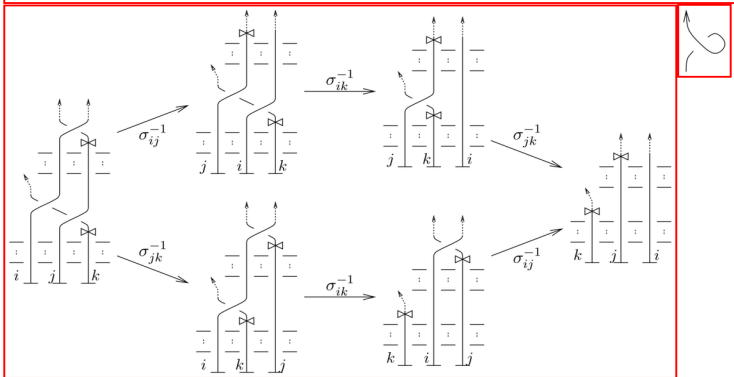


n -strand (pure) virtual braids with $(\leq m)$ -xing:

$m \backslash n$	2	3	4	5	6	General n
0	1	1	1	1	1	1
1	5	13	25	41	61	$2n^2 - 2n + 1$
2	17	145	529	1361	2881	$2n^4 + 4n^3 - 18n^2 + 12n + 1$
3	53	1561	10873	43121	127021	$\frac{1}{3}(4n^6 + 36n^5 - 2n^4 - 546n^3 + 1066n^2 - 558n + 3)$
4	161	16717	222289	1351481	5484721	
5	485	178873	4540201			
6	1457	1913737				



OVER THEN UNDER TANGLES

DROR BAR-NATAN, SZUSZSANNA DANCOS, AND ROLAND VAN DER VEEN

ABSTRACT. Brilliant wrong ideas should not be buried and forgotten. Instead, they should be mined for the gold that lies underneath the layer of wrong. In this paper we explain how “over then under tangles” lead to an easy classification of knots, and under the surface, also to some valid mathematics: a separation theorem for braids and virtual braids, a topological understanding of the Drinfel’d double construction of quantum group theory, and more.

SetAttributes[VD, Orderless]

```
Tidy[vd_VD] := Module[{ps = Union @@ (List @@@ vd)},
  Replace[vd, Thread[ps -> Range@Length@ps], {2}]]
```

```
R12Reduce1[vd_VD] := Tidy@Module[{R2s, R2}, Which[
  Length[R2s] = Cases[vd, X_[[i, j]] -> X_s[[i + 1, j + 1]]] > 0,
  Complement[vd, VD[R2 = First@R2s, R2 /. X_s[[i, j]] -> X_s[[i - 1, j - 1]]],
  Length[R2s] = Cases[vd, X_[[i, j]] -> X_s[[i + 1, j - 1]]] > 0,
  Complement[vd, VD[R2 = First@R2s, R2 /. X_s[[i, j]] -> X_s[[i - 1, j + 1]]],
  True, DeleteCases[vd, X_[[i, j]] /. Abs[i - j] = 1]]]
```

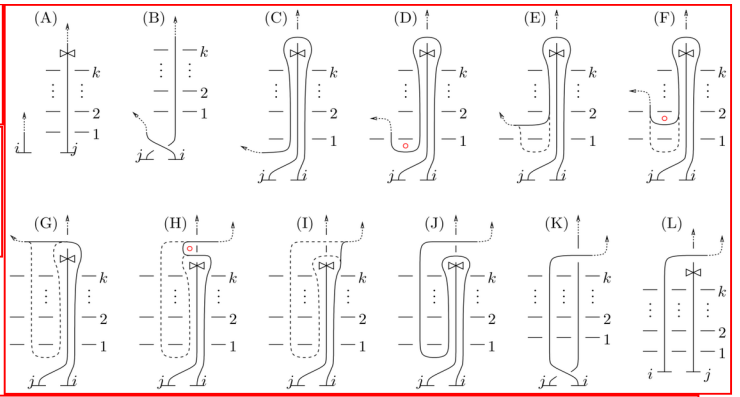
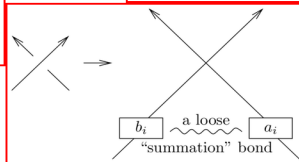
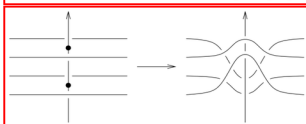
R12Reduce[vd_VD] := FixedPoint[R12Reduce1, vd]

```
Y[vd_VD] := Module[{js, s1, i1, j1, s2, i2, j2},
  js = Cases[vd, X_[[i, j]] -> j] & Cases[vd, X_[[i, _]] -> i - 1];
  If[Length[js] == 0, vd,
  j1 = RandomChoice[js]; i2 = j1 + 1;
  Cases[vd, X_s[[i, j1]] -> {s1 = s; i1 = i}];
  Cases[vd, X_s[[i2, j_]] -> {s2 = s; j2 = j}];
  Tidy@Join[Complement[vd, VD[X_s1[[i1, j1], X_s2[[i2, j2]]],
  VD[X_s2[[j1, j2], X_s1[[i1, i2], X_s1_s2[[i1 - s1/3, j2 + s2/3],
  X_s1_s2[[i1 + s1/3, j2 - s2/3]]]]],
  1]]]
```

F[vd_VD] := FixedPoint[Y, vd, 2^8]

F[T_] /; Head[T] != VD := F[VD[T]]

- Enriquez’ universal quantization of Lie bi-algebra.
- All else about quantization of Lie bi-algebra.
- PBW / normal ordering.
- Audoux-Meilhan “Characterization of the Reduced Peripheral System of Links”.
- B-N’s “Balloons and Hoops” paper.



F[vd_VD] := FixedPoint[R12ReduceY, vd, 2^8]**

F[T_] /; Head[T] != VD := F[VD[T]]

VPB[n_, {os_}] := VPB[n, os];

```
VD /: vd1_VD ** vd2_VD := Module[{es1, es2, m2},
  es1 = Cases[vd1, EOS[i_] -> i];
  m2 = Max[es2 = Cases[vd2, EOS[i_] -> i]];
  Tidy[
  vd1 |> Replace[DeleteCases[vd2, _EOS],
  i_ -> i/m2 - 1 + es1[[1 + Count[es2, e_ /; i > e]]], {2}]]]
```

```
VD[VPB[n_]] := VD @@ (EOS /@ Range[n]);
VD[VPB[n_, sigma_i,j_]] := Tidy@Append[VD @@ (EOS /@ Range[n]), X_1[[i - 0.5, j - 0.5]];
VD[VPB[n_, sigma_i,j_]] := Tidy@Append[VD @@ (EOS /@ Range[n]), X_1[[i - 0.5, j - 0.5]];
VD[VPB[n_, sigma_]] := VD[VPB[n, sigma]] ** VD[VPB[n, os]]]
```

VPBGenerators[n_] :=

VPBGenerators[n] =

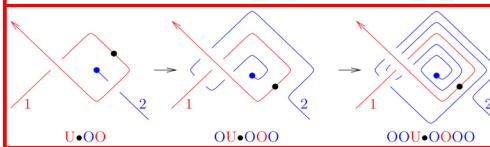
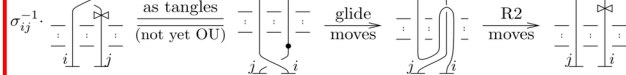
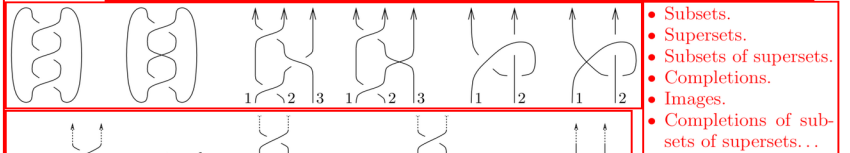
```
Flatten@Table[{sigma_i,j, sigma_i,j}, {i, n}, {j, DeleteCases[Range@n, i]}];
ProudFollowers[n_, sigma_i,j_] := ProudFollowers[n, sigma_i,j] = Module[{p, q, s},
  Flatten@{sigma_i,j, sigma_j,i, sigma_i,i},
  Table[{sigma_p,q, sigma_q,p, sigma_p,q, sigma_q,p}, {p, {i, j}}, {q, Complement[Range[n], {i, j}]}],
  Table[{sigma_p,q, sigma_q,p}, {p, Complement[Range[i + 1, n], {j}]},
  {q, Complement[Range[n], {i, j, p}]}]]];
```

ProudFollowers[n_, sigma_i,j_] :=

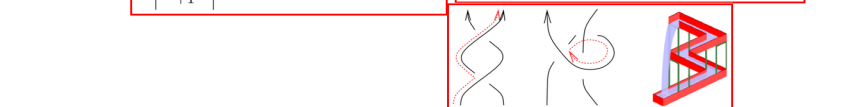
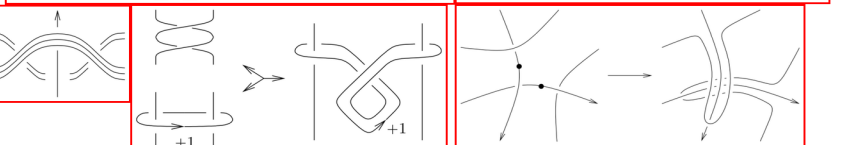
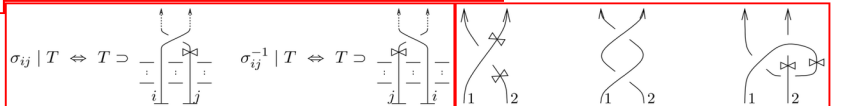
```
ProudFollowers[n, sigma_i,j] = ProudFollowers[n, sigma_i,j] /. sigma_i,j -> sigma_i,j;
ProudVPBs[n_, 0] := {VPB[n]};
ProudVPBs[n_, 1] := VPB[n, #] & /@ VPBGenerators[n];
ProudVPBs[n_, m_] /; m > 1 :=
  Flatten[ProudVPBs[n, m - 1] /.
  VPB[n, os_]] -> (VPB[n, os, #] & /@ ProudFollowers[n, sigma])]
```

CountOUForms[n_, m_] := Module[{k},

Length@Union@Flatten@Table[F@vpb, {k, 0, m}, {vpb, ProudVPBs[n, k]}]]



See <http://drorbn.net/mo20>.



Audio and more at <http://www.math.toronto.edu/~drorbn/Talks/MoscowByWeb-2004//>