

δ_{aa} relations in the M&M model

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Eliminated in the M&M model.

δ_{aa} relations

VS = False;

"First sort tails then sort heads"

Standard Swinging - sorts heads, if support is 4 strands:

```
S[ $\delta_{aa}[f, i, j, k, l]$ ] /;  $DQ[i, j, k, l] \wedge OQ[i, k] \wedge !OQ[j, l] := ($   
  If[VS, Print["Standard swinging on ",  $\delta_{aa}[f, i, j, k, l]$ ]];  
  S[ $\delta_{aa}[f, i, l, k, j] + ca[b_k f, l, i, j] - ca[b_i f, l, k, j] -$   
     $ca[b_k f, j, i, l] + ca[b_i f, j, k, l]$   
];
```

Locality - sorts tails when supports are disjoint:

```
S[ $\delta_{aa}[f, i, j, k, l]$ ] /;  $(\{i, j\} \cap \{k, l\} === \{\}) \wedge !OQ[i, k] := ($   
  If[VS, Print["Locality on ",  $\delta_{aa}[f, i, j, k, l]$ ]];  
   $\delta_{aa}[f, k, l, i, j]$  // S  
);
```

Commute Heads - sorts tails when the heads are the same:

```
S[ $\delta_{aa}[f, i, k, j, k]$ ] /;  $DQ[i, j, k] \wedge !OQ[i, j] := ($   
  If[VS, Print["Commute heads on ",  $\delta_{aa}[f, i, k, j, k]$ ]];  
  S[ $\delta_{aa}[f, j, k, i, k] + \delta_a[-b_i f, j, k] + \delta_a[b_j f, i, k]$   
];
```

Commute Head/Tail - sorts tails:

```
S[ $\delta_{aa}[f, i, j, k, i]$ ] /;  $DQ[i, j, k] \wedge !OQ[i, k] := ($   
  If[VS, Print["Commute head/tail on ",  $\delta_{aa}[f, i, j, k, i]$ ]];  
  S[  
     $\delta_{aa}[f, k, i, i, j] + \delta_{aa}[f, k, j, i, j] - \delta_{aa}[f, i, j, k, j]$   
  ]  
);
```

Commute Head/Tail - sorts heads where heads & tails are both broken:

```
S[ $\delta_{aa}[f, k, j, j, i]$ ] /;  $DQ[i, j, k] \wedge OQ[i, j, k] := ($   
  If[VS, Print["Commute head/tail on ",  $\delta_{aa}[f, k, j, j, i]$ ]];  
  S[  
     $\delta_{aa}[f, j, i, k, j] + \delta_{aa}[f, j, i, k, i] - \delta_{aa}[f, k, i, j, i]$   
  ]  
);
```

2113 Swinging - sorts tails:

```
S[ $\delta_{aa}[f, i, j, k, l]$ ] /;  $DQ[i, j, k, l] \wedge !OQ[i, k] \wedge !OQ[j, l] := ($ 
```

2113 Swinging - sorts tails:

```
 $\delta_{aa}[f, j, i, ii, k]$  // S
```

Locality on $\delta_{aa}[f, j, i, ii, k]$

Standard swinging on $\delta_{aa}[f, ii, k, j, i]$

```
ca[-f bii, i, j, k] + ca[f bii, k, j, i] +  
ca[-f bj, k, ii, i] + ca[f bj, i, ii, k] +  $\delta_{aa}[f, ii, i, j, k]$ 
```

```
S[ $\delta_{aa}[f_, j_, i_, ii_, k_]$ ] /; DQ[i, j, k]  $\wedge$  OQ[i, j, k] := (  
  If[VS, Print["2113 swinging on ",  $\delta_{aa}[f, j, i, ii, k]$ ]];  
  S[ca[-f bi, i, j, k] + ca[f bi, k, j, i] + c[-f bj, k] ** aop[1, i] +  
    ca[f bj, i, ii, k] + aop[f, i] **  $\delta_a[1, j, k]$ ]  
);
```

```
 $\delta_{aa}[f, j, i, i, k]$  // S
```

```
c[f bi bj, k] + ca[-f bi, i, j, k] + ca[f bi, k, j, i] +  
ca[-f bj, k, i, i] + ca[f bj, i, i, k] +  $\delta_a[-f b_i, j, k]$  +  $\delta_{aa}[f, i, i, j, k]$ 
```

3112 Swinging - sorts tails:

```
 $\delta_{aa}[f, k, i, ii, j]$  // S
```

Locality on $\delta_{aa}[f, k, i, ii, j]$

Standard swinging on $\delta_{aa}[f, ii, j, k, i]$

```
ca[-f bii, i, k, j] + ca[f bii, j, k, i] +  
ca[-f bk, j, ii, i] + ca[f bk, i, ii, j] +  $\delta_{aa}[f, ii, i, k, j]$ 
```

```
S[ $\delta_{aa}[f_, k_, i_, ii_, j_]$ ] /; DQ[i, j, k]  $\wedge$  OQ[i, j, k] := (  
  If[VS, Print["3112 swinging on ",  $\delta_{aa}[f, k, i, ii, j]$ ]];  
  S[ca[-f bi, i, k, j] + ca[f bi, j, k, i] + c[-f bk, j] ** aop[1, i] +  
    ca[f bk, i, ii, j] + aop[1, i] **  $\delta_a[f, k, j]$ ]  
);
```

```
 $\delta_{aa}[f, k, i, i, j]$  // S
```

```
c[f bi bk, j] + ca[-f bi, i, k, j] + ca[f bi, j, k, i] +  
ca[-f bk, j, i, i] + ca[f bk, i, i, j] +  $\delta_a[-f b_i, k, j]$  +  $\delta_{aa}[f, i, i, k, j]$ 
```

Tails Commute - sorts heads when the tails are the same:

```
S[ $\delta_{aa}[f_, i_, j_, ii_, l_]$ ] /; DQ[i, j, l]  $\wedge$  !OQ[j, l] := (  
  If[VS, Print["Tails commute on ",  $\delta_{aa}[f, i, j, ii, l]$ ]];  
   $\delta_{aa}[f, i, l, ii, j]$  // S  
);
```

1321 Swinging - sorts heads:

```
 $\delta_{aa}[f, i, k, j, ii]$  // S
```

Standard swinging on $\delta_{aa}[f, i, k, j, ii]$

```
ca[-f bi, ii, j, k] + ca[f bi, k, j, ii] +  
ca[-f bj, k, i, ii] + ca[f bj, ii, i, k] +  $\delta_{aa}[f, i, ii, j, k]$ 
```

```
ca[-f bj, k, i, ii] + ca[f bj, ii, i, k] + δaa[f, i, ii, j, k]
```

```
S[δaa[f-, i-, k-, j-, i-]] /; DQ[i, j, k] ∧ OQ[i, j, k] := (  
  If[VS, Print["1321 swinging on ", δaa[f, i, k, j, i]]];  
  S[ca[-f bi, i, j, k] + ca[f bi, k, j, i] + ca[-f bj, k, i, i] +  
    ac[f bj, i, k, i] + δaa[f, i, i, j, k]]  
);
```

1322 Swinging - sorts heads, but breaks tails:

```
δaa[f, i, k, j, jj] // S
```

Standard swinging on δ_{aa}[f, i, k, j, jj]

```
ca[-f bi, jj, j, k] + ca[f bi, k, j, jj] +  
ca[-f bj, k, i, jj] + ca[f bj, jj, i, k] + δaa[f, i, jj, j, k]
```

```
S[δaa[f-, i-, k-, j-, j-]] /; DQ[i, j, k] ∧ OQ[i, j, k] := (  
  If[VS, Print["1322 swinging on ", δaa[f, i, k, j, j]]];  
  S[ac[-f bi, j, k, j] + ca[f bi, k, j, j] + ca[-f bj, k, i, j] +  
    ca[f bj, j, i, k] + δaa[f, j, k, i, j]]  
);
```

1332 Swinging - sorts heads:

```
δaa[f, i, k, kk, j] // S
```

Standard swinging on δ_{aa}[f, i, k, kk, j]

```
ca[-f bi, j, kk, k] + ca[f bi, k, kk, j] +  
ca[-f bkk, k, i, j] + ca[f bkk, j, i, k] + δaa[f, i, j, kk, k]
```

```
S[δaa[f-, i-, k-, k-, j-]] /; DQ[i, j, k] ∧ OQ[i, j, k] := (  
  If[VS, Print["1332 swinging on ", δaa[f, i, k, k, j]]];  
  S[c[-f bi, j] ** aop[1, k] + ca[f bi, k, k, j] + ca[-f bk, k, i, j] +  
    ca[f bk, j, i, k] + δa[f, i, j] ** aop[1, k]]  
);
```

```
δaa[f, i, k, k, j] // S
```

```
c[f bi bk, j] + ca[-f bi, j, k, k] + ca[f bi, k, k, j] +  
ca[-f bk, k, i, j] + ca[f bk, j, i, k] + δa[-f bk, i, j] + δaa[f, i, j, k, k]
```

1231 Swinging - sorts heads:

```
δaa[f, i, j, k, ii] // S
```

Standard swinging on δ_{aa}[f, i, j, k, ii]

```
ca[-f bi, ii, k, j] + ca[f bi, j, k, ii] +  
ca[-f bk, j, i, ii] + ca[f bk, ii, i, j] + δaa[f, i, ii, k, j]
```

```
S[δaa[f-, i-, j-, k-, i-]] /; DQ[i, j, k] ∧ OQ[i, j, k] := (  
  If[VS, Print["1231 swinging on ", δaa[f, i, j, k, i]]];  
  S[ac[-f bi, k, j, i] + ca[f bi, j, k, i] + ca[-f bk, j, i, i] +  
    ac[f bk, i, j, i] + δaa[f, i, i, k, j]]  
);
```

1211 sliding - sorts heads:

```
);
```

1211 sliding - sorts heads:

```
S[ $\delta_{aa}[f, i, j, i, i]$ ] /; DQ[i, j]  $\wedge$  OQ[i, j] := (  
  If[VS, Print["1211 sliding on ",  $\delta_{aa}[f, i, j, i, i]$ ]];  
  S[ $\delta_{aa}[f, i, i, i, j]$ ]  
);
```

2111 sliding - sorts tails:

```
S[ $\delta_{aa}[f, j, i, i, i]$ ] /; DQ[i, j]  $\wedge$  OQ[i, j] := (  
  If[VS, Print["2111 sliding on ",  $\delta_{aa}[f, j, i, i, i]$ ]];  
  S[ $\delta_{aa}[f, i, i, j, i]$ ]  
);
```

2212 sliding - sorts tails:

```
S[ $\delta_{aa}[f, j, j, i, j]$ ] /; DQ[i, j]  $\wedge$  OQ[i, j] := (  
  If[VS, Print["2212 sliding on ",  $\delta_{aa}[f, j, j, i, j]$ ]];  
  S[ $\delta_{aa}[f, i, j, j, j]$ ]  
);
```

2221 sliding - sorts heads:

```
S[ $\delta_{aa}[f, j, j, j, i]$ ] /; DQ[i, j]  $\wedge$  OQ[i, j] := (  
  If[VS, Print["2221 sliding on ",  $\delta_{aa}[f, j, j, j, i]$ ]];  
  S[ $\delta_{aa}[f, j, i, j, j]$ ]  
);
```

2231 Swinging - sorts heads:

```
 $\delta_{aa}[f, j, jj, k, i]$  // S
```

Standard swinging on $\delta_{aa}[f, j, jj, k, i]$

```
ca[-f bj, i, k, jj] + ca[f bj, jj, k, i] +  
ca[-f bk, jj, j, i] + ca[f bk, i, j, jj] +  $\delta_{aa}[f, j, i, k, jj]$ 
```

```
S[ $\delta_{aa}[f, j, j, k, i]$ ] /; DQ[i, j, k]  $\wedge$  OQ[i, j, k] := (  
  If[VS, Print["2231 swinging on ",  $\delta_{aa}[f, j, j, k, i]$ ]];  
  S[ca[-f bj, i, k, j] + ca[f bj, j, k, i] + ac[-f bk, j, i, j] +  
    ca[f bk, i, j, j] +  $\delta_{aa}[f, j, i, k, j]$ ]  
);
```

2331 Swinging - sorts heads:

```
 $\delta_{aa}[f, j, k, kk, i]$  // S
```

```
ca[-f bj, i, kk, k] + ca[f bj, k, kk, i] +  
ca[-f bkk, k, j, i] + ca[f bkk, i, j, k] +  $\delta_{aa}[f, j, i, kk, k]$ 
```

```
S[ $\delta_{aa}[f, j, k, k, i]$ ] /; DQ[i, j, k]  $\wedge$  OQ[i, j, k] := (  
  If[VS, Print["2331 swinging on ",  $\delta_{aa}[f, j, k, k, i]$ ]];  
  S[c[-f bj, i] ** aop[1, k] + ca[f bj, k, k, i] + ca[-f bk, k, j, i] +  
    ca[f bk, i, j, k] +  $\delta_{aa}[f, j, i]$  ** aop[1, k]]  
);
```

```
ca[f bk, i, j, k] + δa[f, j, i] ** aop[1, k]
);
```

Backie jkkj Swinging - sorts tails or heads:

```
δaa[f, j, k, kk, jj] // S
```

```
ca[-f bj, jj, kk, k] + ca[f bj, k, kk, jj] +  
ca[-f bkk, k, j, jj] + ca[f bkk, jj, j, k] + δaa[f, j, jj, kk, k]
```

```
S[δaa[f-, j-, k-, k-, j-]] /; DQ[j, k] := (  
  If[VS, Print["Backie swinging on ", δaa[f, j, k, k, j]]];  
  S[c[-f bj, j] ** aop[1, k] + ca[f bj, k, k, j] + ca[-f bk, k, j, j] +  
    ac[f bk, j, k, j] + δa[f, j, j] ** aop[1, k]]  
);
```

Almost all is eliminated!