

Dancing with Swarms

The University of Calgary's iGEM Project



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CALGARY

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Faculty of Medicine—**Bachelor of Health Sciences**



Computer Science—Faculty of Science

O'Brien Centre for the 
BACHELOR OF HEALTH SCIENCES PROGRAM

the **SWARM** aspect (I)



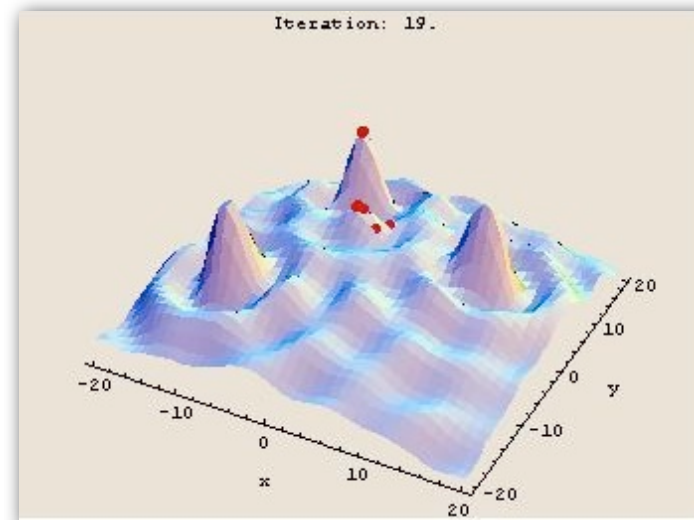
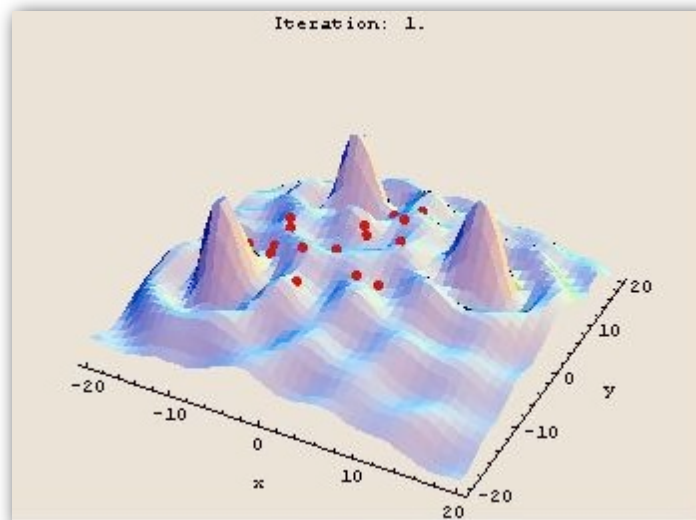
inspired by living organisms,
successfully applied in
various disciplines of
computer science

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the **SWARM** aspect (2)

ADAPTATION



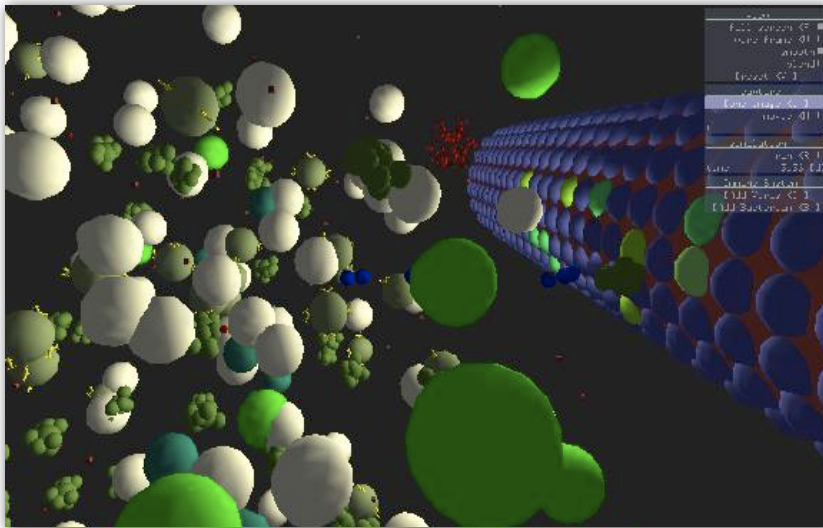
Particle Swarm Optimization by Namrata Khemka

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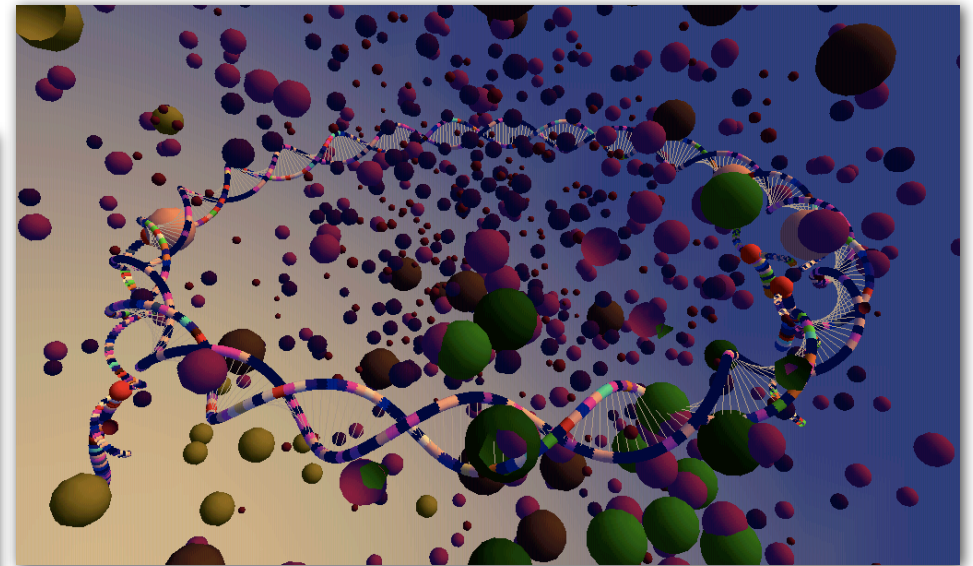
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the **SWARM** aspect (3)

EMERGENCE



Artificial Immune System
by S. Steil, K. Bergmann



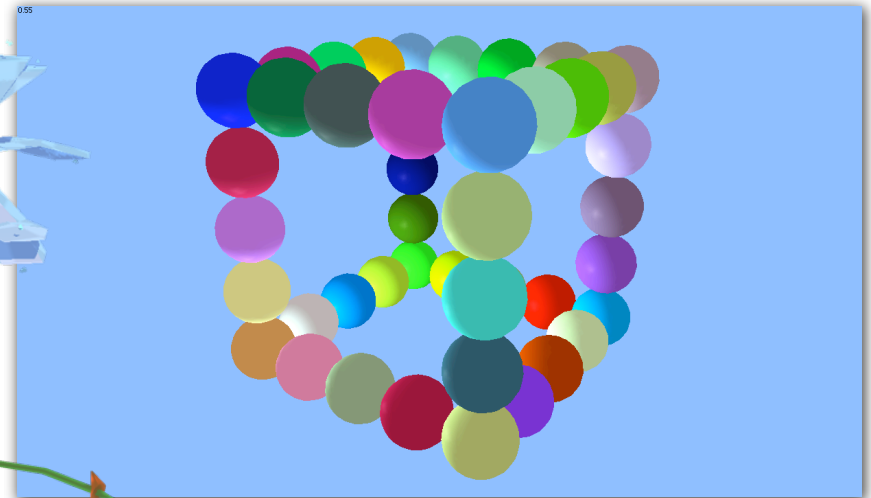
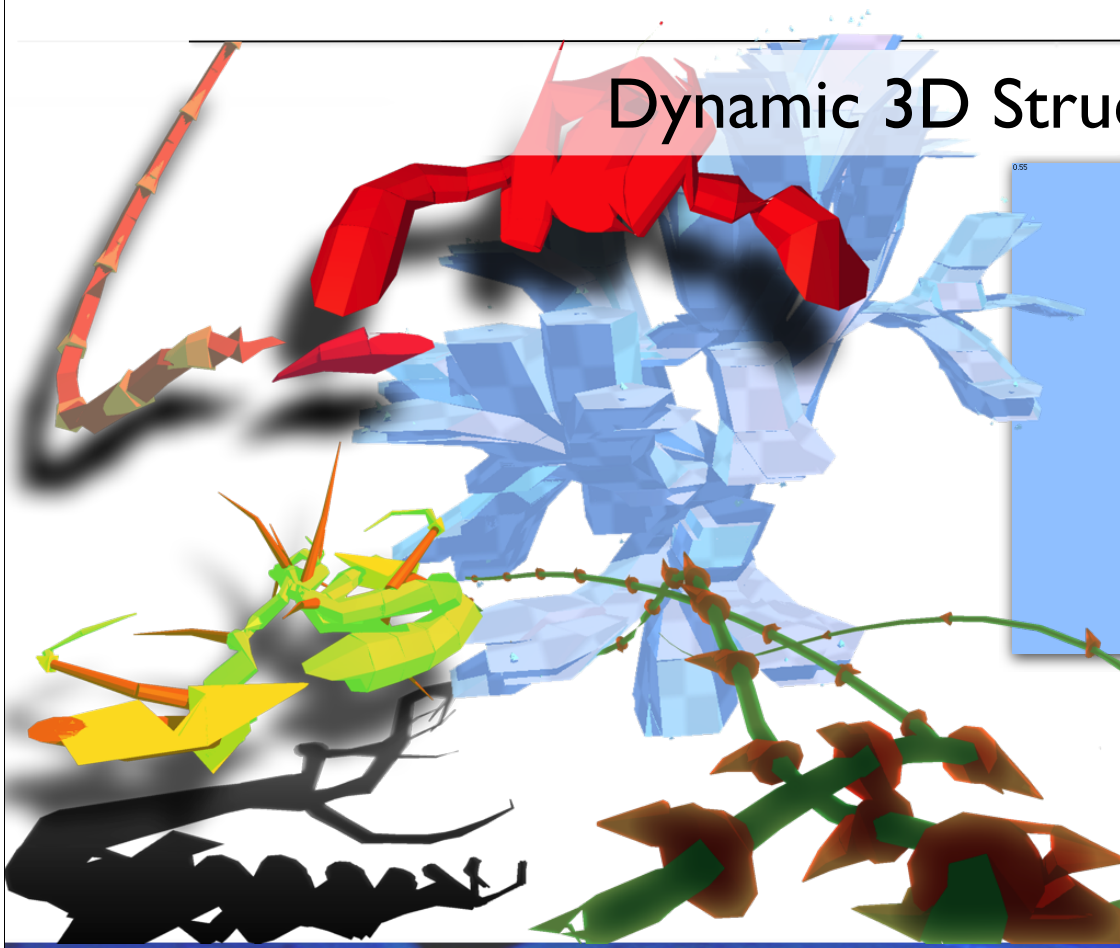
Gene Regulation
by I. Burleigh, A. Gavinski, B. Shabash

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the **SWARM** aspect (4)

Dynamic 3D Structures



Swarm Self-Assembly
by Navneet Bhalla

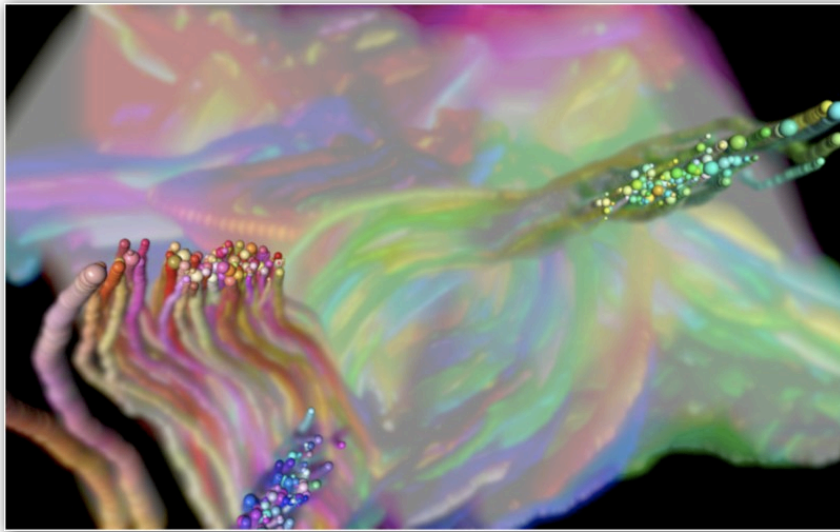
Swarm Grammars
by Sebastian von Mammen

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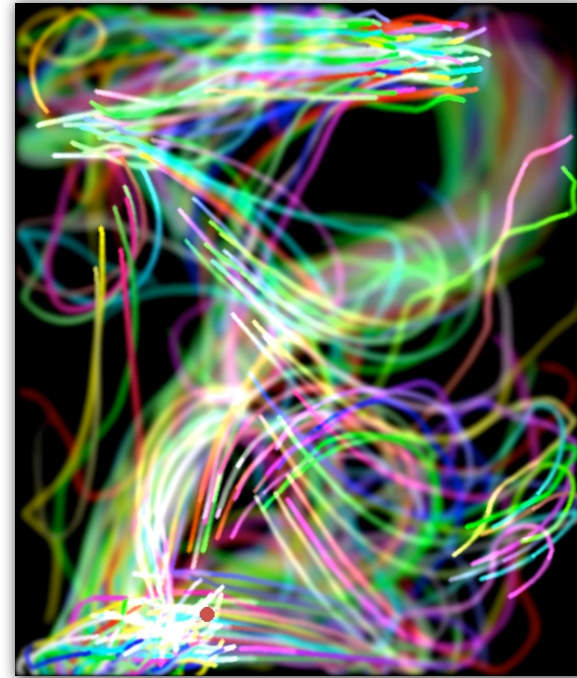
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the **SWARM** aspect (5)

ARTS



Pictures from www.SwarmArt.com



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the **SWARM** aspect (6)

numbers

Bacterial Swarms?

other
actuators

now, the circle completes:
from programming back to life!

Interaction!

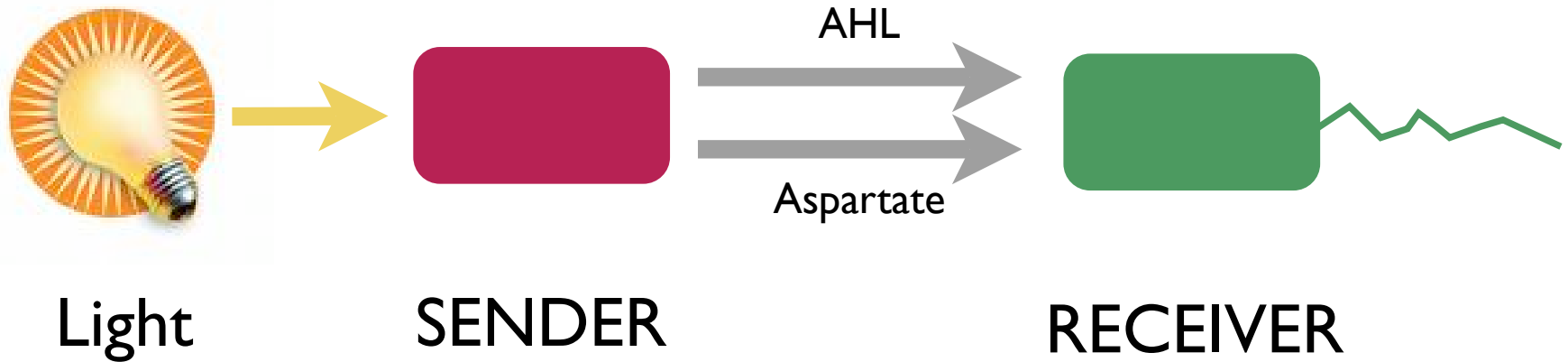
Sensors

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Senders & Receivers



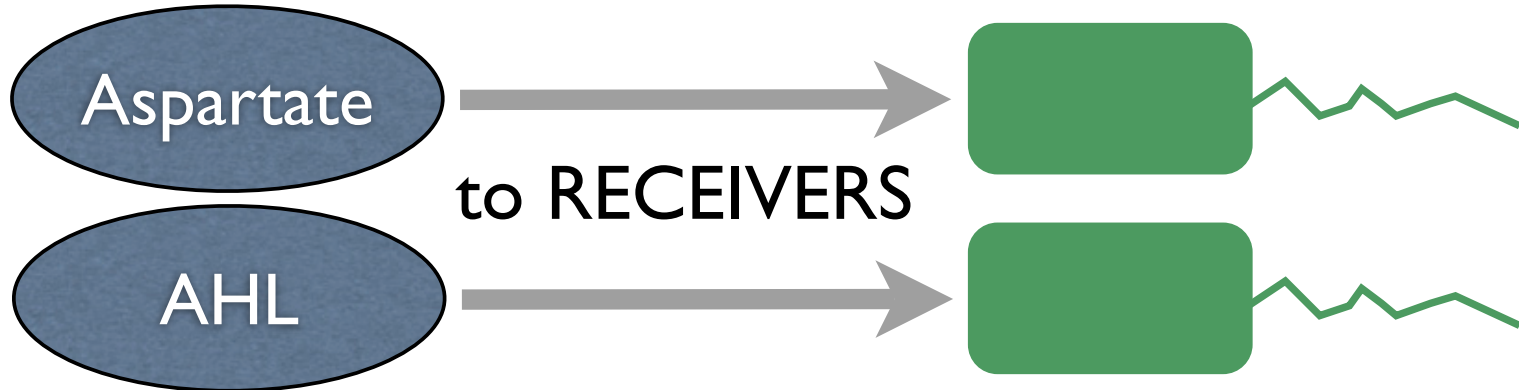
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SENDERS

- non motile
- light-activated
- emitting signals



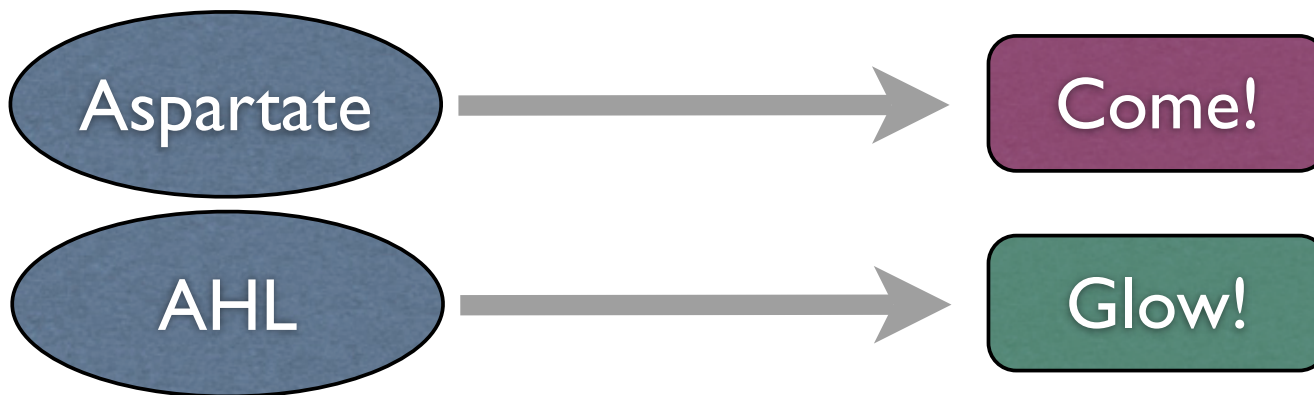
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RECEIVERS



- respond to SENDER signals
- consume Aspartate

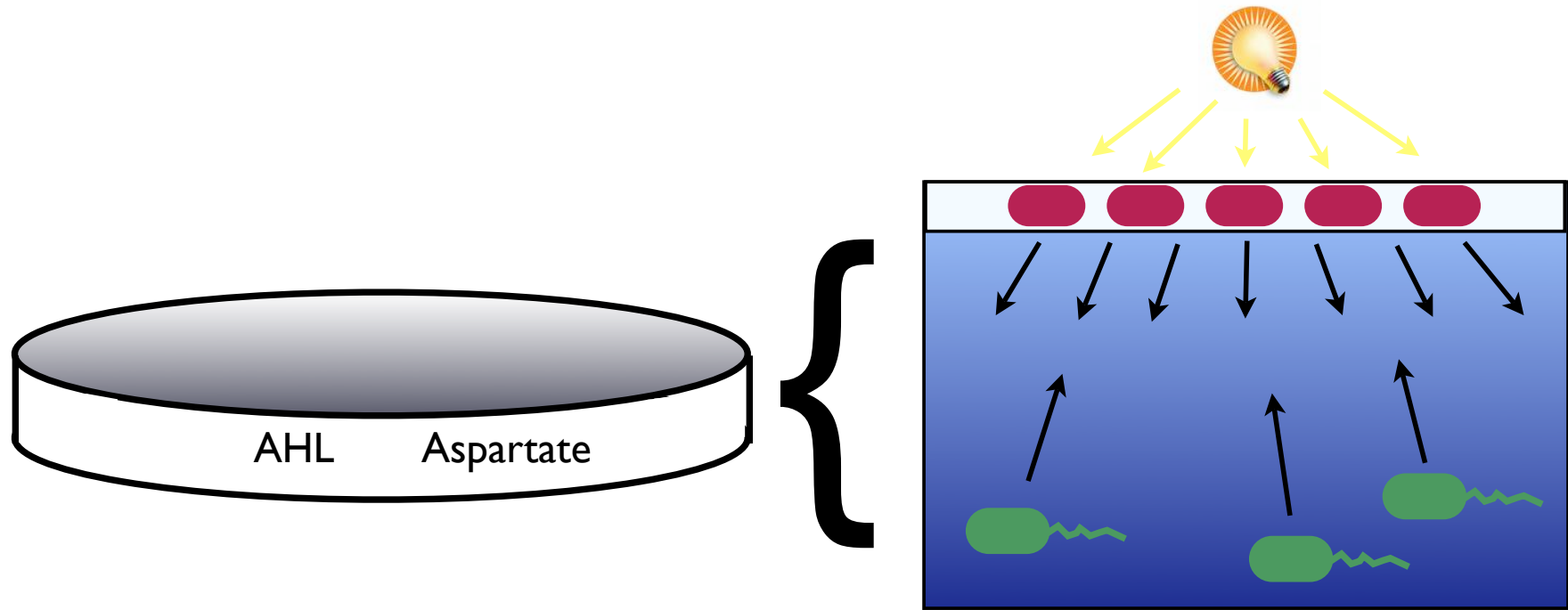


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Senders & Receivers



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Simulation

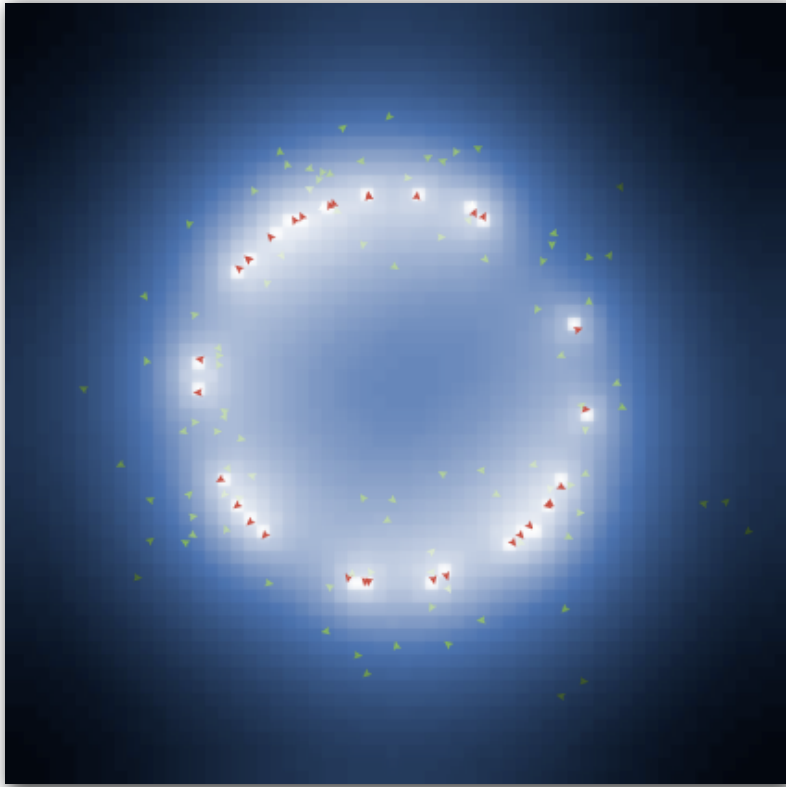


- grid-based
- interaction-based
- agent-based
- adjustable

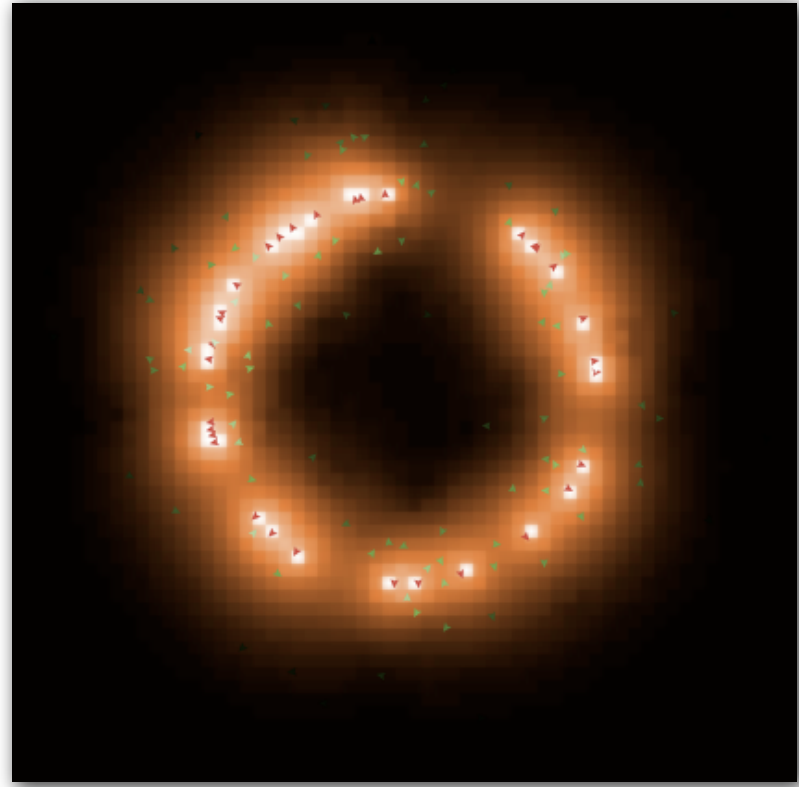
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AHL

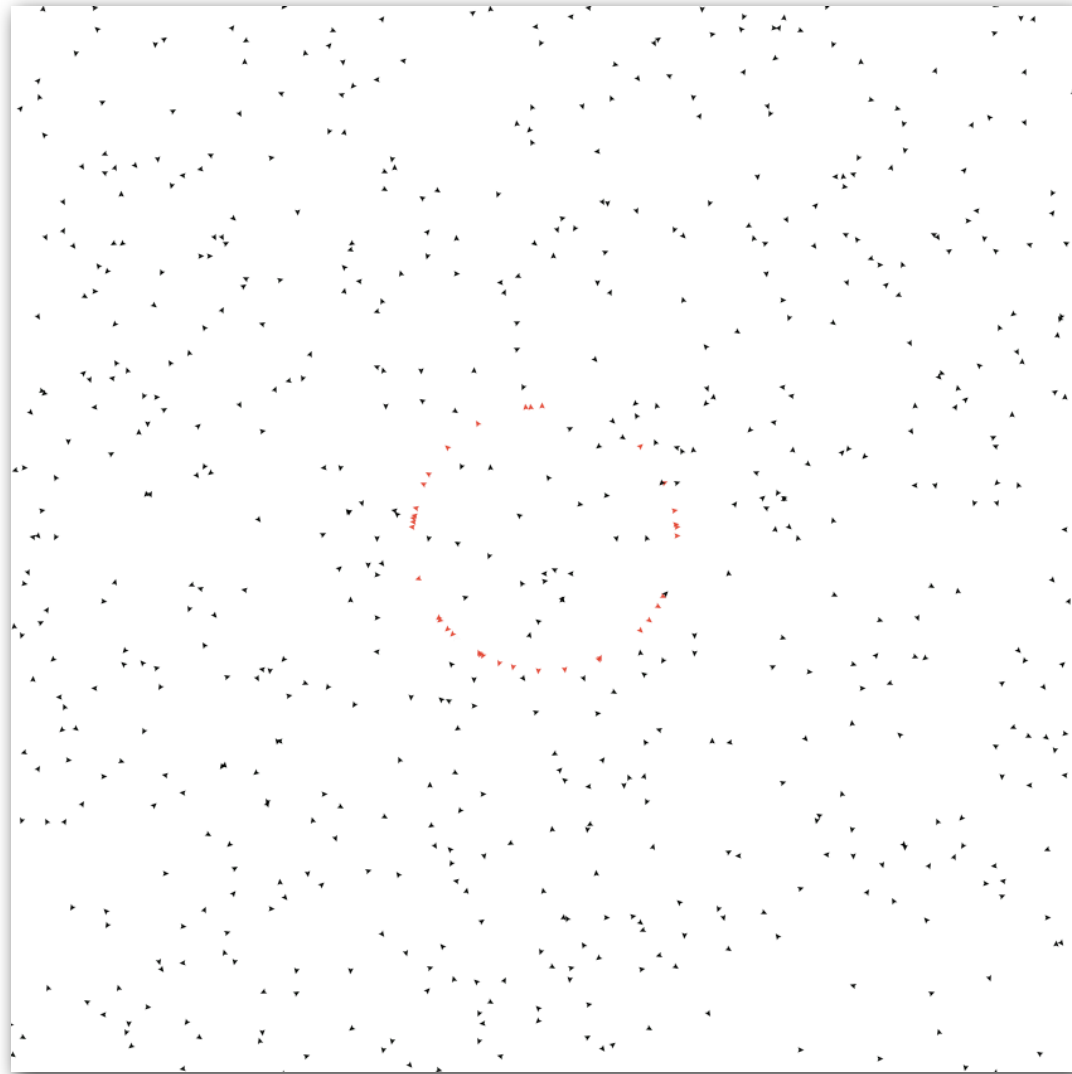


Aspartate

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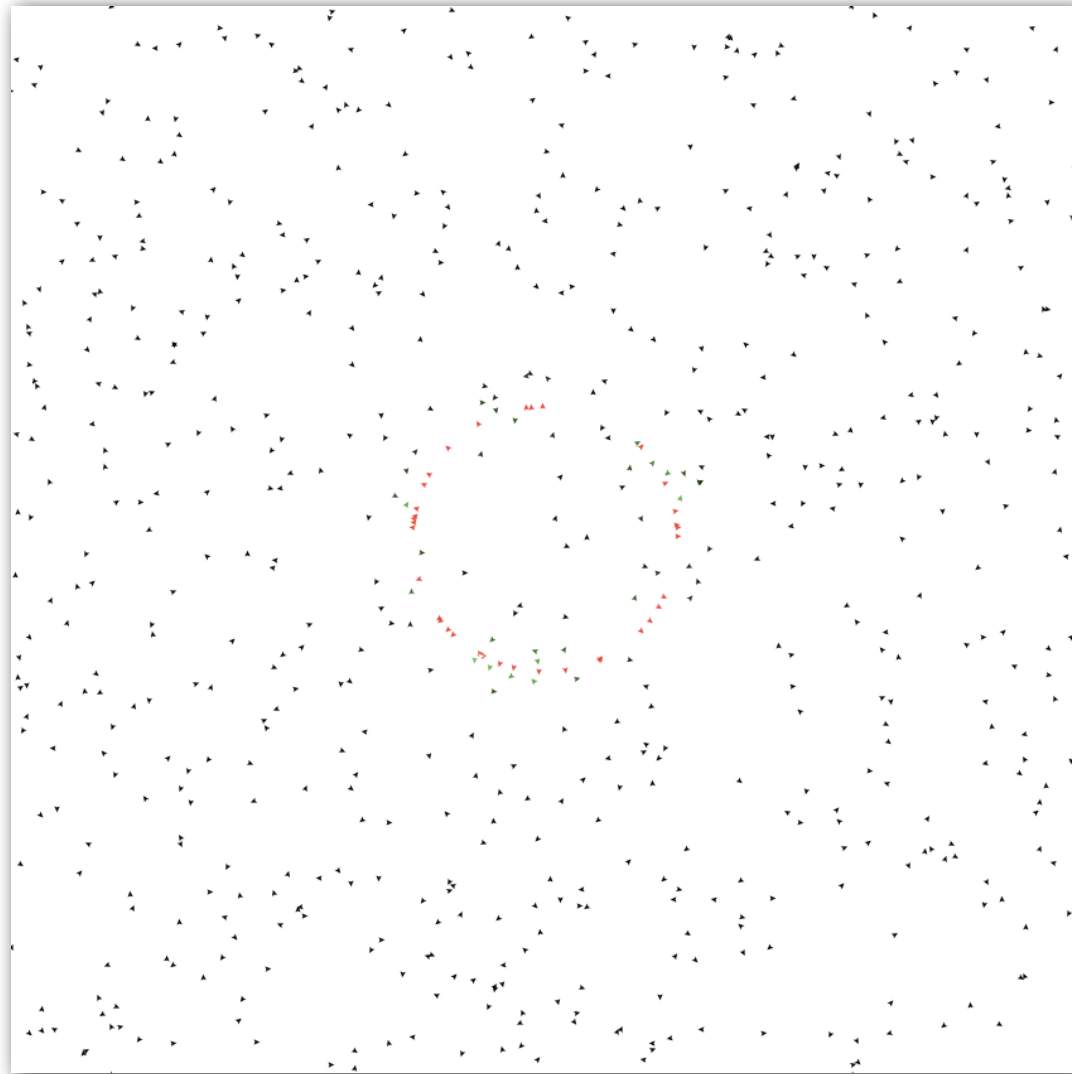


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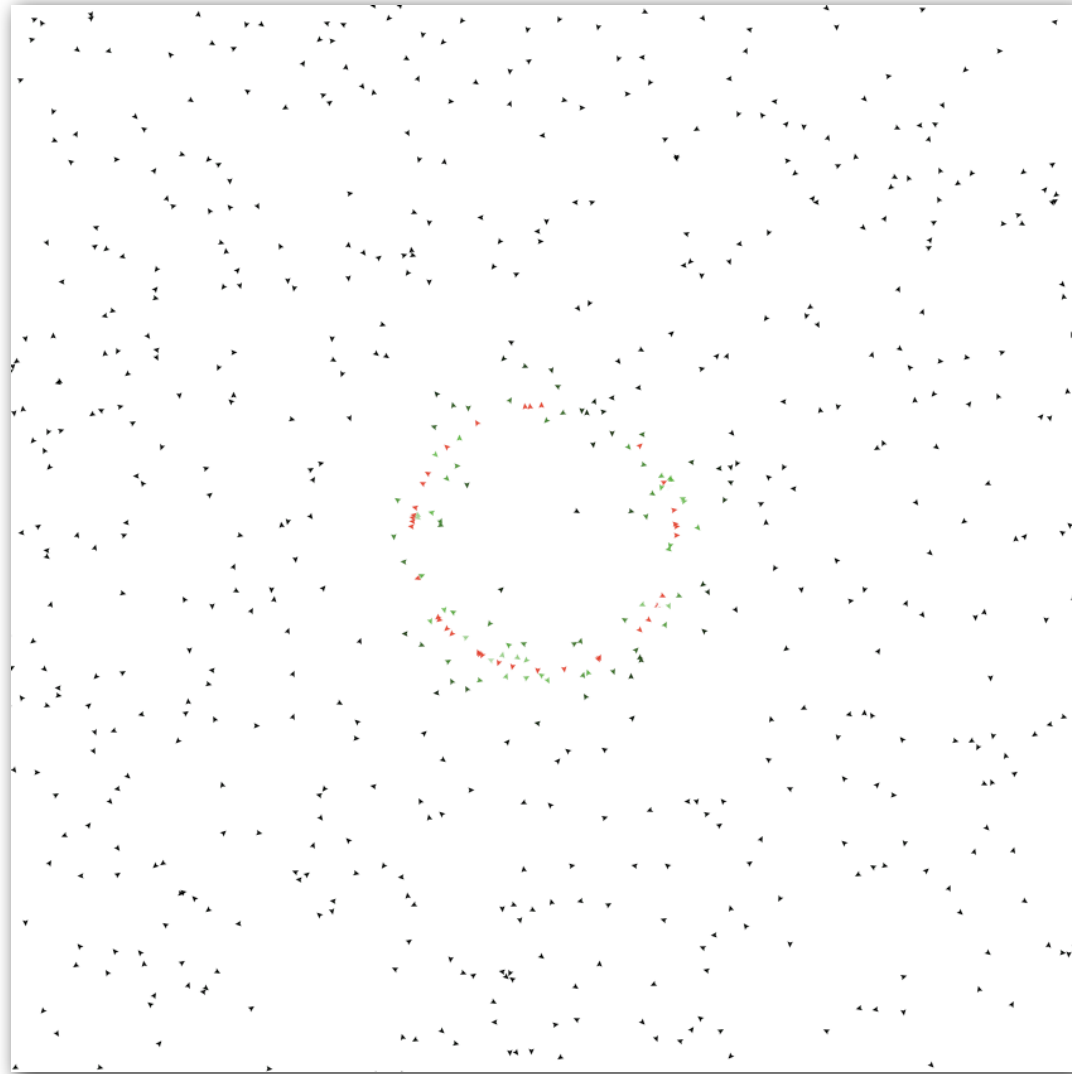


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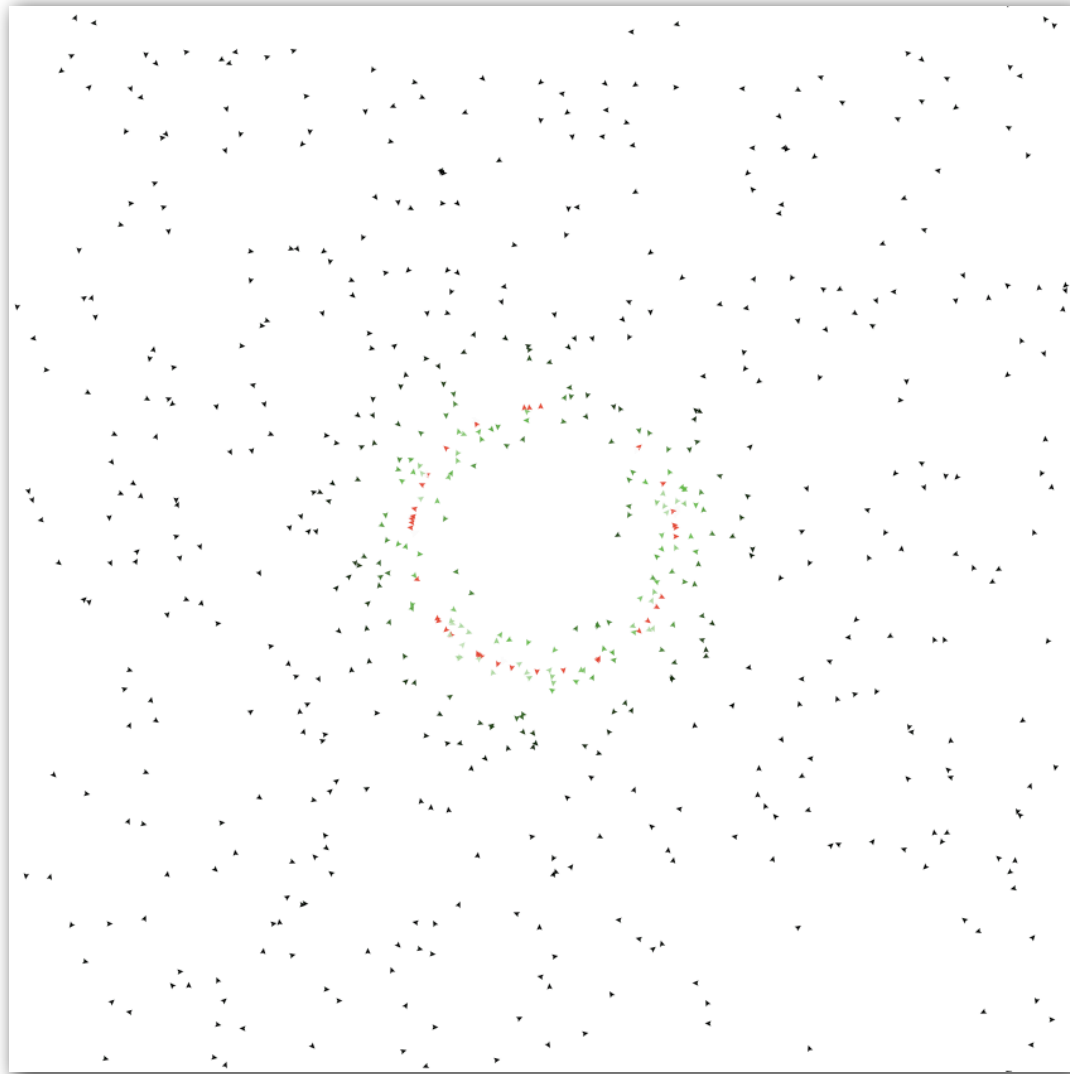


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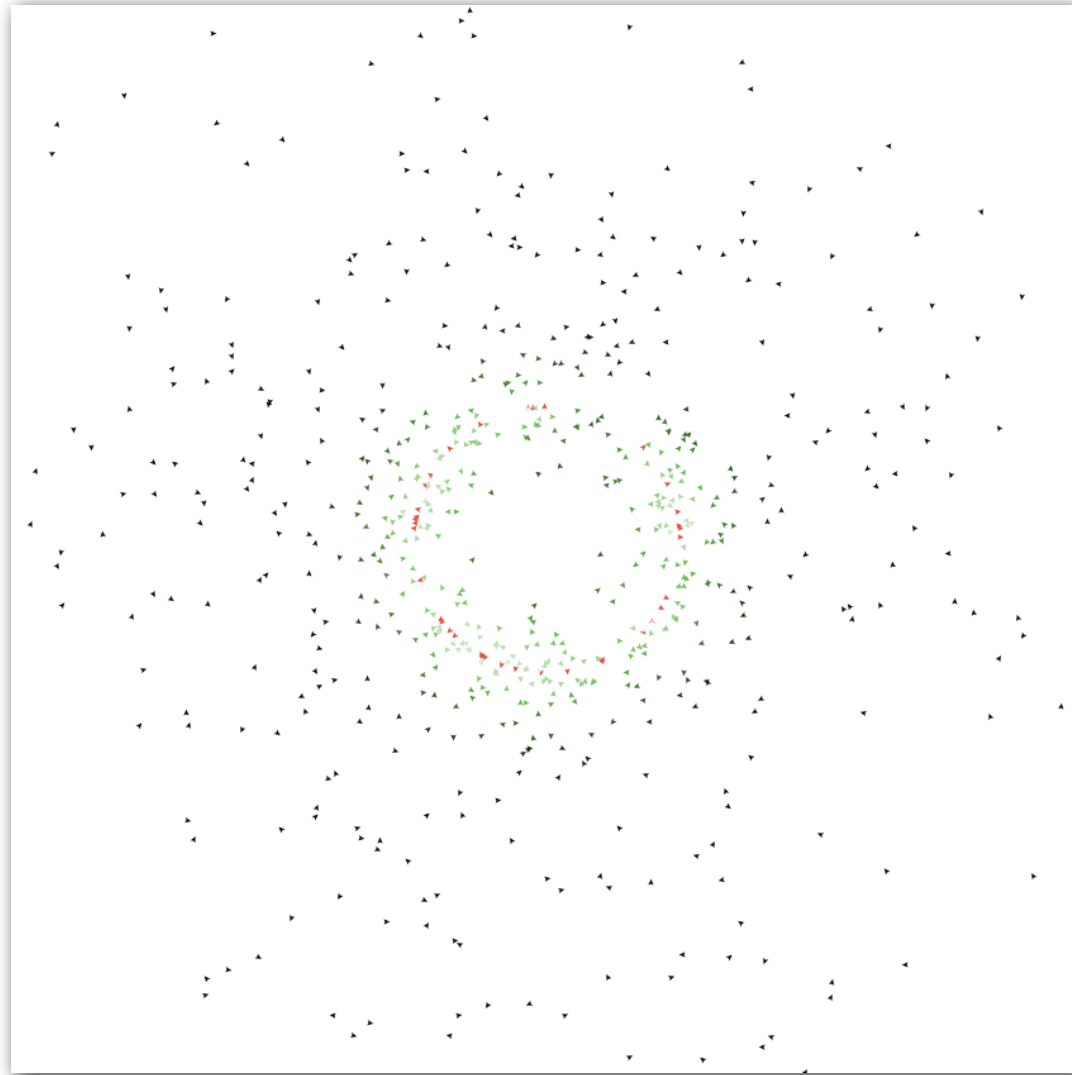
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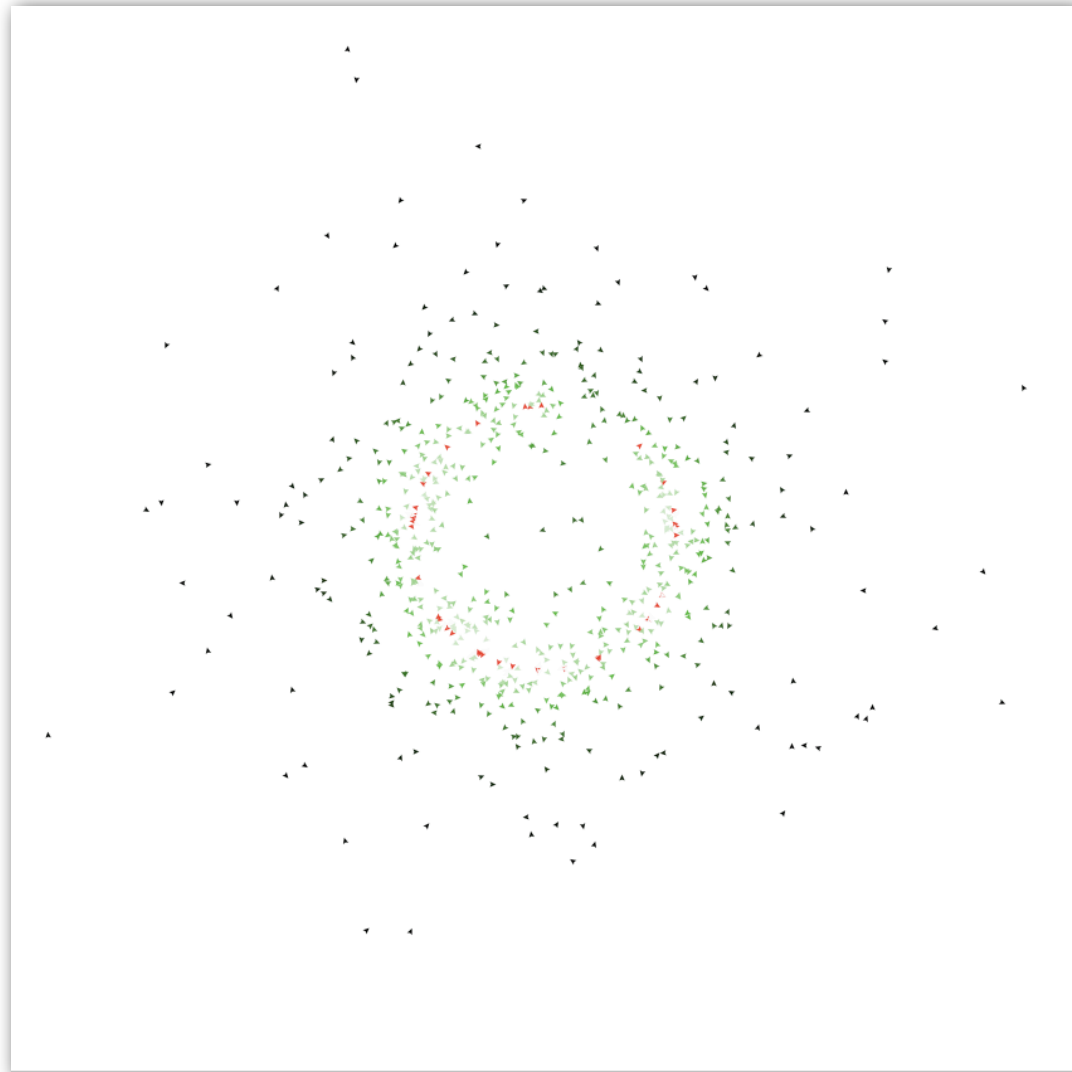


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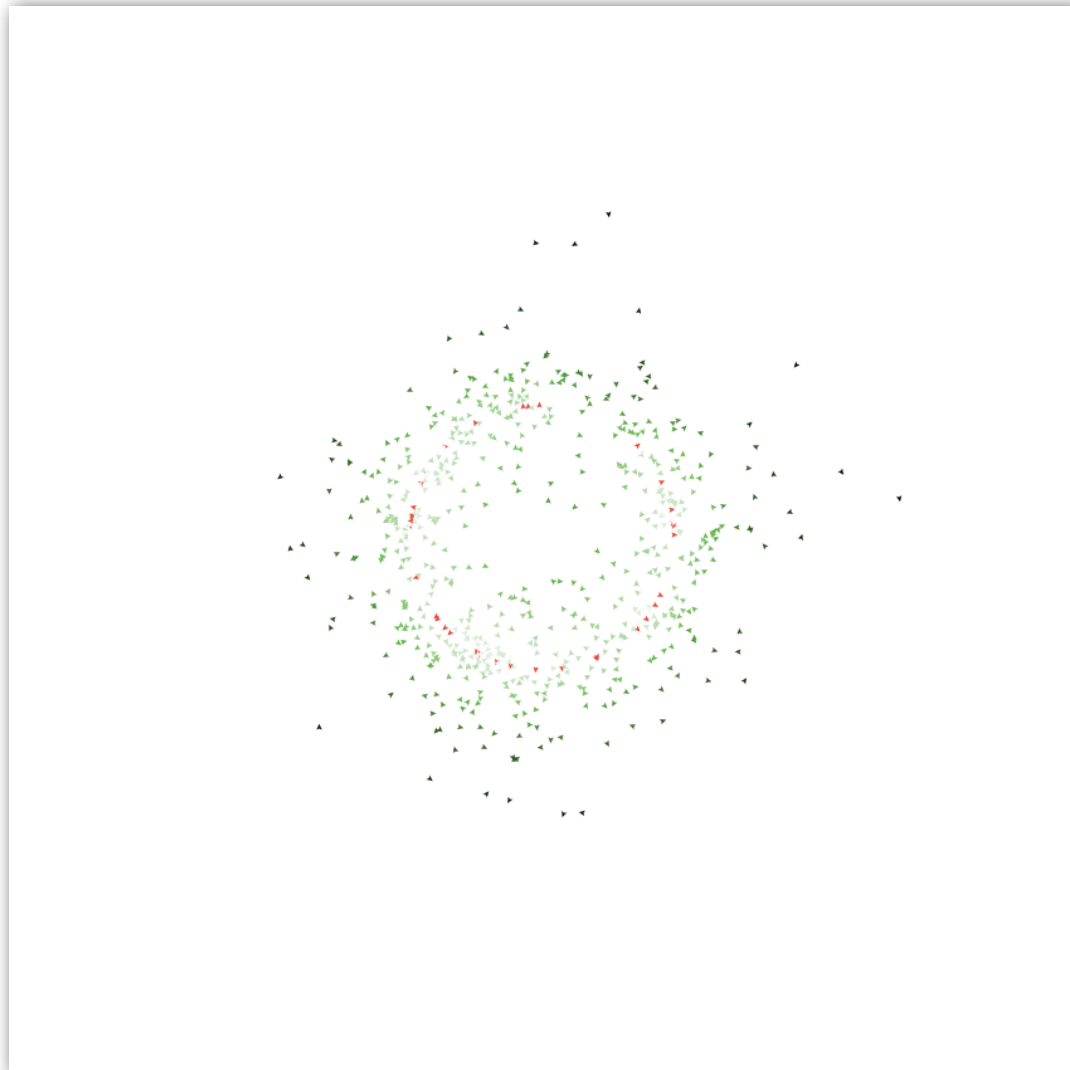


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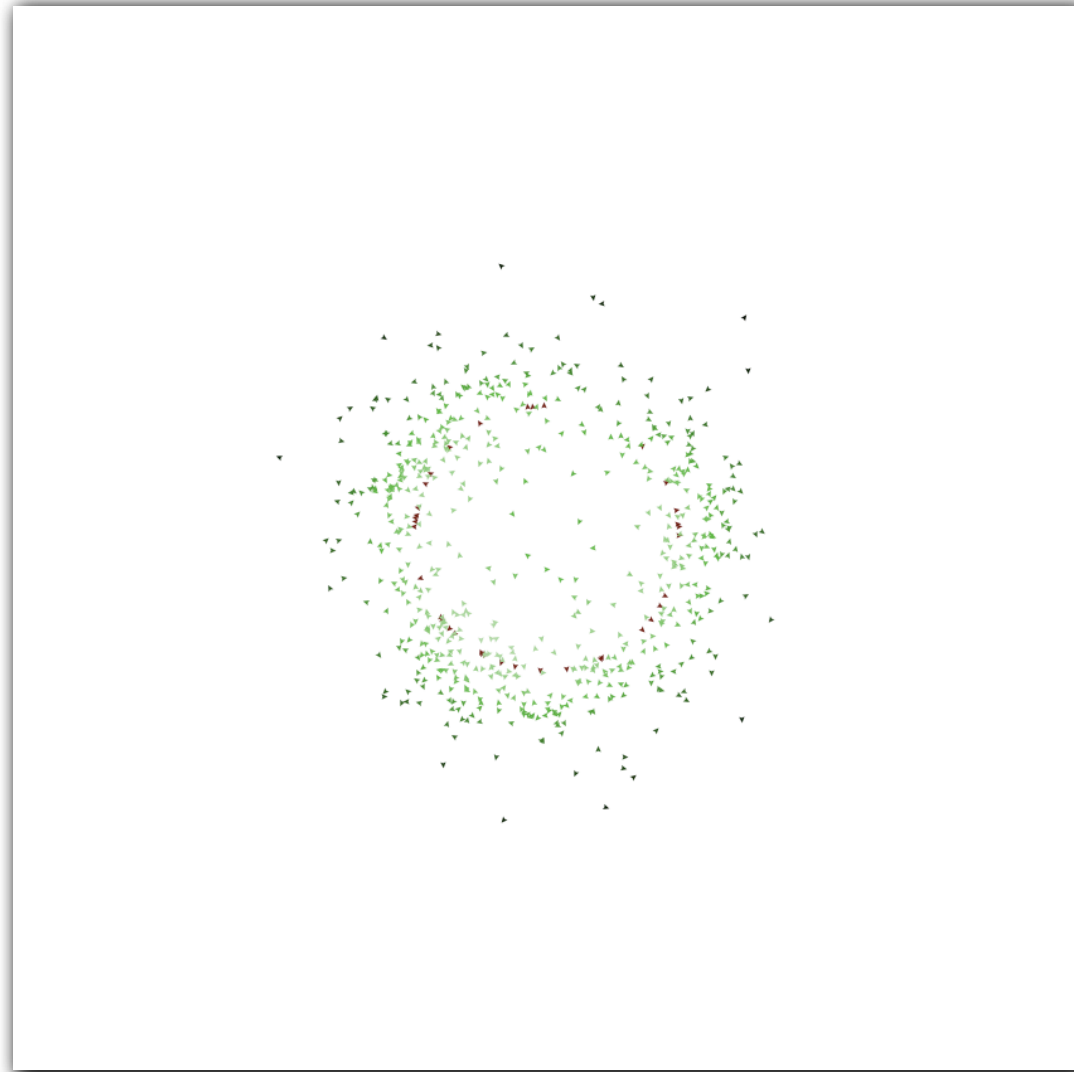


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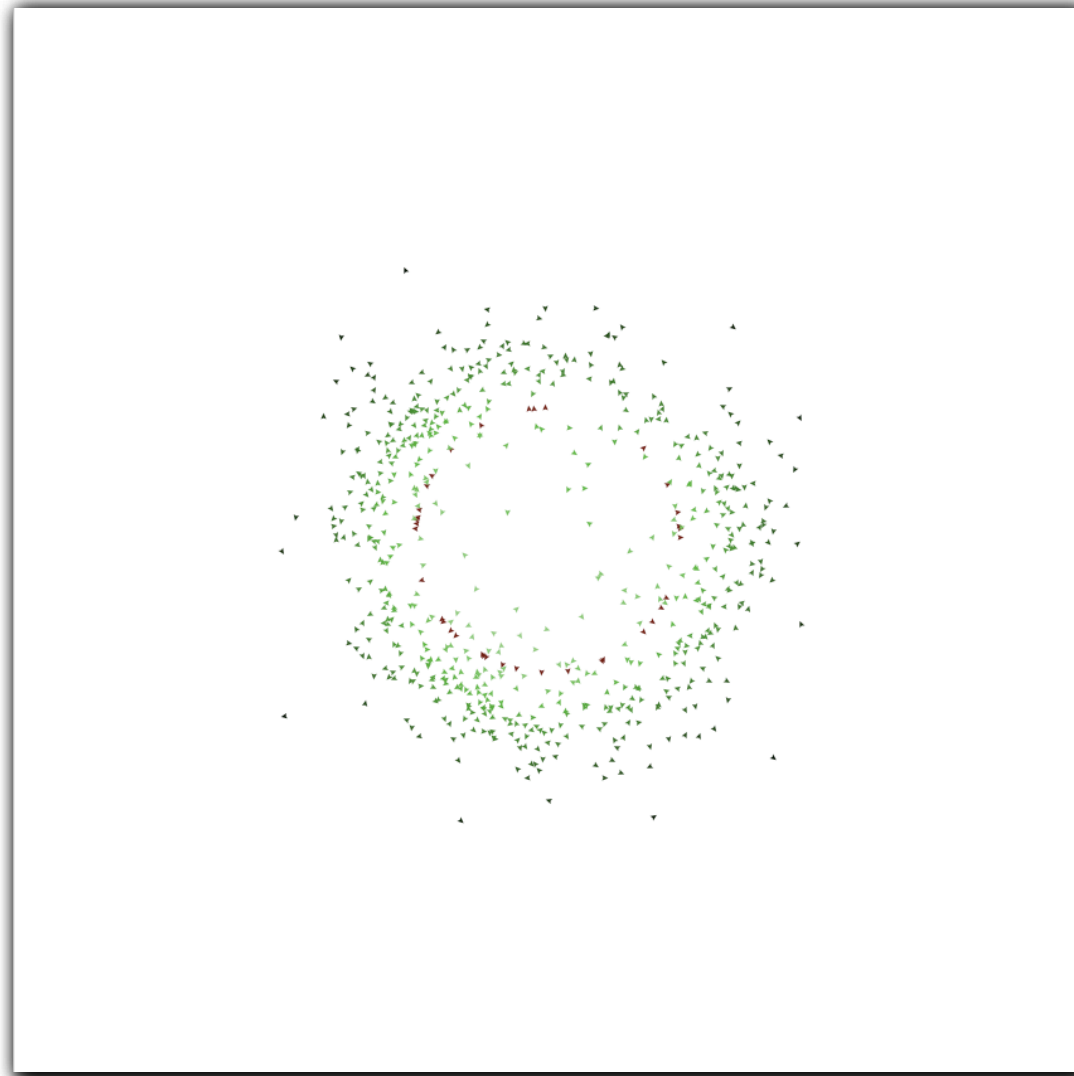
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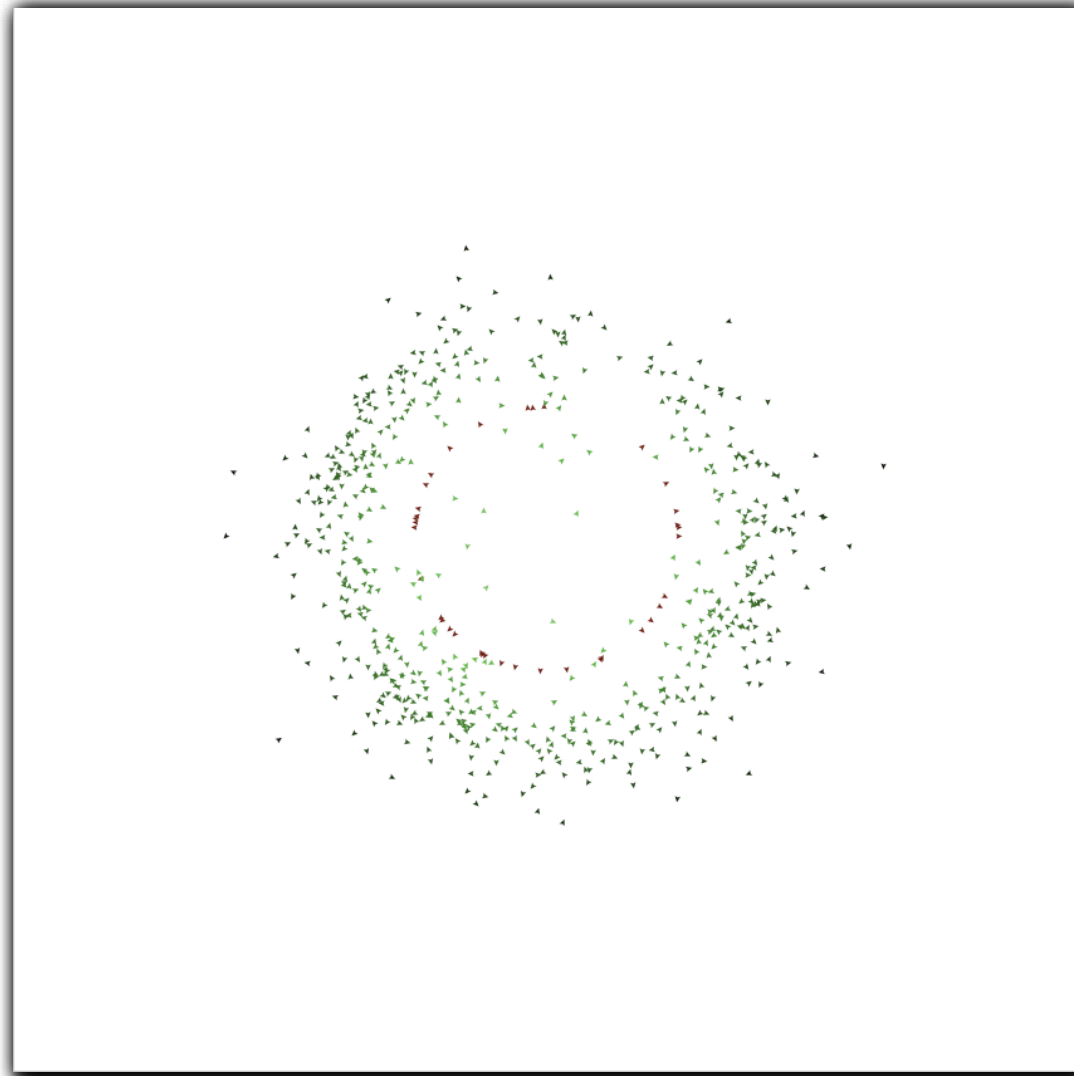


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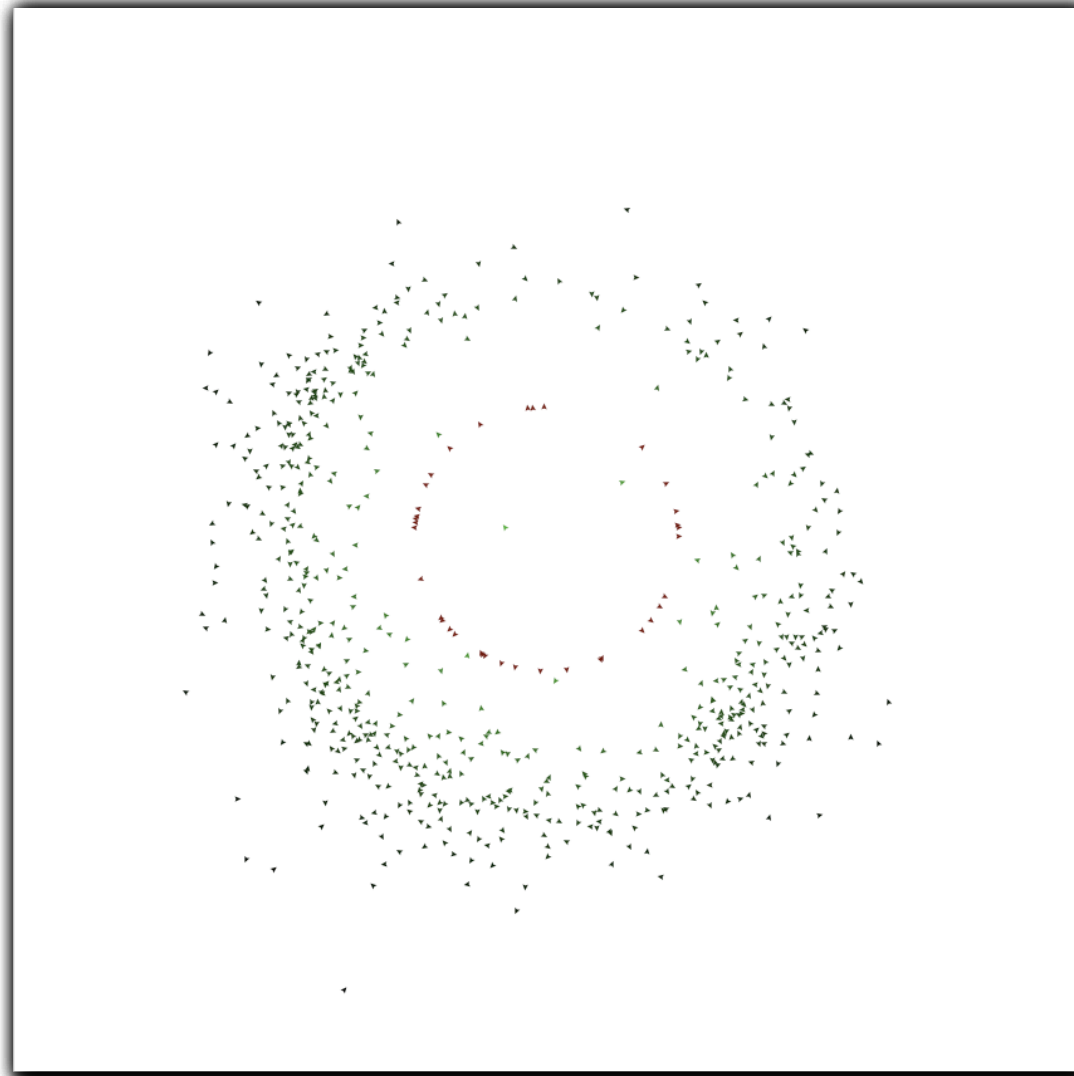


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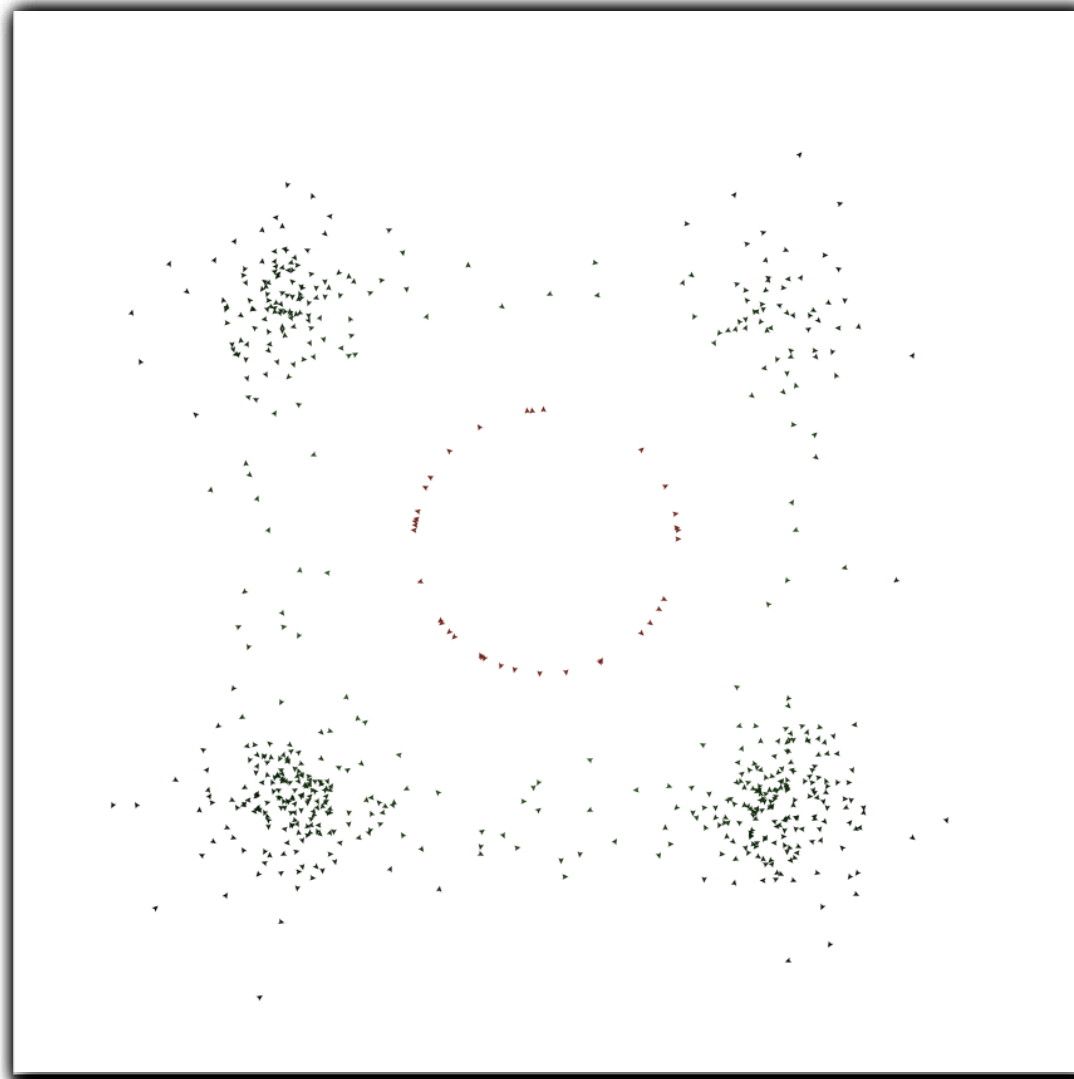
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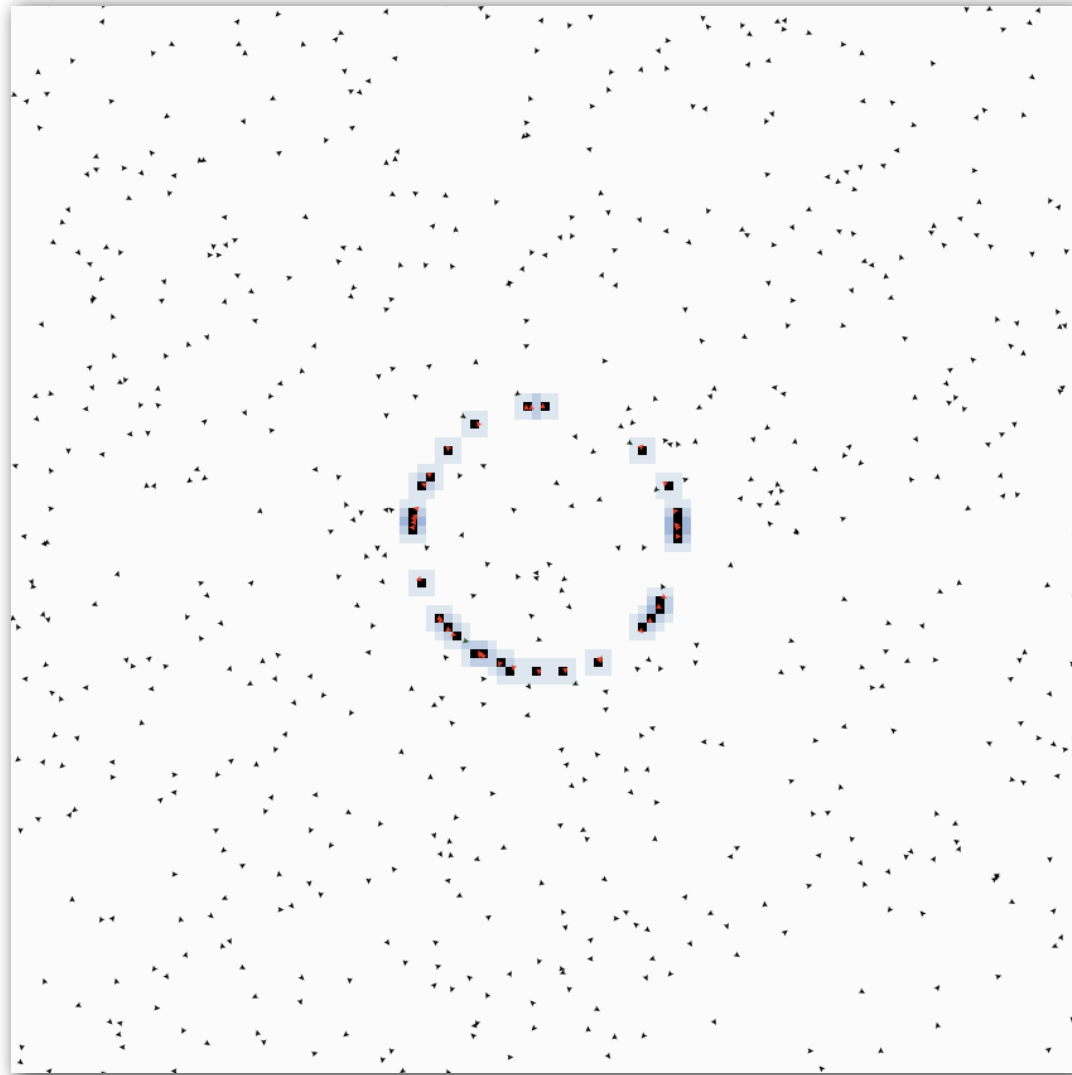
Restart

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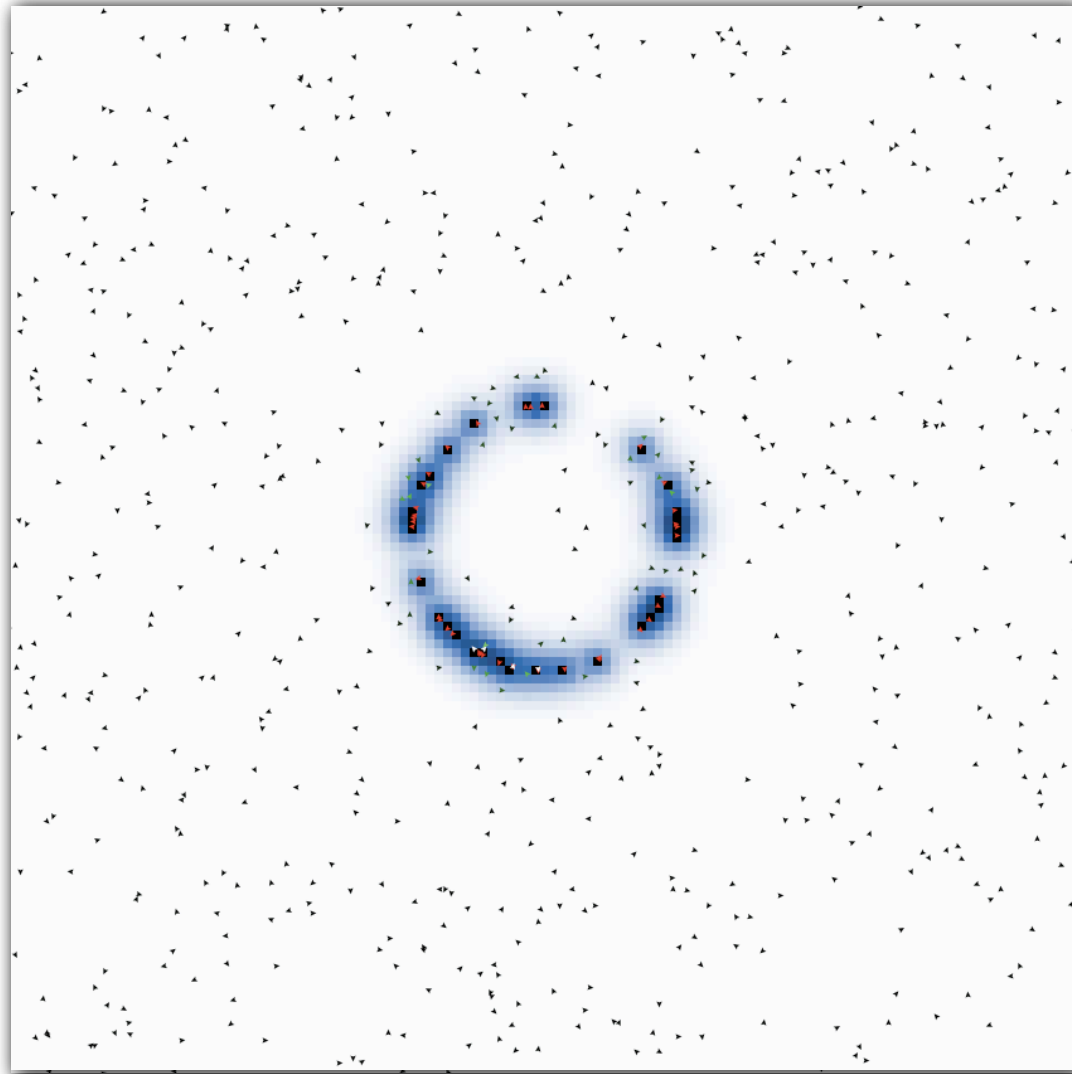
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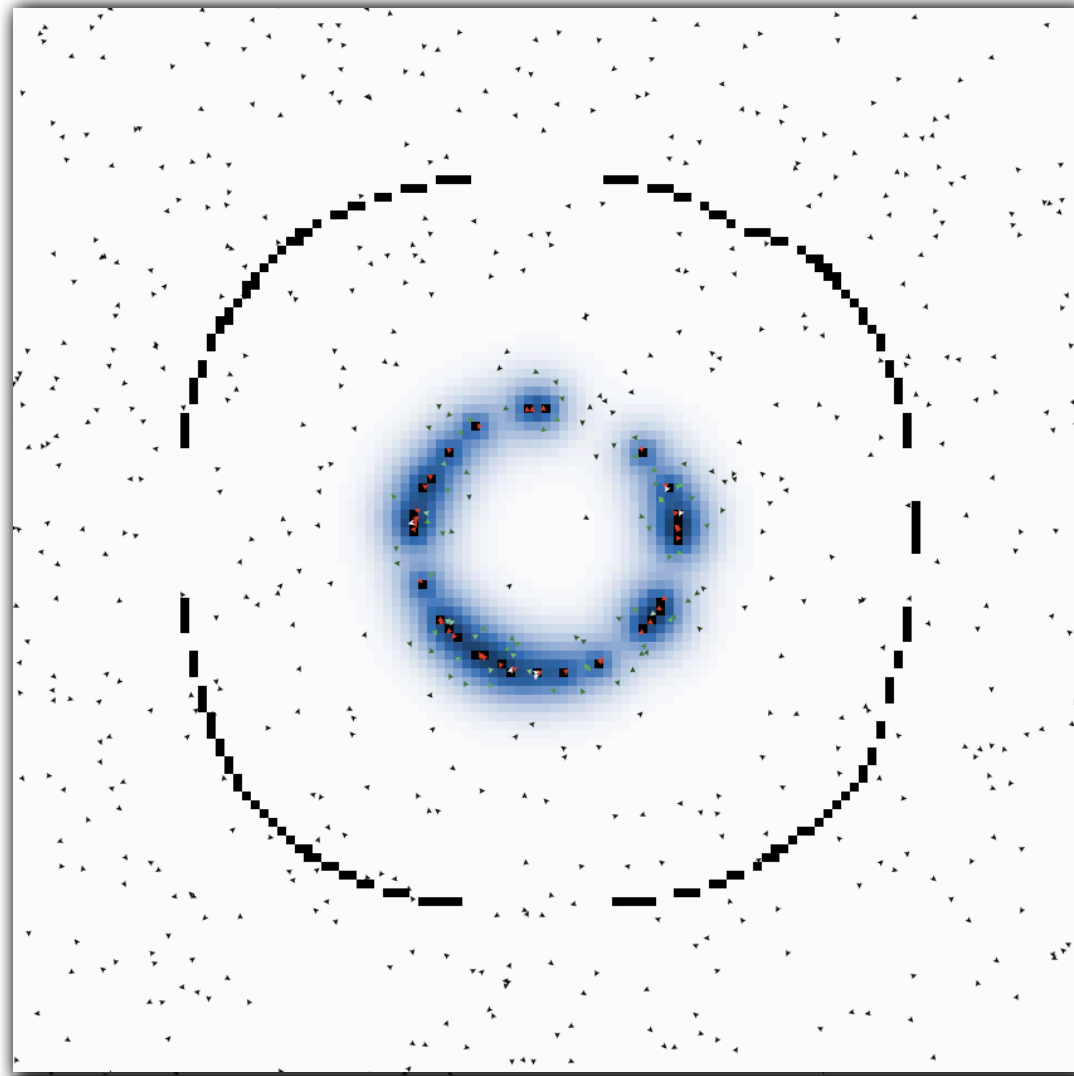


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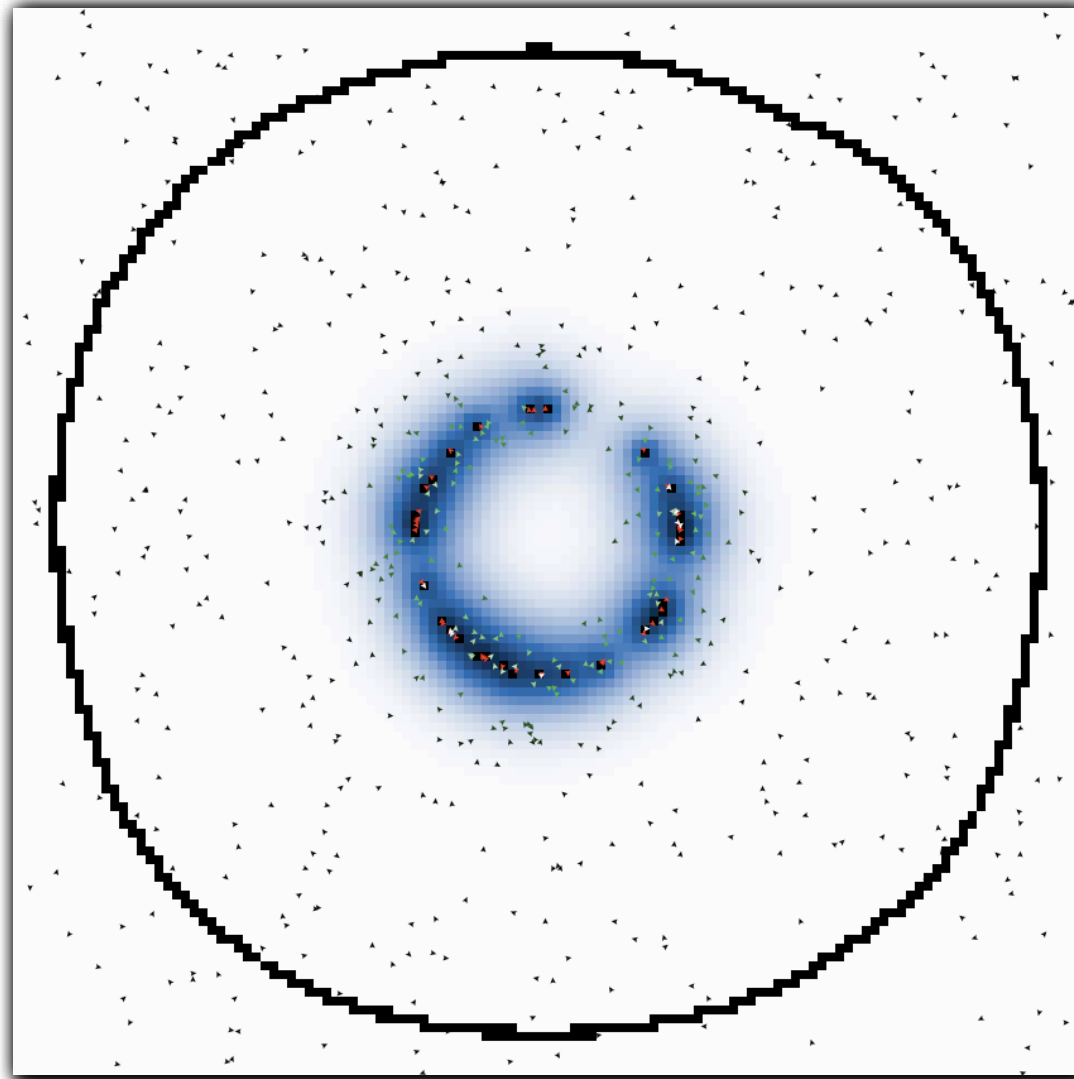


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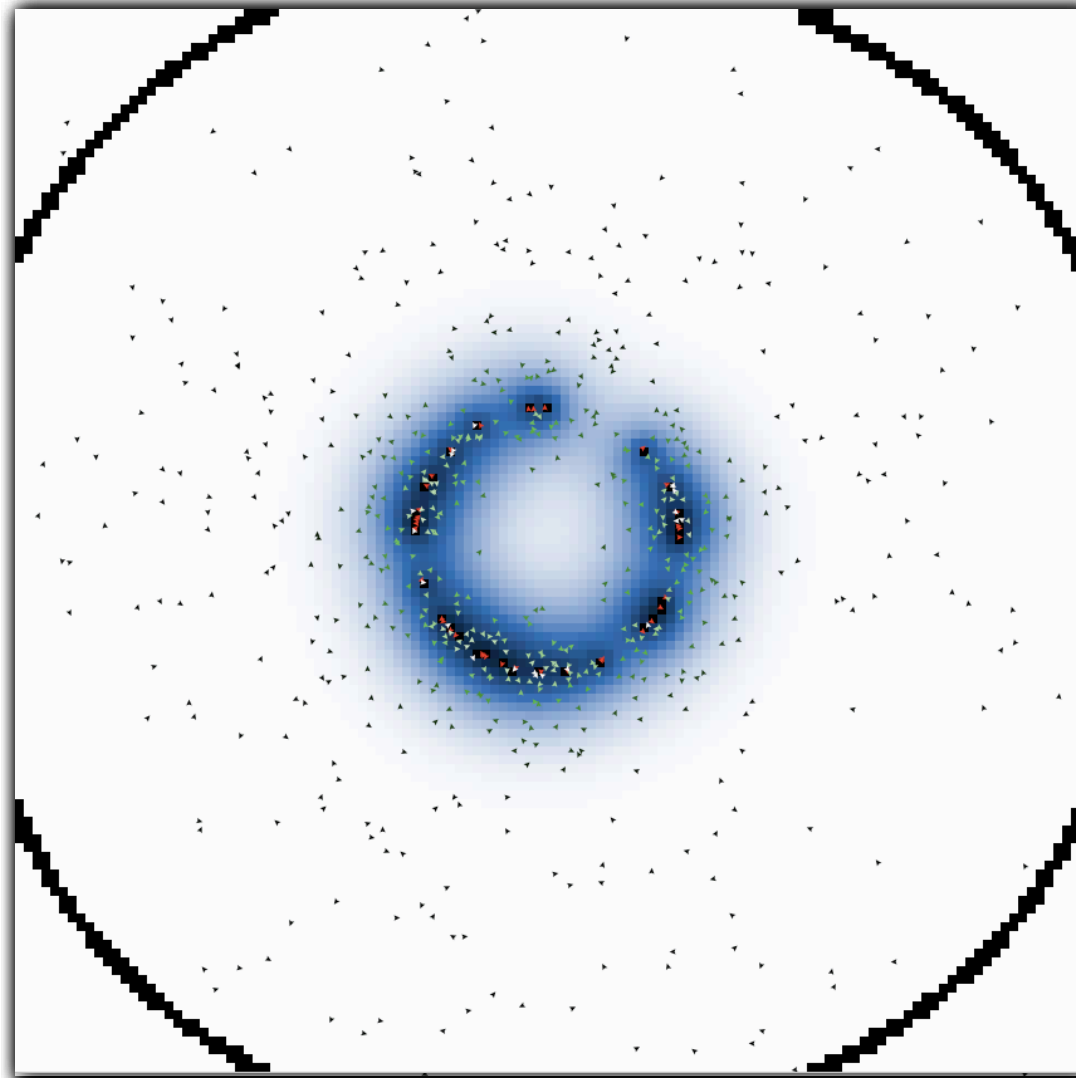


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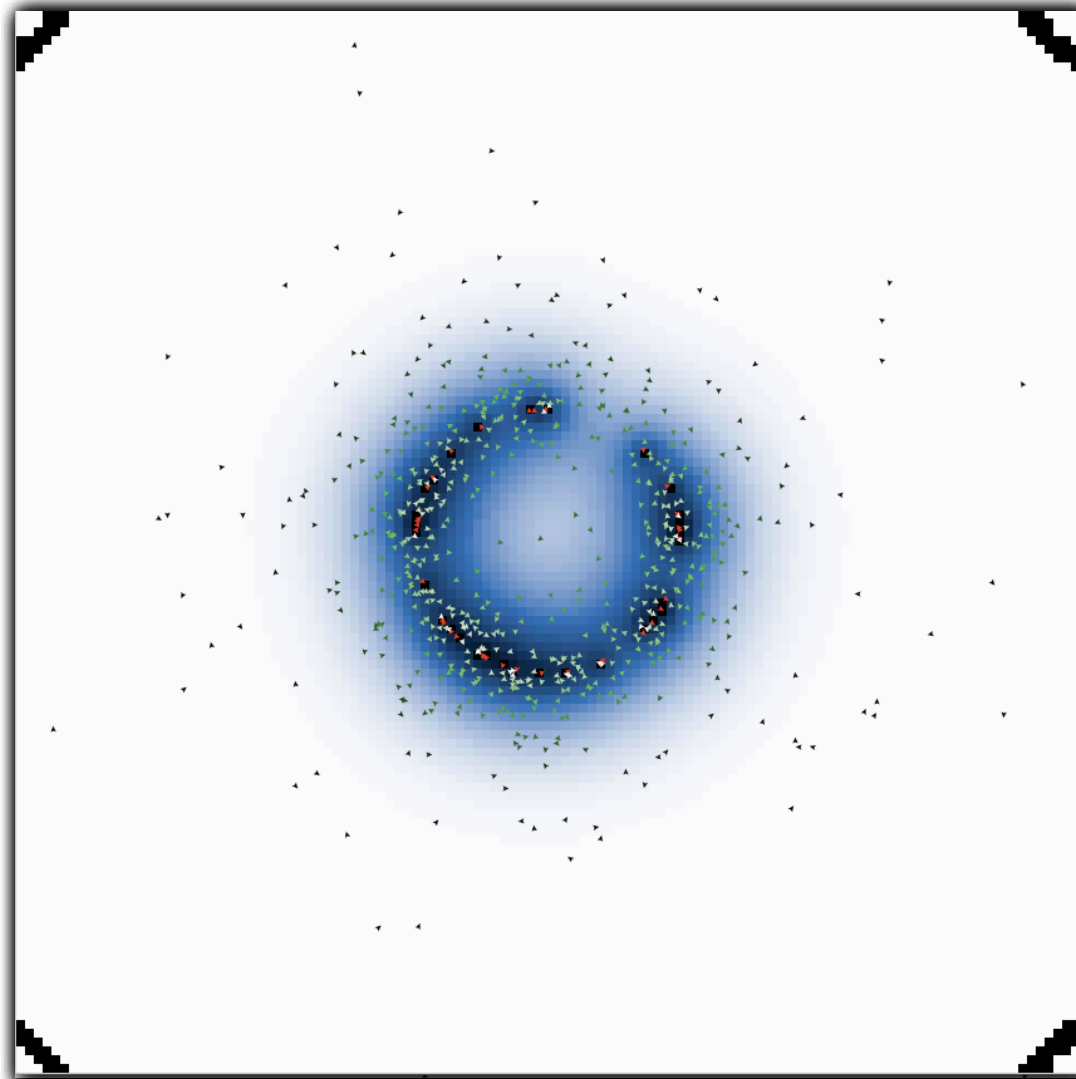
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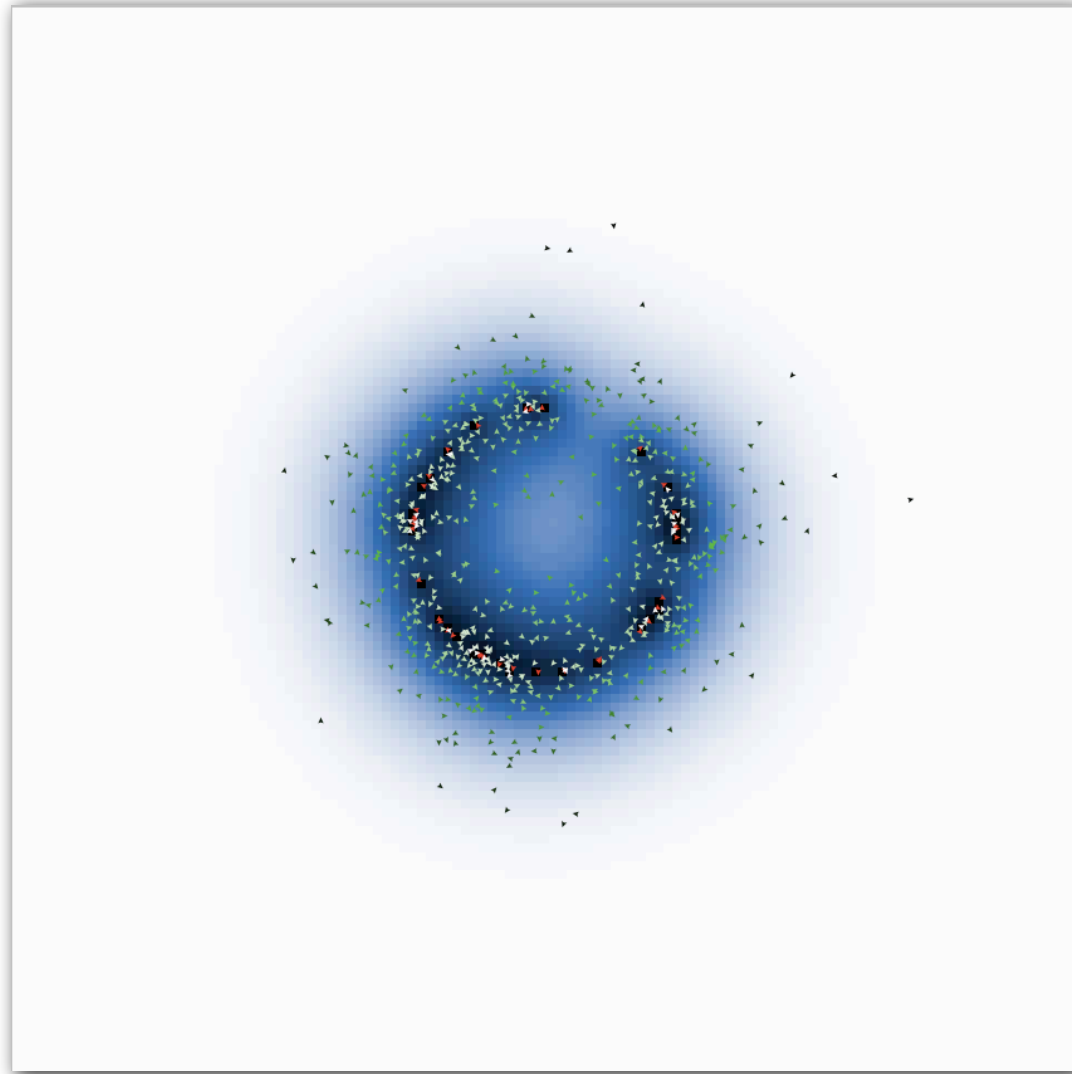


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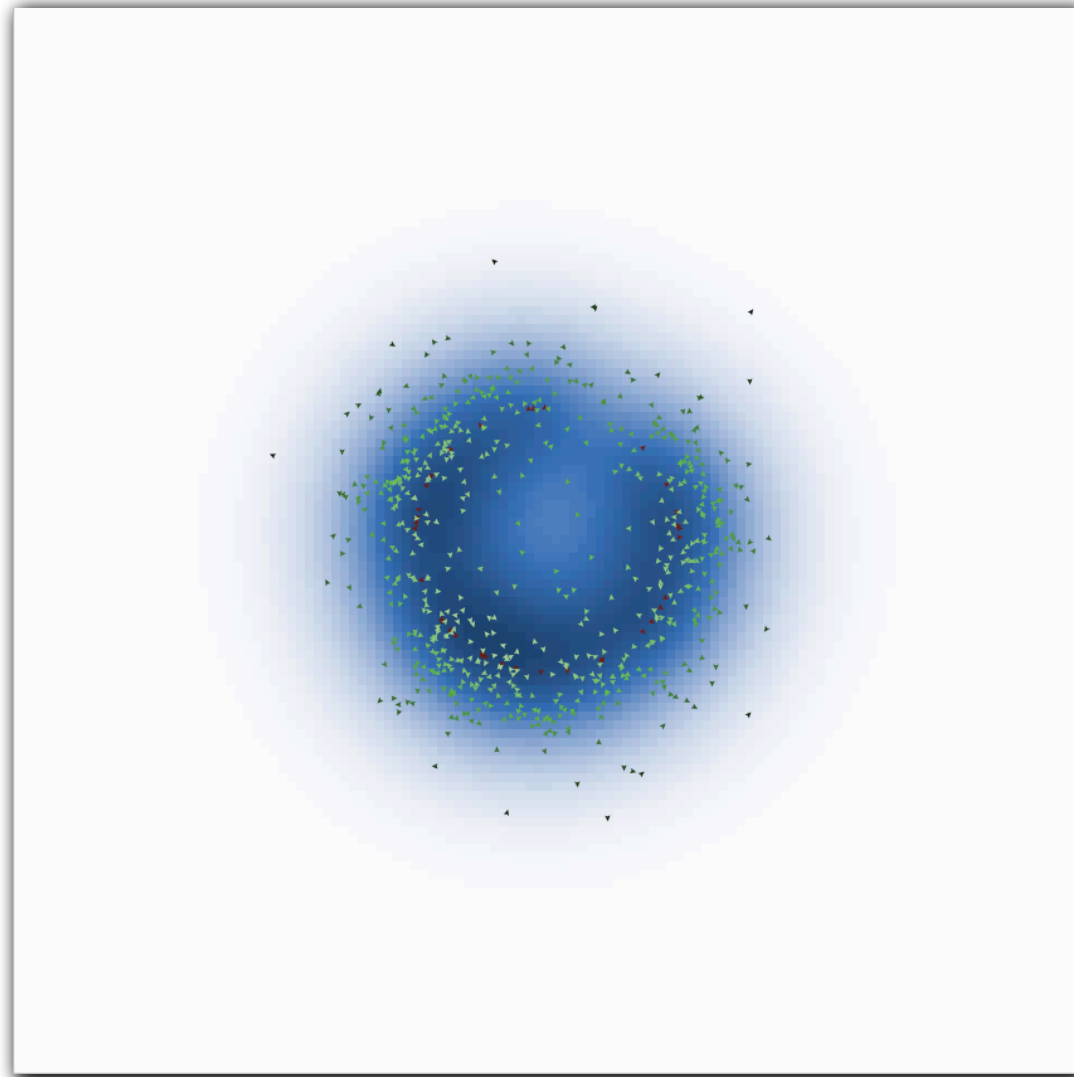


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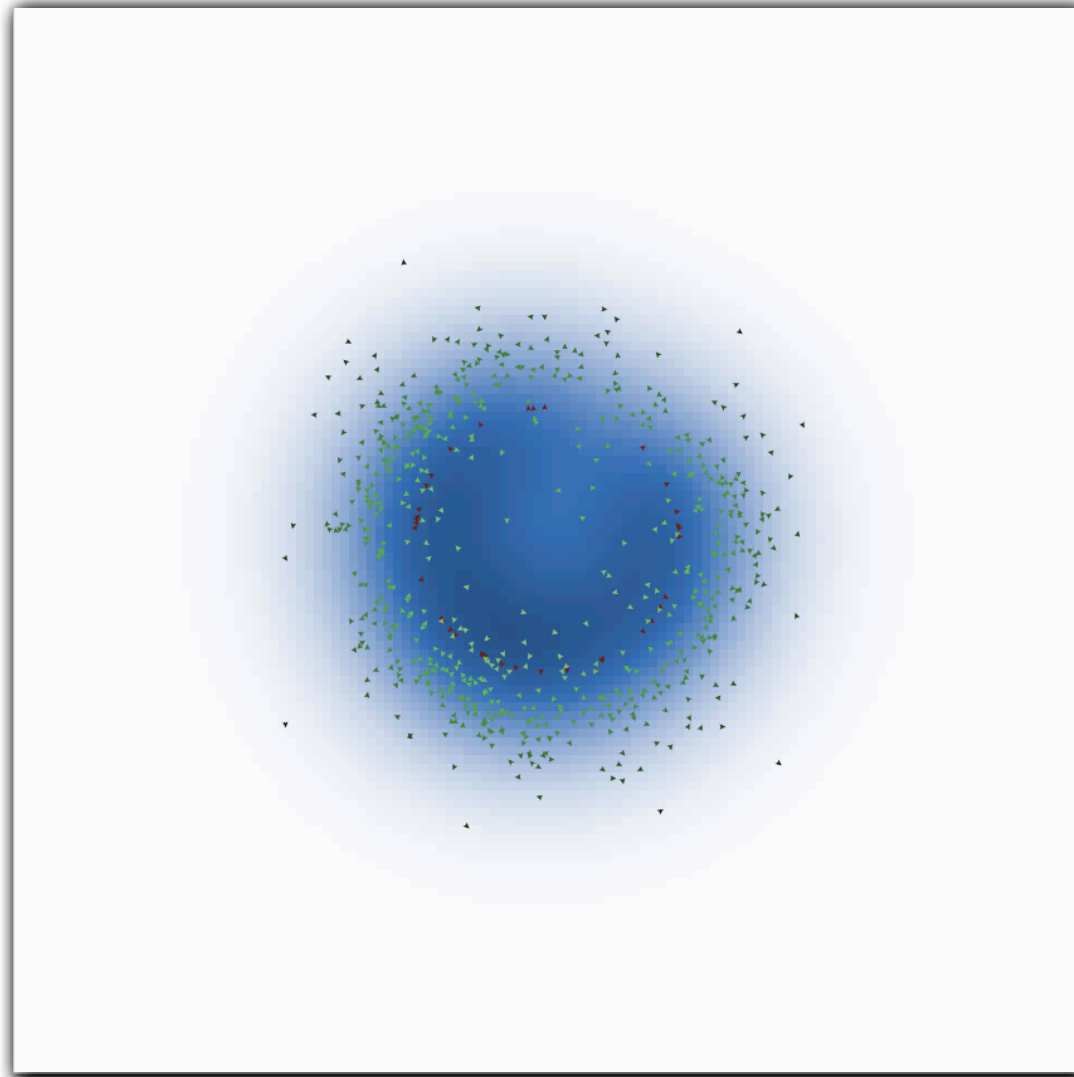


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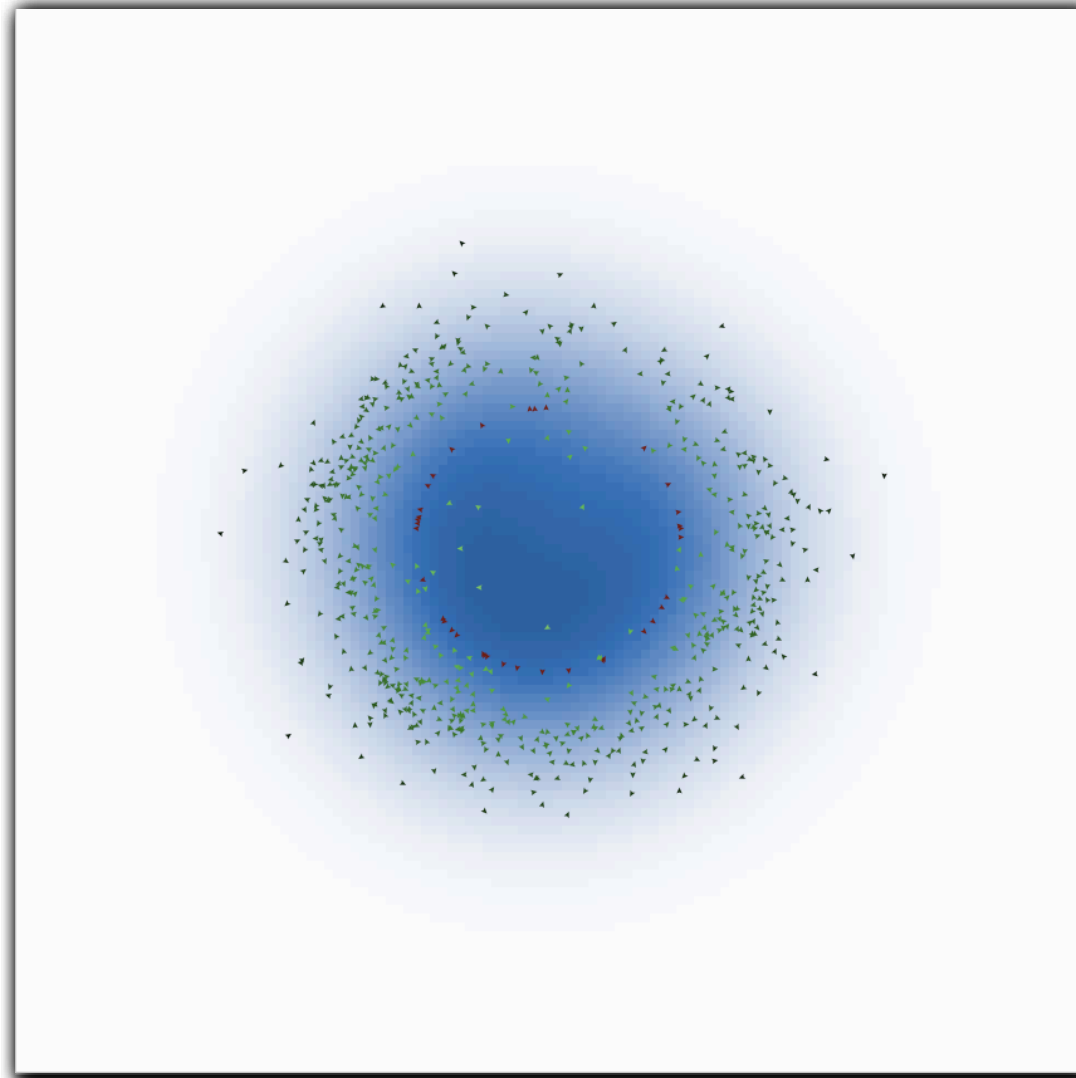


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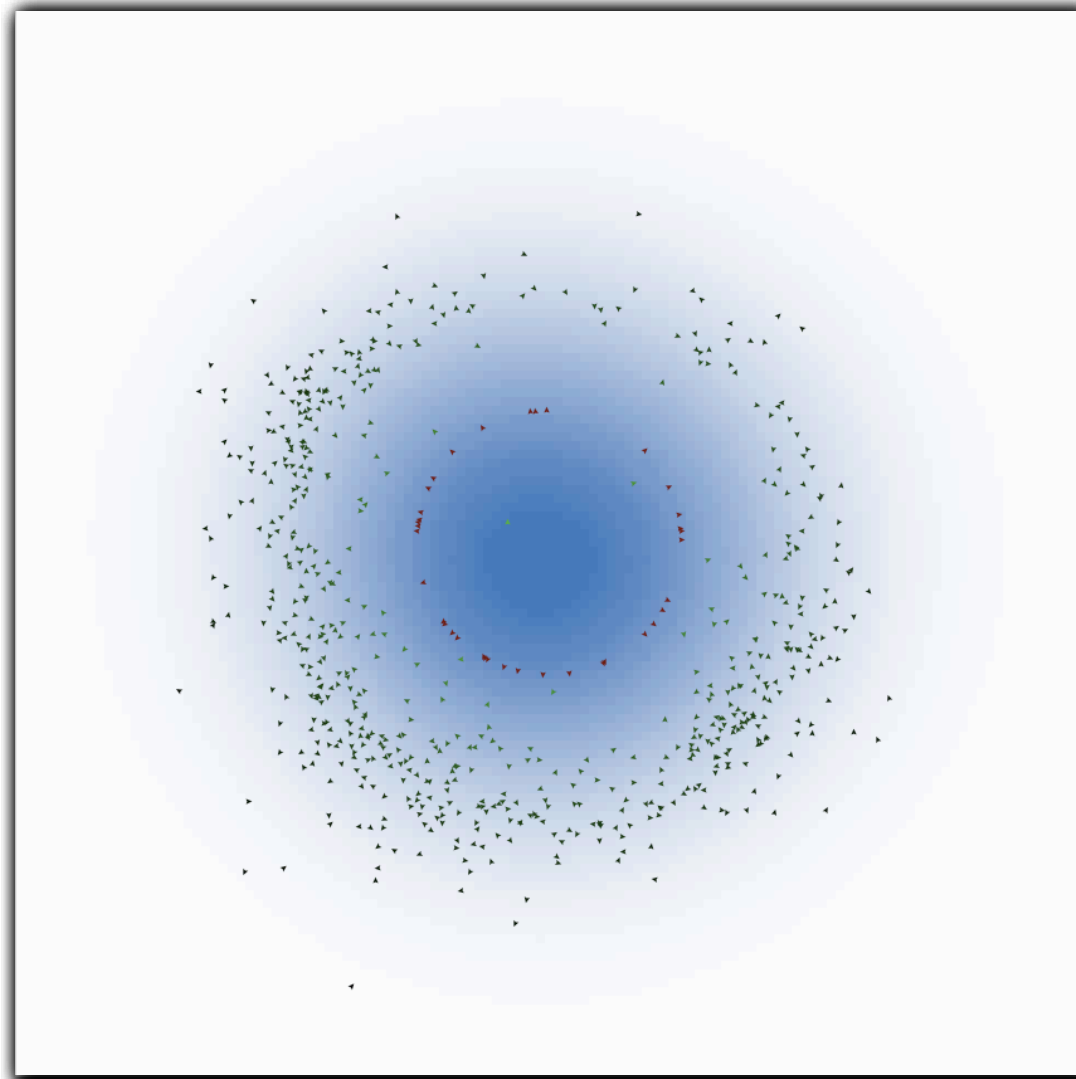
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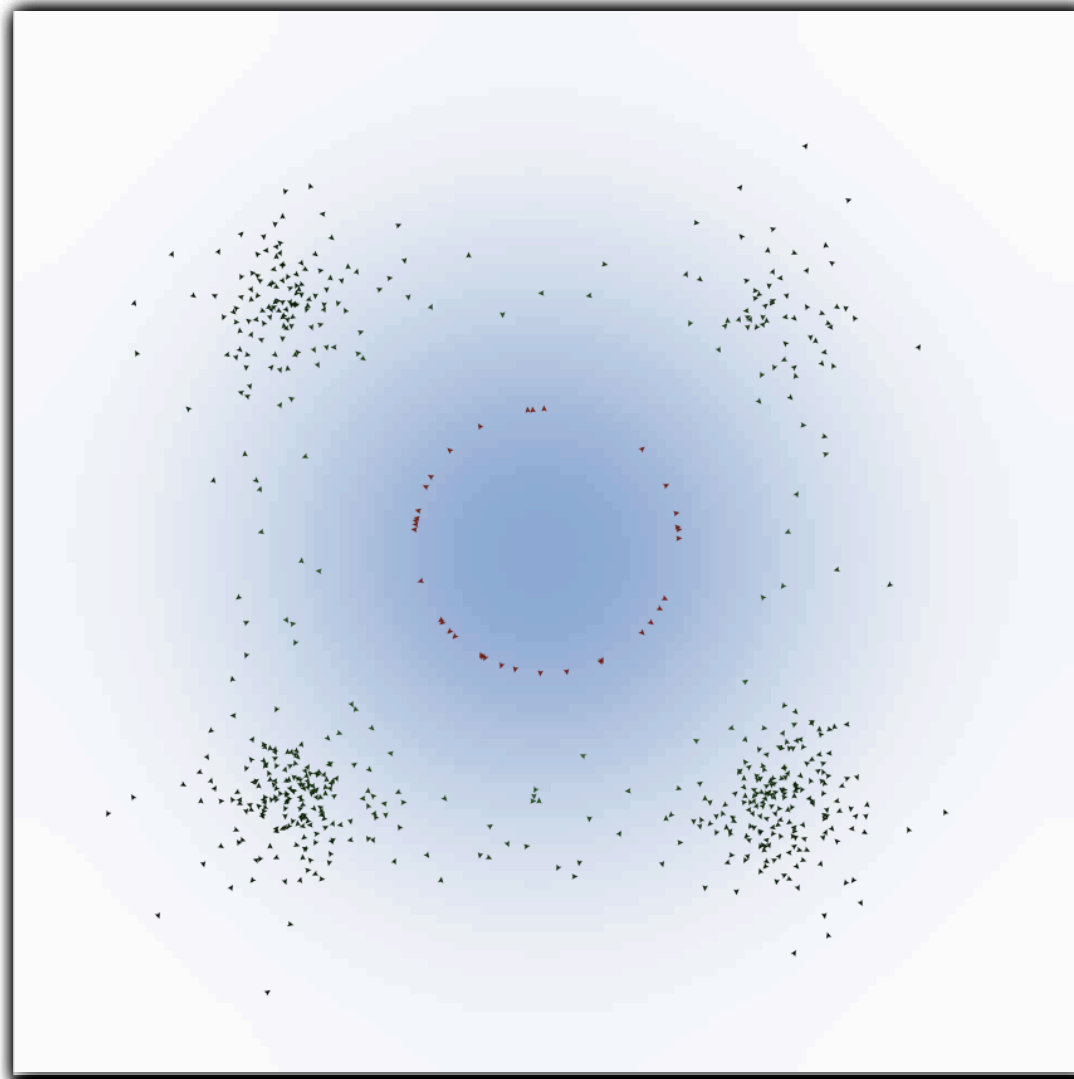


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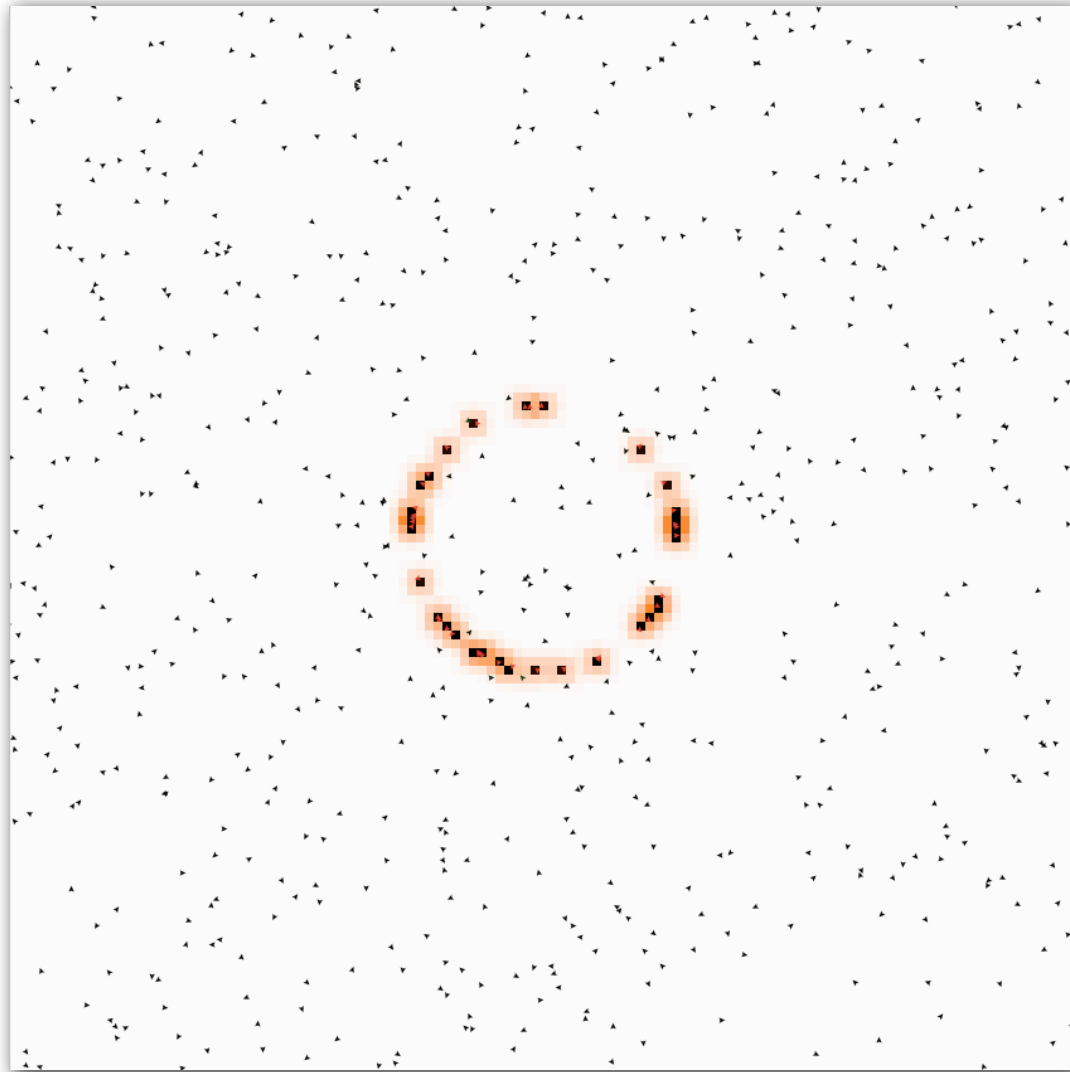
Restart

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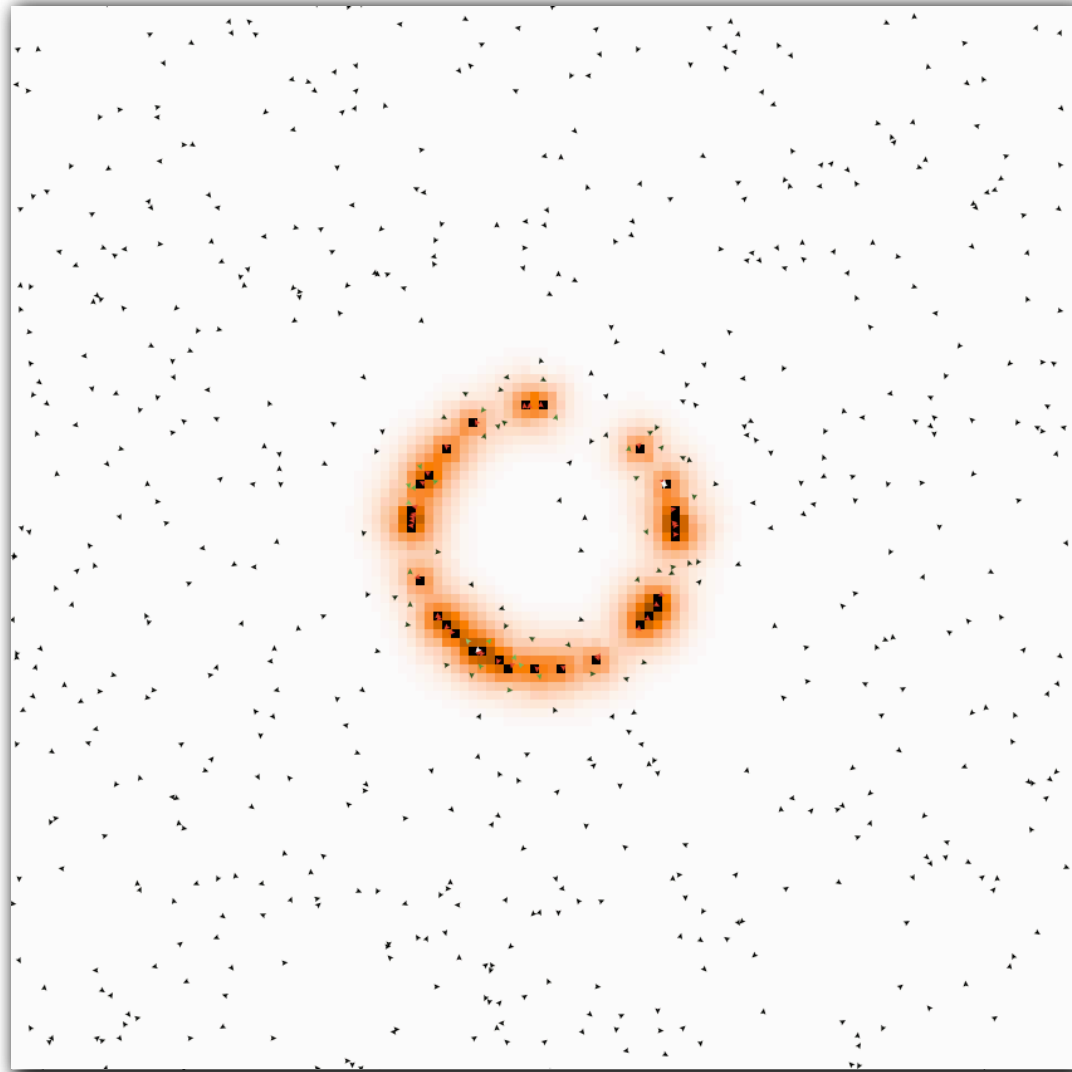


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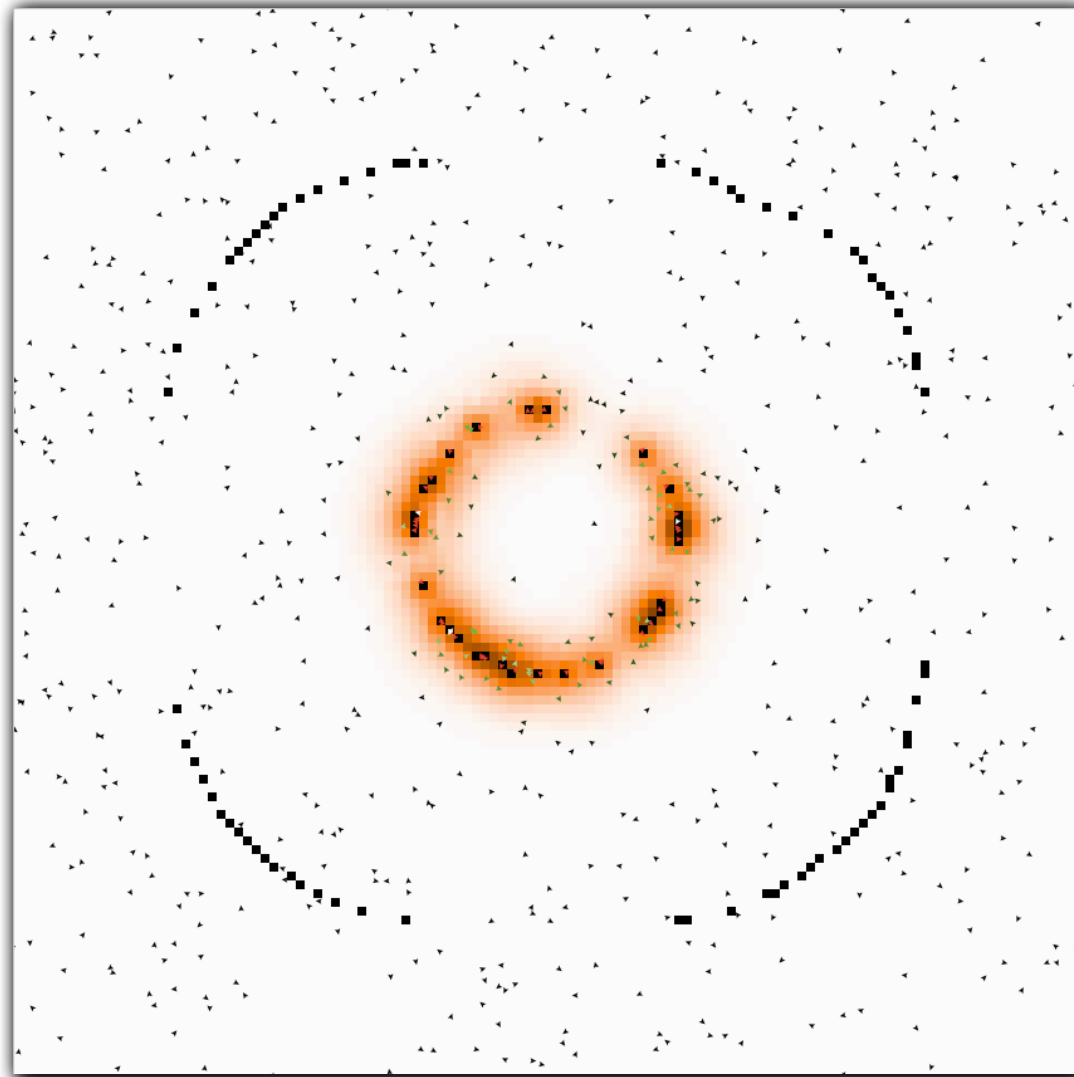


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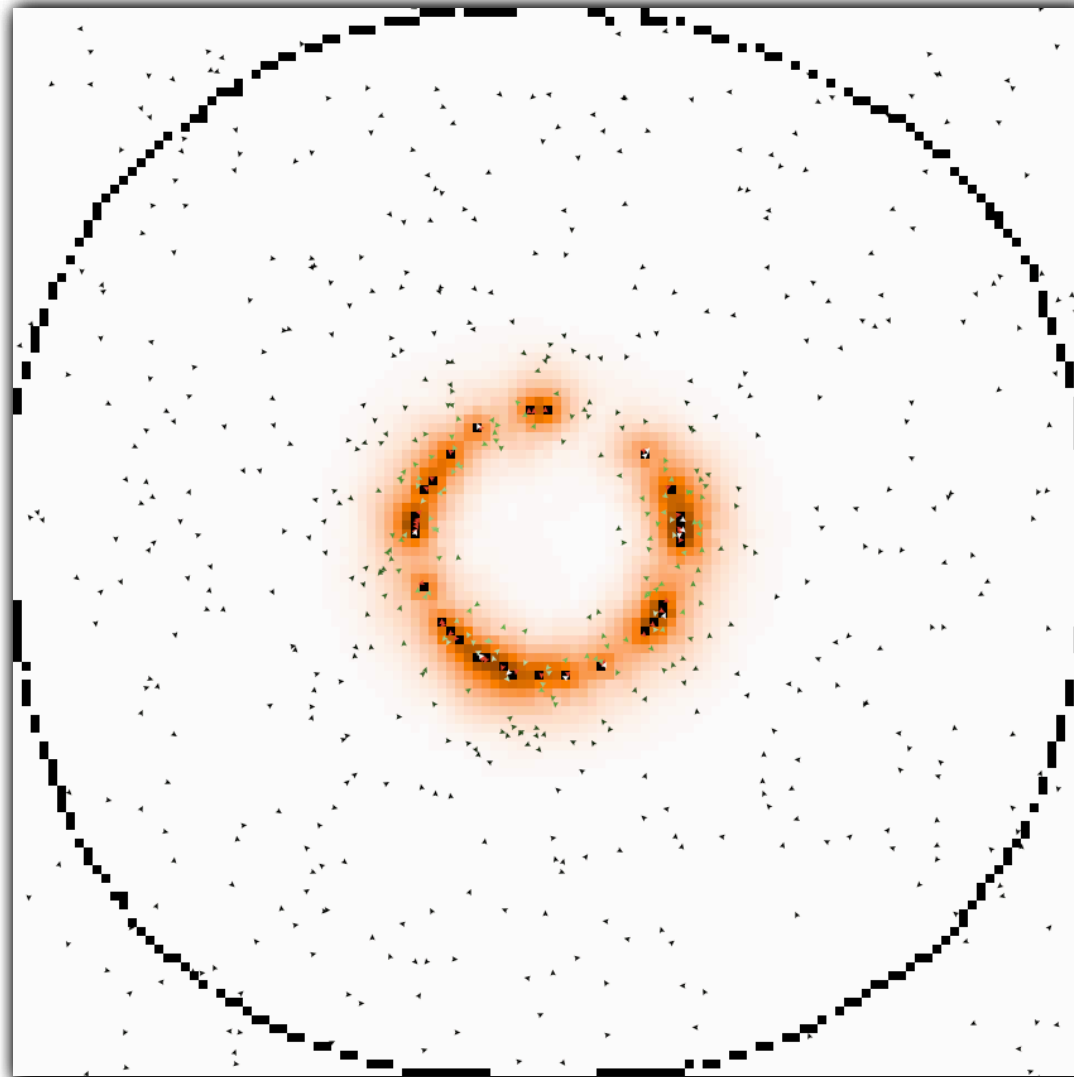


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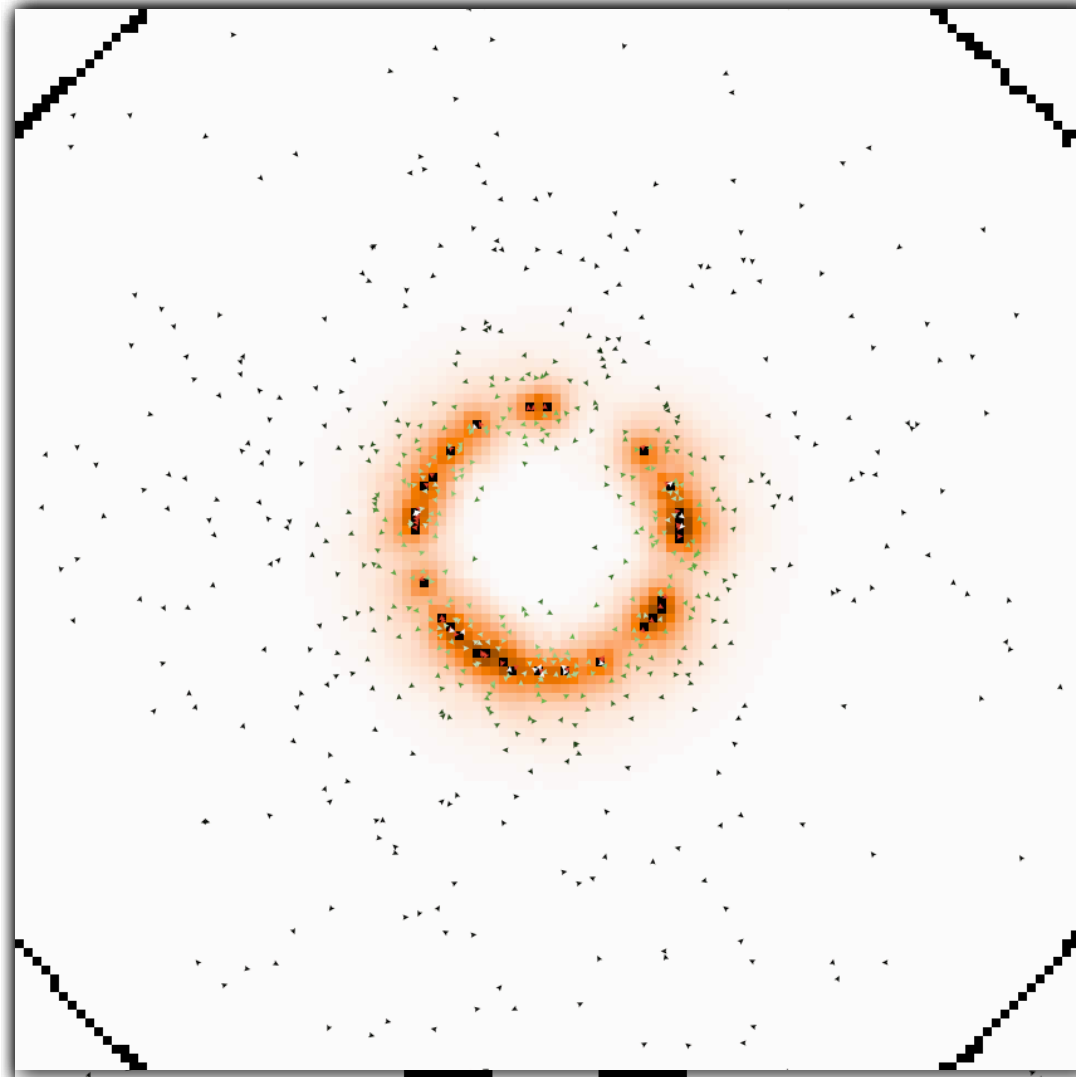


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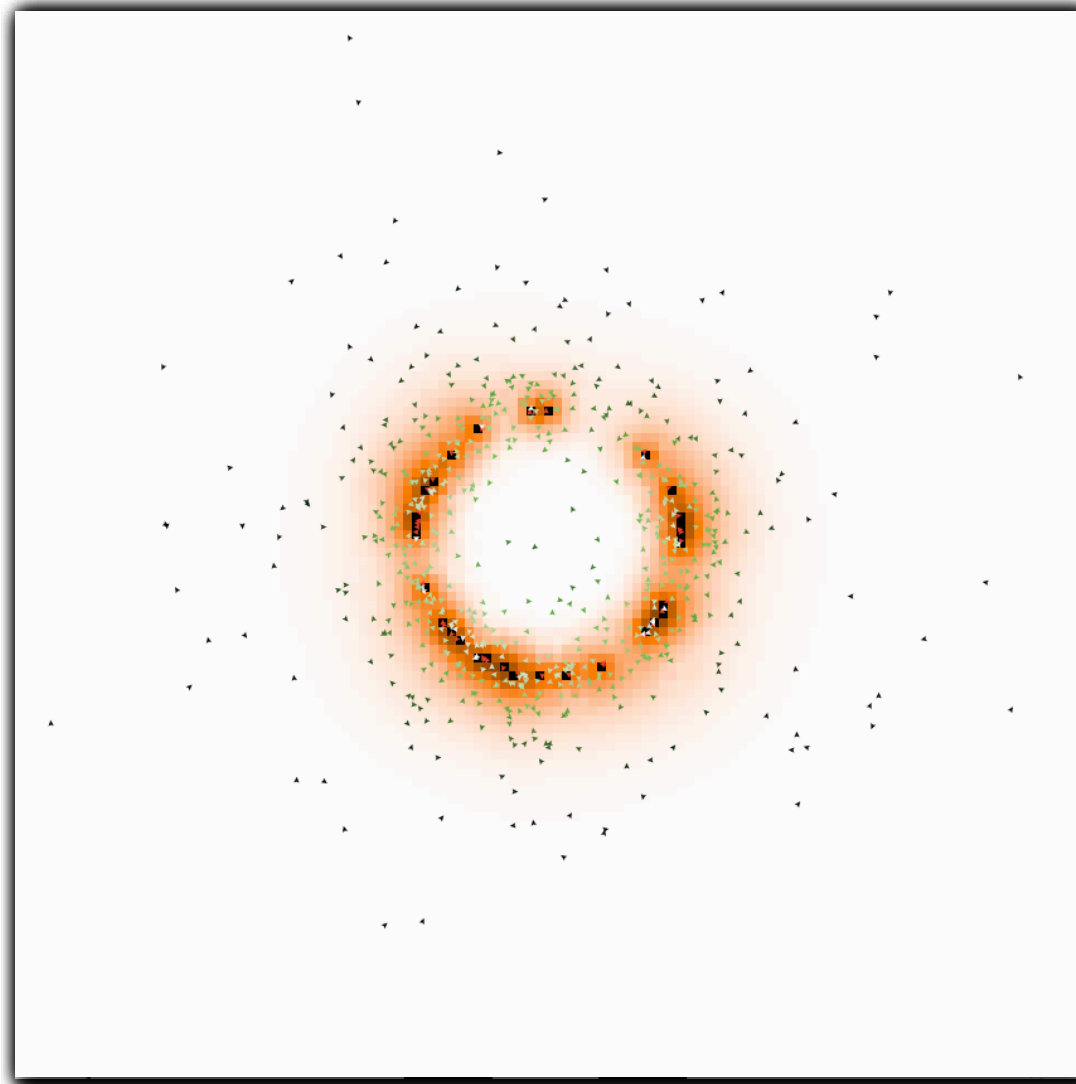


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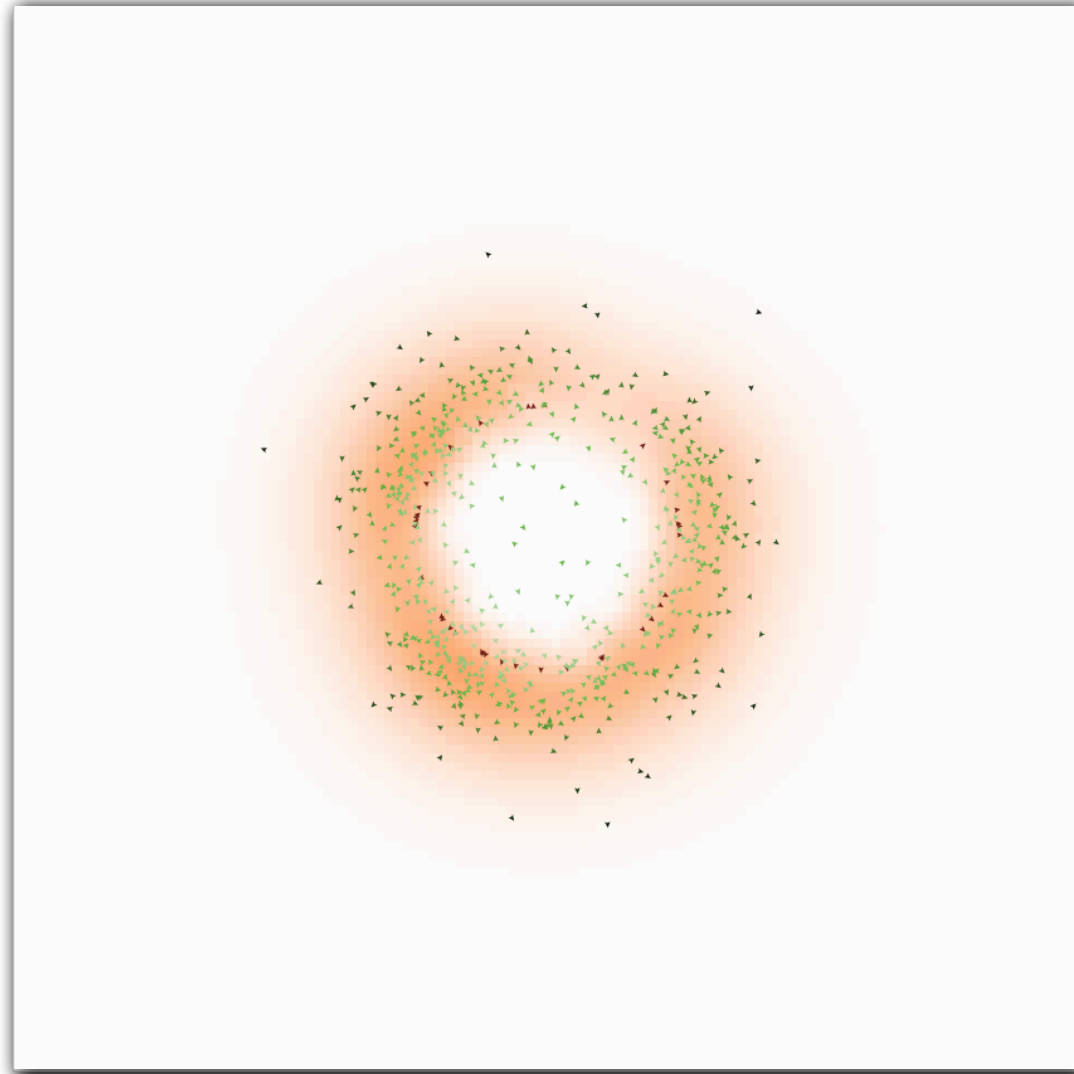


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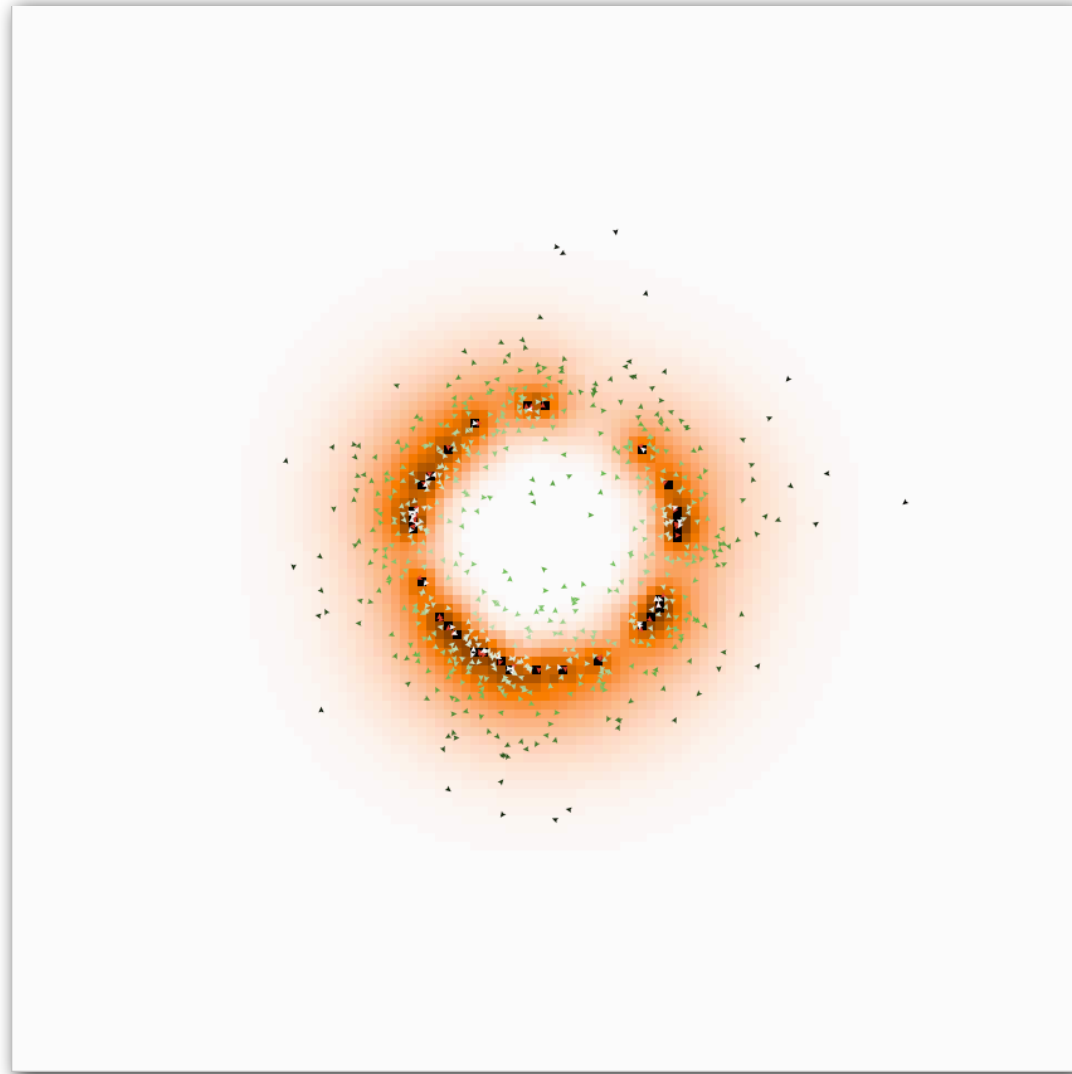


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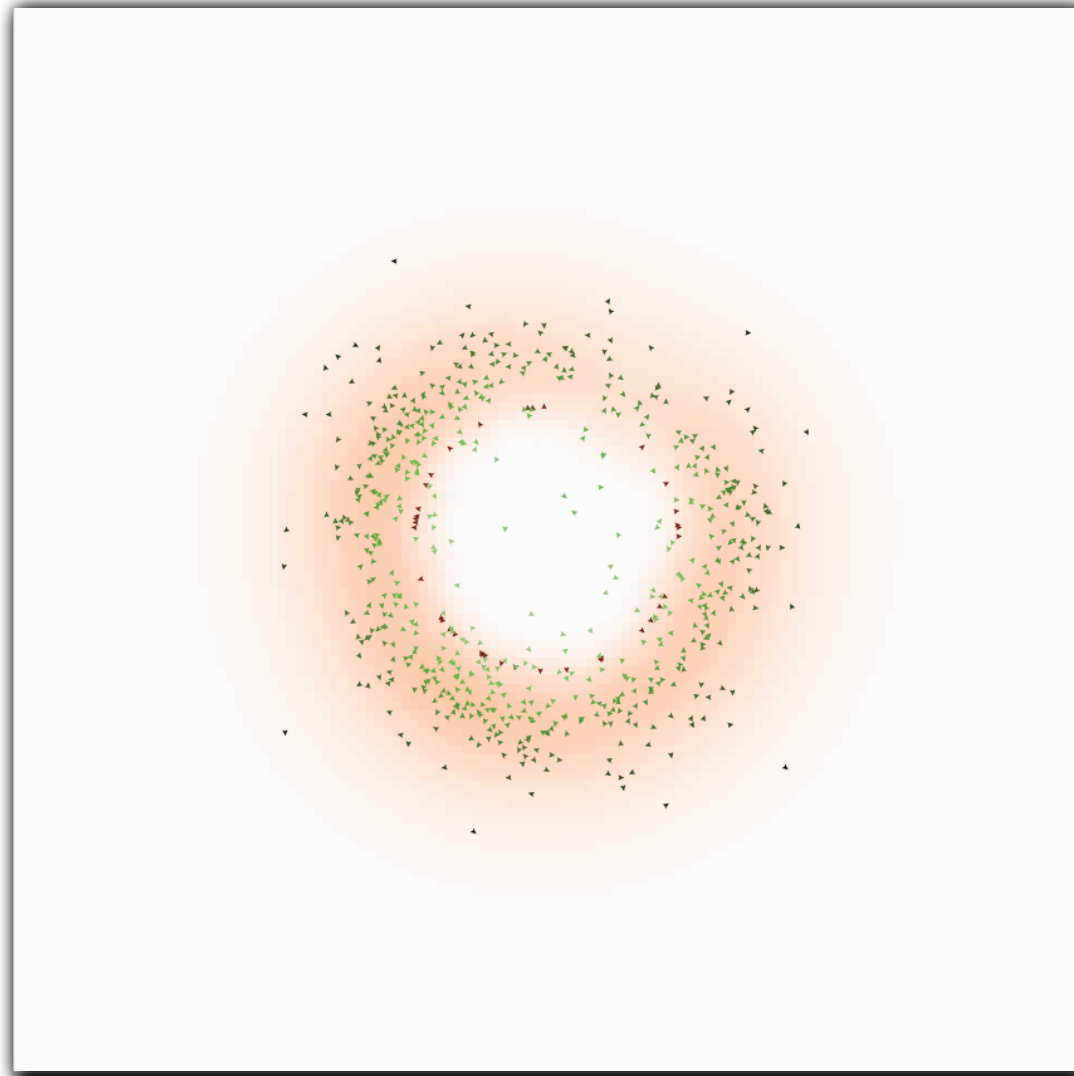


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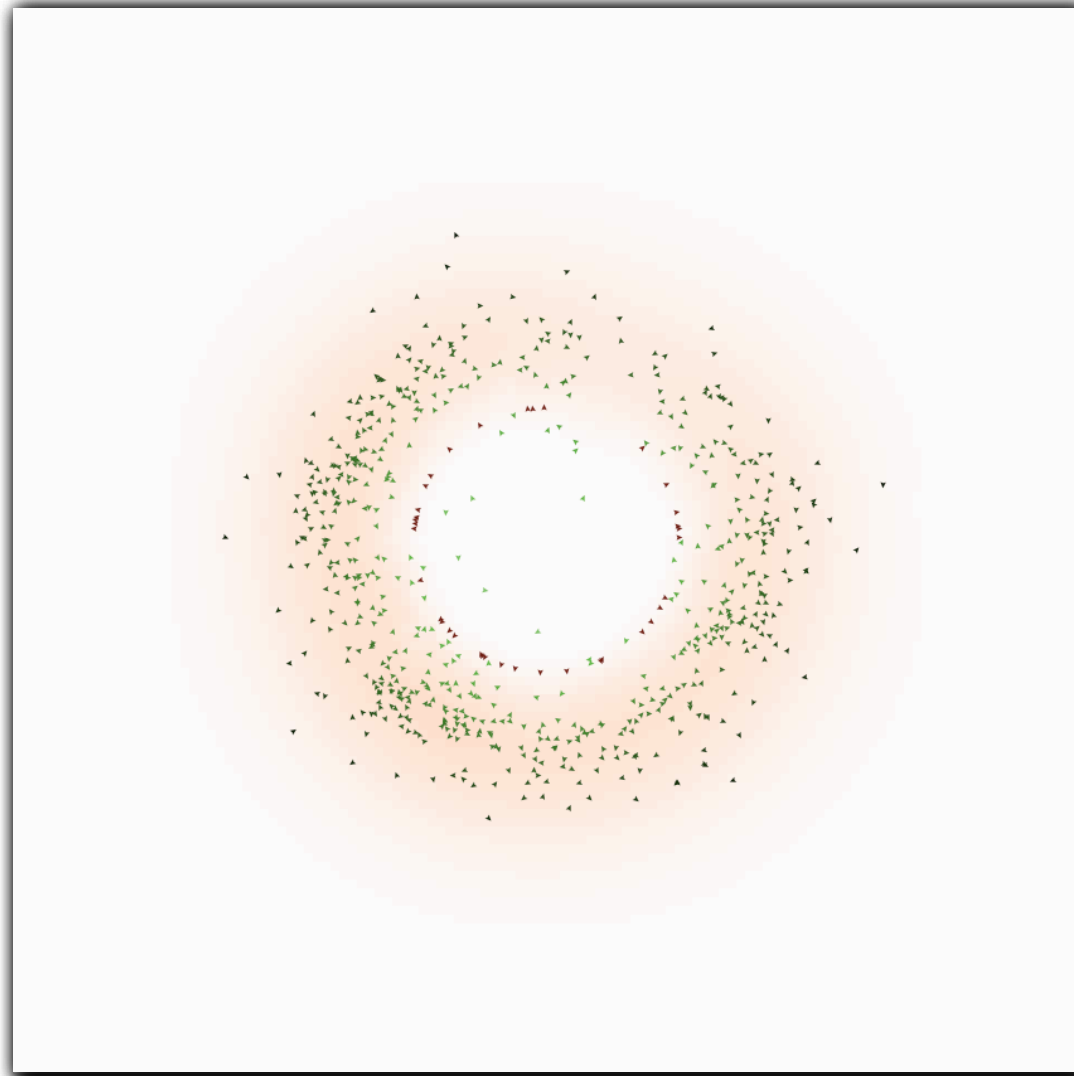


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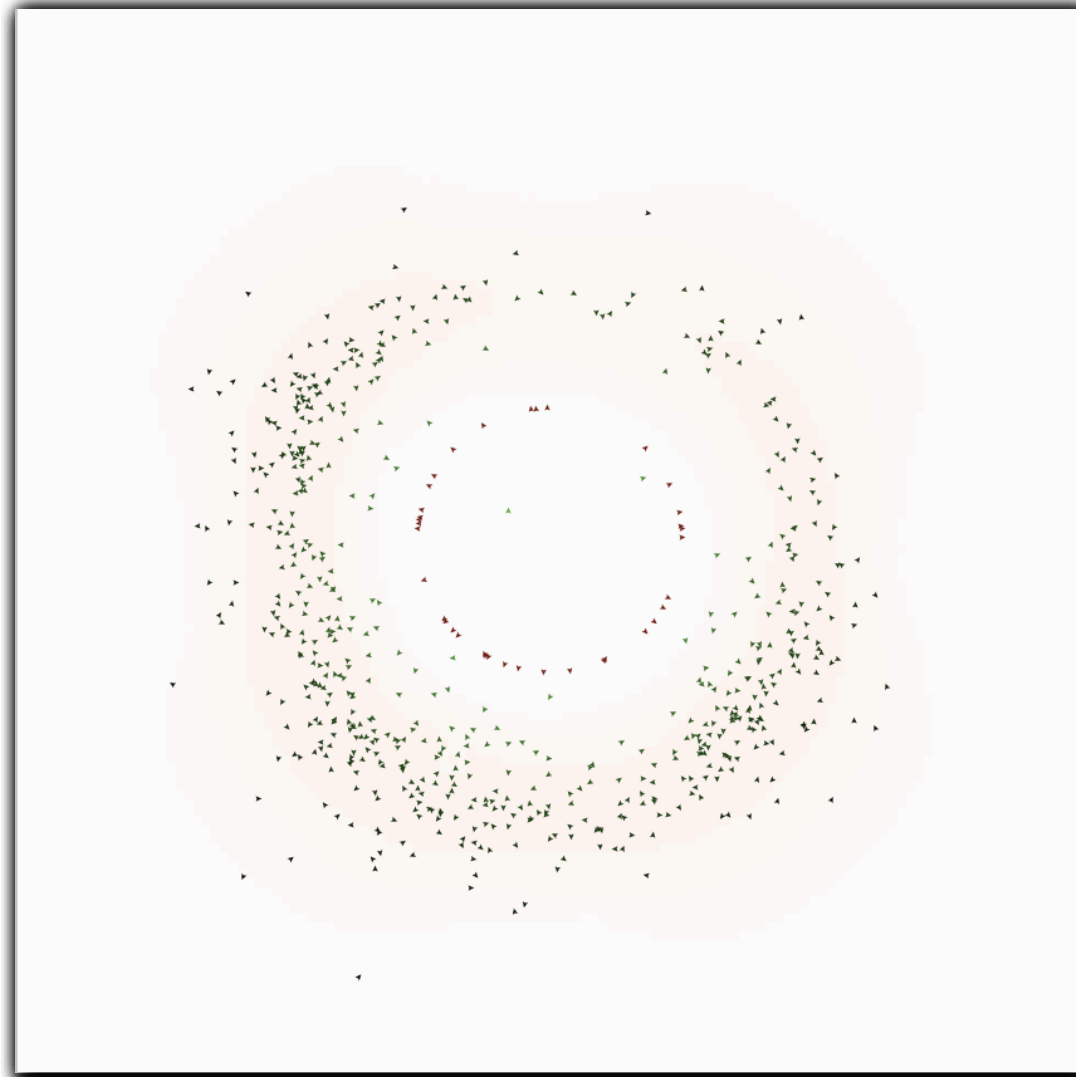


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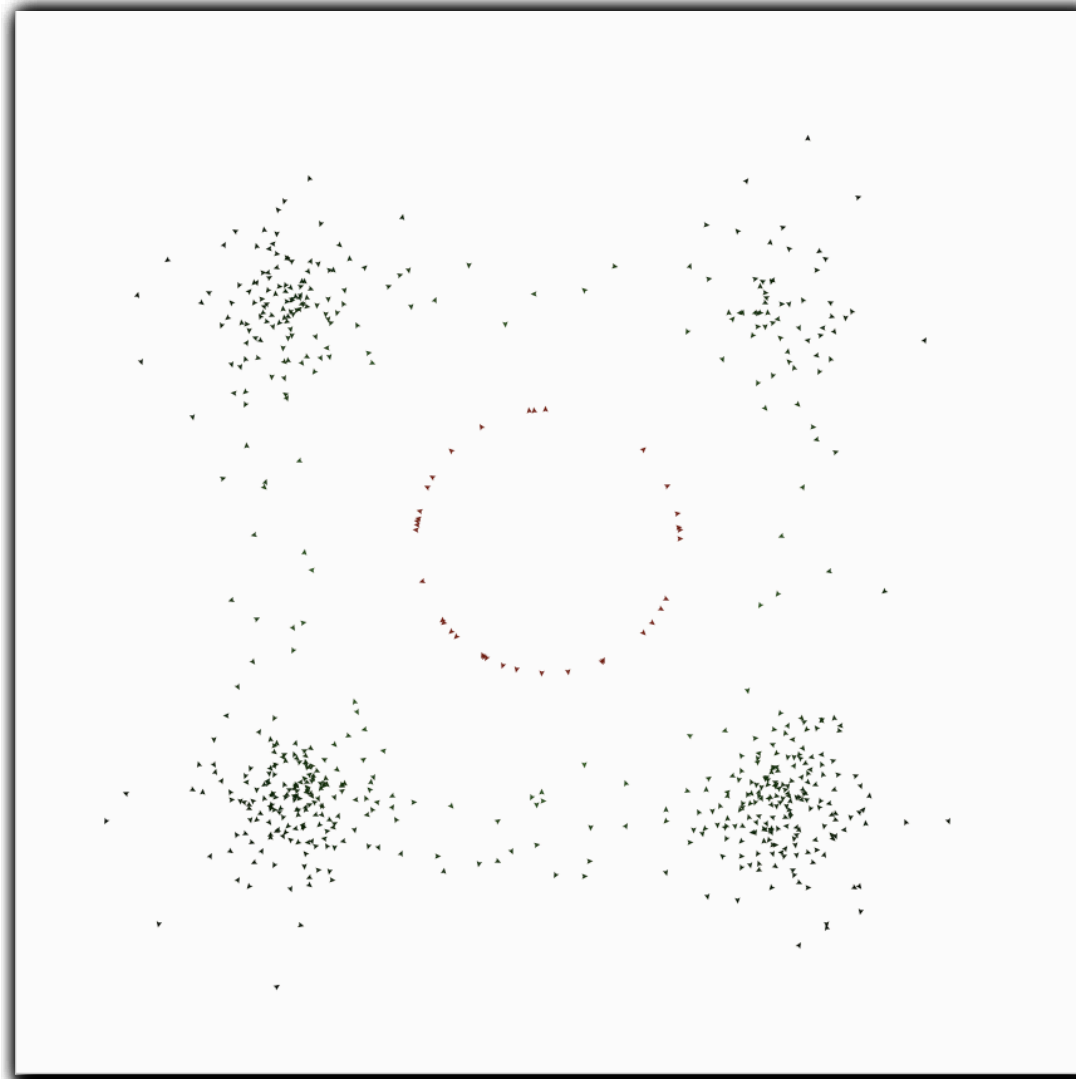
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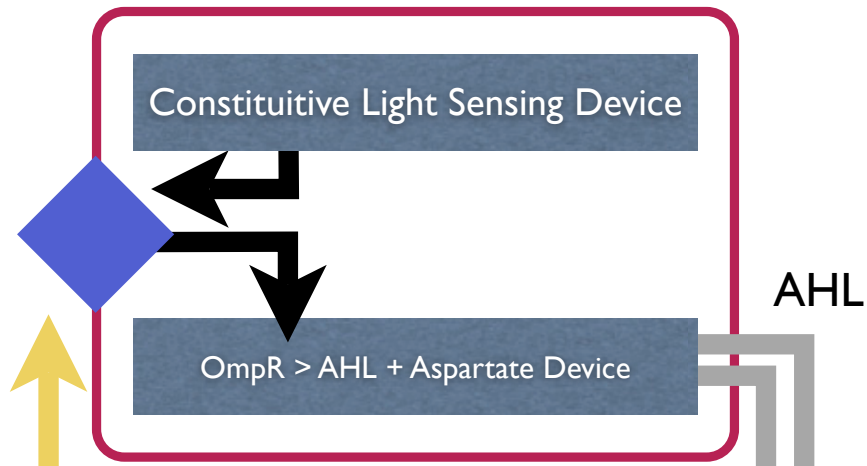
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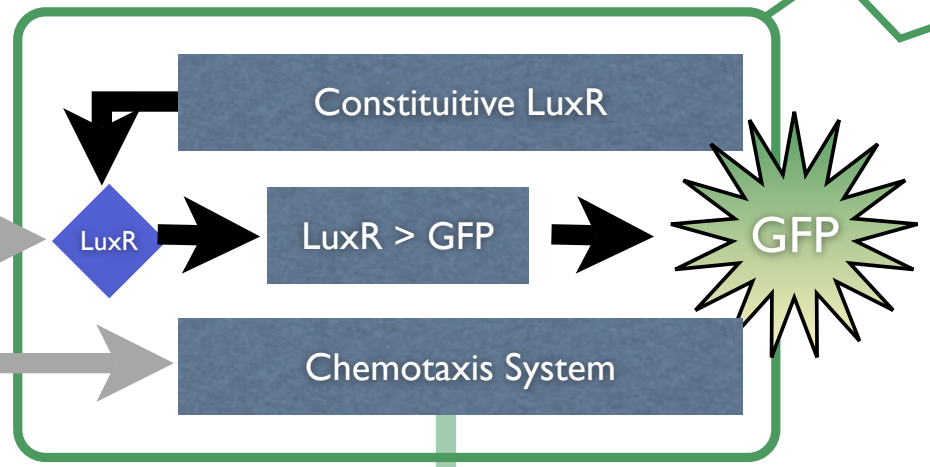
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SENDER



RECEIVER



Chemotaxis:
moves down Aspartate gradient

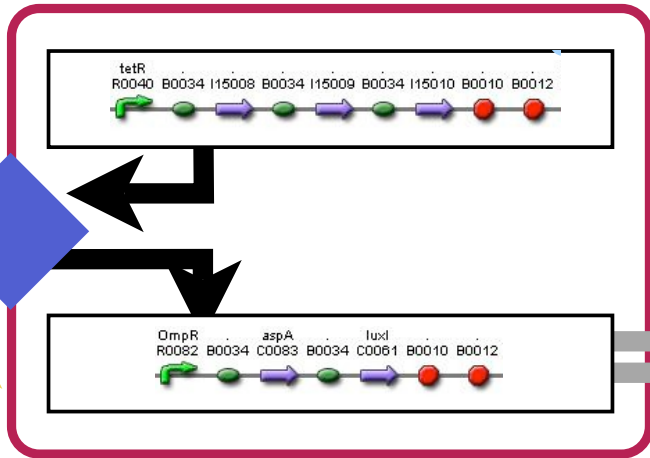


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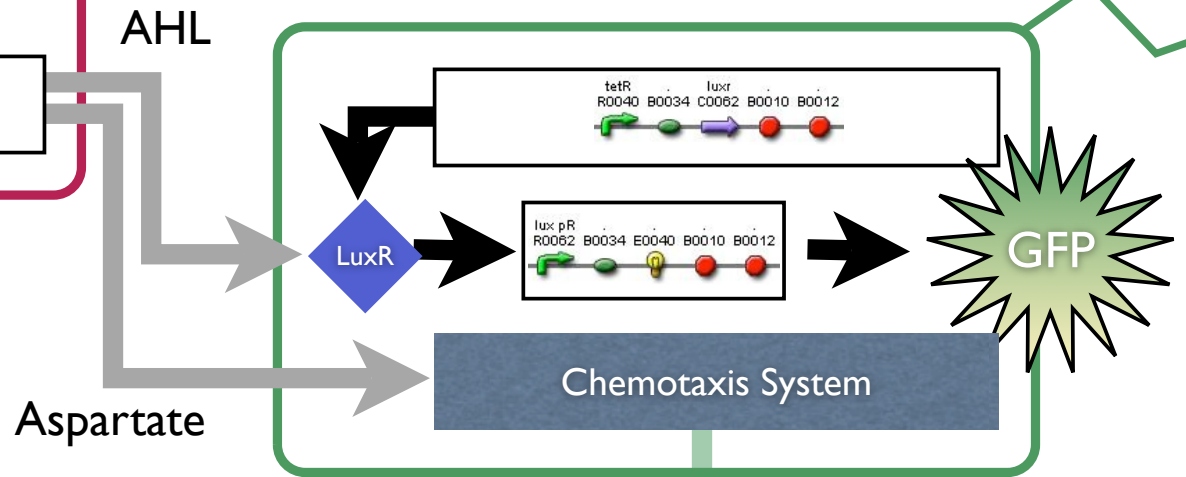
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RECEIVER



Chemotaxis:
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July 27, 2006

STRAIN A (New Motile)

2 RBS

design in vivo light sensitive population of receiver cells & cells are likely naturally auxotrophic or lab made dependent strains.

5 ACTAGT
TGATCA

X TGTAGA
AGATGT

★ UPSTREAM KEEP UPSTREAM RE
★ DOWNSTREAM KEEP DOWNSTREAM

General Lab Practices

- Rinse all used glassware and place in disinfectant
- All plates, pipette tips, waste bottles
- Glass gear in yellow (autoclave)
- Gloves go in regular garbage
- To operate Autoclave press 2
- Don't do anything 5 minutes before
- Lab closes at 4:30 be done by
- Don't place flaming spreader in

Autoclaving ONLY FILL 80% FULL!!

- Do not fill bottles more than 1/2
- Most of the bottles/flasks are autoclave
- Leave lids on bottles loose!
- Use a autoclave basket - always.
- Press 24 for menu, 30 minute liquid

Storage

- Wrap swim plates in parafilm
- Store swim plates < 7 days (they deg. out)
- Most antibiotics can be stored 6 months
- Tetracycline is light sensitive (store in the dark)

Stocks

- 60-80% glycerol can be used
- Final concentration should be 20%

Systems Biology / Synthetic Biology

- Luciferase is simple: bacteria produce in diff agar is 0.25% Bayleaf agar is 0.1%
- Signal can be chemotactant or a Rep
- Paper disks / filter paper can be used to add S
- E. coli has 5 receptors (20 possible attractants)
- Speed is 0.5-0.9 cm / hour max cell
- Mutants that cannot metabolize attractant

It is possible to control dumb

Strains from RP4: MG16 MG16 DH5

Ca. 100 nM series can be used as attractant

Time Course

Forming Ring! Probably Bacteria Make Gradient

Without any attractant, metabolism produces a gradient

Can you obtain media to see where bacteria are?

* If you attractants are metabolites? At the same time

JAMES BROWN July 23, 2006
Cold Spring Harbor / Cambridge / MIT / Harvard

E-N-X - S-N-P

Engineering Graduate from Cambridge
↳ All fields: CPE / Civil / Chemical
↳ social to biology -> Chemotaxis
↳ PhD in Synthetic Biology!

Devices => Systems

* Synthetic Biology
The design and construction of biological parts and systems

Graph: cI vs t

Diagram: IN -> [cI] -> [cI]

Investor

Bacteria other than E. coli? 100x harder to work with!
↳ Much more difficult to transform!

Reporter Transcription can be Constitutive or Threshold

Graph: Reporter Transcription vs Time

TYPE	Excitation λ	Emission λ
GFP	485 nm	515 nm
YFP	485 nm	530 nm
CFP	415 nm	610 nm

Paint on the attractant or event! All!

Make virtually any shape

Presentation by Karla Davidson on Transcriptional Networks

July 6, 2006

Pattern Formation -> Reporter Constructs (vectors)

Diagram: PROMOTER -> GENE -> PROTEIN

Diagram: σ70 -> GCATC -> TATA -> OPERATOR / RNA POLYMERASE BINDING SITE -> Prib. AT -> Terminator Region

Sigma 70 Promoters are Always On (constitutive)

Repressors are 20 bp sequences which are typically palindromes.

Diagram: RBX 599

Intercalate with DNA to view (Ethidium Bromide)

200 μg / μl
260 / 280 nm
Tecline 1000 dilution

Copy Number Varies and depends on the ORI (origin of replication)

- ~1-2 Low Copy Number
- ~40 Medium Copy Number
- ~200+ High Copy Number

80 bp can be comfortably synthesized chemically.

Primers are 10-15 bp
for PCR there are 2, 1 upstream, 1 downstream

DATA & BACTERIA

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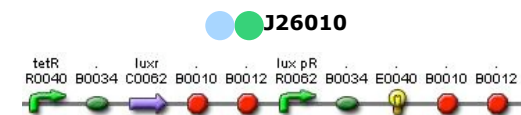


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Assembly Plan

Legend

- Source Part
- Intermediate
- Submit to Registry
- Final Project



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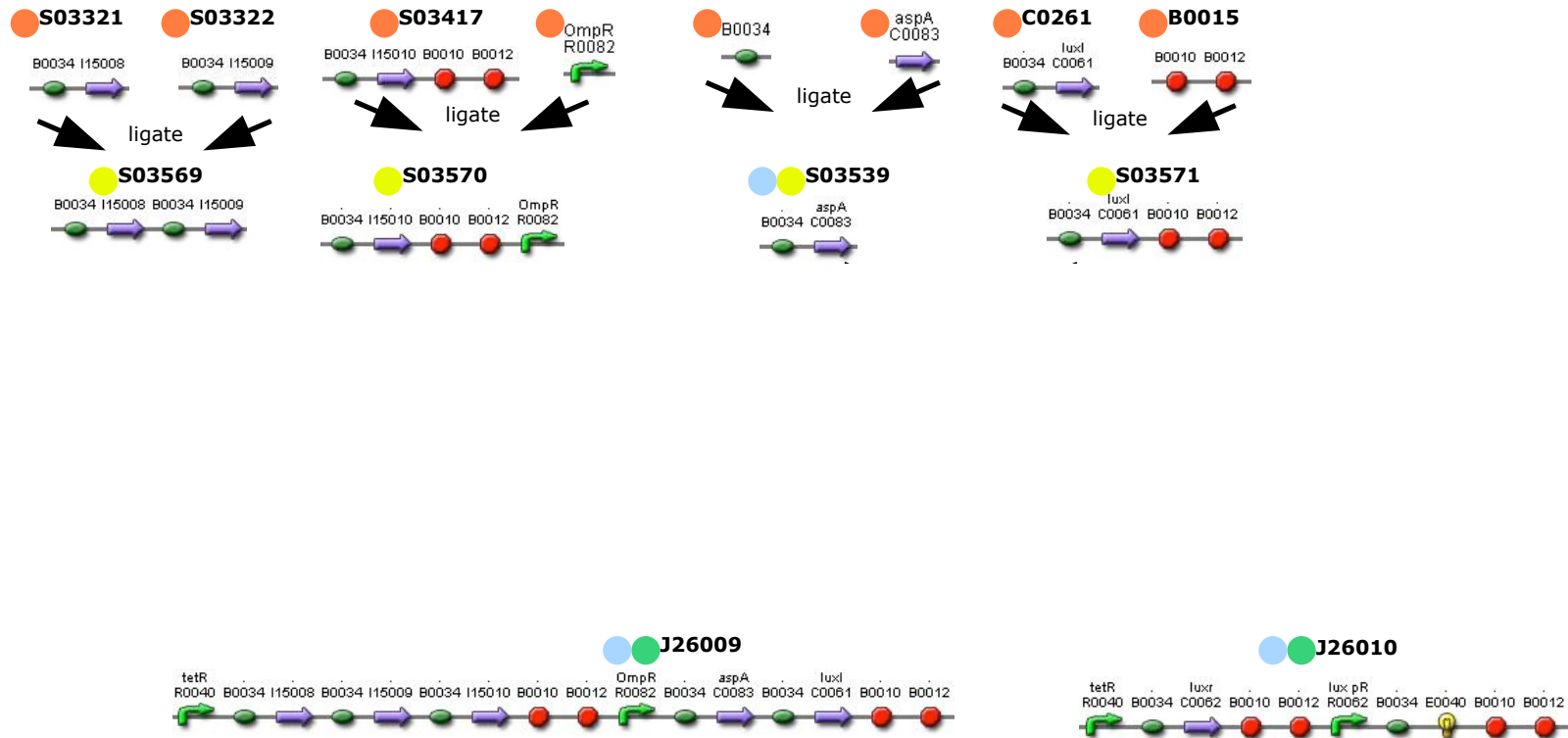


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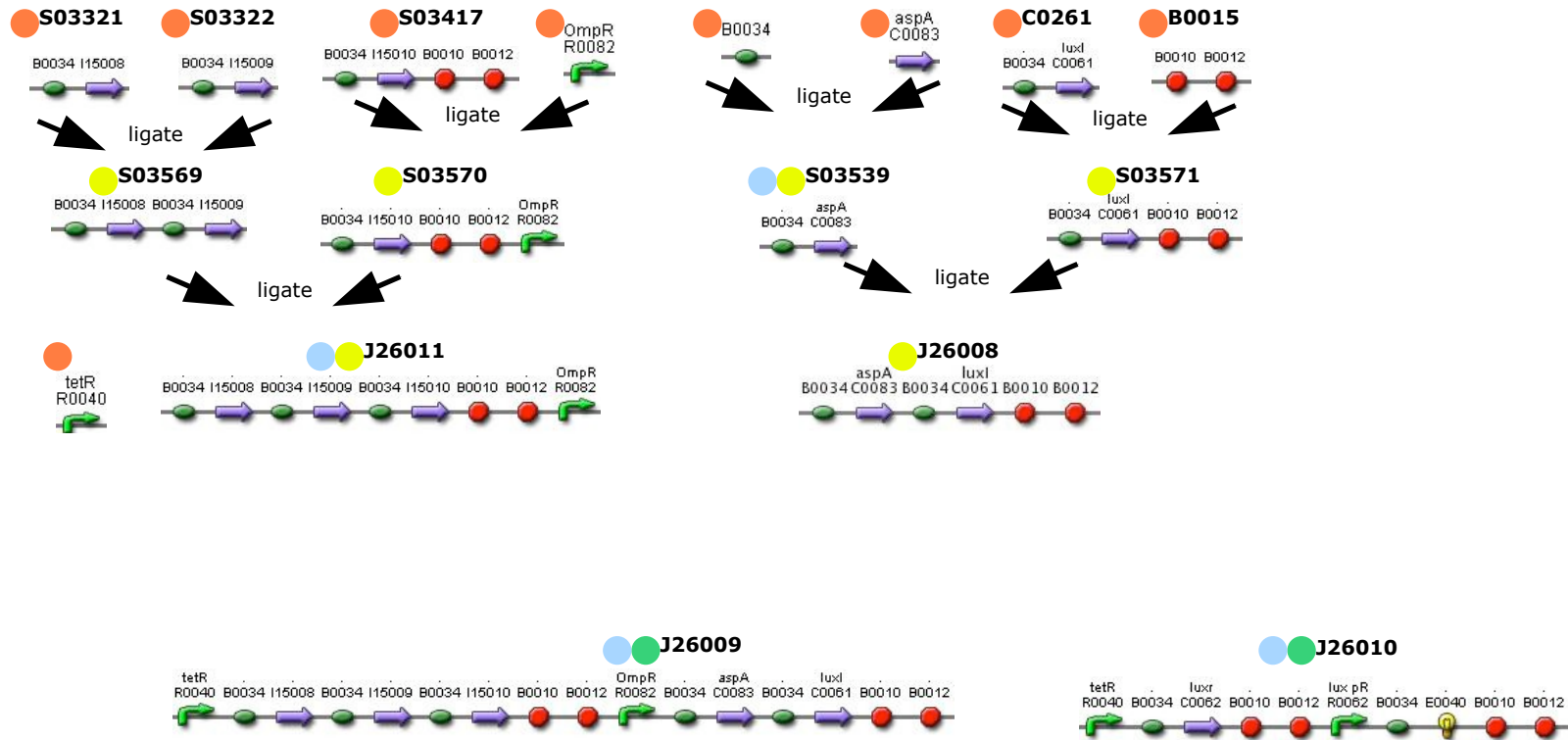


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Assembly Plan

Legend

- Source Part
- Intermediate
- Submit to Registry
- Final Project



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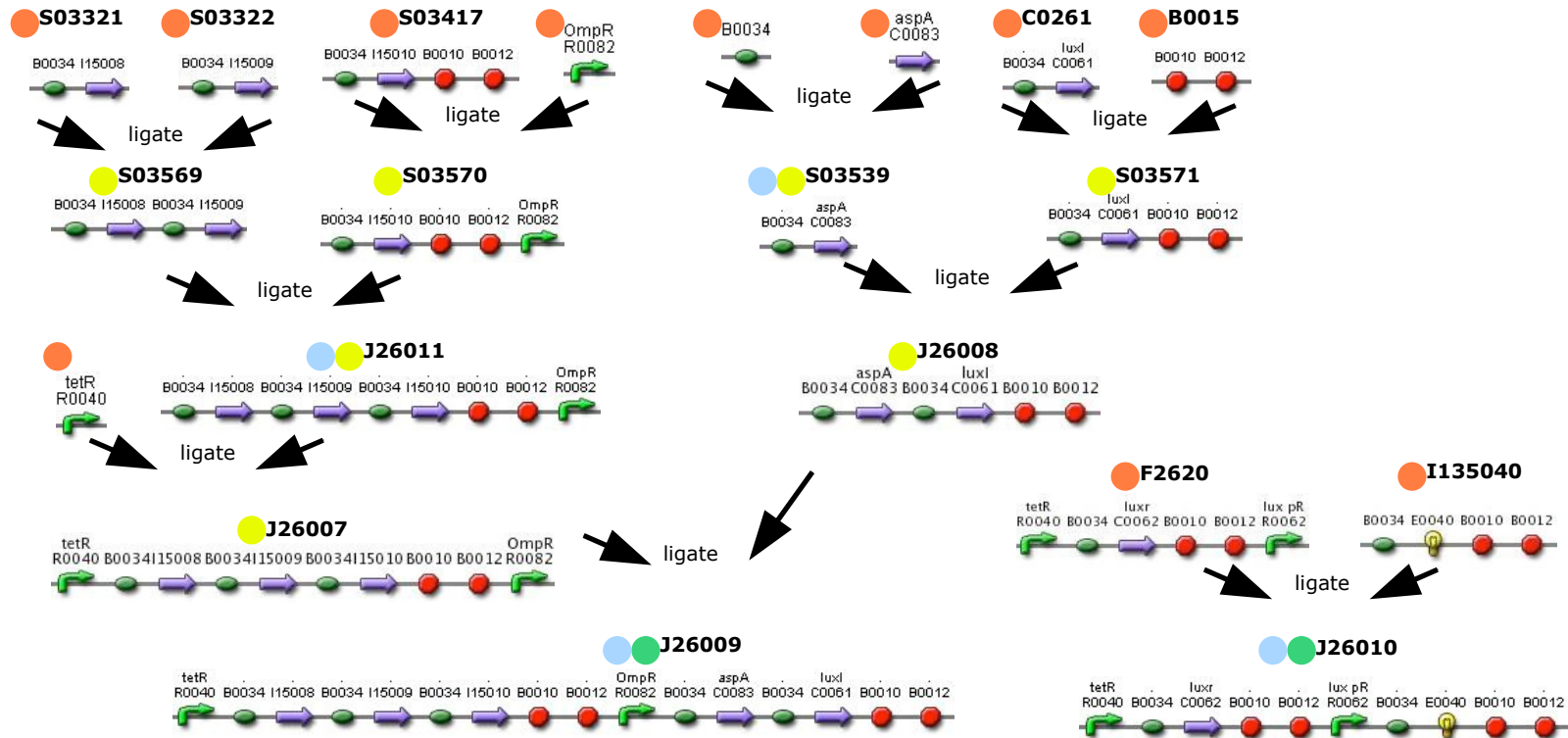


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Assembly Plan

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Part Assembly

Standard Assembly

- Plasmid isolation
- Low yields
- Extremely slow

PCR Assembly

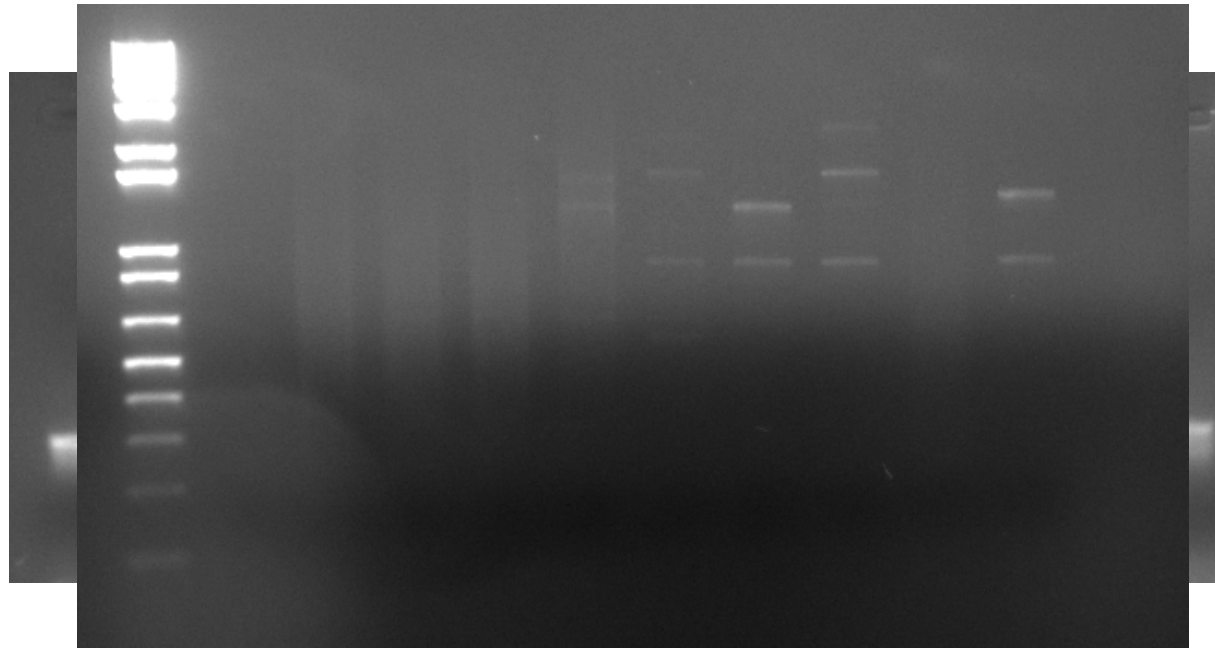
- No plasmid isolation
- Many parts generated in parallel
- Extremely fast
- DNA all the way along

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PCR

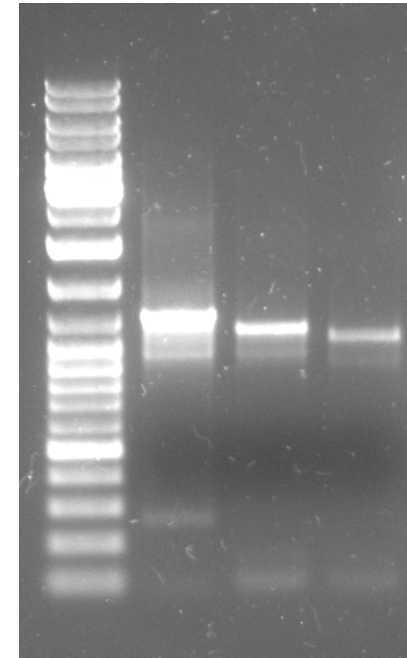
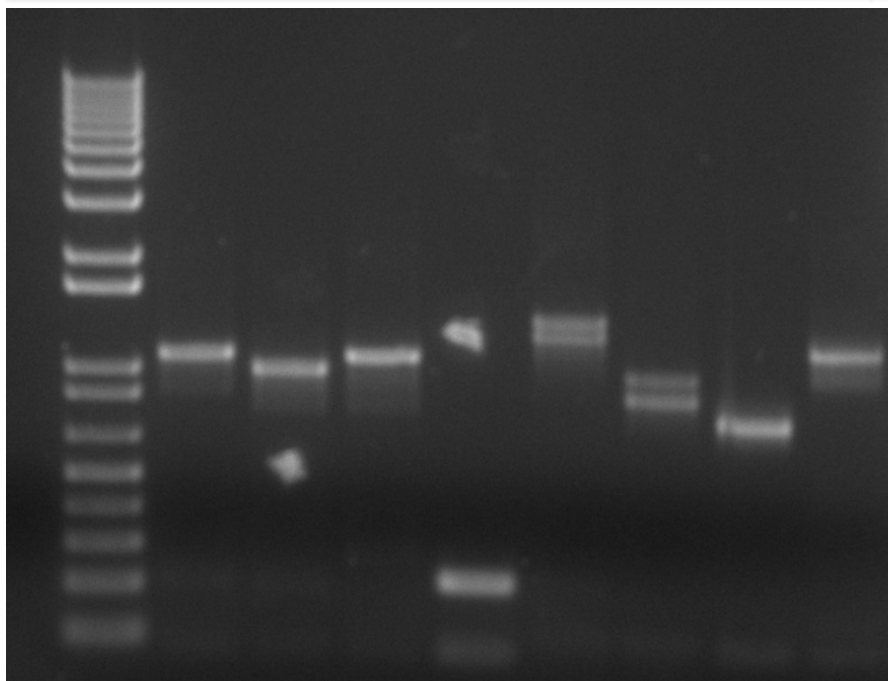


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Digests



PCR Products



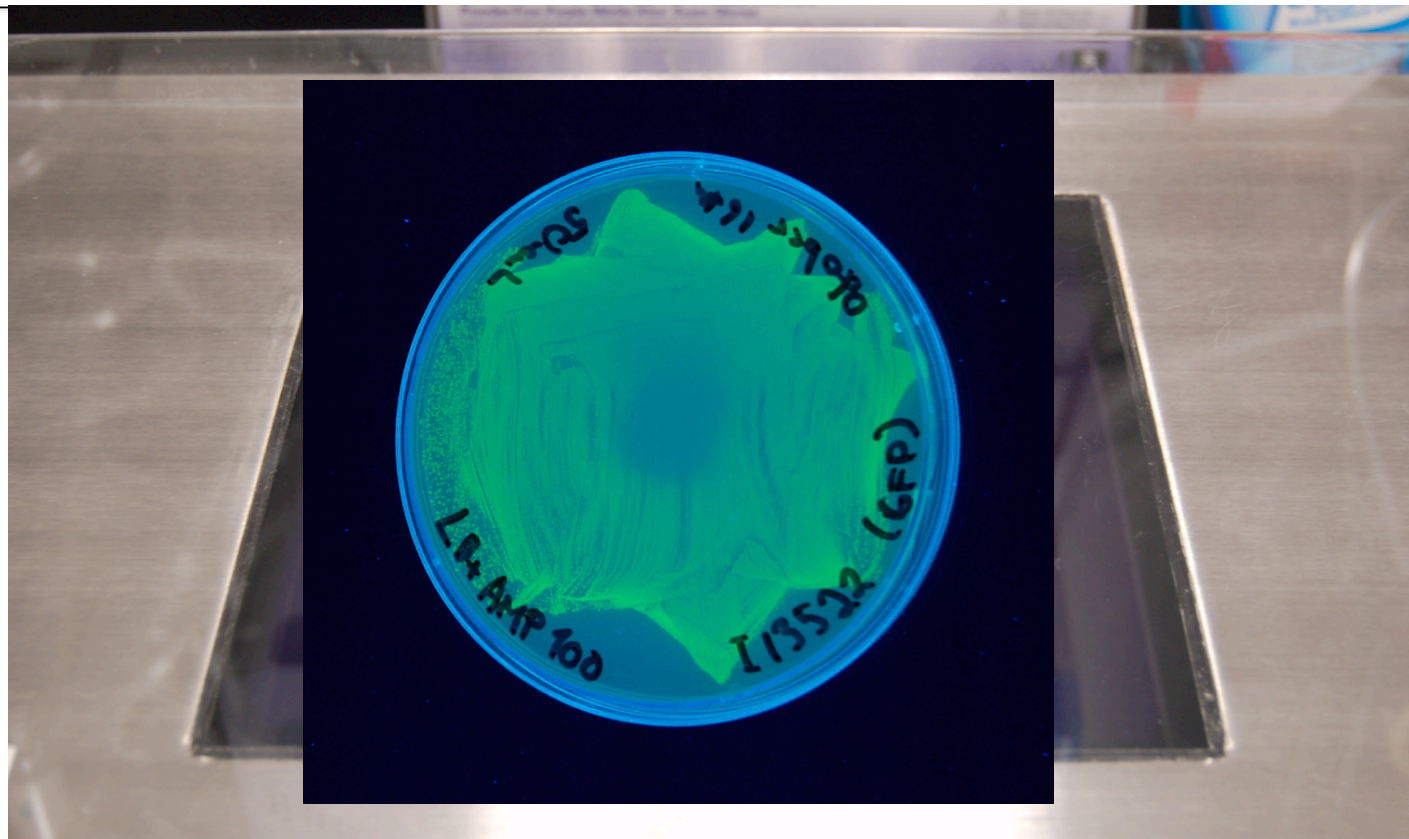
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Assay

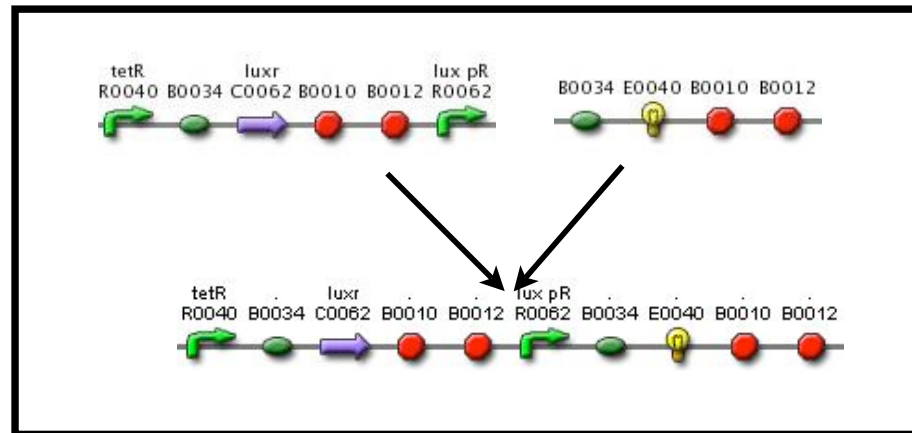
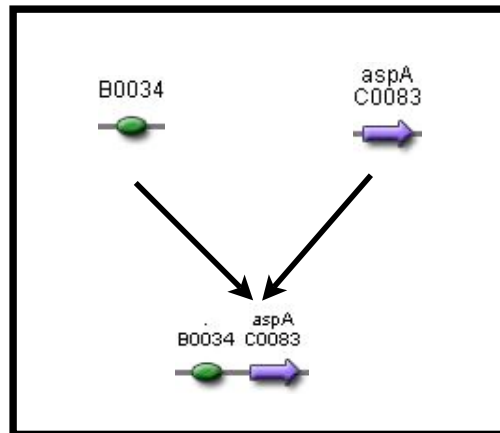


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Results

Successfully constructed two of the project intermediates



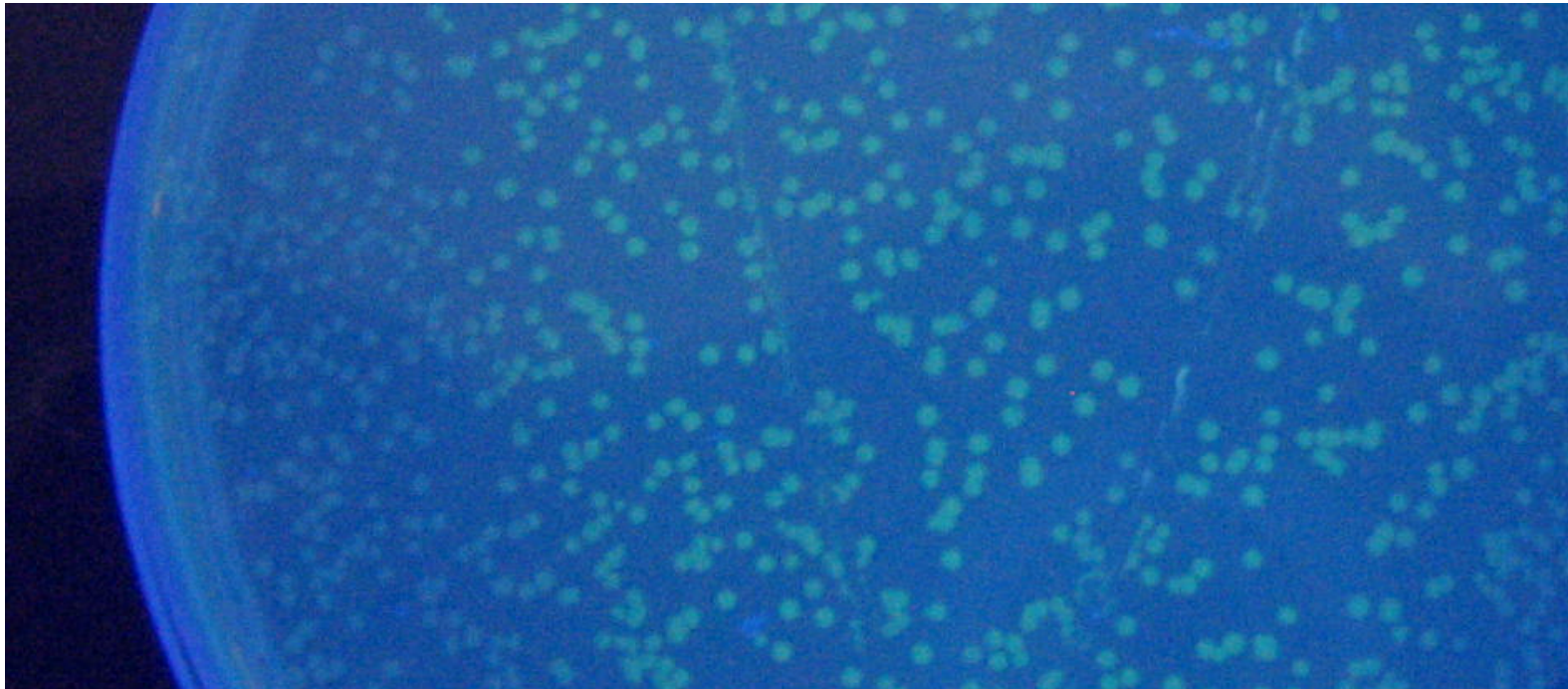
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Results

AHL Gradient (inducing GFP)



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Aspirations

- Increased student pool
- Full time commitment
- Early start date
- Broader student background

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Bachelor of Health Sciences

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