!-Graphs



Node-vertices : {●, ○}

Wire-vertices : {•}

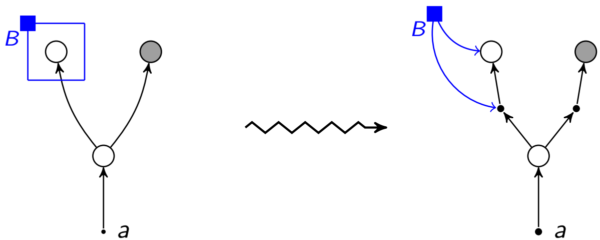
!-Graphs



Node-vertices : {●, ○}

Wire-vertices : {•}

!-Graphs

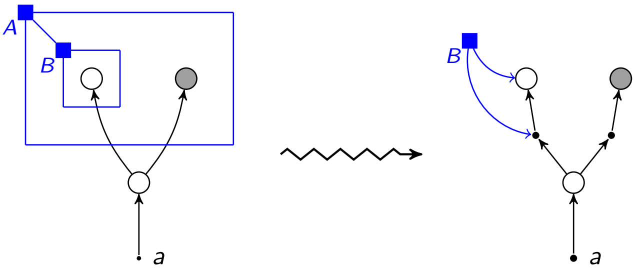


Node-vertices : {●, ○}

Wire-vertices : $\{\bullet\}$

Box-vertices : {■}

!-Graphs

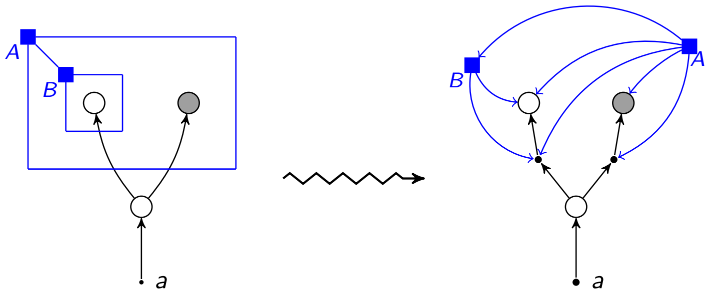


Node-vertices : {◉, ○}

Wire-vertices : {•}

Box-vertices : {■}

!-Graphs

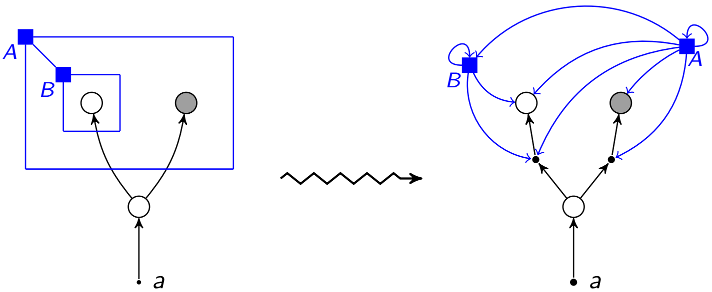


Node-vertices : {●, ○}

Wire-vertices : {•}

Box-vertices : {■}

!-Graphs

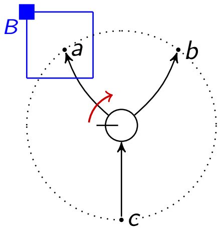


Node-vertices : {●, ○}

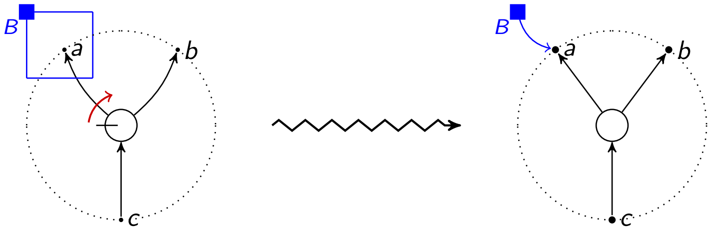
Wire-vertices : {•}

Box-vertices : {■}

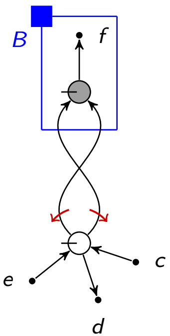
Neighbourhood Orders



Neighbourhood Orders

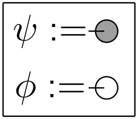


Neighbourhood Orders

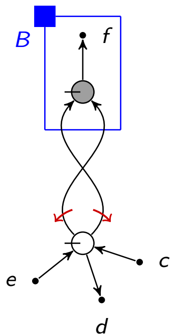


!-Tensor Expression

$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^{B} \phi_{\langle \hat{a}]^{B}[\hat{b}\rangle^{B}\check{c}\hat{d}\check{e}}$$

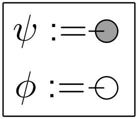


Neighbourhood Orders

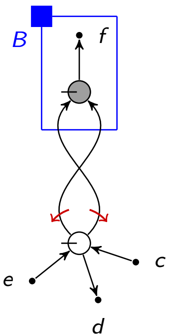


!-Tensor Expression

$$\left[\psi_{\hat{f}\check{a}\check{b}}\right]^B \phi_{\langle\hat{a}]^B[\hat{b}\rangle^B\check{c}\hat{d}\check{e}}$$



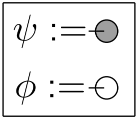
Neighbourhood Orders



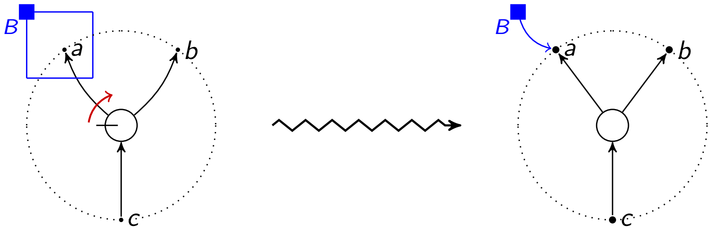
!-Tensor Expression

$$[\psi_{\hat{f}\check{a}\check{b}}]^B \phi_{\langle\hat{a}]^B[\hat{b}\rangle^B\check{c}\hat{d}\check{e}}$$

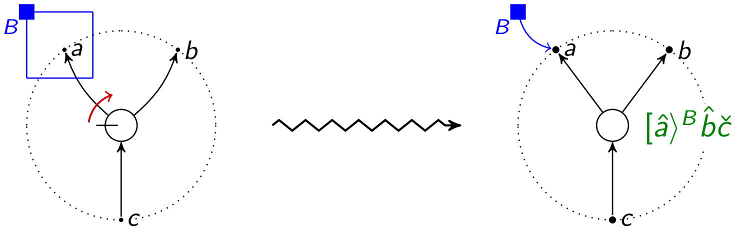
Edgeterms



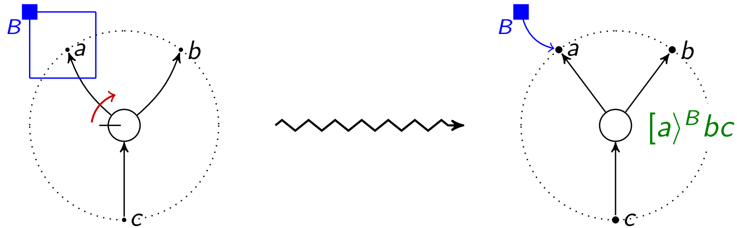
Neighbourhood Orders



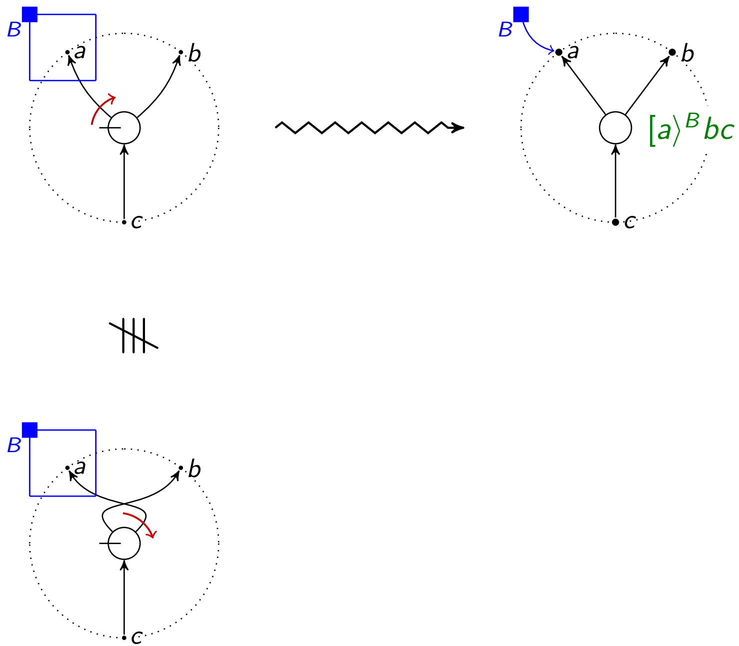
Neighbourhood Orders



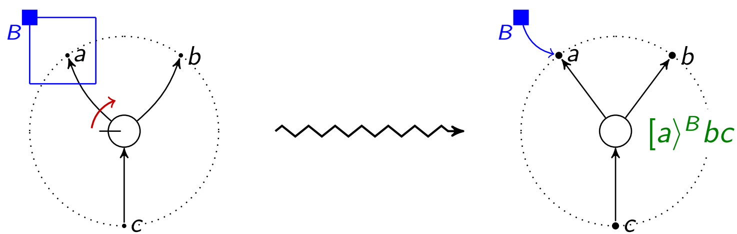
Neighbourhood Orders

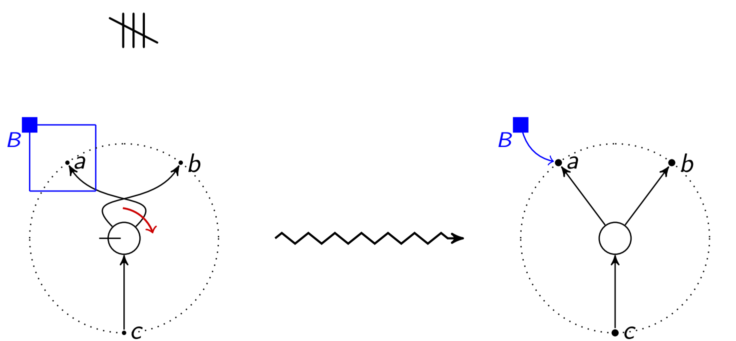


Neighbourhood Orders

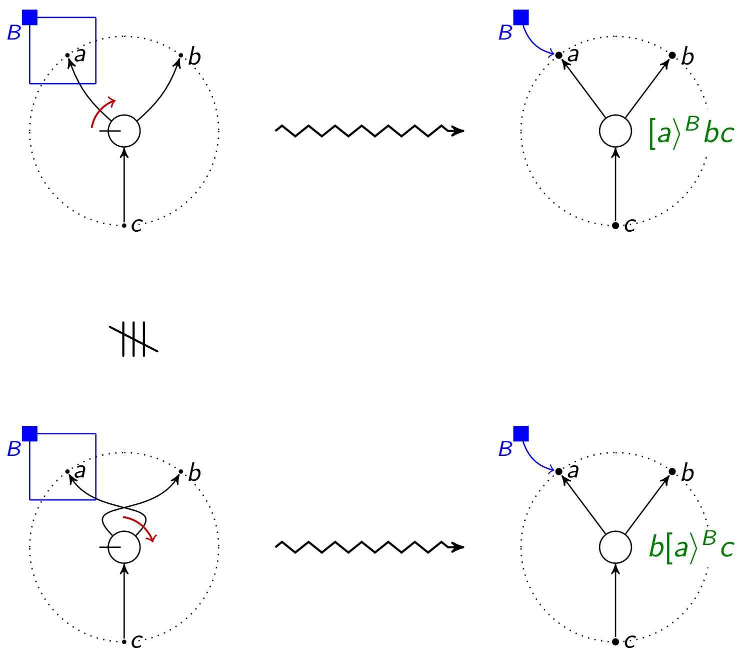


Neighbourhood Orders

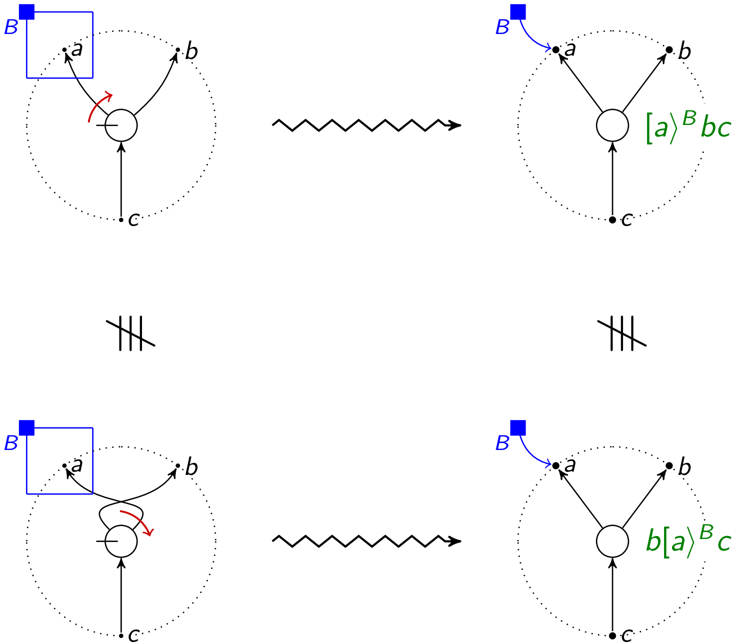




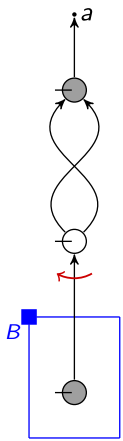
Neighbourhood Orders

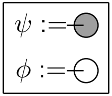


Neighbourhood Orders

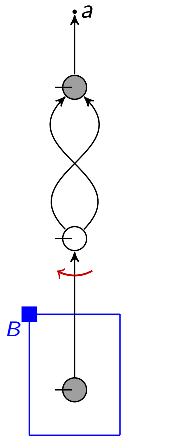


Isomorphism

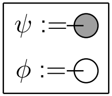




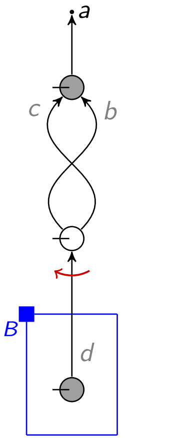
Isomorphism



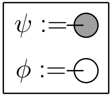
$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$



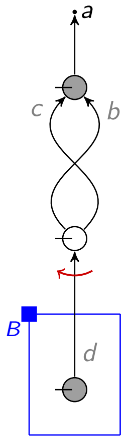
Isomorphism



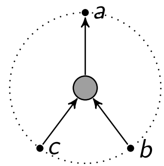
$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^{B}}\left[\psi_{\hat{d}}\right]^{B}$$

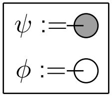


Isomorphism

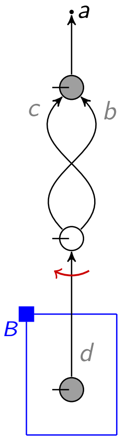


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

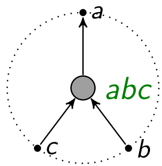


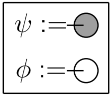


Isomorphism

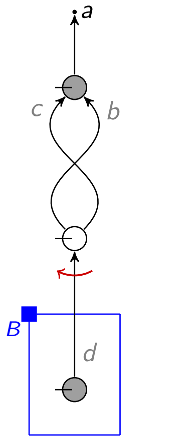


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^{B}}\left[\psi_{\hat{d}}\right]^{B}$$

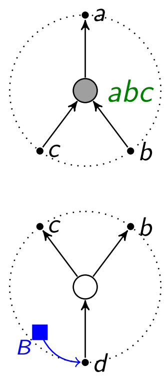


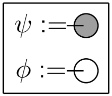


Isomorphism

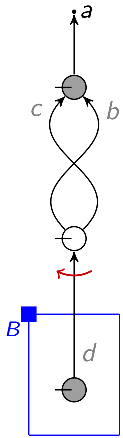


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

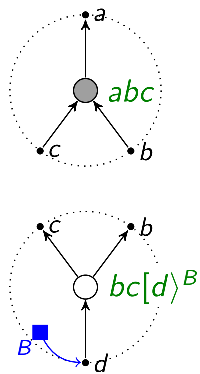


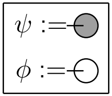


Isomorphism

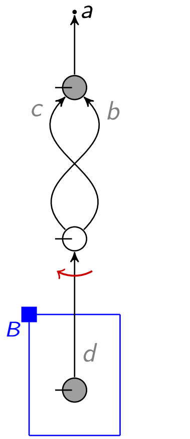


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^{B}}\left[\psi_{\hat{d}}\right]^{B}$$

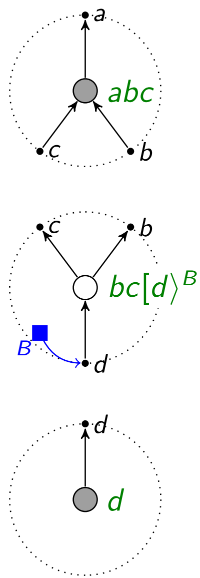


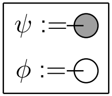


Isomorphism

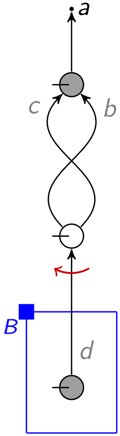


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

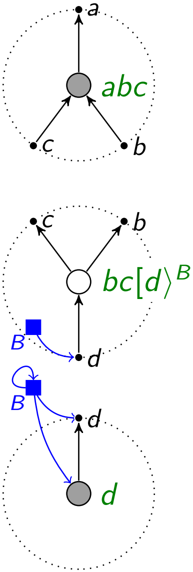


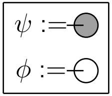


Isomorphism

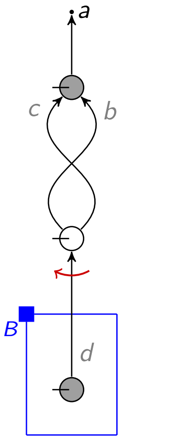


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

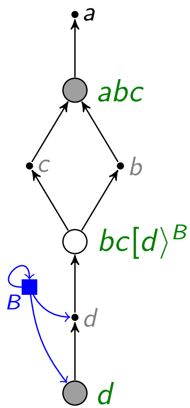


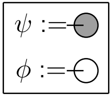


Isomorphism

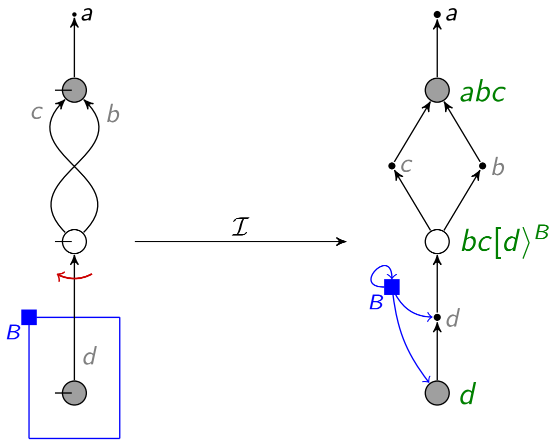


$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$

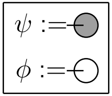




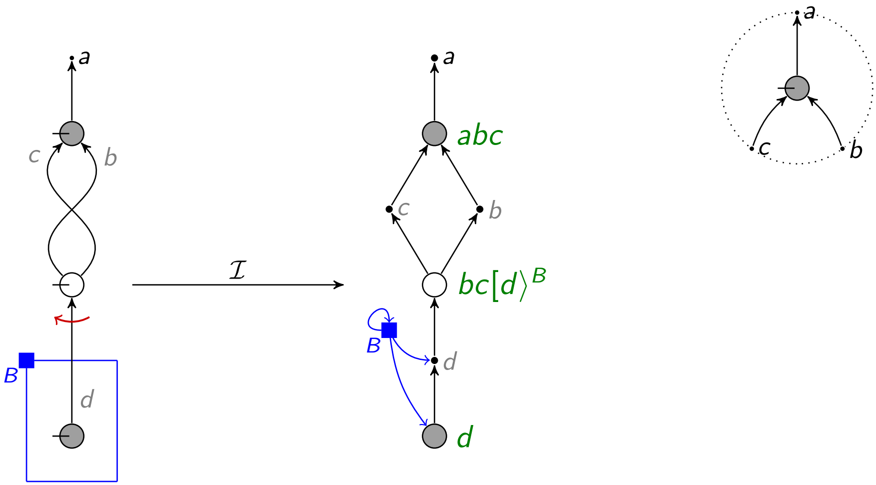
Isomorphism



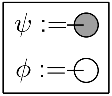
$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$



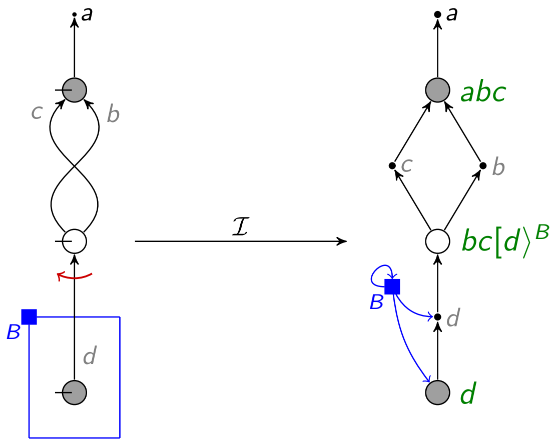
Isomorphism



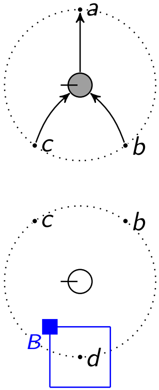
$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

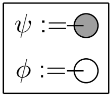


Isomorphism

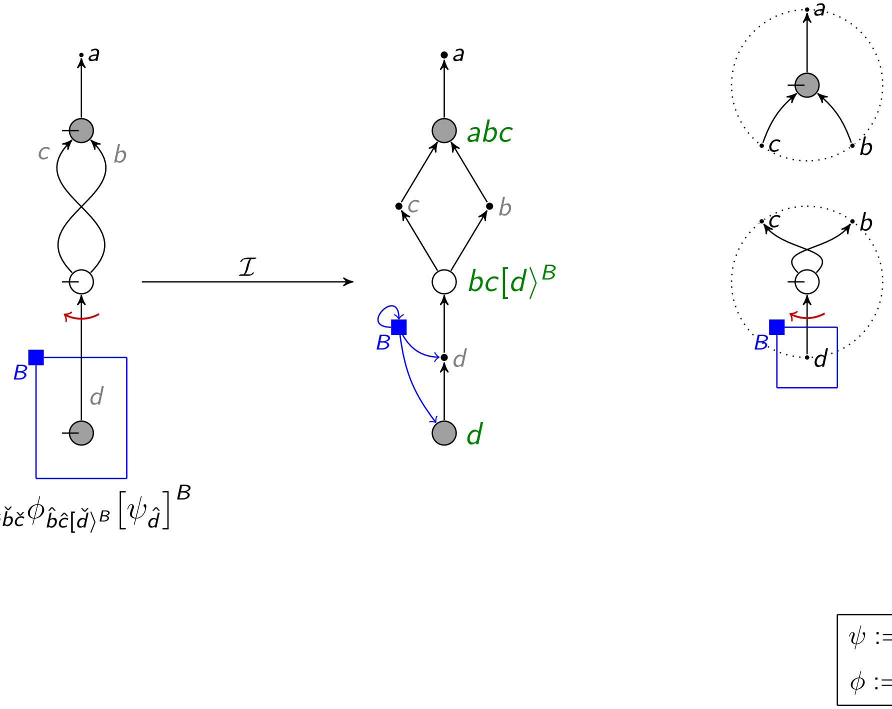


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$



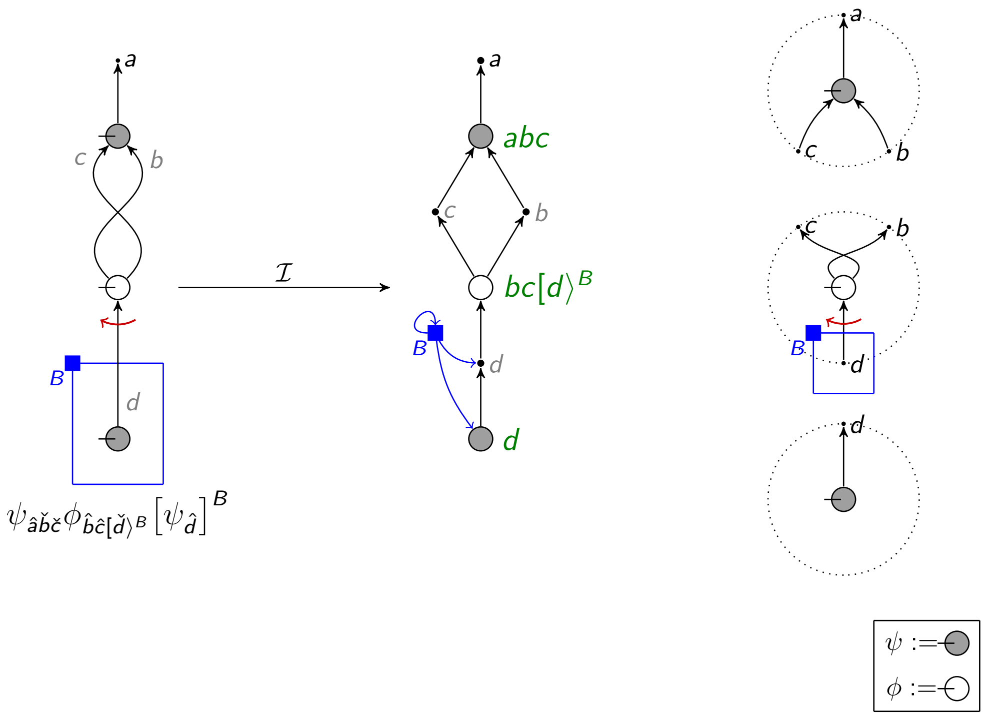


Isomorphism

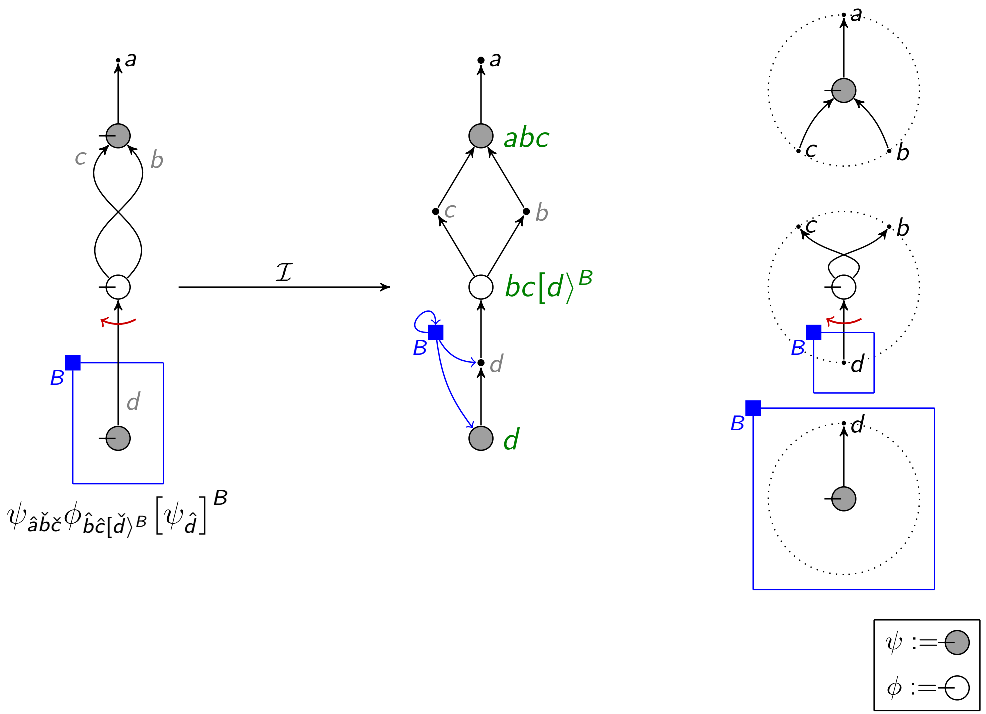


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

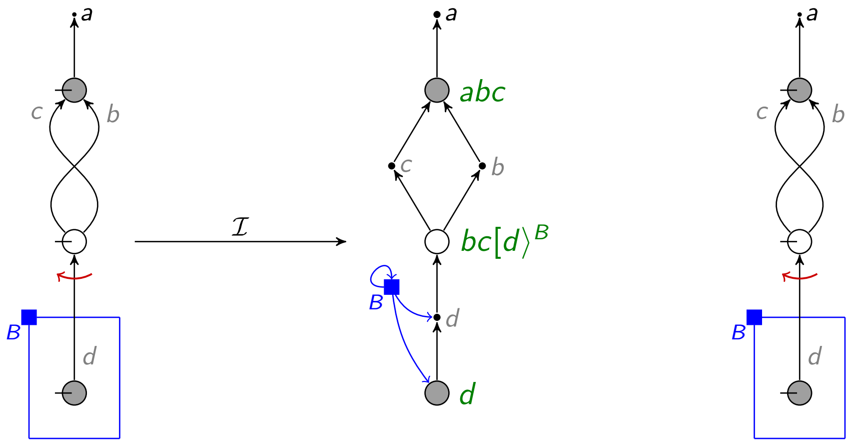
Isomorphism



Isomorphism



Isomorphism

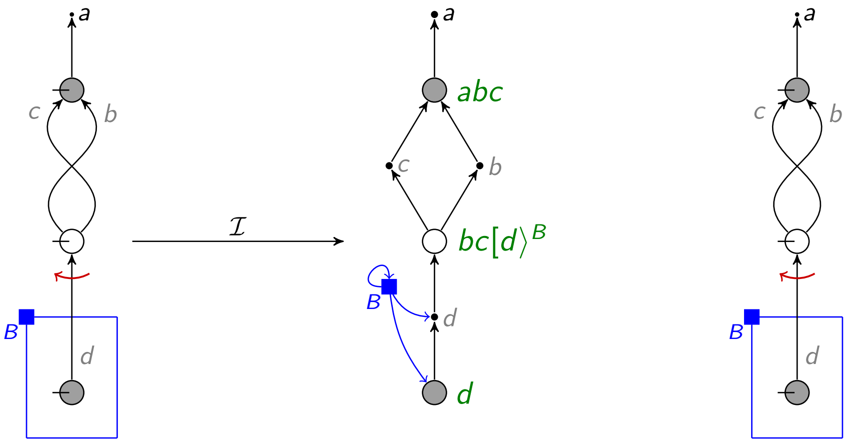


$$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$$

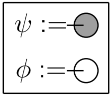
$\psi :=$ (grey node)

$\phi :=$ (white node)

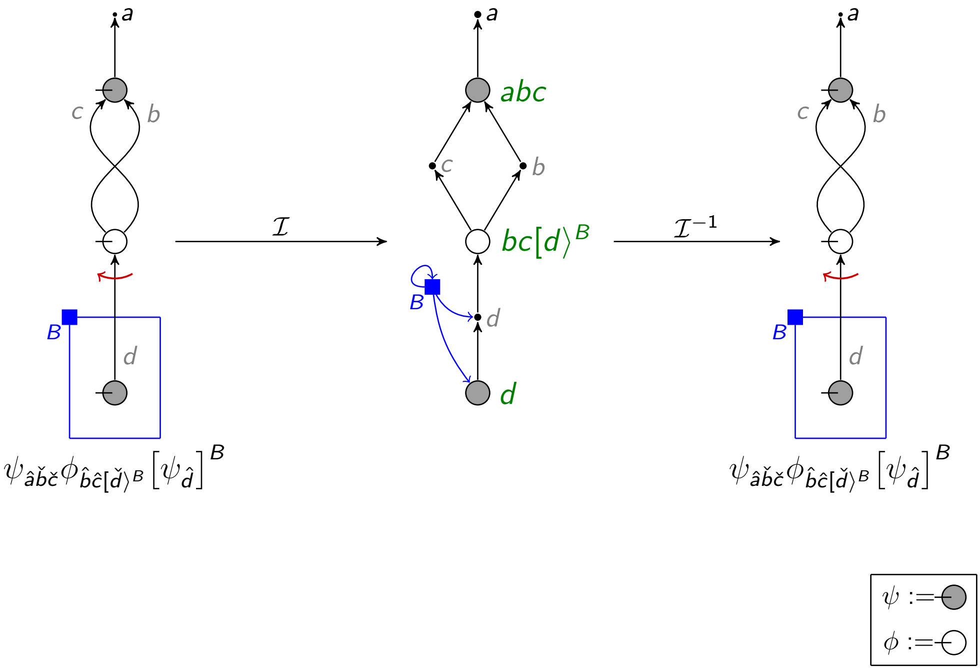
Isomorphism



$\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$ $\psi_{\hat{a}\check{b}\check{c}}\phi_{\hat{b}\hat{c}[\check{d}\rangle^B}\left[\psi_{\hat{d}}\right]^B$



Isomorphism



Properties

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

For G, H two !-tensor expressions, $G \equiv H \implies \mathcal{I}(G) \equiv \mathcal{I}(H)$

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

For G, H two !-tensor expressions, $G \equiv H \implies \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs} + \text{nhd-orders}$$

Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs} + \text{nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem

$$\text{!-Tensors} \xrightarrow{\quad \mathcal{I} \quad} \begin{array}{l}\text{!-Graphs +} \\ \text{nhd-orders}\end{array}$$

Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

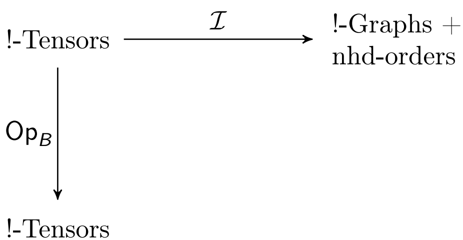
Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem



Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

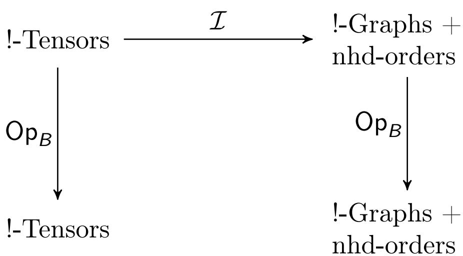
Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem



Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

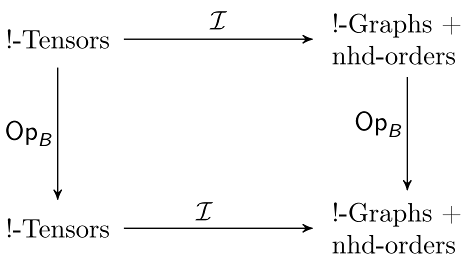
Theorem

For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem



Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

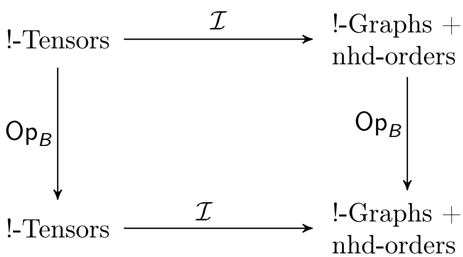
For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem

The following commutes:



Properties

$$\mathcal{I} : \text{!-Tensor expressions} \longrightarrow \text{!-Graphs + nhd-orders}$$

Theorem

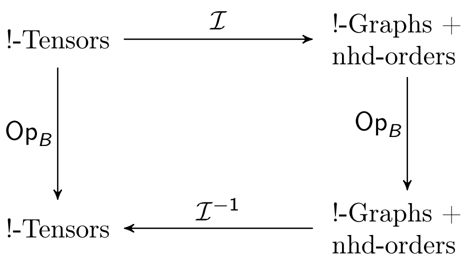
For G, H two !-tensor expressions, $G \equiv H \iff \mathcal{I}(G) \equiv \mathcal{I}(H)$

$$\mathcal{I} : \text{!-Tensors} \longrightarrow \text{!-Graphs + nhd-orders}$$

with a left inverse $\mathcal{I}^{-1}$.

Theorem

The following commutes:



Summary

Summary

- Quantomatic can't work with !-tensors

Summary

- Quantomatic can't work with !-tensors

!-Tensor
expressions

-

Summary

- Quantomatic can't work with !-tensors

!-Tensor expressions

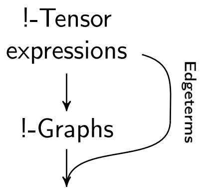
↓

!-Graphs

-

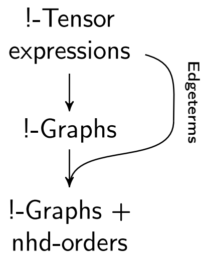
Summary

- Quantomatic can't work with !-tensors

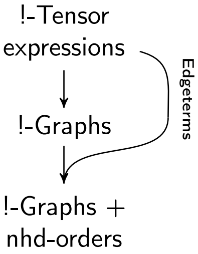


-

Summary

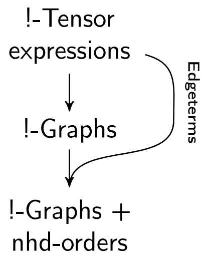
- Quantomatic can't work with !-tensors
- 

Summary

- Quantomatic can't work with !-tensors
- 

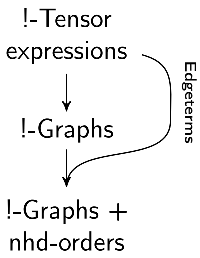
- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders

Summary

- Quantomatic can't work with !-tensors
- 

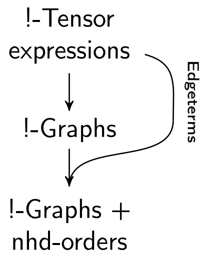
- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving

Summary

- Quantomatic can't work with !-tensors
- 

- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving
- Encode !-tensors in Quantomatic

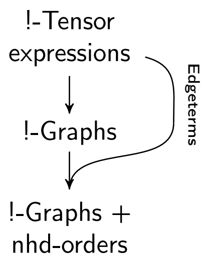
Summary

- Quantomatic can't work with !-tensors
- 

- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving
- Encode !-tensors in Quantomatic

$\Rightarrow$ **Automated reasoning with non-commutative structures**

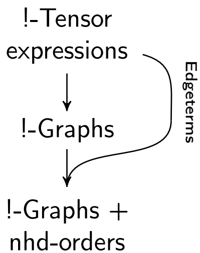
Summary

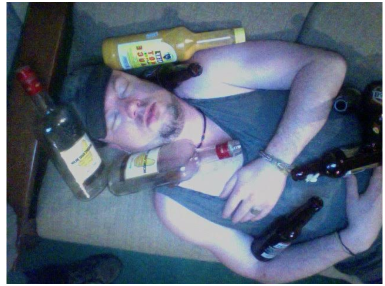
- Quantomatic can't work with !-tensors
- 

- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving
- Encode !-tensors in Quantomatic

$\Rightarrow$ **Automated reasoning with non-commutative structures**

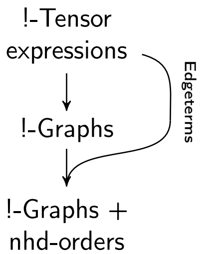
Summary

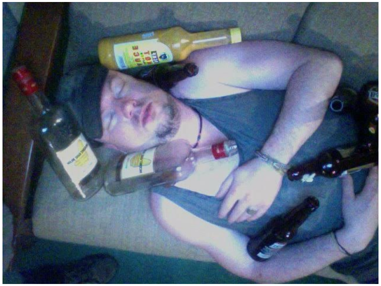
- Quantomatic can't work with !-tensors
- 


- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving
- Encode !-tensors in Quantomatic

$\Rightarrow$ **Automated reasoning with non-commutative structures**

Summary

- Quantomatic can't work with !-tensors
- 


- Lift to $\mathcal{I}$: !-Tensors $\longrightarrow$!-Graphs + nhd-orders
- Structure preserving
- Encode !-tensors in Quantomatic

$\Rightarrow$ **Automated reasoning with non-commutative structures**

Thanks