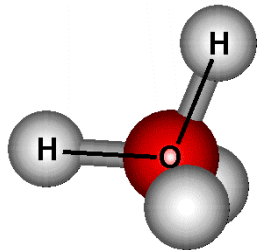




snowflakes and fractals

tsp water project 2004



team leader
David Curtin

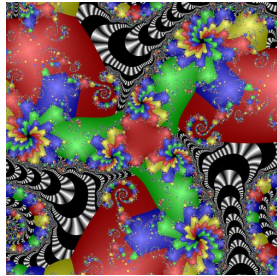
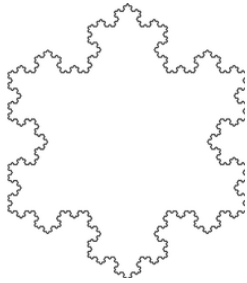
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team members
Thomas Clement
Julian Gibbons
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Enoch Lau
Ozan Onay
John Sun

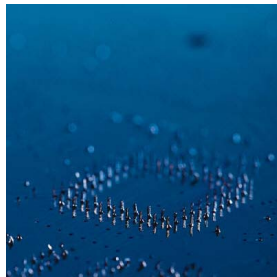
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Snowflakes and Fractals

- **Mathematics** Focus Group



- **Computing** Focus Group

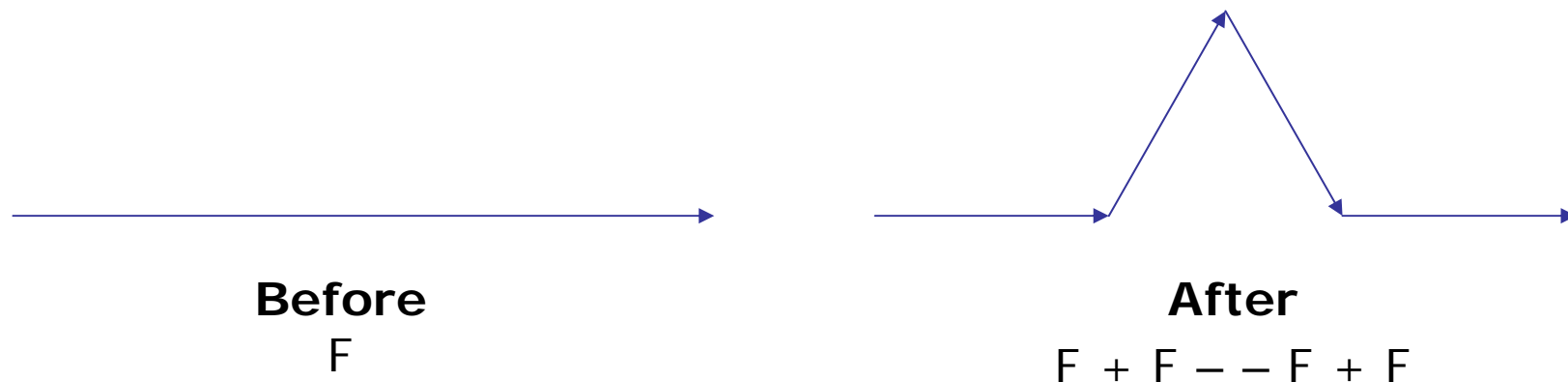


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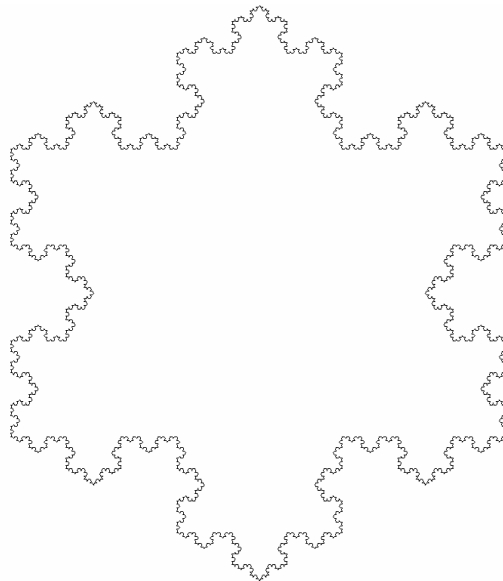
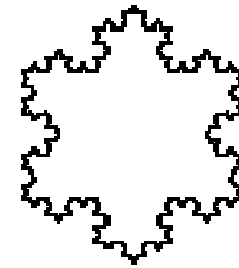
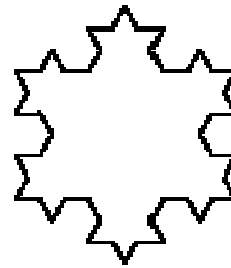
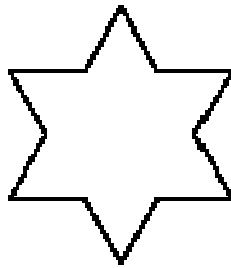
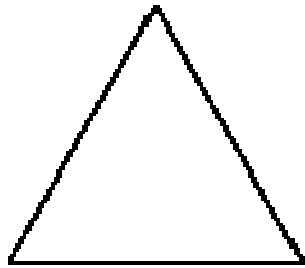


L-Systems

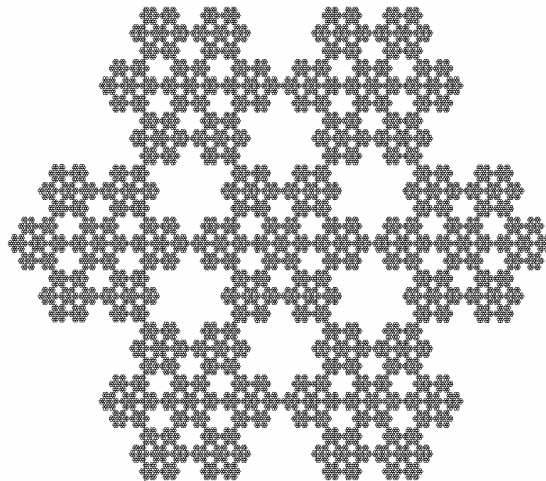
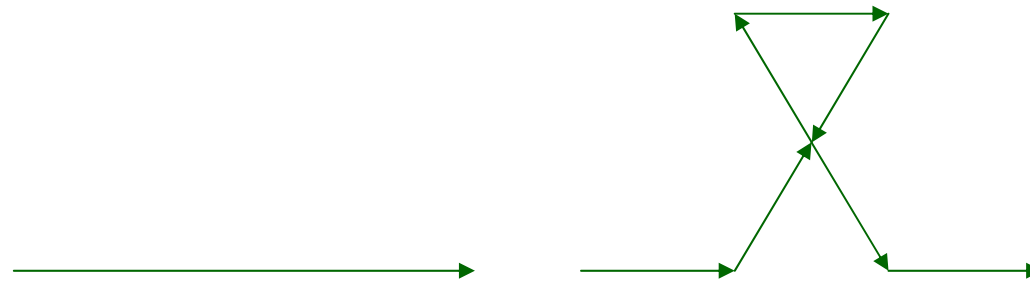
- **Iterative approach** to fractal construction.
- Repeatedly replaces line segments with pre-determined constructions.
- Fractal is the result of infinitely many iterations.



Koch Snowflake

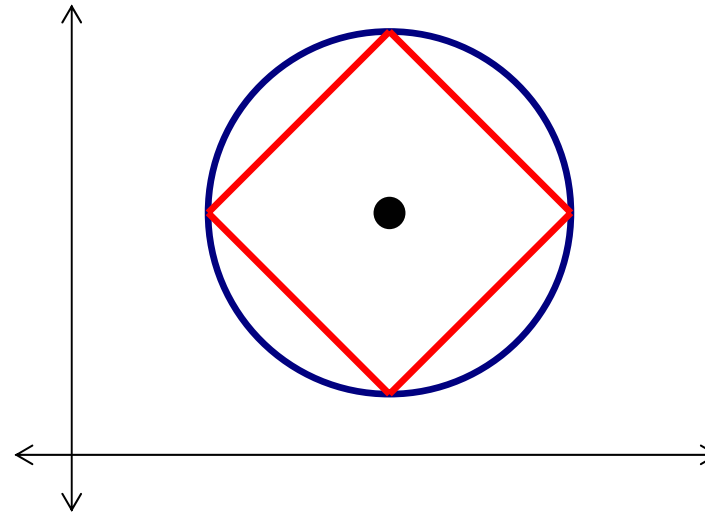
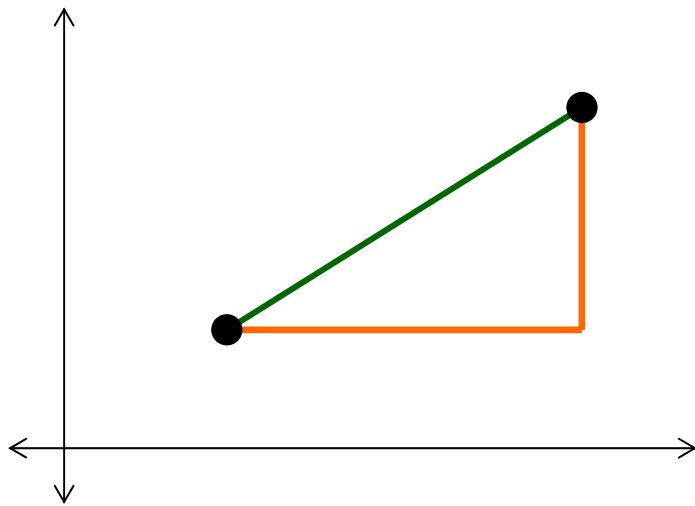


L-System Snowflake



Metric Spaces

- Different definitions of **distance**.
- Use the new definition to prove desired results.



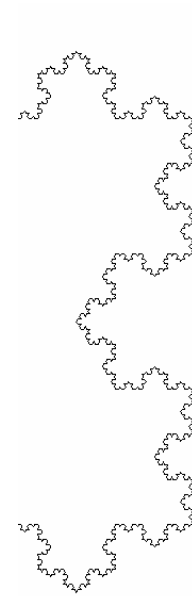
Koch Snowflake

- The **Hausdorff metric** is *complete* – all Cauchy sequences in it converge.
- For Koch curve, Hausdorff distance translated into the height of the triangles added by each iteration (red).

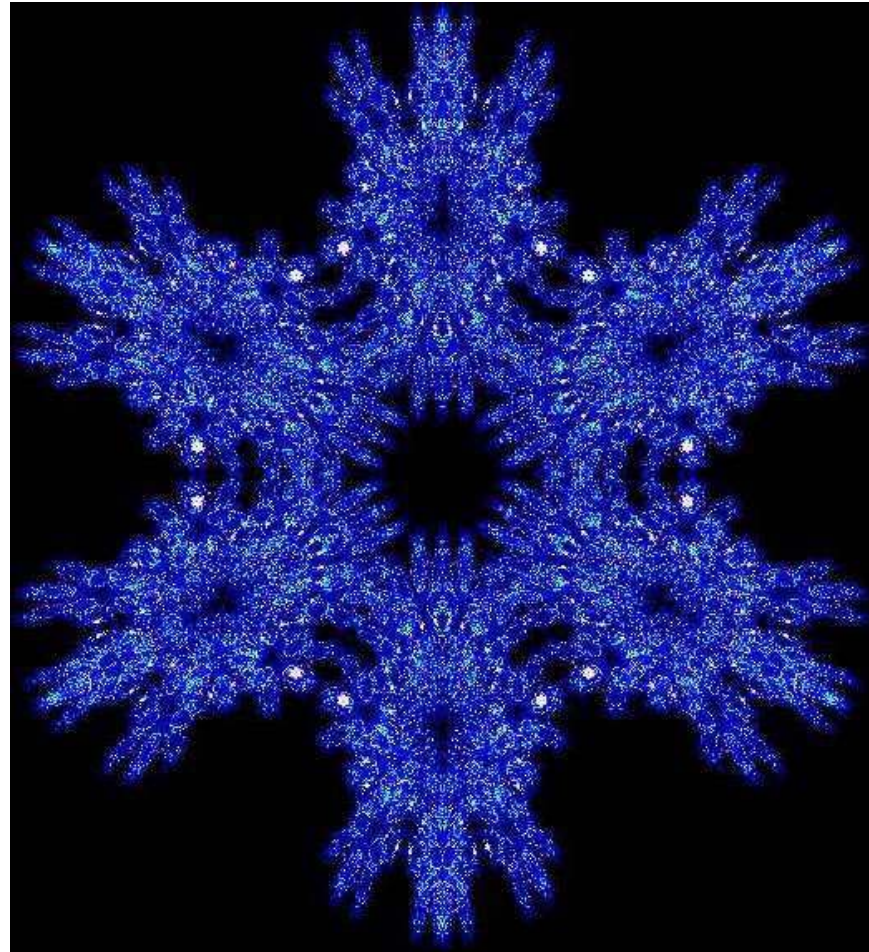


Implications

- The Koch curve exists – it does not spread out infinitely far.
- The image we produce is unique – this method of generating fractals is not chaotic, but thoroughly systematic.
- Snowflake formation follows a very different model!



Snowflakes on Computer

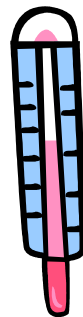
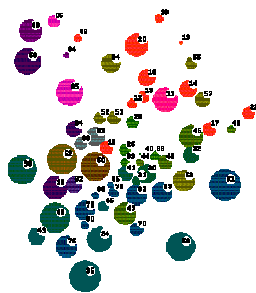


Snowflakes and Fractals
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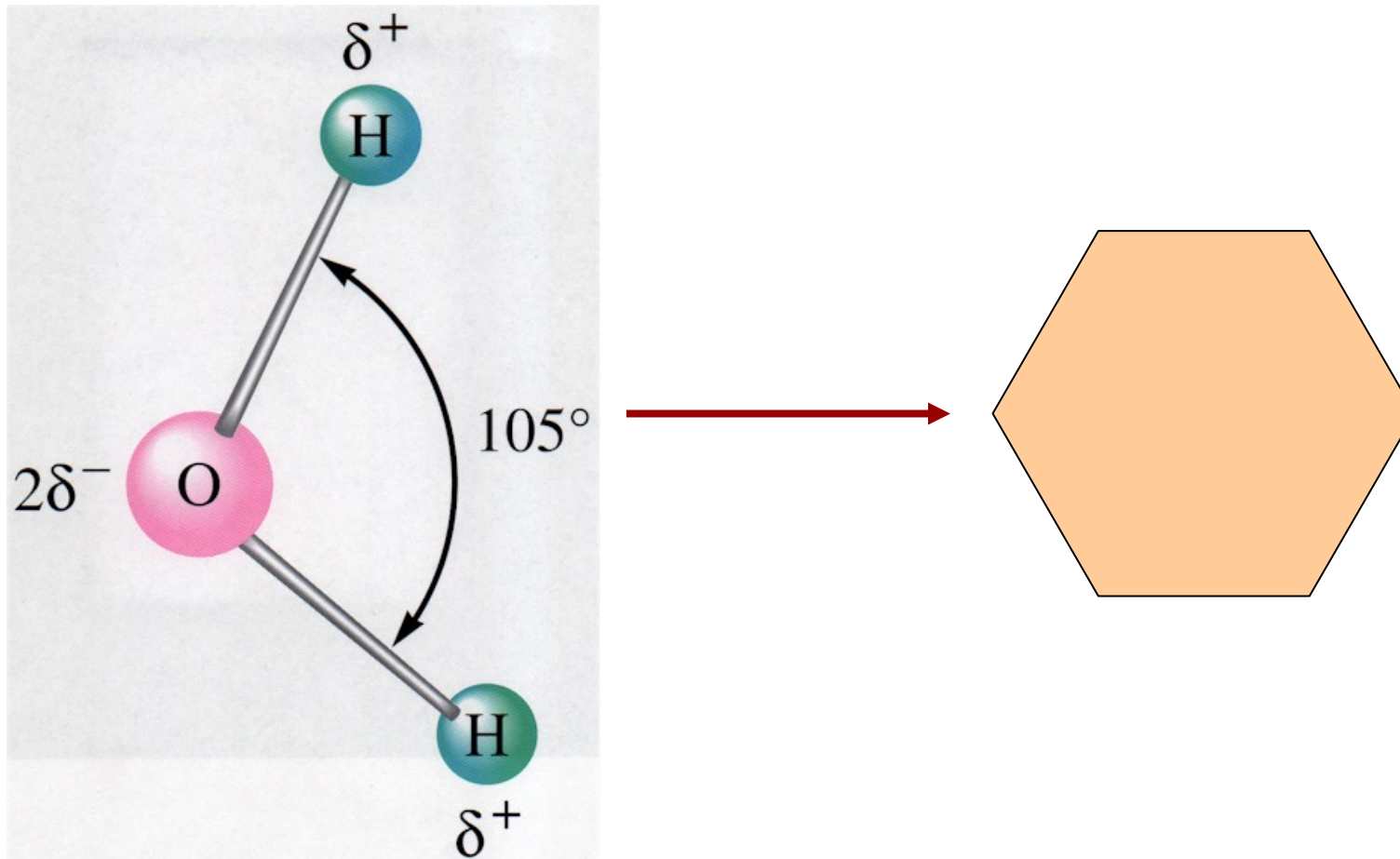


Physical Principles

- **Snowflakes** are not merely frozen water, as they exhibit crystalline structures.
- **Variations in snowflake formation** is due to dust particles, temperature and humidity.



Physical Principles

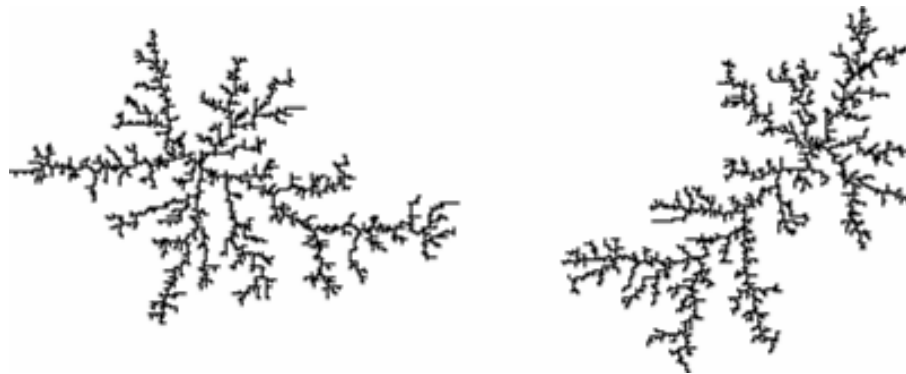


Snowflakes and Fractals
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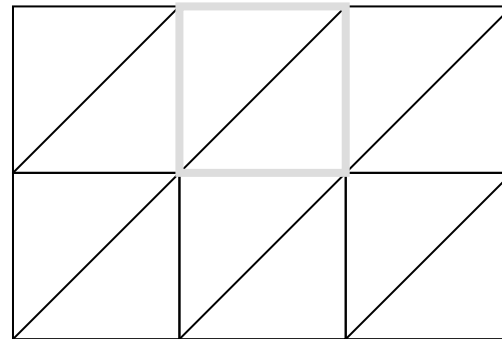
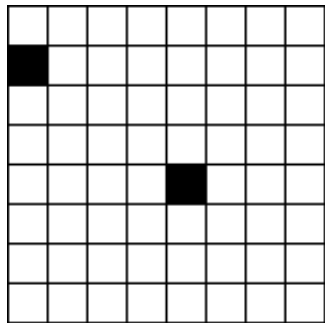
Diffusion Limited Aggregation

- **DLA** approximates real-life snowflake construction.
- Begin with a **seed cluster** in the middle.
- **Free particles** move until they collide with the main cluster.



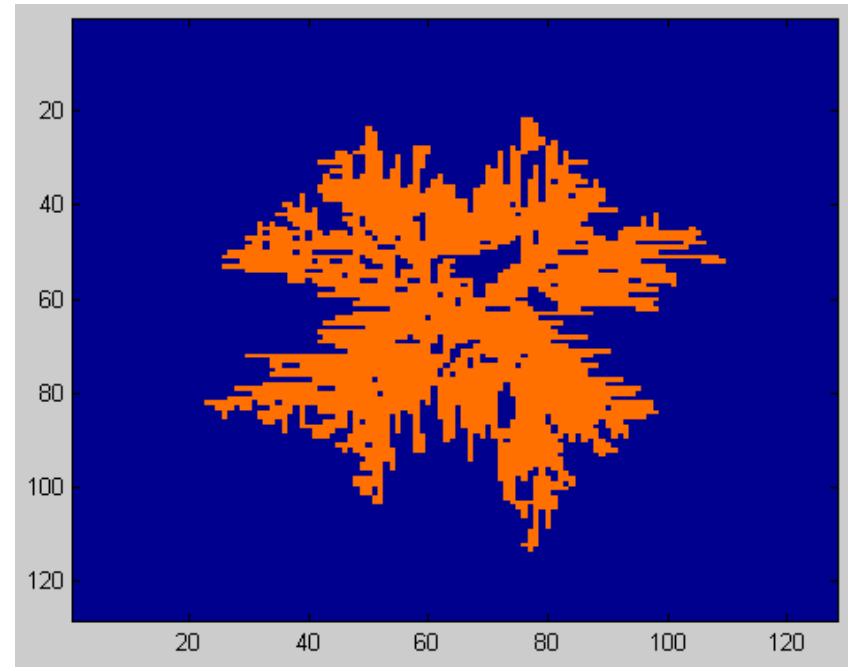
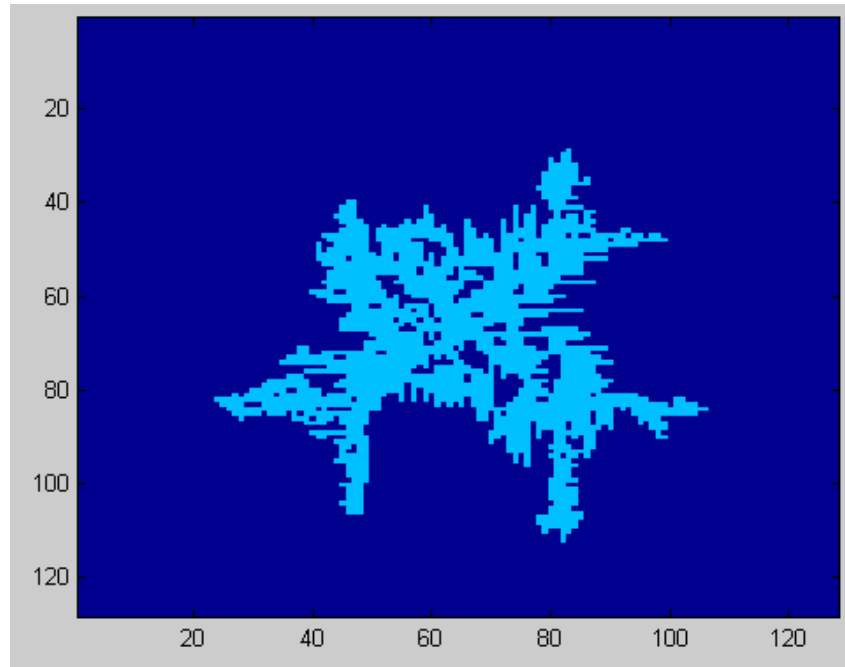
Grid-based Implementation

- **Matrix elements** store different numbers to represent “on” and “off” positions.
- By treating each element as two points, it behaves like a triangular/hexagonal grid.



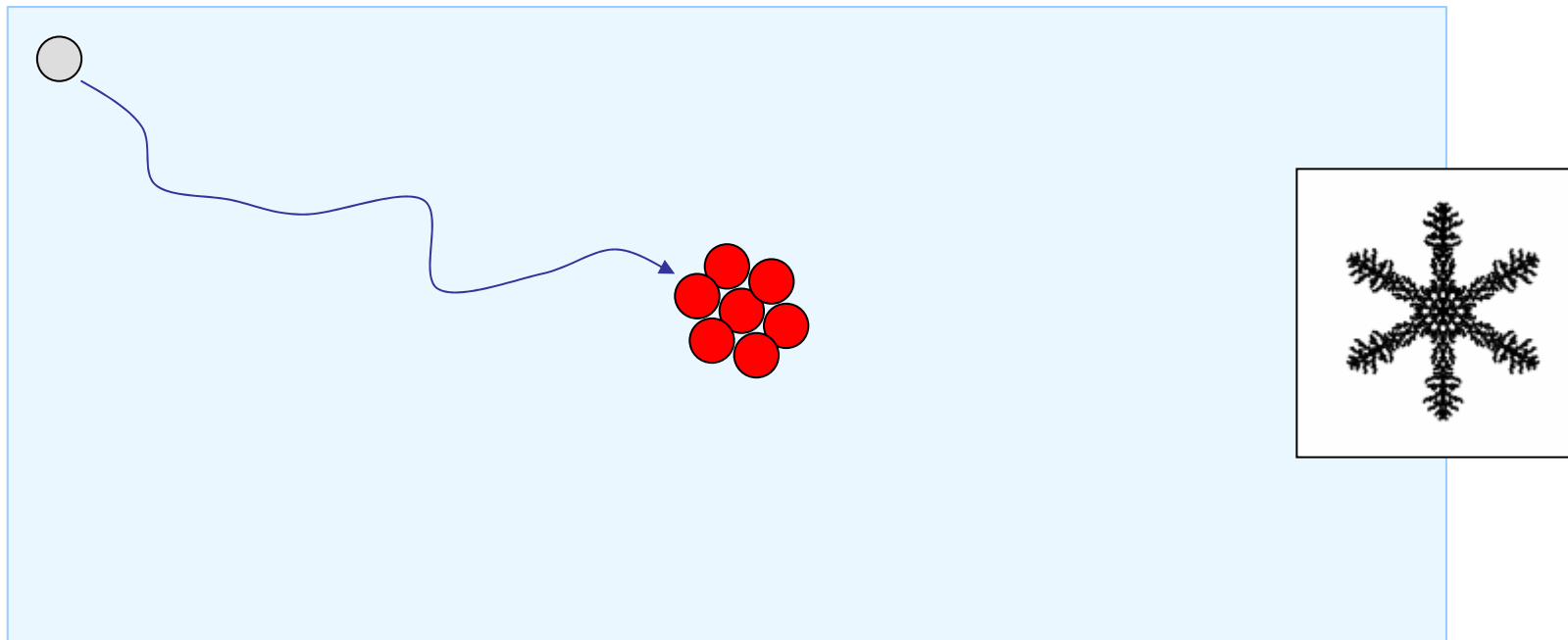
Grid-based Implementation

- **Triangular grid** had no effect on symmetry.



Particle-based Implementation

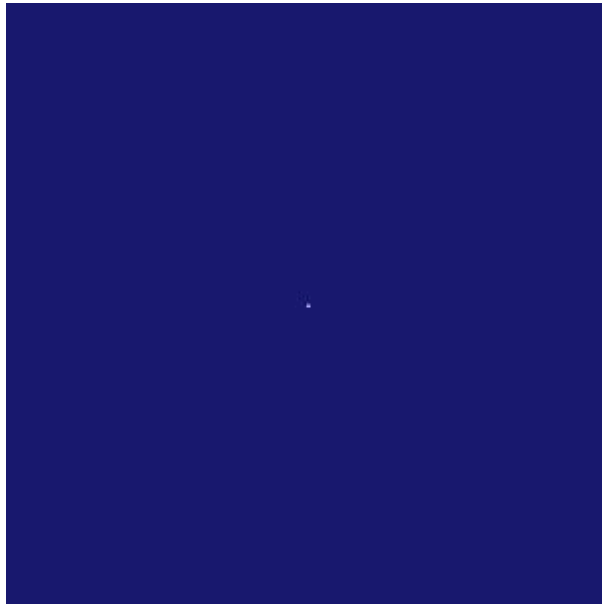
- **Virtual particles** move in a simulated environment.



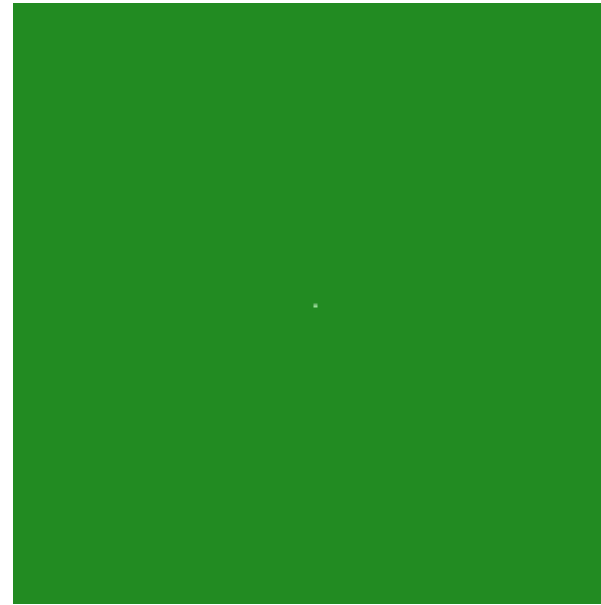
Simulated Environment



Particle-based Implementation



[QuickTime version](#)



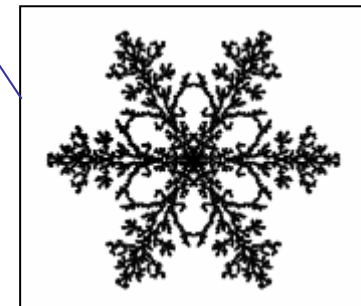
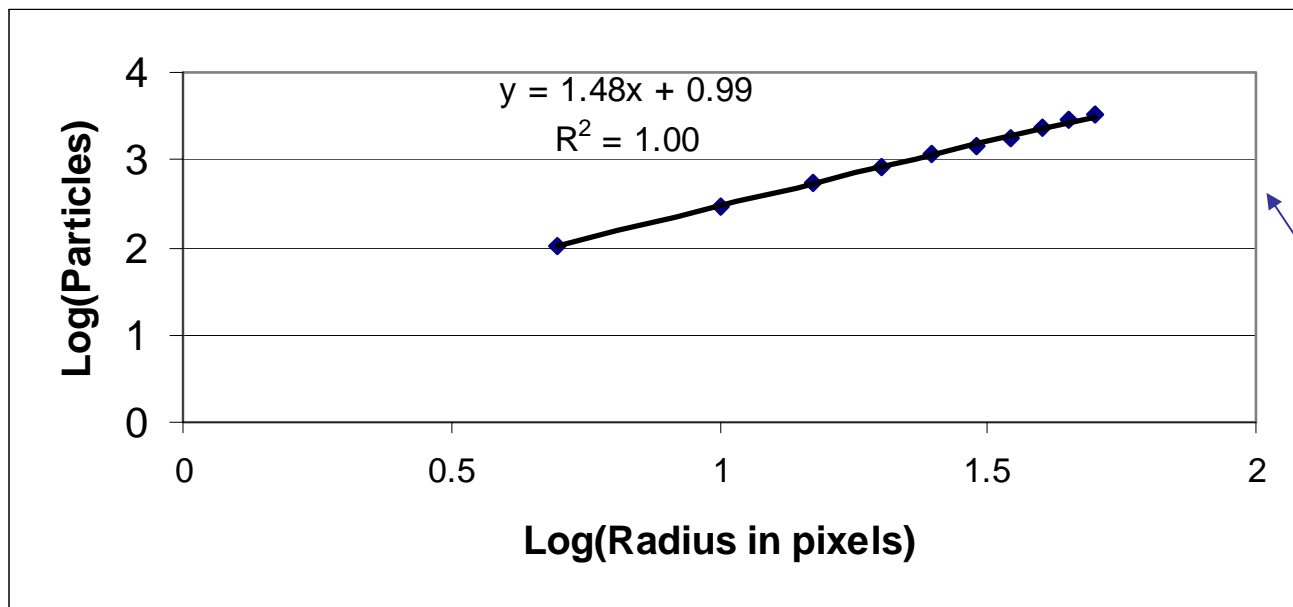
[QuickTime version](#)



Particle-based Implementation

- Fits the dimension equation very well:

$$N(r) = k.r^d$$



Conclusion

