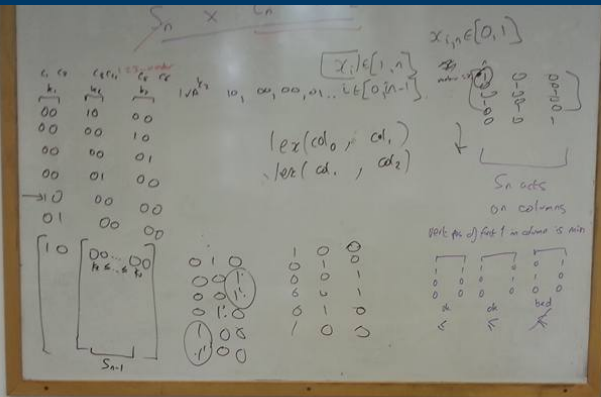


Enumeration of (unique reduced alternating) knot diagrams

Ciaran McCreesh, Alice Miller, Patrick Prosser,
Craig Reilly, James Trimble

University
of Glasgow

What is a knot?

- A *knot* is an embedding of the circle in \mathbb{R}^3 .

What is a knot?

- A *knot* is an embedding of the circle in \mathbb{R}^3 .
- An intuitive way to think about this is to consider a knot as a knotted piece of string with the ends glued together.

Drawing knots on paper

- A function $f : \mathbb{R}^3 \rightarrow \mathbb{R}^2$ where $f(x, y, z) = f(x, y)$, is called a *projection map*, and the image of a knot K under f is called the *projection* of K .
- Such a projection is often referred to as the *shadow* of K .

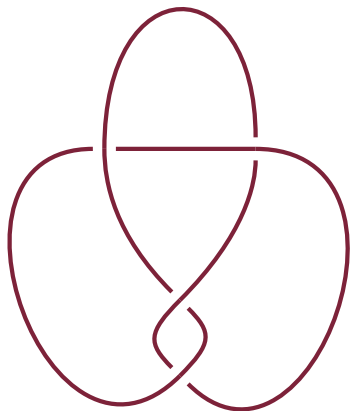
Drawing knots on paper

- Information regarding the orientation of arcs at crossings is given by leaving gaps in a knot's shadow..

Drawing knots on paper



Drawing knots on paper



Representations of knots

- Knot diagrams are really just 4-valent planar graphs.
 - The vertices in the graph correspond to the crossings in the knot diagram.
 - The arcs between vertices correspond to arcs between crossings in the knot diagram.
 - The arcs are decorated with their orientation at their source and target crossings.
- Other data structures familiar to computer scientists can be used, linked lists of crossings were popular in the 1950's.

Representations of knots

- The representations used by topologists are typically also used for representing knots in a computer.
- Examples are Dowker-Thistlethwait codes (DT codes), **Gauss codes**, braid representatives, Conway notation, and many more.

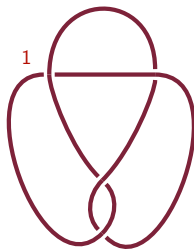
Representing knots with Gauss codes

- The strategy for representing a given knot (with n crossings) by a Gauss code is as follows.
 - 1 Label the crossings with the numbers 1 to n .
 - 2 Pick a point on the knot.
 - 3 Pick a direction and walk around the knot, writing out a list of the numbers you come to (with a negative sign indicating that a crossing was visited on an under strand). Stop when each number appears twice once with each sign.



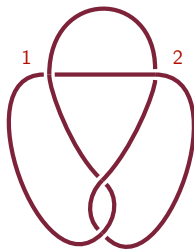
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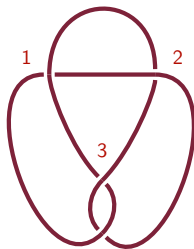
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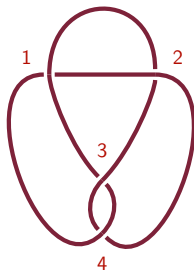
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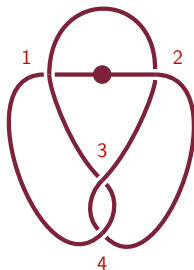
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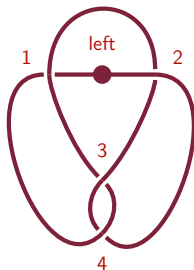
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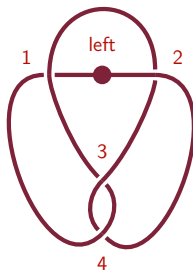
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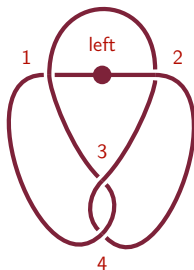
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—1

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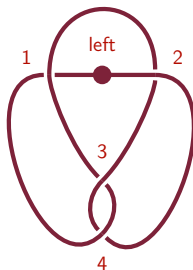
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$-1, 4$

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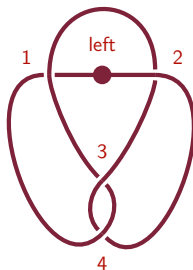
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$-1, 4, -3$

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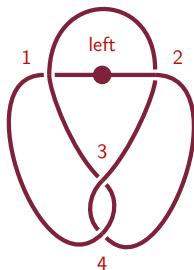
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$-1, 4, -3, 1$

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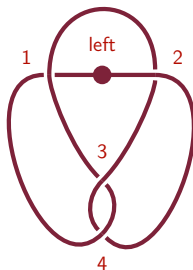
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$-1, 4, -3, 1, -2$

Representing knots with Gauss codes

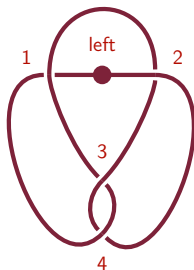
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-1 , 4 , -3 , 1 , -2 , 3

Representing knots with Gauss codes

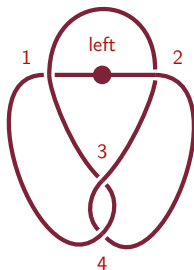
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$-1, 4, -3, 1, -2, 3, -4, 2$

Knot enumeration by Gauss codes

- There are three sensible questions to ask:
 - Do all knots give rise to a Gauss code?
 - Can two Gauss codes correspond to the same knot?
 - Do all Gauss codes represent a knot?

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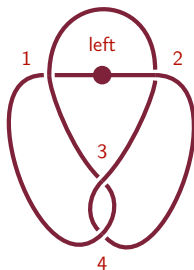
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 - Do all knots give rise to a Gauss code? Yes. Trivially.
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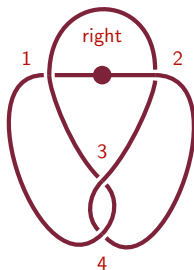
A candidate for a canonical Gauss code

- $-1, 4, -3, 1, -2, 3, -4, 2$



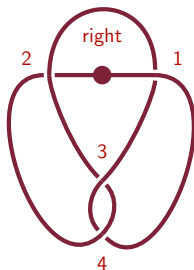
A candidate for a canonical Gauss code

- $-1, 4, -3, 1, -2, 3, -4, 2$
- $2, -4, 3, -2, 1, -3, 4, -1$



A candidate for a canonical Gauss code

- $-1, 4, -3, 1, -2, 3, -4, 2$
- $2, -4, 3, -2, 1, -3, 4, -1$
- $1, -4, 3, -1, 2, -3, 4, -2$



A candidate for a canonical Gauss code

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- $1, -4, 3, -1, 2, -3, 4, -2$
- I wonder what this should be

