Intrinsically universal one dimensional quantum cellular automata

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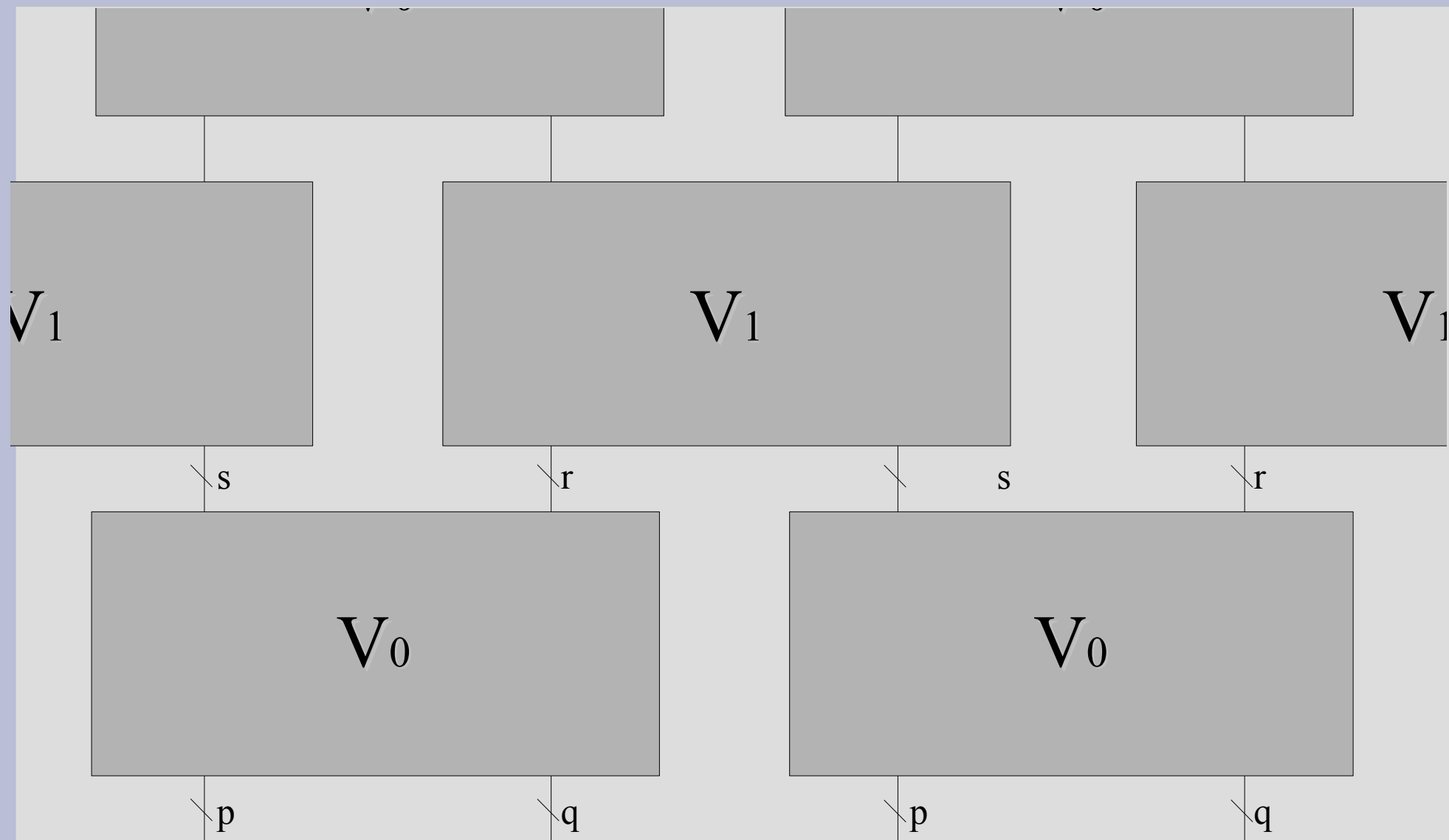Renan Fargetton (renan.fargetton@imag.fr)

University of Grenoble.

1D QCA: Definition

A line of quantum systems.
Identical, finite dimensional.
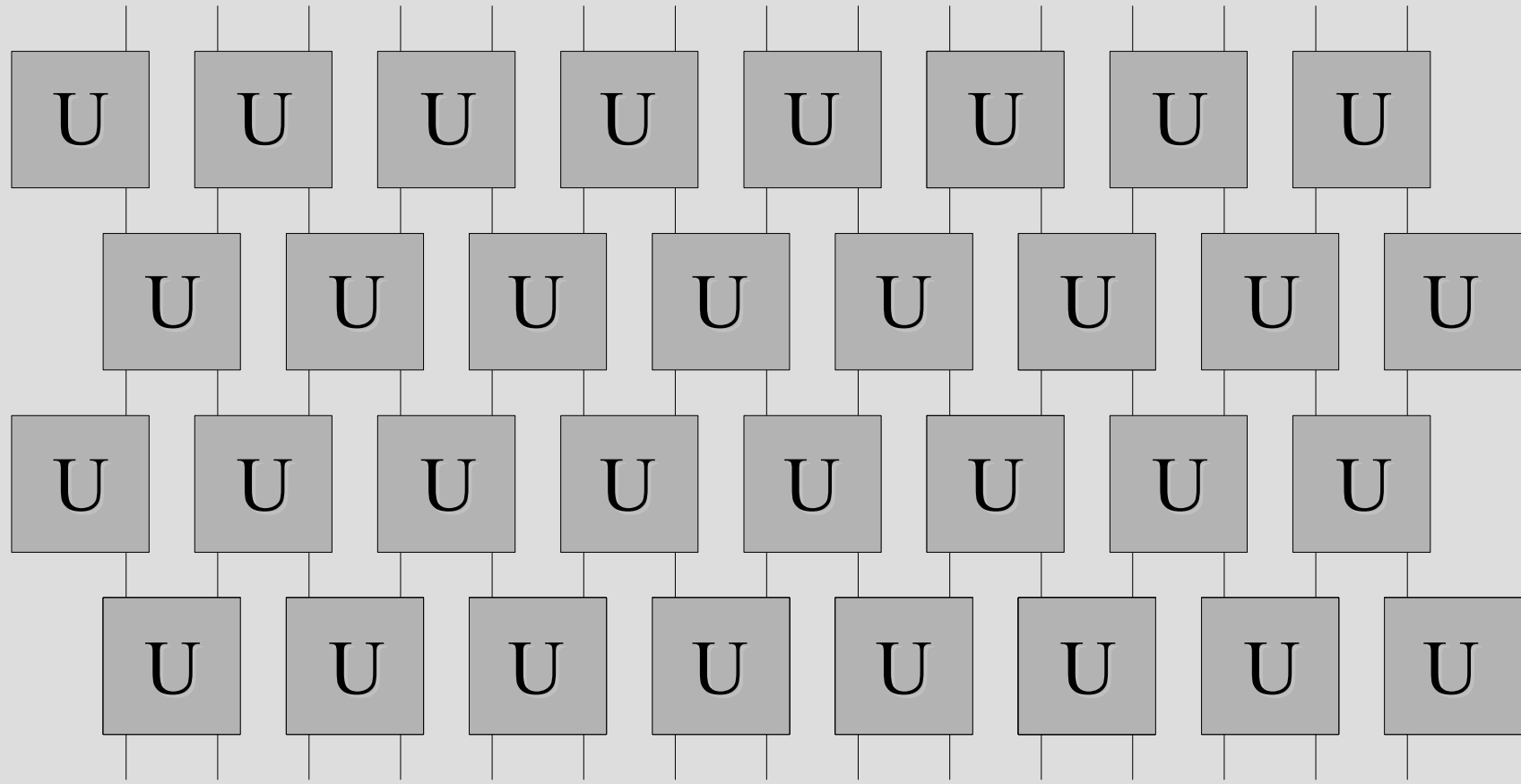E.g. Ising Model.
(Discrete space)

Evolving according to a global unitary.
Translation invariant, local.
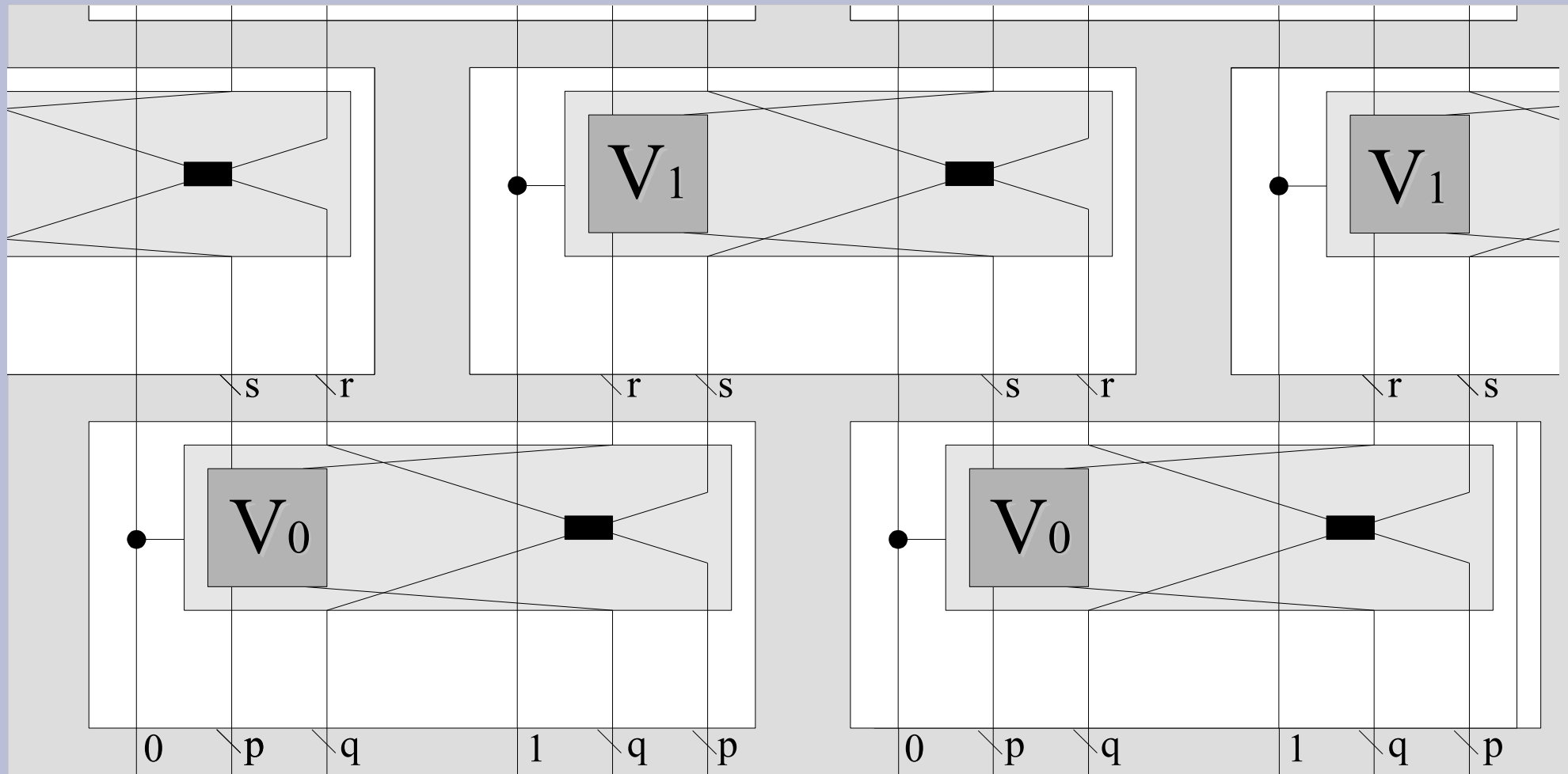(Discrete time)

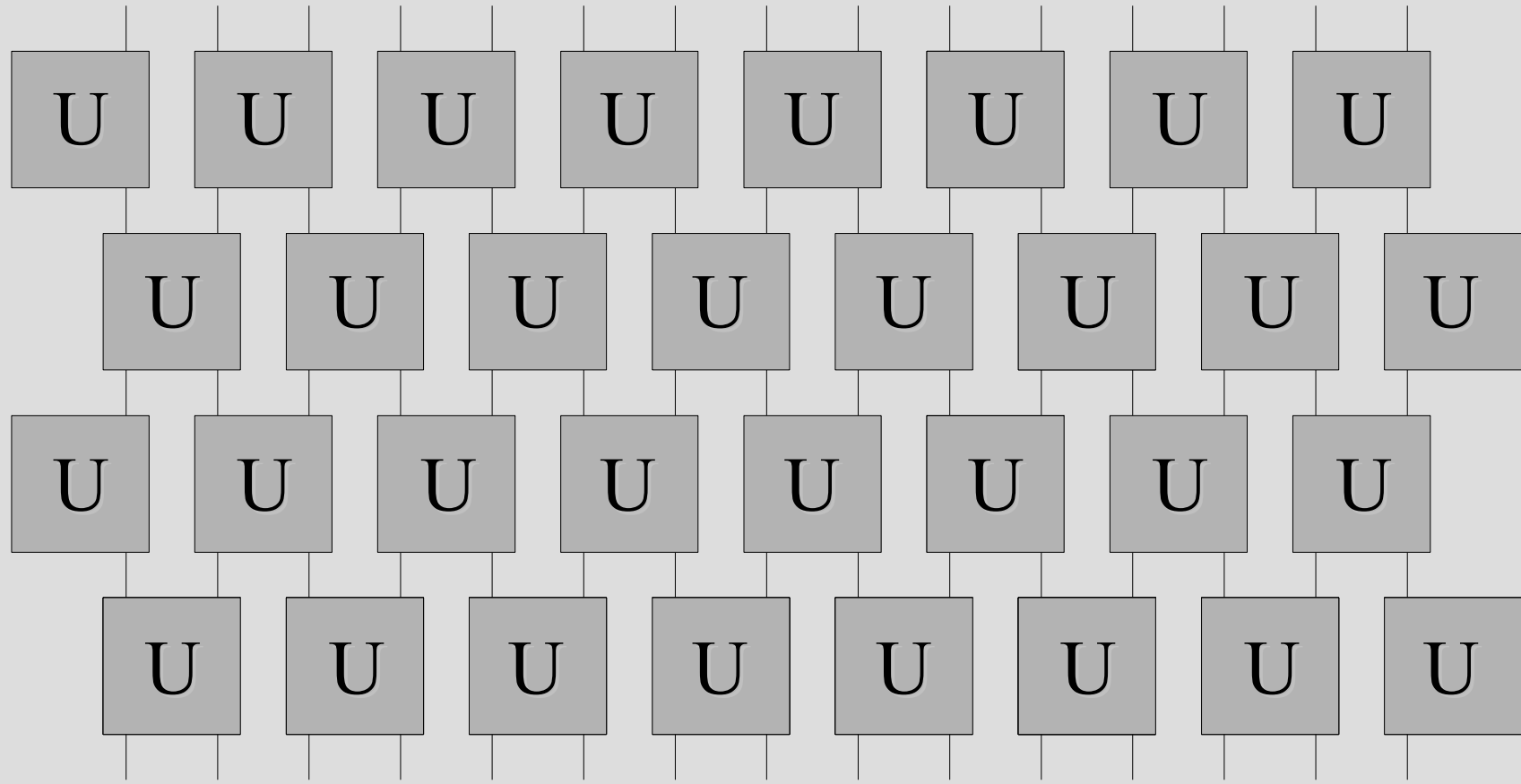Discrete space & time idealized model.

1D QCA: Werner style

V_1

V_1

V_1

s

r

s

r

V_0

V_0

p

q

p

q
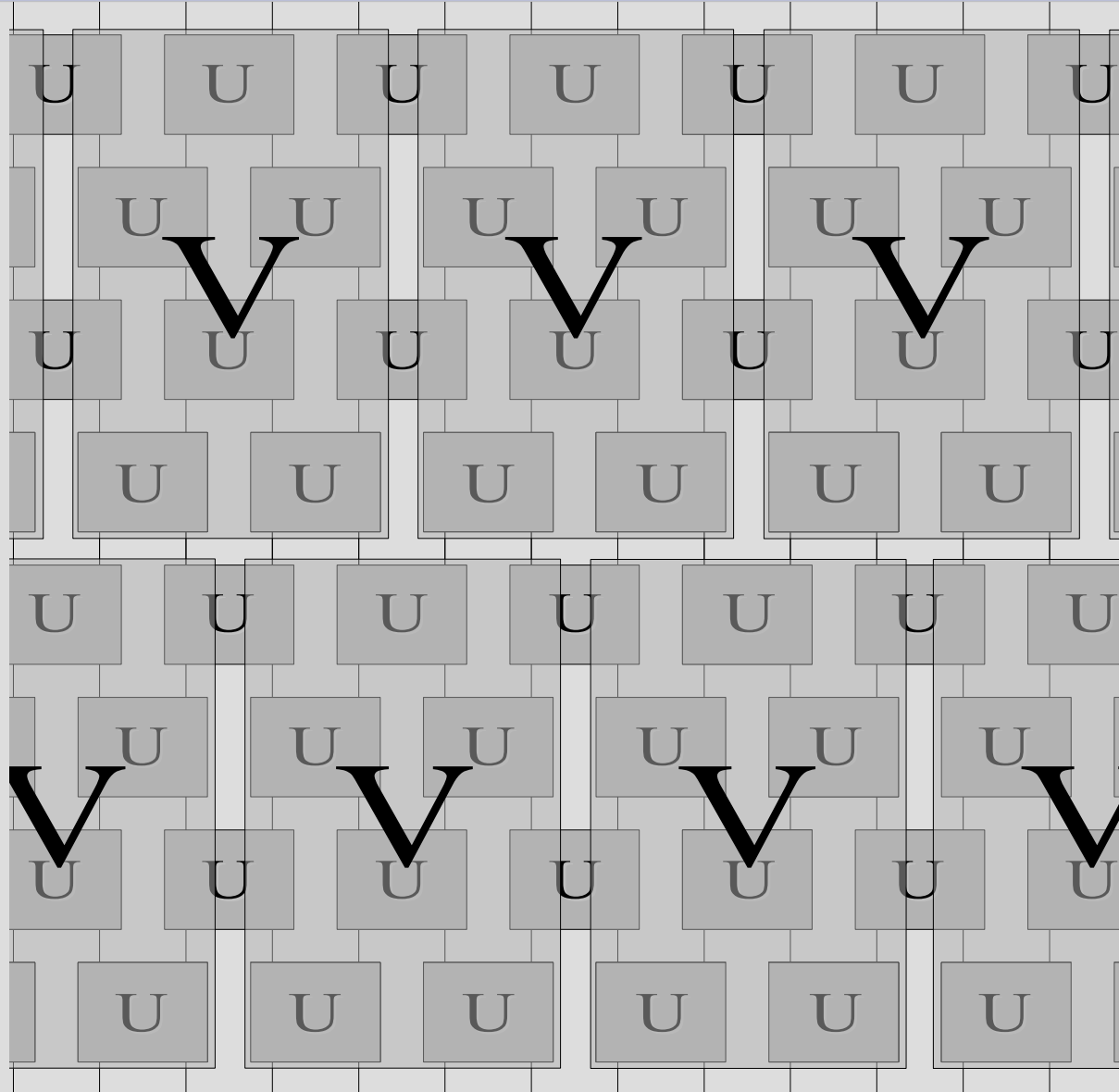
1D QCA: Partitioned

Partitioned simulates Werner style

1D QCA: Partitioned

Intrinsic universality
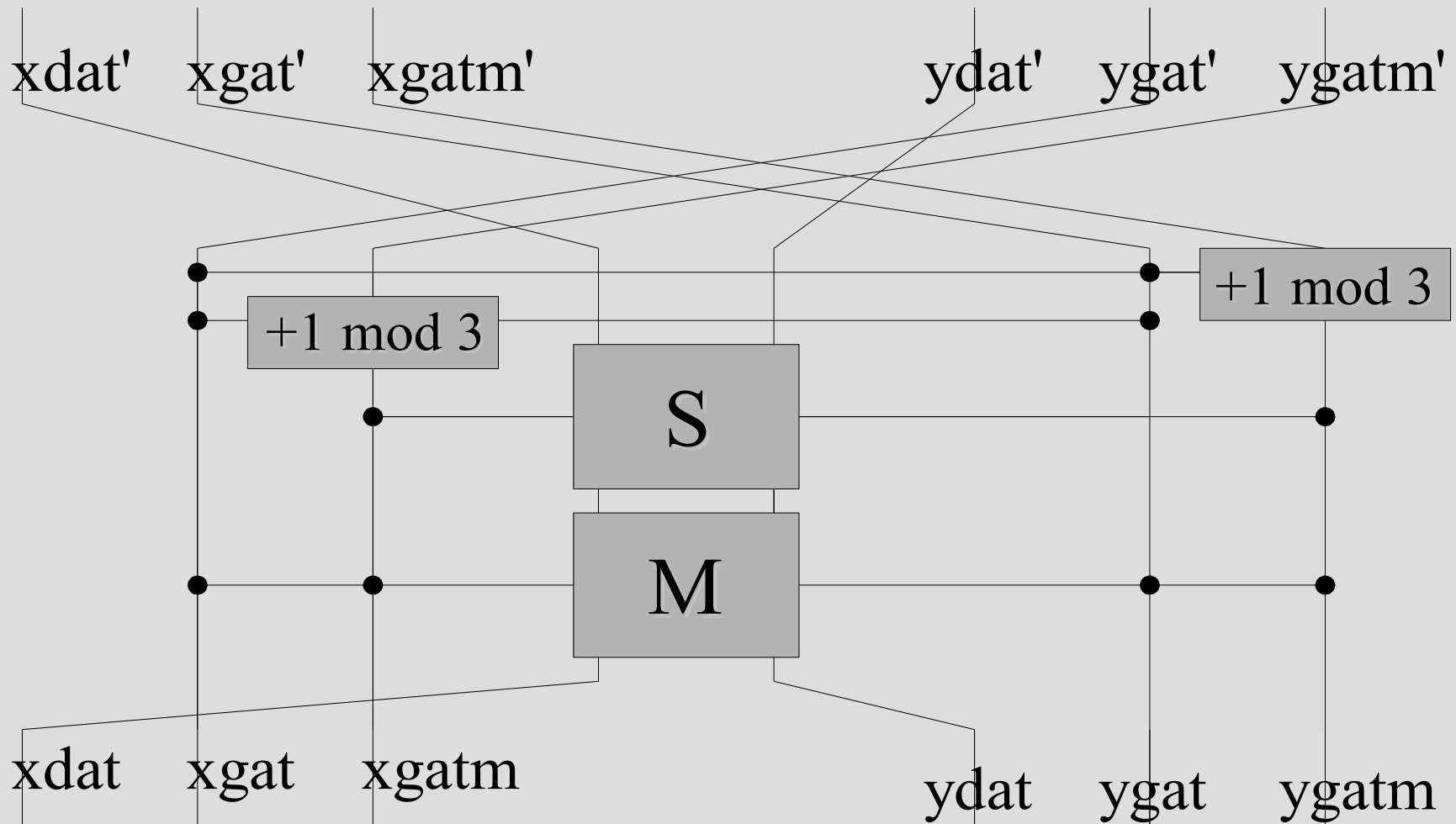
Why

(Q)CA for modelling
- distributed (quantum) computation
- (quantum) physical phenomena
- implementation architectures

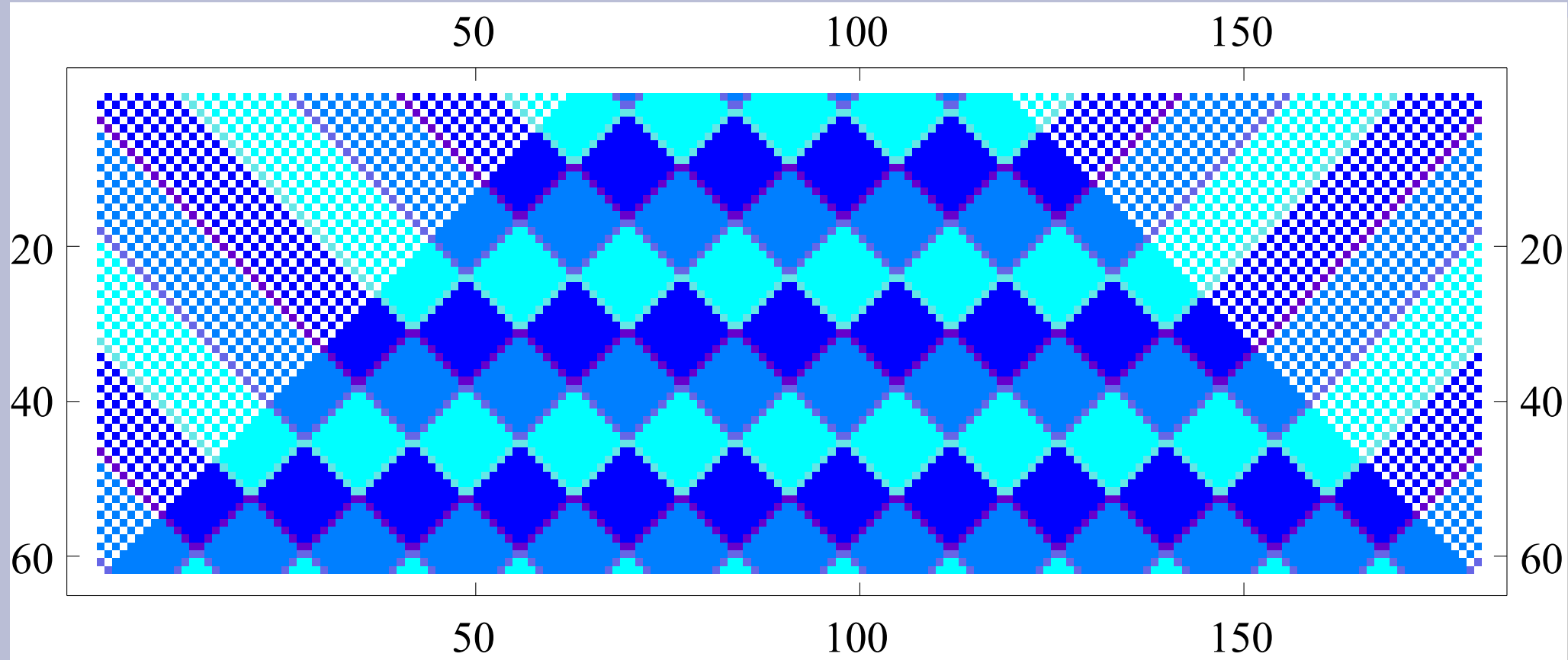So simulations must be topology preserving.
Hence intrinsic universality.

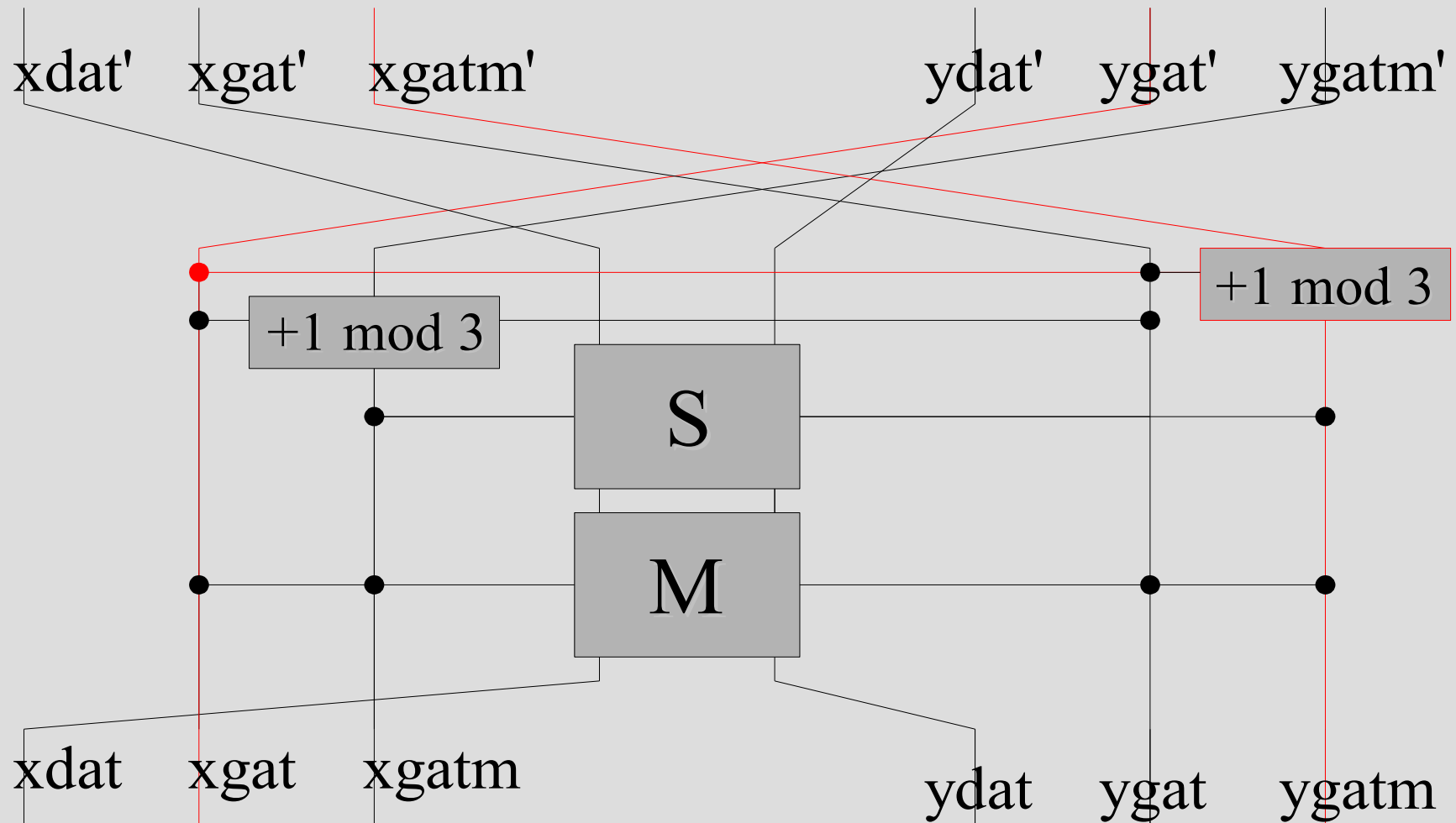Classically:
Curlik, Delorme&Mazoyer, Durand-Lose...

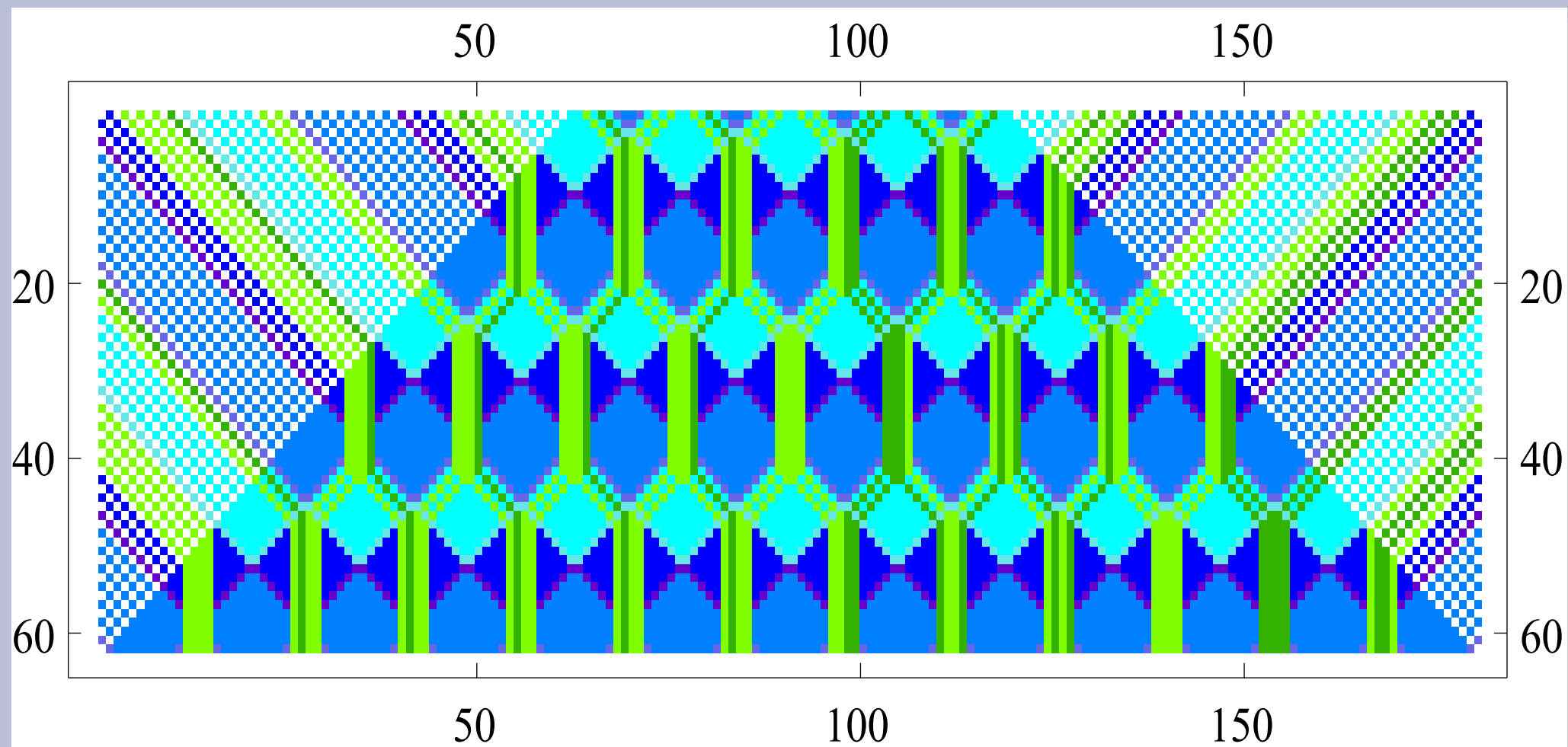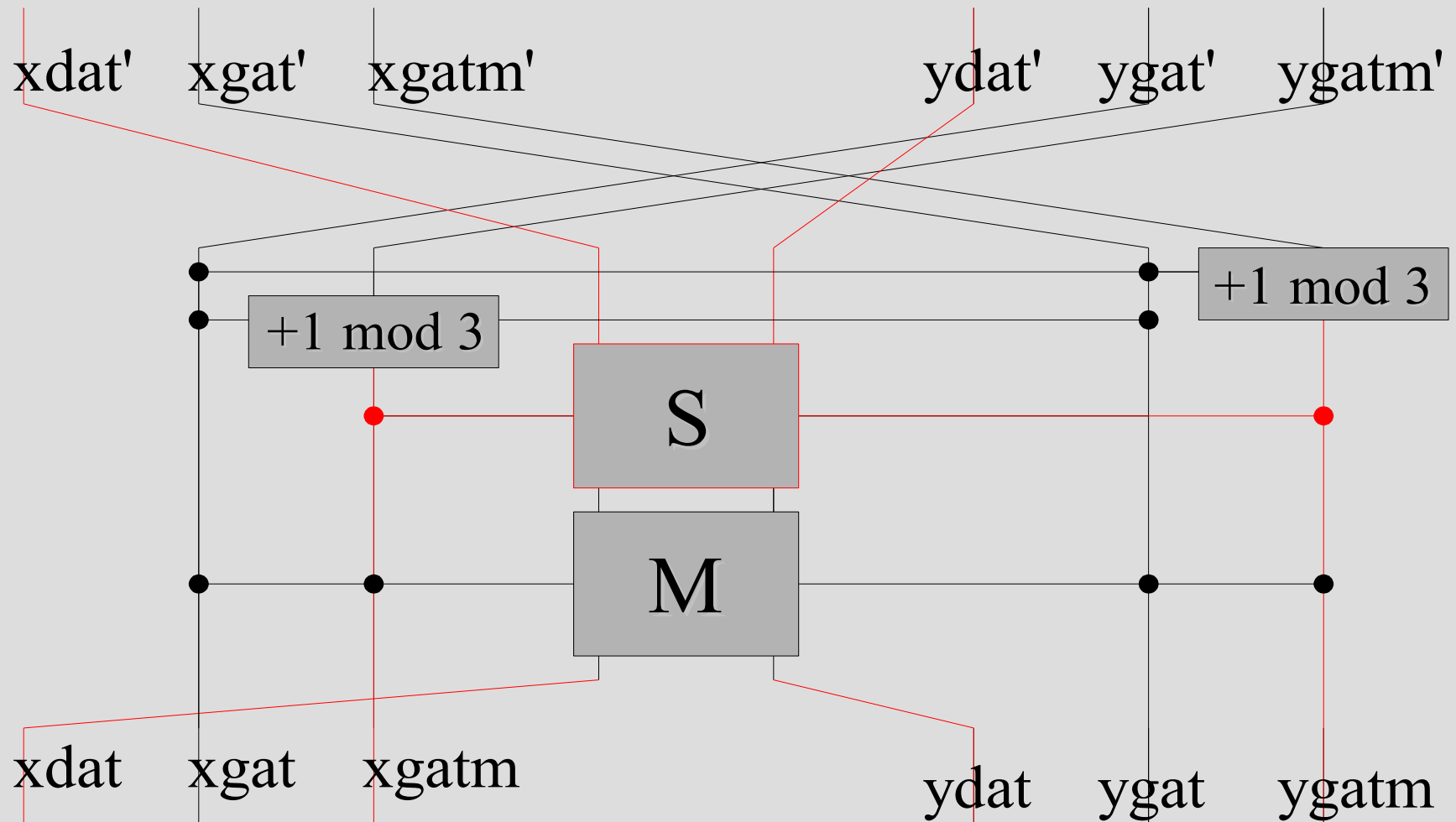# The universal <u>unitary</u> interaction *U*
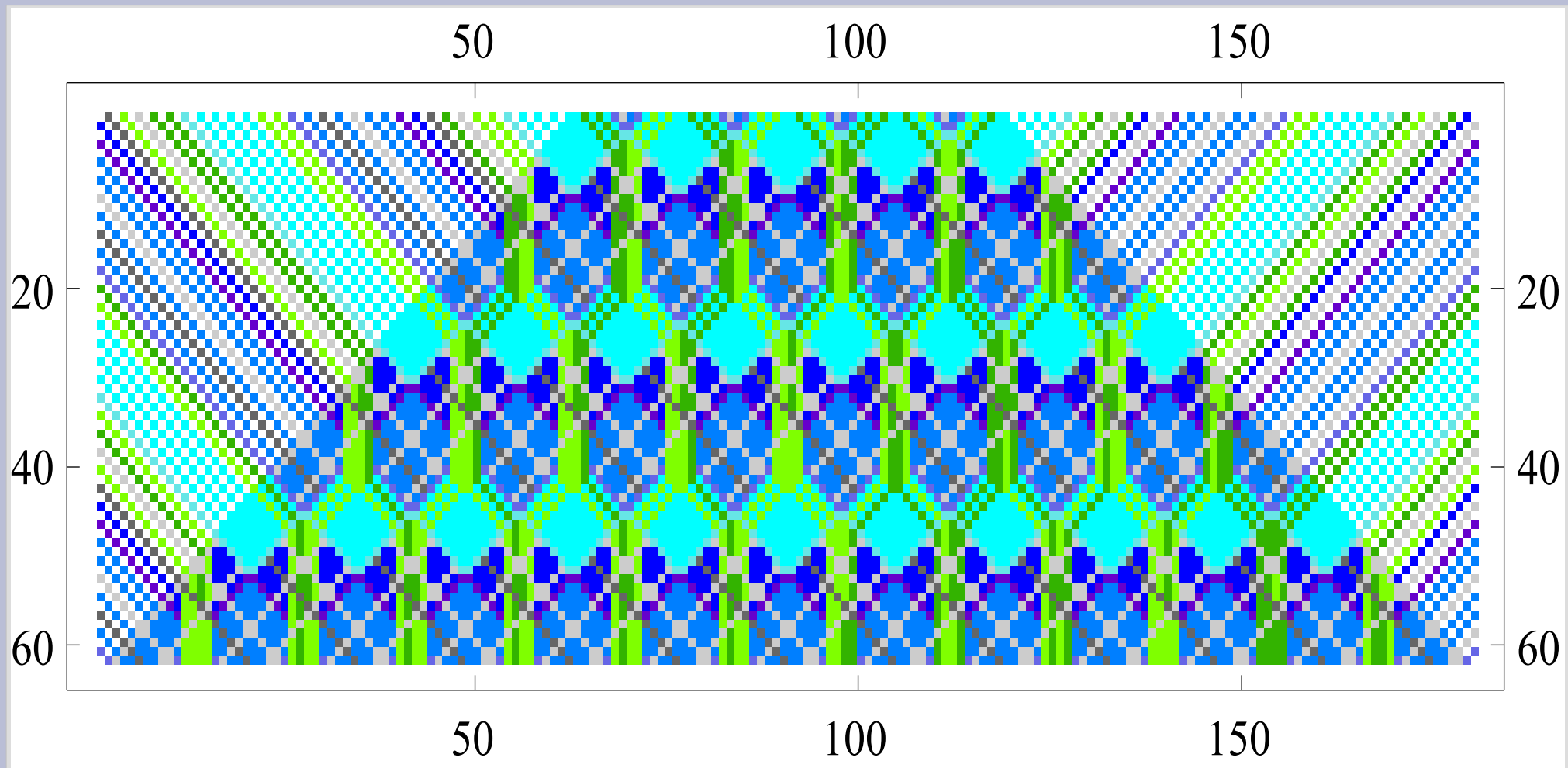
Ternary background pattern

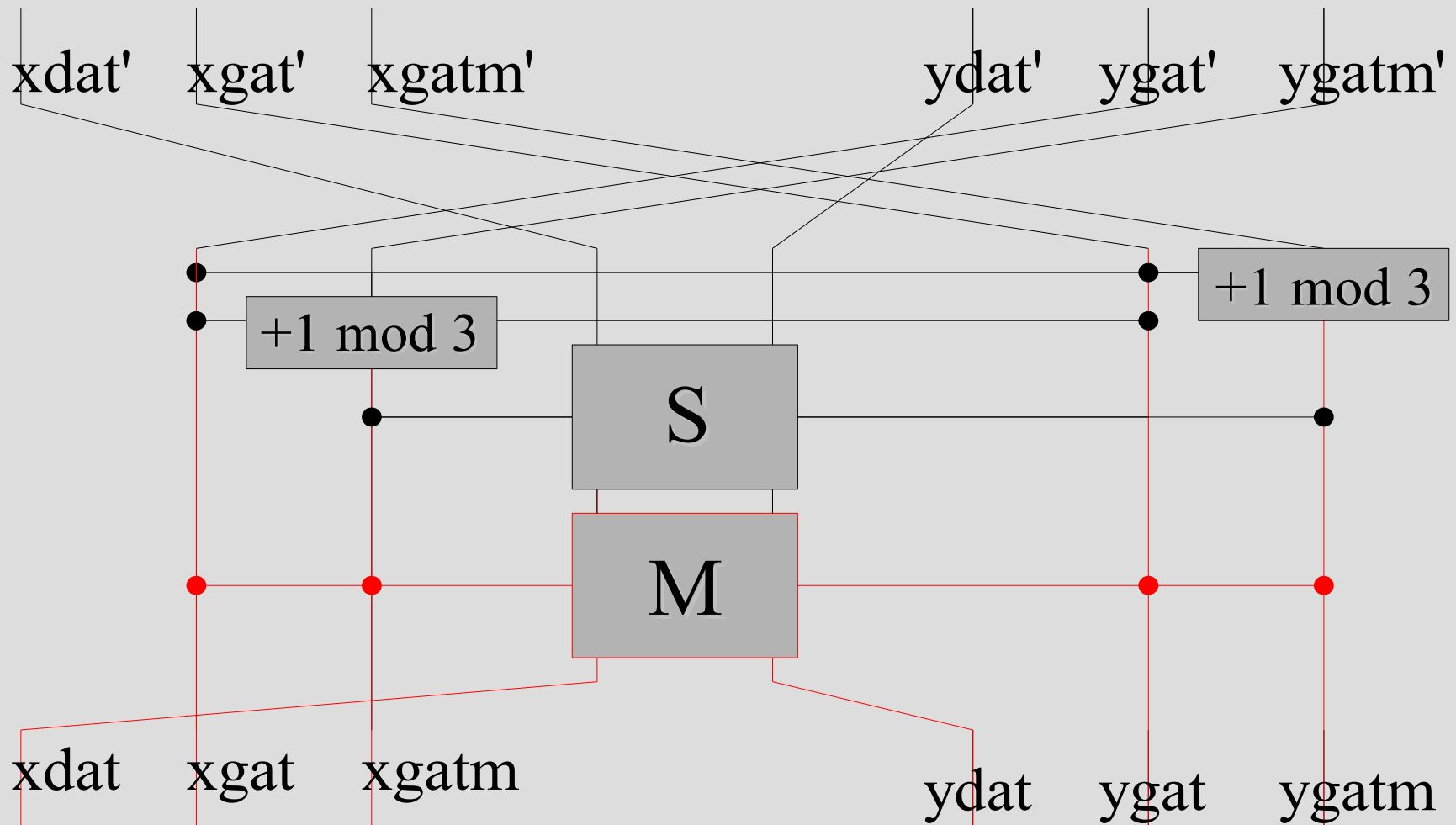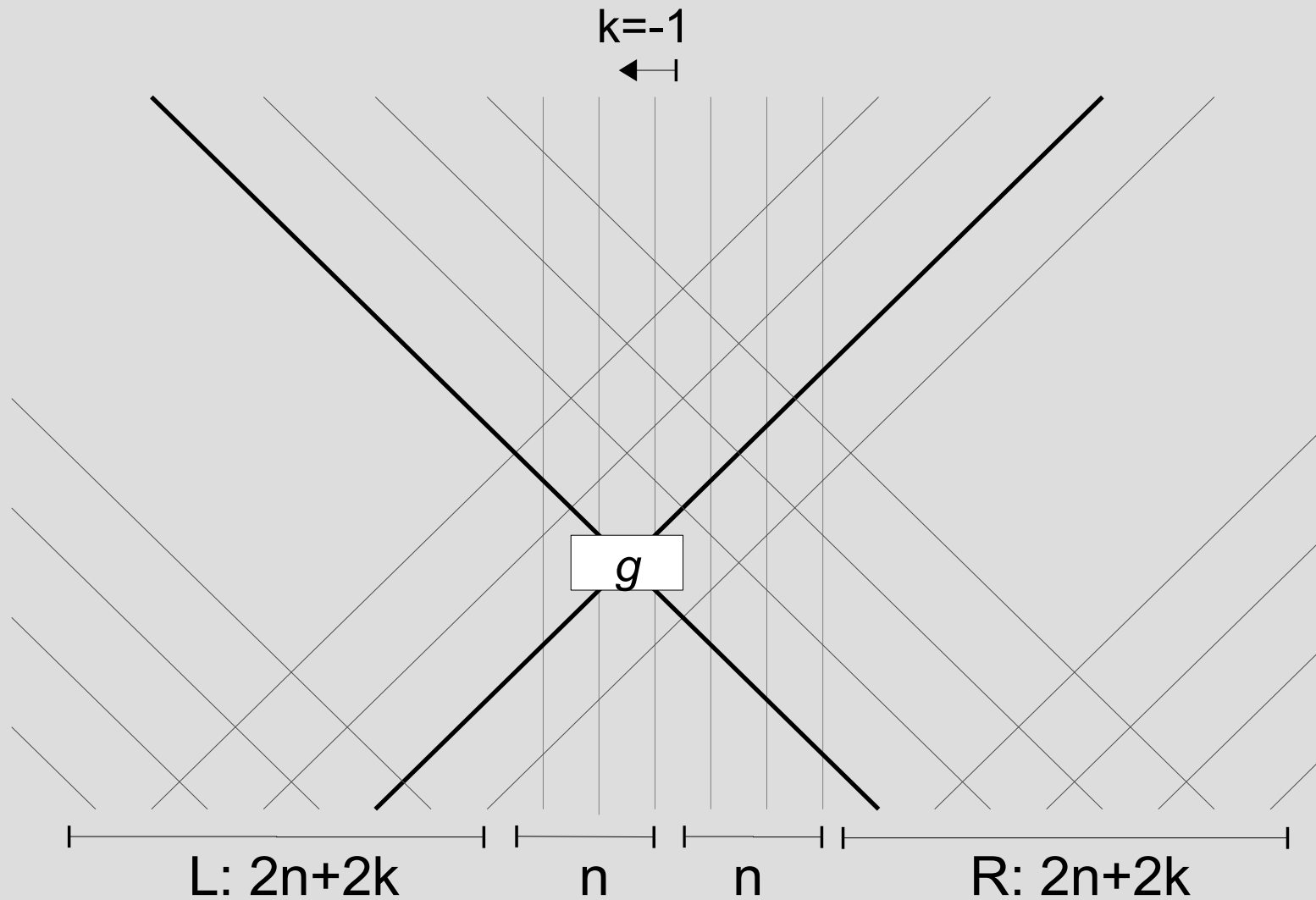# The +1 mod 3 gate

Hexagonal data flow

The S gate

xdat' xgat' xgatm'   ydat' ygat' ygatm'

+1 mod 3

+1 mod 3

S

M

xdat xgat xgatm   ydat ygat ygatm

Circuitry

The M gate

The encoding

k=-1

g

L: 2n+2k   n   n   R: 2n+2k

End

A precise encoding with complexity
- space O(4mn), time O(6mn)
- where V has m gates, 2n qubits

Cell dimension 45.

See the paper http://arxiv.org/abs/0704.3961

Future work
- d dimensions
- Symmetries in QCA