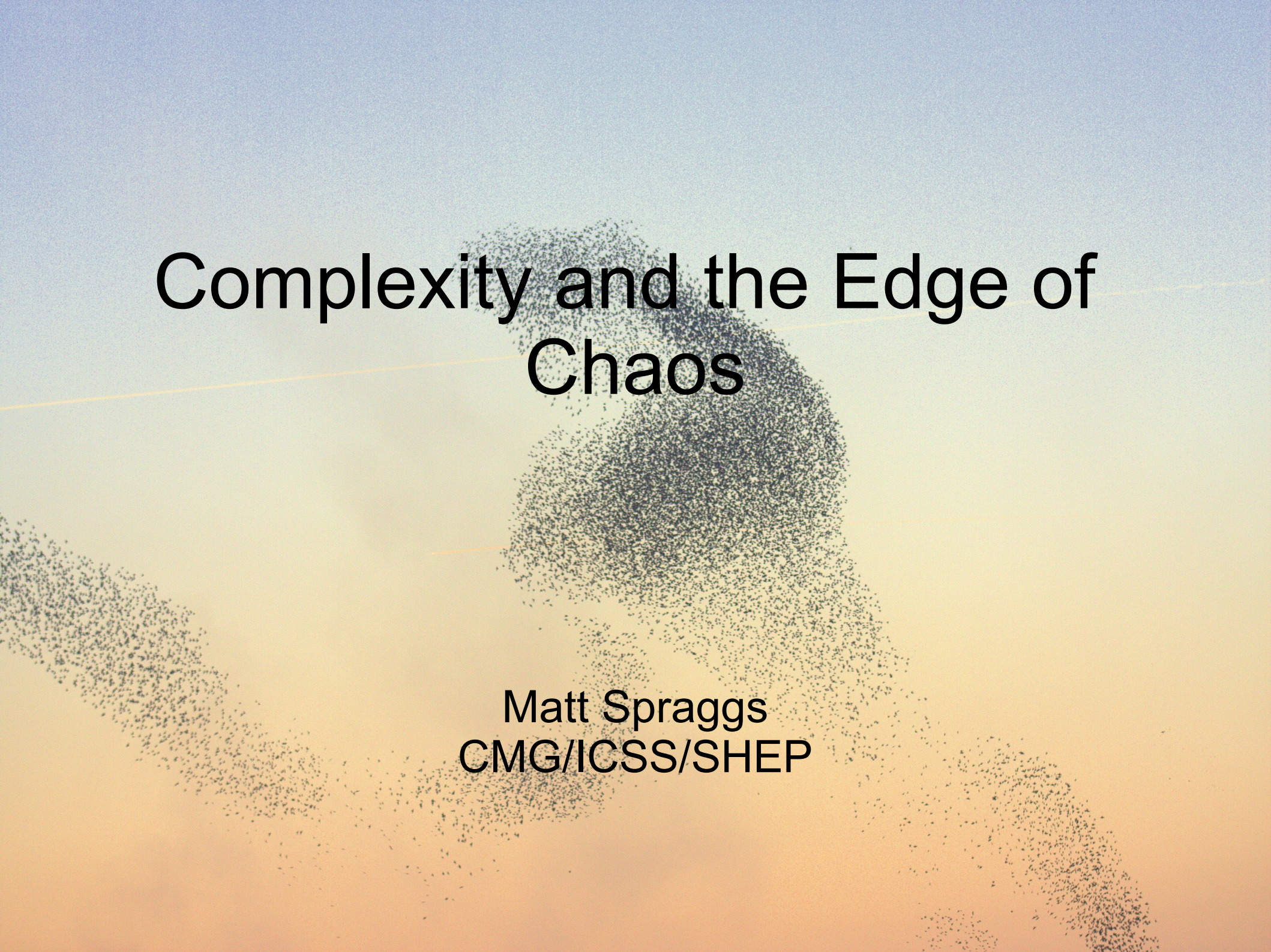

Complexity and the Edge of Chaos

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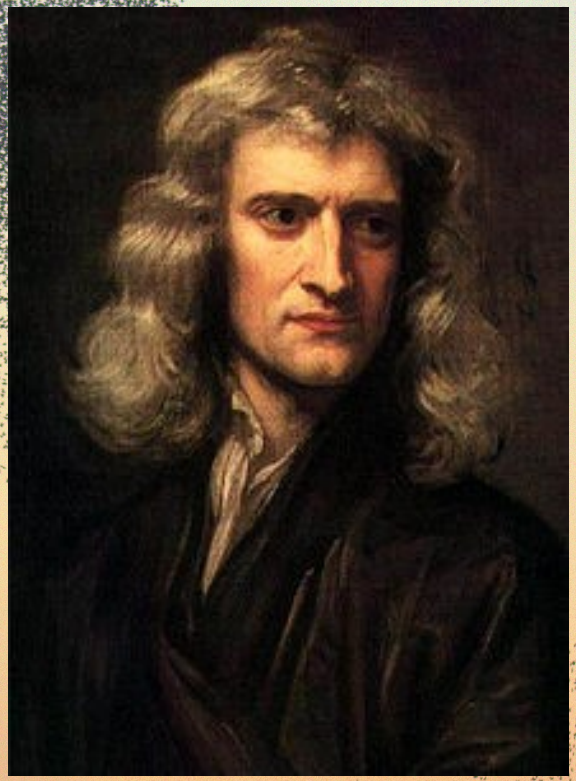
Overview

- History
- Definitions and Characteristics
- Examples
- The Future

History: The Scientific Revolution

- Descartes: reductionism
- Newton: determinism



History: Laplace's Demon

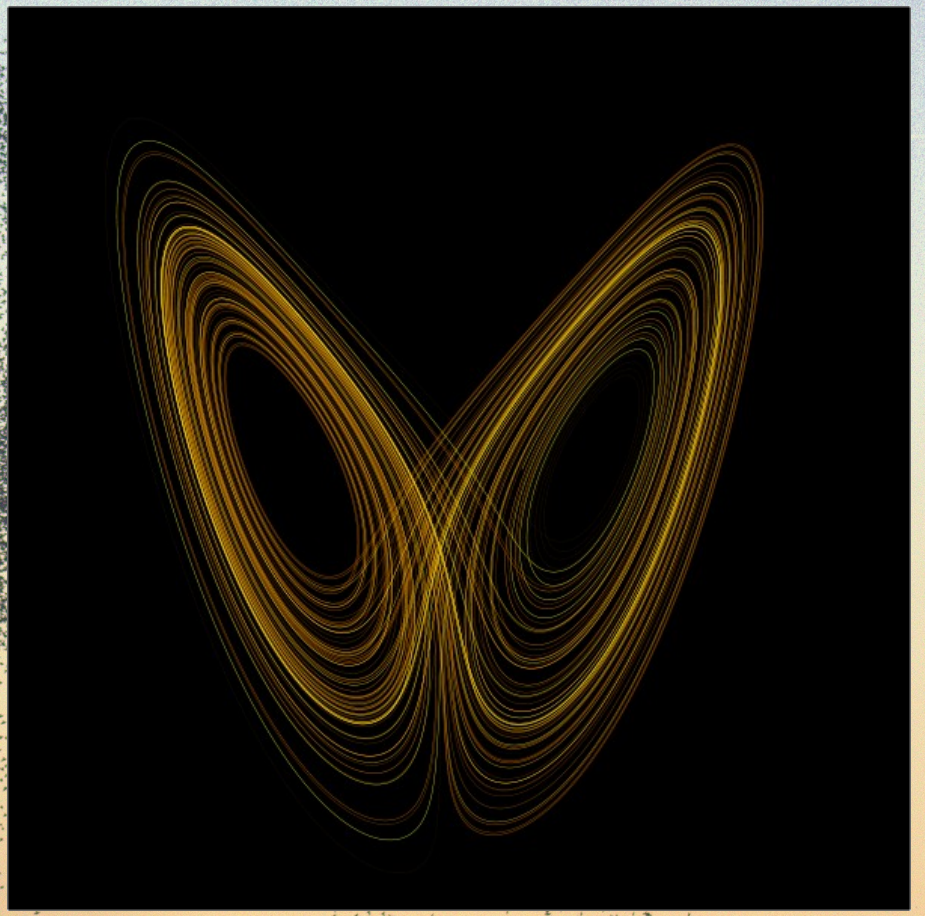
- Unlimited:
  - Computational power
  - Knowledge of dynamics
  - Precision in variables
- Hence unlimited predictive power

History: Poincaré

- Three body problem
  - Aperiodic orbits
  - Some solutions
  - Sensitivity to initial conditions
- King Oscar II prize

History: The Clock Breaks Down

- Quantum Theory
  - True stochastic behaviour
- Chaos Theory
  - Sensitivity to initial conditions



History: A New Approach

- Some systems are "greater than the sum of their parts"
- Dispense with reductionism
- "What I cannot create, I do not understand."

What is Complexity?

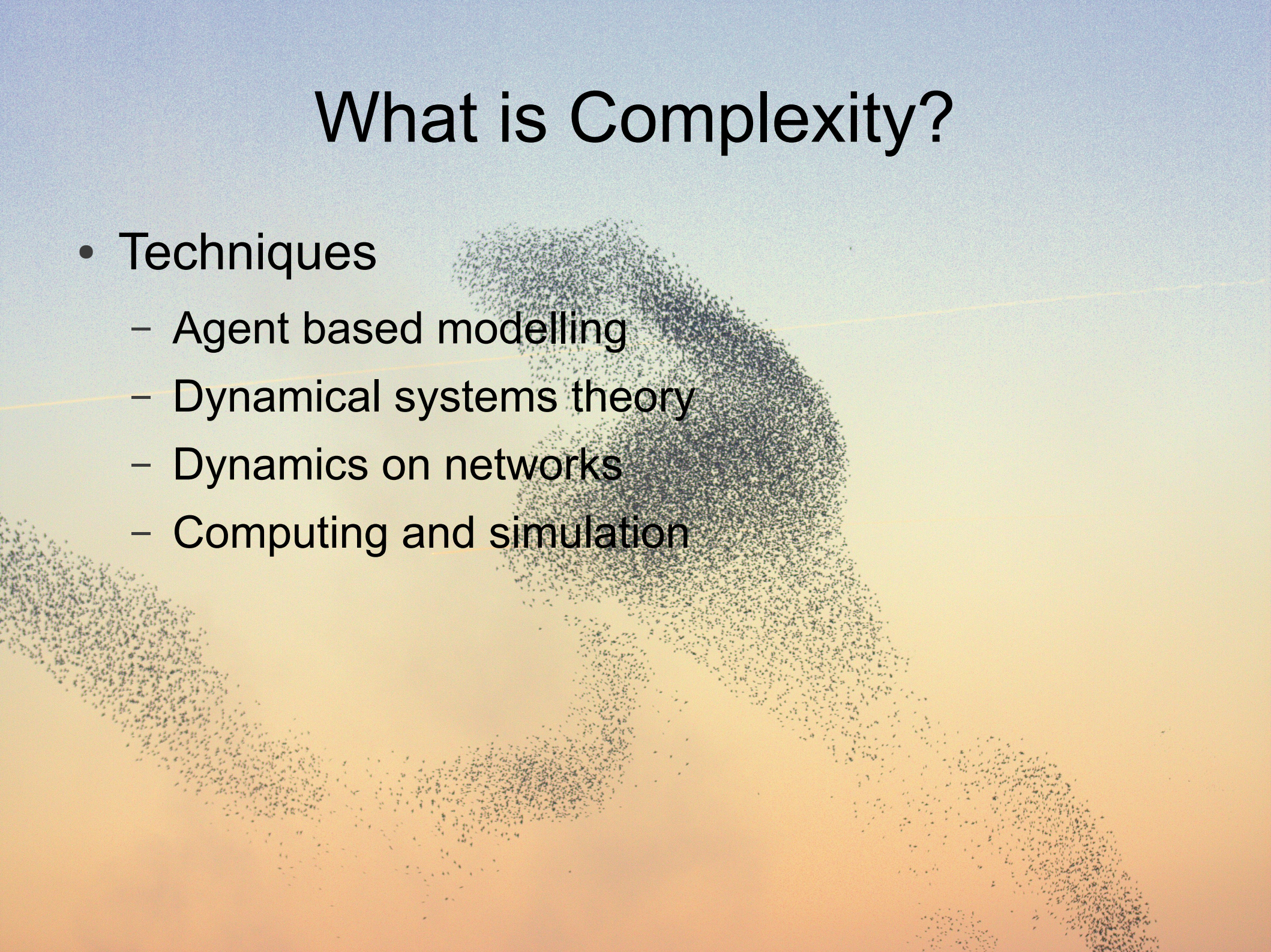
- Intuitive notions exist
- Many formal definitions, for example:
  - Size
  - Entropy
  - Algorithmic
- Each definition has its problems

What is Complexity?

- Many interacting elements
- Sensitivity to system parameters
- Levels of behaviour/organisation
- “Emergent” group behaviour
- Self-organisation
- The “edge of chaos”

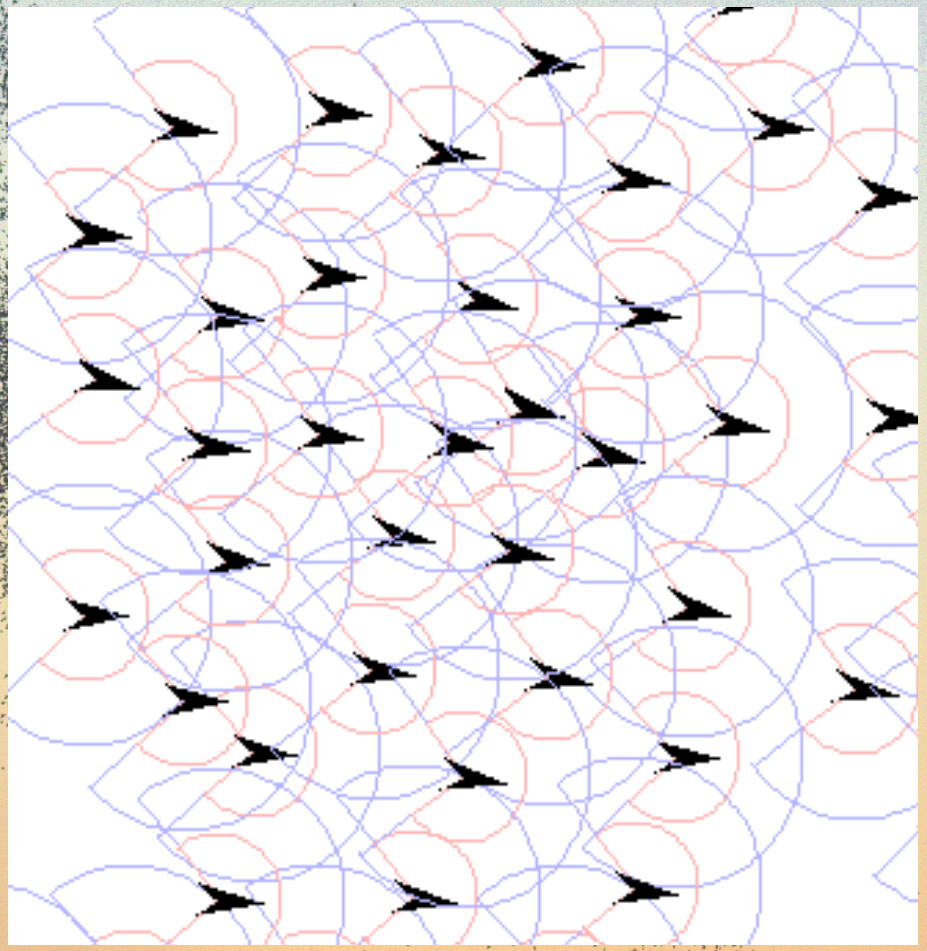
What is Complexity?

- Techniques
  - Agent based modelling
  - Dynamical systems theory
  - Dynamics on networks
  - Computing and simulation



Examples: Flocking

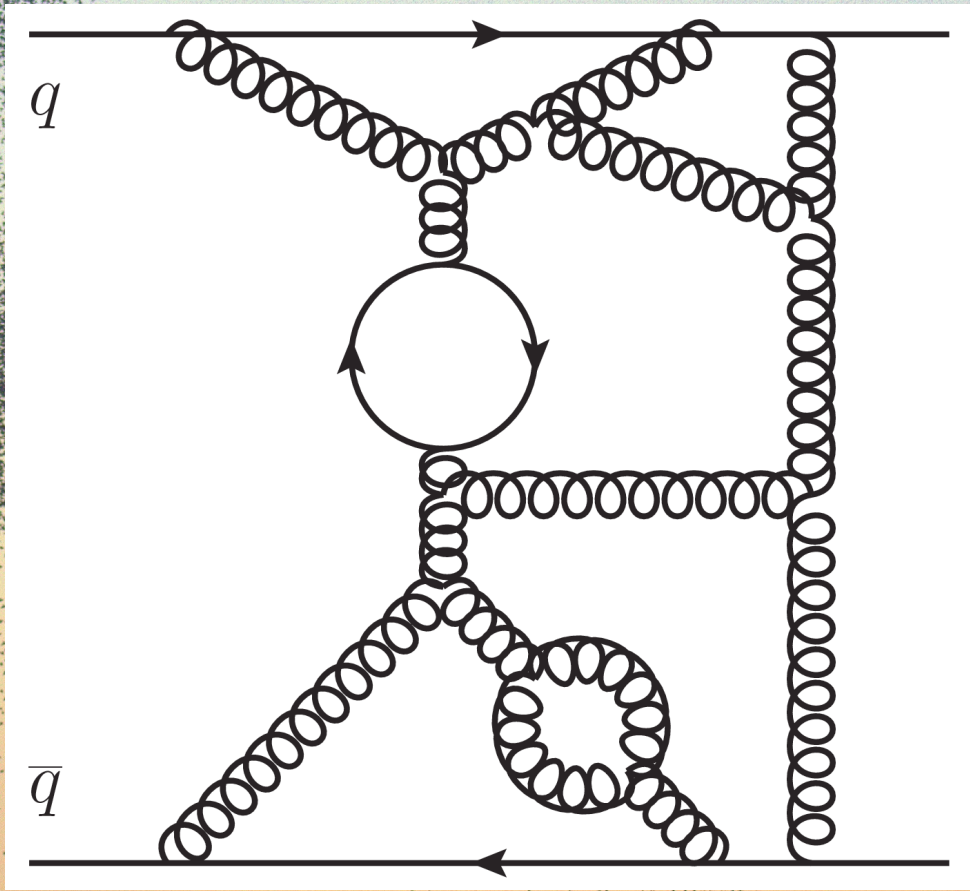
- Boids – 1986
- Three rules
  - Avoidance
  - Cohesion
  - Alignment
- No centralised control
- Self organisation



http://www.youtube.com/watch?feature=player_detailpage&v=eakKfY5aHmY#t=143s

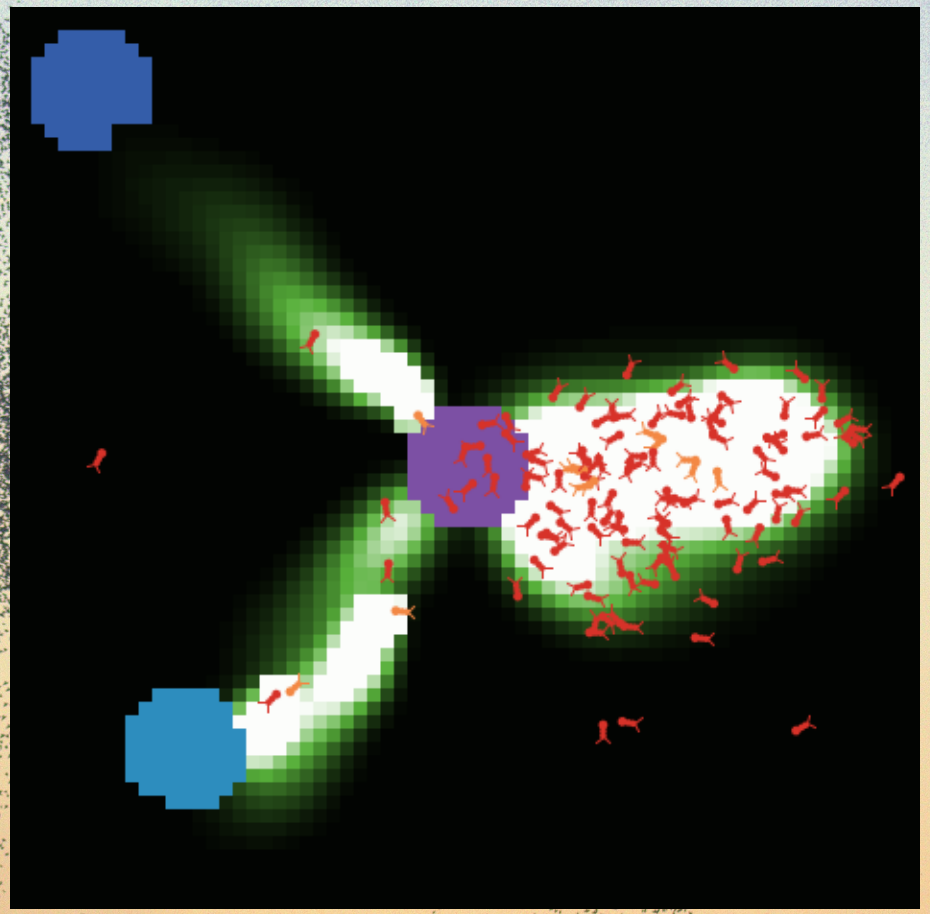
Examples: Lattice QCD

- Quarks and gluons
- Nonlinear Lagrangian
- Complex phenomena:
  - Hadrons
  - Asymptotic freedom
  - Confinement and hadronization



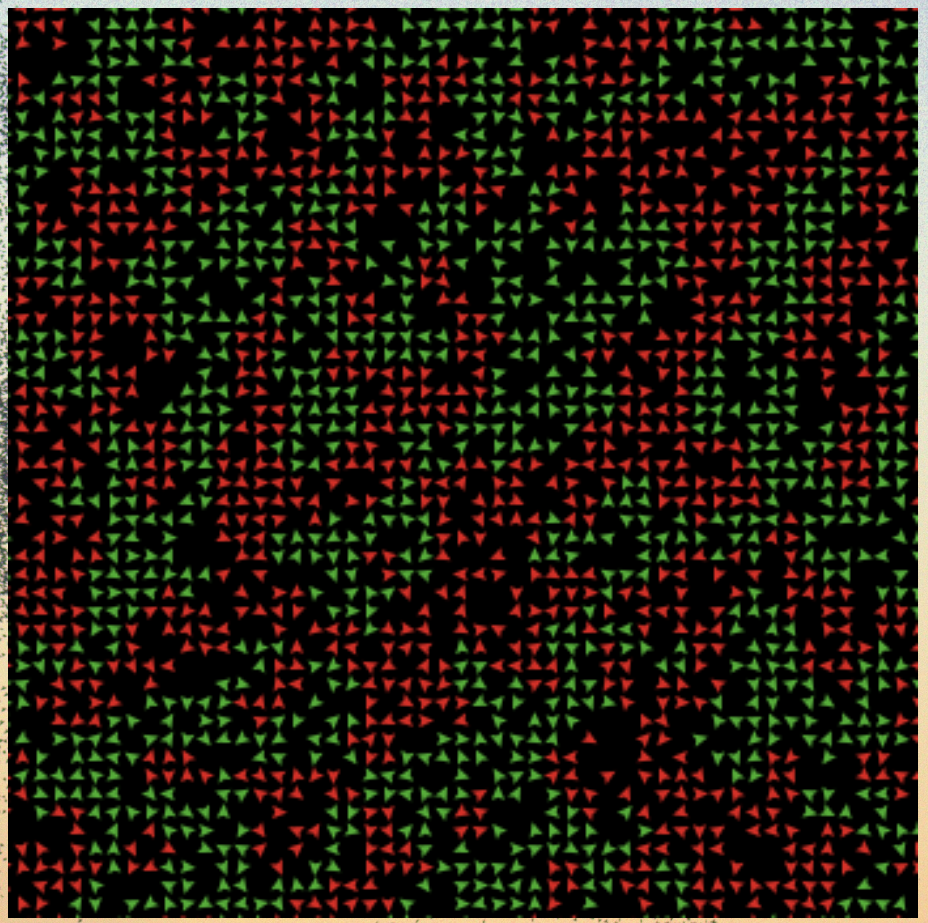
Examples: Foraging

- How do ants find food?
- Simple rules, complex behaviour
- Decentralised



Examples: Segregation

- Schelling model
- Agents are tolerant
  - E.g. 30% of neighbours must be like ourselves
- Segregation
  - Highly mixed configuration improbable



The Future

- A young discipline
- Increasing computing power
- “I think the next century will be the century of complexity.”