Pensieve header: Verifying the commutation relations of frakg_1.

```
SetDirectory["C:\\drorbn\\AcademicPensieve\\Projects\\OneCo-1606"];
<< OneCo.m
```

Testing g_1

$a_{1,2}$

$b_1 U[c_2] - \epsilon U[c_1, c_2] + U[u_1, w_2]$

```
Table[x → B[U@x, a_{1,2}], {x, {c_1, c_2, u_1, u_2, w_1, w_2, c_3, u_3, w_3}}] // Column
```

$c_1 \to U[u_1, w_2]$
$c_2 \to -U[u_1, w_2]$
$u_1 \to \epsilon U[c_2, u_1]$
$u_2 \to b_2 U[u_1] - b_1 U[u_2] + \epsilon U[c_1, u_2] - 2 \epsilon U[c_2, u_1]$
$w_1 \to -b_1 U[w_2] + 2 \epsilon U[c_1, w_2] - \epsilon U[c_2, w_1]$
$w_2 \to b_1 U[w_2] - \epsilon U[c_1, w_2]$
$c_3 \to 0$
$u_3 \to 0$
$w_3 \to 0$

```
B[a_{1,3}, a_{2,3}] + B[a_{1,2}, a_{2,3}] + B[a_{1,2}, a_{1,3}]
```

0

```
{t1 = B[a_{1,2}, a_{1,3}], t2 = ϵ U@c_3 ** a_{1,2} - ϵ U@c_2 ** a_{1,3}, t1 - t2} // Expand // Column
```

$-\epsilon U[c_2, u_1, w_3] + \epsilon U[c_3, u_1, w_2]$
$-\epsilon U[c_2, u_1, w_3] + \epsilon U[c_3, u_1, w_2]$
0

```
{t1 = B[a_{1,3}, a_{2,3}], t2 = bc_2 ** a_{1,3} - bc_1 ** a_{2,3}, t1 - t2} // Expand // Column
```

$b_2 U[u_1, w_3] - b_1 U[u_2, w_3] + \epsilon U[c_1, u_2, w_3] - \epsilon U[c_2, u_1, w_3]$
$b_2 U[u_1, w_3] - b_1 U[u_2, w_3] + \epsilon U[c_1, u_2, w_3] - \epsilon U[c_2, u_1, w_3]$
0

```
{t1 = a_{1,3} ** a_{2,4} - a_{1,4} ** a_{2,3},
  t2 = a_{1,3} ** bc_2 ** U@c_4 - a_{2,3} ** bc_1 ** U@c_4 - a_{1,4} ** bc_2 ** U@c_3 + a_{2,4} ** bc_1 ** U@c_3,
  t1 - t2
 } // Column
```

$-b_2 U[c_3, u_1, w_4] + b_1 U[c_3, u_2, w_4] + b_2 U[c_4, u_1, w_3] - b_1 U[c_4, u_2, w_3] - \epsilon U[c_1, c_3, u_2, w_4] + \epsilon U[c_1, c_4, u_2, w_3] + \epsilon U[c_2, c_3, u_1, w_4] - \epsilon U[c_2, c_4, u_1, w_3]$
$-b_2 U[c_3, u_1, w_4] + b_1 U[c_3, u_2, w_4] + b_2 U[c_4, u_1, w_3] - b_1 U[c_4, u_2, w_3] - \epsilon U[c_1, c_3, u_2, w_4] + \epsilon U[c_1, c_4, u_2, w_3] + \epsilon U[c_2, c_3, u_1, w_4] - \epsilon U[c_2, c_4, u_1, w_3]$
0

```
LBasis[2]
```

{U[], ∈ U[], U[c₁], U[c₂], U[u₁], U[u₂], U[w₁], U[w₂], ∈ U[c₁], ∈ U[c₂], ∈ U[u₁], ∈ U[u₂], ∈ U[w₁], ∈ U[w₂], U[u₁, w₁], U[u₁, w₂], U[u₂, w₁], U[u₂, w₂], ∈ U[c₁, c₁], ∈ U[c₁, c₂], ∈ U[c₁, u₁], ∈ U[c₁, u₂], ∈ U[c₁, w₁], ∈ U[c₁, w₂], ∈ U[c₂, c₂], ∈ U[c₂, u₁], ∈ U[c₂, u₂], ∈ U[c₂, w₁], ∈ U[c₂, w₂], ∈ U[u₁, w₁], ∈ U[u₁, w₂], ∈ U[u₂, w₁], ∈ U[u₂, w₂], ∈ U[c₁, u₁, w₁], ∈ U[c₁, u₁, w₂], ∈ U[c₁, u₂, w₁], ∈ U[c₁, u₂, w₂], ∈ U[c₂, u₁, w₁], ∈ U[c₂, u₁, w₂], ∈ U[c₂, u₂, w₁], ∈ U[c₂, u₂, w₂], ∈ U[u₁, u₁, w₁], ∈ U[u₁, u₁, w₂], ∈ U[u₁, u₂, w₁], ∈ U[u₁, u₂, w₂], ∈ U[u₁, w₁, w₁], ∈ U[u₁, w₁, w₂], ∈ U[u₁, w₂, w₂], ∈ U[u₂, u₂, w₁], ∈ U[u₂, u₂, w₂], ∈ U[u₂, w₁, w₁], ∈ U[u₂, w₁, w₂], ∈ U[u₂, w₂, w₂], ∈ U[u₁, u₁, w₁, w₁], ∈ U[u₁, u₁, w₁, w₂], ∈ U[u₁, u₁, w₂, w₂], ∈ U[u₁, u₂, w₁, w₁], ∈ U[u₁, u₂, w₁, w₂], ∈ U[u₁, u₂, w₂, w₂], ∈ U[u₂, u₂, w₁, w₁], ∈ U[u₂, u₂, w₁, w₂], ∈ U[u₂, u₂, w₂, w₂]}

```
bas = LBasis[2];
Table[B[x, y] + B[y, x], {x, bas}, {y, bas}] // Flatten // Union
```

{0}

```
bas = LBasis[2]; Timing[
 Table[
   {x, y, z} = xyz;
   Simp[B[B[x, y], z] + B[B[y, z], x] + B[B[z, x], y]],
   {xyz, Subsets[bas, {3}]}
  ] // Flatten // Union
]
```

{31., {0}}

Infinitesimal Spinner Relations

$s_{i\_} := \frac{b_i}{2} U[] - \epsilon\, U[c_i]$

$a_{1,2}$

$b_1 U[c_2] - \epsilon\, U[c_1, c_2] + U[u_1, w_2]$

$B[a_{1,2}, s_1]$

$\epsilon\, U[u_1, w_2]$

$B[a_{1,2}, s_2]$

$-\epsilon\, U[u_1, w_2]$

$B[a_{1,2}, s_1 + s_2]$ // Simplify

0

$B[a_{1,3}, a_{2,3}]$

$b_2 U[u_1, w_3] - b_1 U[u_2, w_3] + \epsilon\, U[c_1, u_2, w_3] - \epsilon\, U[c_2, u_1, w_3]$

$\text{Simplify}[b_1 UU[u_1, w_3] - b_1 UU[u_1, w_3] + \epsilon\, UU[c_1, u_1, w_3] - \epsilon\, UU[u_1, c_1, w_3]]$

$\epsilon\, U[u_1, w_3]$

Testing bi-local exponential relations in g_0

1. The Yang-Baxter Element.
2. c Relations.

```
B[U[c], U[u, w]]
```

```
0
```

```
With[{n = 7}, Collect[
  UExp[β U@u, n] ** UExp[α U@c, n] - UExp[α U@c, n] ** UExp[ⅇ^-α β U@u, n],
  _U, Series[#, {α, 0, n}] &
 ]]
```

$O[\alpha]^8$

```
With[{n = 7}, Collect[
  UExp[β U@w, n] ** UExp[α U@c, n] - UExp[α U@c, n] ** UExp[ⅇ^α β U@w, n],
  _U, Series[#, {α, 0, n}] &
 ]]
```

$O[\alpha]^8$

3. u, w, e^u, e^w.

```
With[{n = 10},
 Simp[B[U@w, UExp[γ U@u, n]] + (b γ U[] - 2 γ ϵ U[c] + ϵ γ^2 U[u]) ** UExp[γ U@u, n]]]
```

$$\left(\frac{b\,\gamma^{11}}{3\,628\,800}+\frac{\gamma^{11}\,\epsilon}{362\,880}\right)U[u,u,u,u,u,u,u,u,u,u]-\frac{\gamma^{11}\,\epsilon\,U[c,u,u,u,u,u,u,u,u,u,u]}{1\,814\,400}+\frac{\gamma^{12}\,\epsilon\,U[u,u,u,u,u,u,u,u,u,u,u]}{3\,628\,800}$$

```
With[{n = 7},
 Simp[B[U@u, UExp[γ U@w, n]] - (b γ U[] - 2 γ ϵ U[c] - ϵ γ^2 U[w]) ** UExp[γ U@w, n]]]
```

$$\left(-\frac{b\,\gamma^{8}}{5040}+\frac{\gamma^{8}\,\epsilon}{720}\right)U[w,w,w,w,w,w,w]+\frac{\gamma^{8}\,\epsilon\,U[c,w,w,w,w,w,w,w]}{2520}+\frac{\gamma^{9}\,\epsilon\,U[w,w,w,w,w,w,w,w]}{5040}$$

4. M_{uw} Relations.

```
Muw[γ_, n_] := Expand[Sum_{k=0}^{n} γ^k/k! UU[u^k, w^k]]
```

```
Muw[γ, 5]
```

$$U[\,]+\gamma\,U[u,w]+\frac{1}{2}\gamma^2\,U[u,u,w,w]+\frac{1}{6}\gamma^3\,U[u,u,u,w,w,w]+\frac{1}{24}\gamma^4\,U[u,u,u,u,w,w,w,w]+\frac{1}{120}\gamma^5\,U[u,u,u,u,u,w,w,w,w,w]$$

```
With[{n = 12},
  Muw[γ, n] ** U[u] - ((1 - b γ - 2 γ ∈) U[u] + 2 γ ∈ U[c, u] - (1 - b γ)^-1 γ^2 ∈ U[u, u, w]) **
   Muw[γ, n]] // Simplify // Expand
```

```
-((b γ^13 U[u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
    (479001600 (-1 + b γ))) +
 (b^2 γ^14 U[u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (479001600 (-1 + b γ)) -
 (γ^13 ∈ U[u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (34214400 (-1 + b γ)) +
 (b γ^14 ∈ U[u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (34214400 (-1 + b γ)) +
 (γ^13 ∈ U[c, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (239500800 (-1 + b γ)) -
 (b γ^14 ∈ U[c, u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (239500800 (-1 + b γ)) -
 (γ^14 ∈ U[u, u, u, u, u, u, u, u, u, u, u, u, u, u, w, w, w, w, w, w, w, w, w, w, w, w, w]) /
  (479001600 (-1 + b γ))
```

```
With[{n = 7}, Simplify[B[U[w], Muw[γ, n]] + b γ Muw[γ, n] ** U[w]]]
```

```
With[{n = 7}, Simplify[
  (∂_α Muw[γ[α], n]) - γ'[α]/(1 - b γ[α]) Muw[γ[α], n] ** U[u, w]
 ]]
```

5. M_{wu} Relations.

```
Mwu[γ_, n_] := Expand[Sum[γ^k/k! UU[w^k, u^k], {k, 0, n}]]
```

```
With[{n = 7}, {t1 = Simplify[B[U[u], Mwu[δ, n]] - b δ Mwu[δ, n] ** U[u]], t1 // ToDegree[n]}]
```

```
With[{n = 7}, {t1 = Simp[B[U[w], Mwu[δ, n]] + b δ U[w] ** Mwu[δ, n]], t1 // ToDegree[n]}]
```

```
With[{n = 7}, {t1 = Simplify[
    (∂_α Mwu[α δ, n]) - δ/(1 + b α δ) Mwu[α δ, n] ** U[w] ** U[u]
   ], t1 // ToDegree[n]}]
```

```
With[{n = 7}, Simplify[
  (∂_α Mwu[α δ, n]) - δ/(1 + b α δ) Mwu[α δ, n] ** (U[u, w] - b U[])
 ]]
```

6. M_{wu} and M_{uw}.

```
With[{n = 10, ν = (1 + b δ)^-1}, t1 = Simp[
   -Mwu[δ, n] + (ν (1 - ν^2 b δ^2 ϵ) U[] + 2 ν^2 δ ϵ U[c]) ** Muw[ν δ, n] +
    (-2 ν^4 b δ^3 ϵ U[u] + 2 ν^3 δ^2 ϵ U[c, u]) ** Muw[ν δ, n] ** U[w] -
    (b ν^5 δ^4 ϵ)/2 U[u, u] ** Muw[ν δ, n] ** U[w, w]
  ] // ToDegree[
   n]]
```

0

```
Coefficient[t1, U[u, u, w, w]] /. ℏ → 1
```

$\frac{1}{2} b \delta^4 \epsilon - \frac{5}{2} b^2 \delta^5 \epsilon + \frac{15}{2} b^3 \delta^6 \epsilon - \frac{35}{2} b^4 \delta^7 \epsilon + 35 b^5 \delta^8 \epsilon - 63 b^6 \delta^9 \epsilon$

```
Series[(b δ^4 ϵ)/(2 (1 + b δ)^5), {b, 0, 7}] // Normal
```

$\frac{1}{2} b \delta^4 \epsilon - \frac{5}{2} b^2 \delta^5 \epsilon + \frac{15}{2} b^3 \delta^6 \epsilon - \frac{35}{2} b^4 \delta^7 \epsilon + 35 b^5 \delta^8 \epsilon - 63 b^6 \delta^9 \epsilon + 105 b^7 \delta^{10} \epsilon$

```
Simplify[(1/(1 + b δ) + (-b δ^2 ϵ)/(1 + b δ)^3)]
```

$\frac{1}{1 + b \delta} - \frac{b \delta^2 \epsilon}{(1 + b \delta)^3}$

7. Hard core uw relations.

```
With[{n = 3}, Simp[
   UExp[α ℏ U@w, n] ** UExp[β U@u, n] - e^(-b ℏ α β) UExp[β U@u, n] ** UExp[α ℏ U@w, n]
  ] // ToDegree[n]]
```

```
n = 14; With[{ν = (1 + b δ)^-1},
 LHS = Expand[e^(b ℏ ν α β) Sum[
     ((α ℏ)^n1 δ^n2 β^n3)/(n1 ! n2 ! n3 !) UU[w^(n1+n2), u^(n2+n3)],
     {n1, 0, n}, {n2, 0, n - n1}, {n3, 0, n - n1 - n2}
    ]];
 RHS = Expand[ν Sum[
     ((ν β)^n1 (ν δ)^n2 (ν α ℏ)^n3)/(n1 ! n2 ! n3 !) UU[u^(n1+n2), w^(n2+n3)],
     {n1, 0, n}, {n2, 0, n - n1}, {n3, 0, n - n1 - n2}
    ]];
]
```

```
t1 = With[{ν = (1 + b δ)^-1}, Simp[ToDegree[14][-LHS +
    RHS - 1/2 b ∈ ν^2 (2 δ^2 + 4 α β δ ν + α^2 β^2 ν^2) RHS + 2 ∈ ν (δ + α β ν) U[c] ** RHS -
    β (1 + 2 b δ) ∈ ν^3 (2 δ + α β ν) U[u] ** RHS + α ∈ ν^3 (2 δ + α β ν) RHS ** U[w] + 2 β δ ν^2 ∈
     U[c, u] ** RHS + 2 α δ ν^2 ∈ U[c] ** RHS ** U[w] - 1/2 β^2 δ (2 + 3 b δ) ∈ ν^4 U[u, u] ** RHS +
    1/2 α^2 δ (2 + b δ) ∈ ν^4 RHS ** U[w, w] - 2 b δ^2 ∈ ν^3 (δ + α β ν) U[u] ** RHS ** U[w] +
    2 δ^2 ν^2 ∈ U[c, u] ** RHS ** U[w] - β δ^2 (1 + 2 b δ) ∈ ν^4 U[u, u] ** RHS ** U[w] +
    α δ^2 ν^4 ∈ U[u] ** RHS ** U[w, w] - 1/2 b δ^4 ν^4 ∈ U[u, u] ** RHS ** U[w, w]
  ]]];
t1 /. ∈ → 0
```

0

```
Expand[t1] /. a_. x_U /; (Count[x, u] + Exponent[a, b] + Exponent[a, α]) > 14 :> 0
```

$\frac{1365}{2} b^{12} \alpha^2 \beta^2 \delta^{11} \in U[\,] - 910 b^{13} \alpha \beta \delta^{13} \in U[\,] - 210 b^{13} \alpha \beta \delta^{13} \in U[c] - \frac{3003}{2} b^{11} \alpha^2 \beta^3 \delta^{10} \in U[u] +$ ⋯ 2058 ⋯ $+ \frac{\cdots 1 \cdots}{222393600} + \frac{\alpha^2 \cdots 2 \cdots U[c,u,u,u,u,u,u,u,u,u,u,u, \cdots 4 \cdots ,w,w,w,w,w,w,w,w,w,w,w]}{239500800} + \frac{\alpha \delta^{14} \in U[u,u,u,u,u,u,u,u,u,u,u,u,u,u,w,w,w,w,w,w,w,w,w,w,w,w,w,w]}{415134720} + \frac{\alpha \delta^{14} \in U[c,u,u,u,u,u,u,u,u,u,u,u,u,u,w,w,w,w,w,w,w,w,w,w,w,w,w,w]}{3113510400}$

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```
Take[Cases[t1, _U, ∞] // Sort, 30]
```

{U[], U[c], U[u], U[w], U[c, u], U[c, w], U[u, u], U[u, w], U[w, w],
U[c, u, u], U[c, u, w], U[c, w, w], U[u, u, u], U[u, u, w], U[u, w, w], U[w, w, w],
U[c, u, u, u], U[c, u, u, w], U[c, u, w, w], U[c, w, w, w], U[u, u, u, u],
U[u, u, u, w], U[u, u, w, w], U[u, w, w, w], U[w, w, w, w], U[c, u, u, u, u],
U[c, u, u, u, w], U[c, u, u, w, w], U[c, u, w, w, w], U[c, w, w, w, w]}

```
t2 = Collect[Coefficient[t1, U[w, w, w, w]] // Simplify, β, Simplify]
```

$-\frac{2145}{16} b^8 \alpha^6 \beta^2 \delta^7 (-1 + 2 b \delta) \in + \frac{143}{12} b^9 \alpha^5 \beta \delta^9 (-205 + 272 b \delta) \in - \frac{91}{12} b^{10} \alpha^4 \delta^{11} (-715 + 552 b \delta) \in$

```
Sum[FindSequenceFunction[CoefficientList[
    1 - 3 b δ + 5 b^2 δ^2 - 5 b^3 δ^3 + 14 b^5 δ^5 - 42 b^6 δ^6 + 90 b^7 δ^7 - 165 b^8 δ^8 + 275 b^9 δ^9 - 429 b^10 δ^10
    , b] /. δ → 1][k + 1] (b δ)^k, {k, 0, ∞}]
```

$\frac{1 + 2 b \delta}{(1 + b \delta)^5}$

```
t3 = With[{ν = (1 + b δ)^-1}, Series[
    1/2 b δ^4 ν^5 ϵ,
    {b, 0, 12}]] // Normal // Simplify
```

$\frac{1}{2} b \delta^4 \left(1 - 5 b \delta + 15 b^2 \delta^2 - 35 b^3 \delta^3 + 70 b^4 \delta^4 - 126 b^5 \delta^5 + 210 b^6 \delta^6 - 330 b^7 \delta^7 + 495 b^8 \delta^8 - 715 b^9 \delta^9 + 1001 b^{10} \delta^{10} - 1365 b^{11} \delta^{11}\right) \epsilon$

```
Series[t2 - t3, {b, 0, 8}]
```

$\frac{6435}{8} \alpha^4 \beta^4 \delta^7 \epsilon\, b^8 + O[b]^9$

```
Simplify[β δ^2 (1 + 2 b δ) ν^4 ϵ]
```

$\beta \delta^2 (1 + 2 b \delta) \epsilon \nu^4$

Logos and testing

```
Logos[M_, ν_] := -1/2 b ν (2 δ^2 + 4 α β δ ν + α^2 β^2 ν^2) M +
   2 (δ + α β ν) U[c]⊗M - β (1 + 2 b δ) ν^2 (2 δ + α β ν) U[u]⊗M + α ν^2 (2 δ + α β ν) M⊗U[w] +
   2 β δ ν U[c, u]⊗M + 2 α δ ν U[c]⊗M⊗U[w] - 1/2 β^2 δ (2 + 3 b δ) ν^3 U[u, u]⊗M +
   1/2 α^2 δ (2 + b δ) ν^3 M⊗U[w, w] - 2 b δ^2 ν^2 (δ + α β ν) U[u]⊗M⊗U[w] + 2 δ^2 ν U[c, u]⊗M⊗U[w] -
   β δ^2 (1 + 2 b δ) ν^3 U[u, u]⊗M⊗U[w] + α δ^2 ν^3 U[u]⊗M⊗U[w, w] - 1/2 b δ^4 ν^3 U[u, u]⊗M⊗U[w, w];
With[{n = 10, ν = (1 + b δ)^-1},
  LHS = Expand[Sum[
     (α)^n1 δ^n2 β^n3 / (n1! n2! n3!) UU[w^(n1+n2), u^(n2+n3)],
     {n1, 0, n}, {n2, 0, n - n1}, {n3, 0, n - n1 - n2}
    ]];
  RHS = Expand[ν ⅇ^(-b ν α β) Sum[
      (ν β)^n1 (ν δ)^n2 (ν α)^n3 / (n1! n2! n3!) UU[u^(n1+n2), w^(n2+n3)],
      {n1, 0, n}, {n2, 0, n - n1}, {n3, 0, n - n1 - n2}
     ]];
  t1 = Simp[-LHS + RHS + ϵ ν Logos[RHS, ν] /. TensorProduct → NonCommutativeMultiply]
 ];
t1 /. ϵ → 0
```

$$\Big(-1 + b\,\alpha\,\beta - \tfrac{1}{2} b^2 \alpha^2 \beta^2 + \tfrac{1}{6} b^3 \alpha^3 \beta^3 - \tfrac{1}{24} b^4 \alpha^4 \beta^4 + \tfrac{1}{120} b^5 \alpha^5 \beta^5 + b\,\delta - 2 b^2 \alpha\,\beta\,\delta + \tfrac{3}{2} b^3 \alpha^2 \beta^2 \delta - \tfrac{2}{3} b^4 \alpha^3 \beta^3 \delta + \tfrac{5}{24} b^5 \alpha^4 \beta^4 \delta - b^2 \delta^2 + \cdots 18 \cdots + b^5 \delta^5 - 6 b^6 \alpha\,\beta\,\delta^5 + \tfrac{21}{2} b^7 \alpha^2 \beta^2 \delta^5 - b^6 \delta^6 + 7 b^7 \alpha\,\beta\,\delta^6 - 14 b^8 \alpha^2 \beta^2 \delta^6 + b^7 \delta^7 - 8 b^8 \alpha\,\beta\,\delta^7 - b^8 \delta^8 + 9 b^9 \alpha\,\beta\,\delta^8 + b^9 \delta^9 - b^{10} \delta^{10} + \frac{e^{-\frac{b\alpha\beta}{1+b\delta}}}{1+b\,\delta}\Big)\,U[\,] + \cdots 119 \cdots + (\cdots 1 \cdots)\,U[u, \cdots 18 \cdots, w]$$

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```
O[ℏ]^11 + (t1 /. ϵ → 0 /. a_. x_U :> (a /. {b → ℏ b, α → ℏ α}) ℏ^Count[x,u] x)
```

$O[\hbar]^{11}$

```
O[ℏ]^11 + (t1 /. a_. x_U :> (a /. {b → ℏ b, α → ℏ α, ϵ → ℏ ϵ}) ℏ^Count[x,u] x)
```

$O[\hbar]^{11}$

```
logos = Logos[1, ν] /. TensorProduct | U → Times
```

$$2\,c\,w\,\alpha\,\delta\,\nu + 2\,c\,u\,\beta\,\delta\,\nu + 2\,c\,u\,w\,\delta^2\,\nu + u\,w^2\,\alpha\,\delta^2\,\nu^3 - \frac{1}{2} b\,u^2 w^2 \delta^4 \nu^3 + \frac{1}{2} w^2 \alpha^2 \delta\,(2 + b\,\delta)\,\nu^3 - u^2 w\,\beta\,\delta^2 (1 + 2\,b\,\delta)\,\nu^3 - \frac{1}{2} u^2 \beta^2 \delta\,(2 + 3\,b\,\delta)\,\nu^3 + 2\,c\,(\delta + \alpha\,\beta\,\nu) - 2\,b\,u\,w\,\delta^2 \nu^2 (\delta + \alpha\,\beta\,\nu) + w\,\alpha\,\nu^2 (2\,\delta + \alpha\,\beta\,\nu) - u\,\beta\,(1 + 2\,b\,\delta)\,\nu^2 (2\,\delta + \alpha\,\beta\,\nu) - \frac{1}{2} b\,\nu\,(2\,\delta^2 + 4\,\alpha\,\beta\,\delta\,\nu + \alpha^2 \beta^2 \nu^2)$$

```
Λ = (Collect[Simplify[logos], {c, u, w}, C[Simplify[#]] &] // Expand) /. C[x_] :→ x
```

$$2 c w \alpha \delta \nu + 2 c u \beta \delta \nu + 2 c u w \delta^2 \nu + u w^2 \alpha \delta^2 \nu^3 - \frac{1}{2} b u^2 w^2 \delta^4 \nu^3 + \frac{1}{2} w^2 \alpha^2 \delta (2 + b \delta) \nu^3 - u^2 w \beta \delta^2 (1 + 2 b \delta) \nu^3 - \frac{1}{2} u^2 \beta^2 \delta (2 + 3 b \delta) \nu^3 + 2 c (\delta + \alpha \beta \nu) - 2 b u w \delta^2 \nu^2 (\delta + \alpha \beta \nu) + w \alpha \nu^2 (2 \delta + \alpha \beta \nu) - u \beta (1 + 2 b \delta) \nu^2 (2 \delta + \alpha \beta \nu) - \frac{1}{2} b \nu (2 \delta^2 + 4 \alpha \beta \delta \nu + \alpha^2 \beta^2 \nu^2)$$

```
Λ // TeXForm
```

```
-\frac{1}{2} b \nu  \left(\alpha ^2 \beta ^2 \nu ^2+4 \alpha  \beta
   \delta  \nu +2 \delta ^2\right)-\frac{1}{2} \beta ^2 \delta  \nu
   ^3 u^2 (3 b \delta +2)-\frac{1}{2} b \delta ^4 \nu ^3 u^2
   w^2-\beta  \delta ^2 \nu ^3 u^2 w (2 b \delta +1)-\beta  \nu ^2 u
   (2 b \delta +1) (\alpha  \beta  \nu +2 \delta )-2 b \delta ^2 \nu
   ^2 u w (\alpha  \beta  \nu +\delta )+\frac{1}{2} \alpha ^2 \delta
   \nu ^3 w^2 (b \delta +2)+2 c (\alpha  \beta  \nu +\delta )+2 \beta
    c \delta  \nu  u+2 c \delta ^2 \nu  u w+2 \alpha  c \delta  \nu
   w+\alpha  \delta ^2 \nu ^3 u w^2+\alpha  \nu ^2 w (\alpha  \beta
   \nu +2 \delta )
```

$$2 c w \alpha \delta \nu + 2 c u \beta \delta \nu + 2 c u w \delta^2 \nu + u w^2 \alpha \delta^2 \nu^3 - \frac{1}{2} b u^2 w^2 \delta^4 \nu^3 + \frac{1}{2} w^2 \alpha^2 \delta (2 + b \delta) \nu^3 - u^2 w \beta \delta^2 (1 + 2 b \delta) \nu^3 - \frac{1}{2} u^2 \beta^2 \delta (2 + 3 b \delta) \nu^3 + 2 c (\delta + \alpha \beta \nu) - 2 b u w \delta^2 \nu^2 (\delta + \alpha \beta \nu) + w \alpha \nu^2 (2 \delta + \alpha \beta \nu) - u \beta (1 + 2 b \delta) \nu^2 (2 \delta + \alpha \beta \nu) - \frac{1}{2} b \nu (2 \delta^2 + 4 \alpha \beta \delta \nu + \alpha^2 \beta^2 \nu^2) \;/.\; \{\delta \to 0,\ \nu \to 1\}$$

$$2 c \alpha \beta + w \alpha^2 \beta - u \alpha \beta^2 - \frac{1}{2} b \alpha^2 \beta^2$$