

The Universality of Critical Behavior

Helmut Satz

Universität Bielefeld, Germany

Karpacz, Poland



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The Fundamental Problems of Physics

constituents

quarks
leptons
gluons, photons
vector bosons (Z , W^\pm)
Higgs

forces

strong
e-m
weak
gravitation
unification, TOE

elementary interactions



complex systems, critical behaviour

states of matter

solid, liquid, gas
glass, gelatine
insulator, conductor
superconductor, ferromagnet
fluid, superfluid

transitions

thermal phase transitions
percolation transitions
scaling and renormalization
critical exponents
universality classes

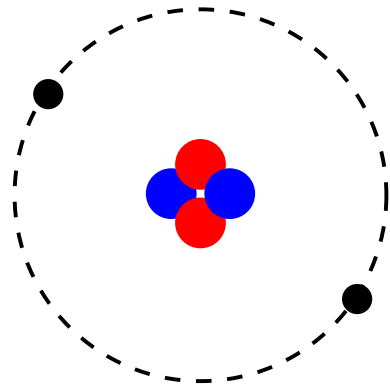
Complex Systems \Rightarrow **New Direction** in Physics

- Given constituents and dynamics of elementary systems, what is the behaviour of complex systems?
- What are the possible states of matter and how can they be specified?
- How do transitions from one state of matter to another occur?
- Is there a general pattern of critical phenomena, independent of specific dynamics?
- Conceptually new physics: renormalization, self-similarity, self-organization, emergence, sand piles, swarm intelligence, ...

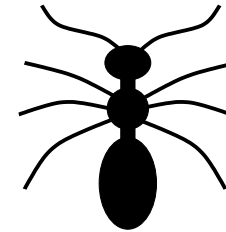
NB: new directions not only in physics

Knowing all there is to know about

the helium atom

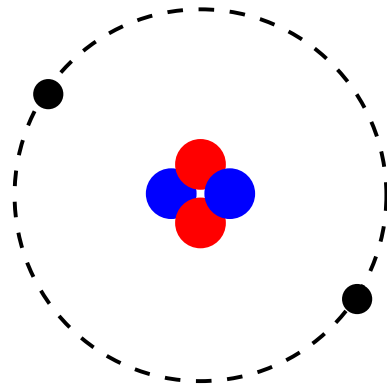


the ant

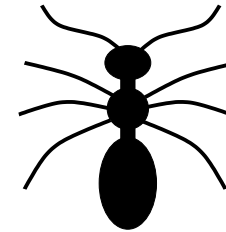


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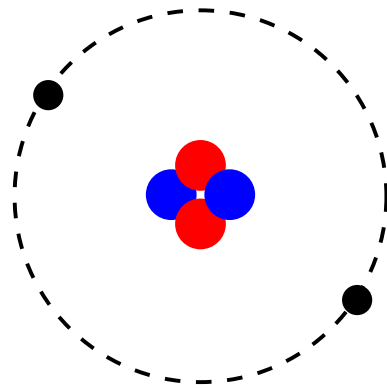
tells you nothing about the behaviour of

liquid helium

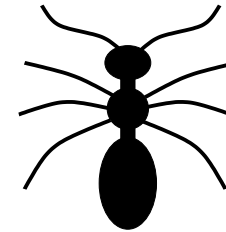
a colony of ants

Knowing all there is to know about

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the ant



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a colony of ants

⇒ even a fully unified fundamental theory does not solve the issue of complex systems

Contents

1. Critical Behavior in Strongly Interacting Matter
2. The Statistical Mechanics of Swarm Formation
3. The Statistical Basis of Language