

# Quark confinement

*Heidelberg, October 8, 2007*

Kurt Langfeld

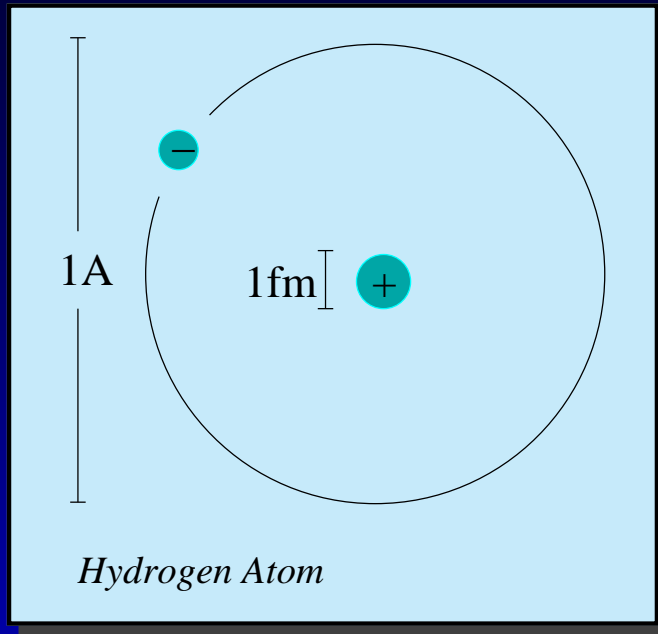
*School of Mathematics and Statistics*

*University of Plymouth*



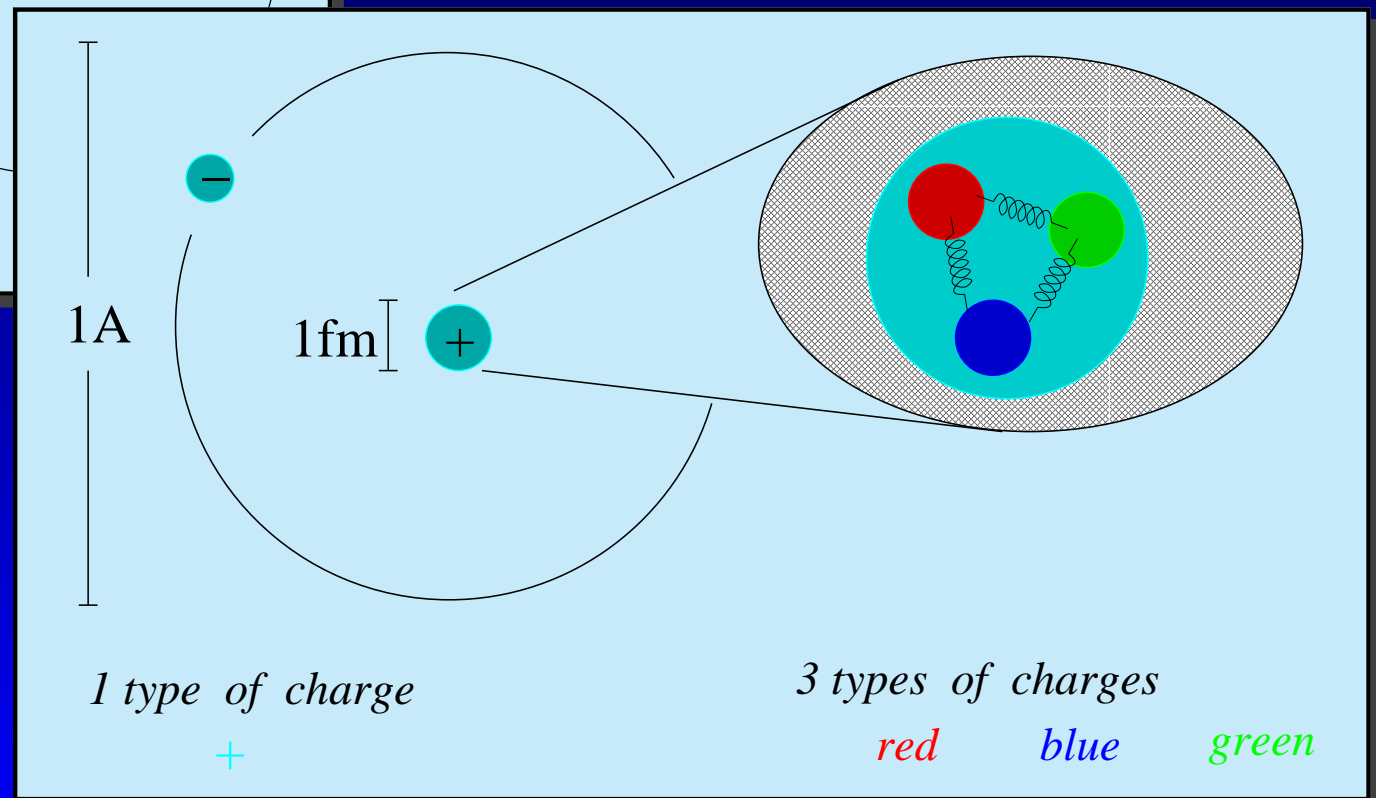
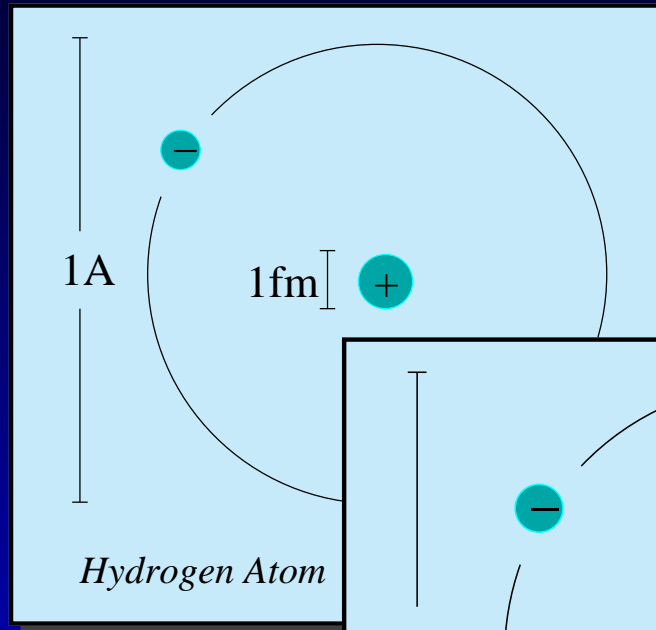
# What is “Quark Confinement”?

Structure of matter:



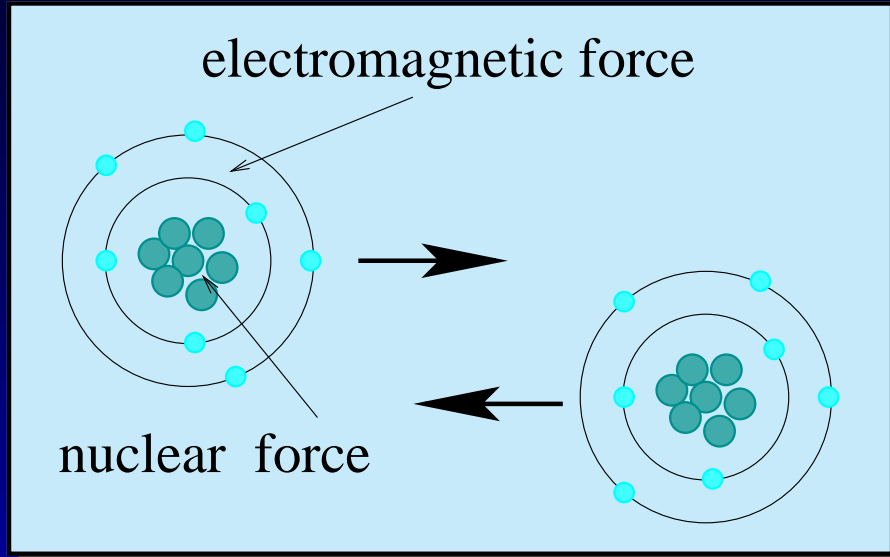
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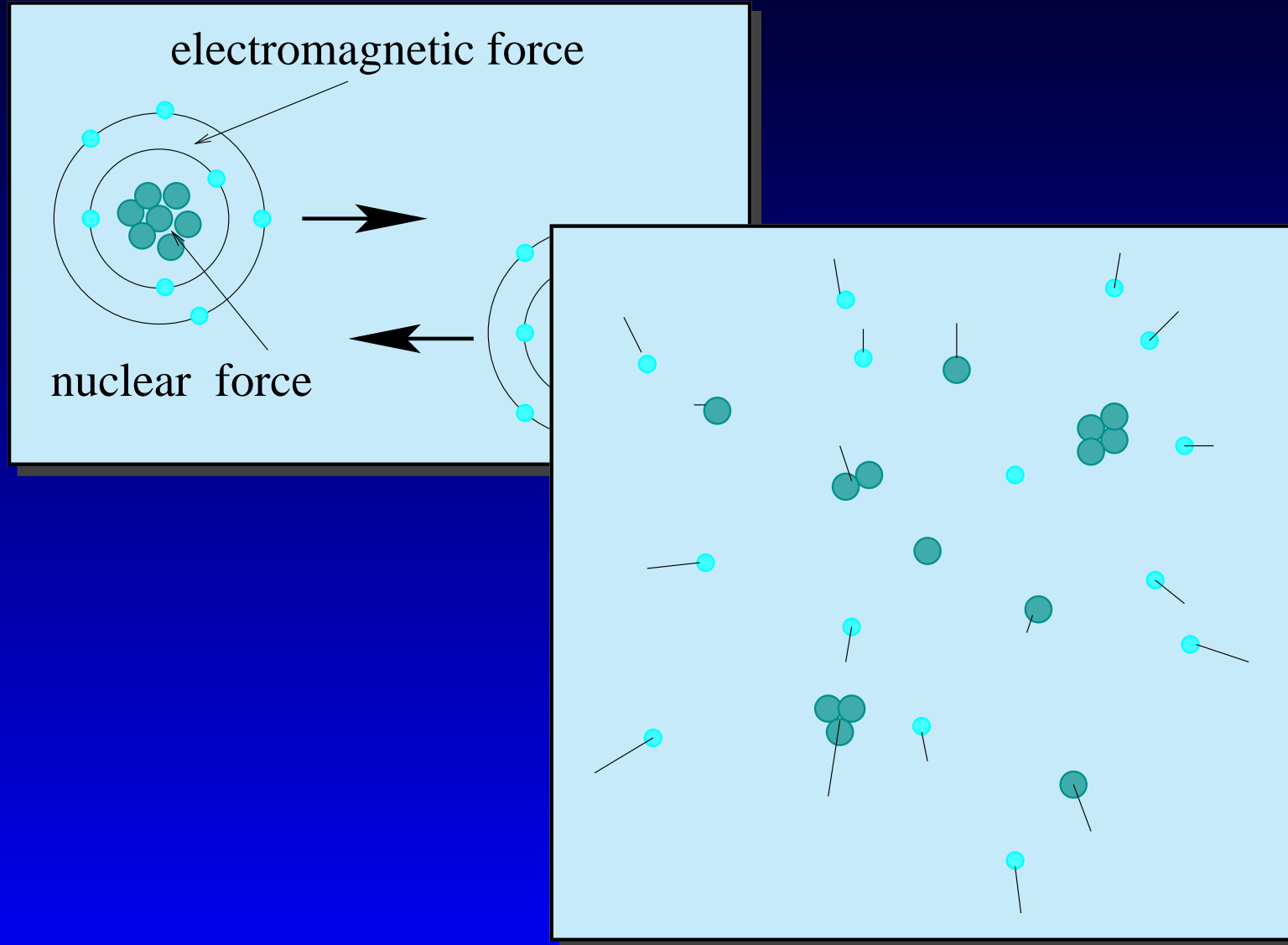
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collision of atoms



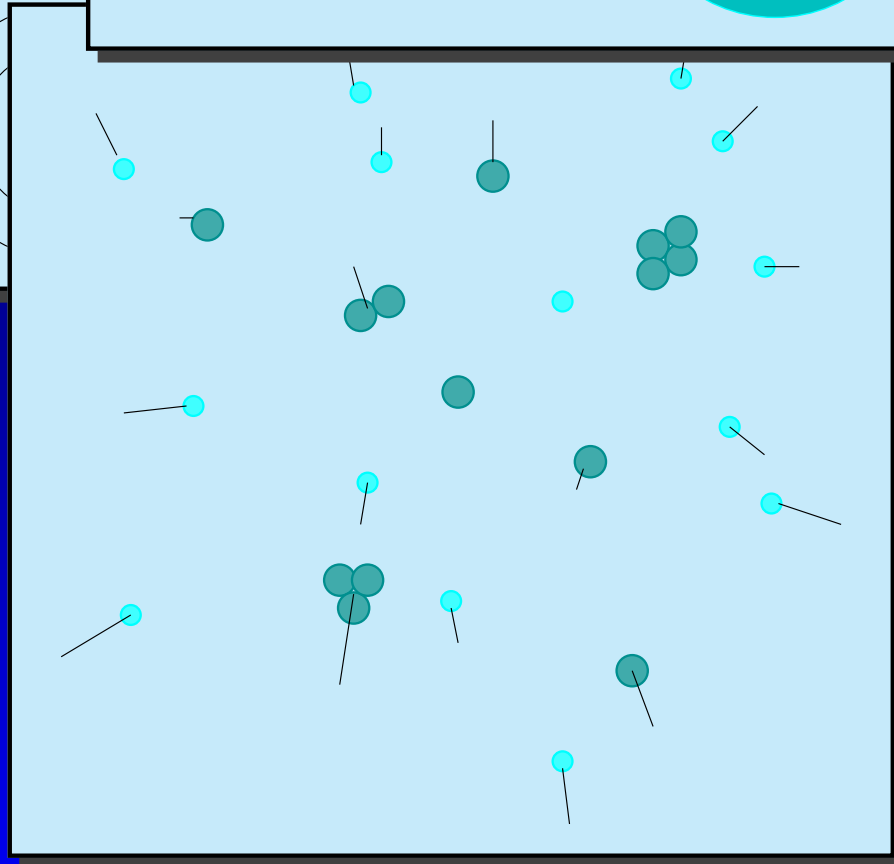
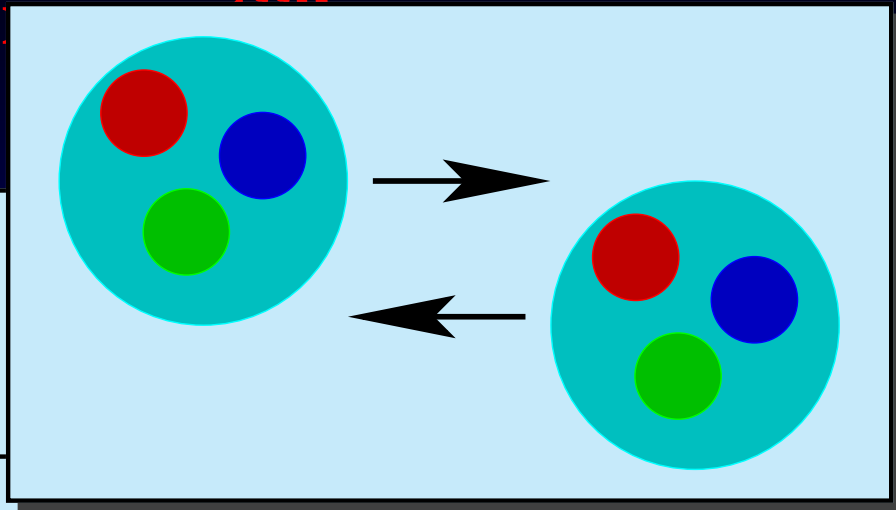
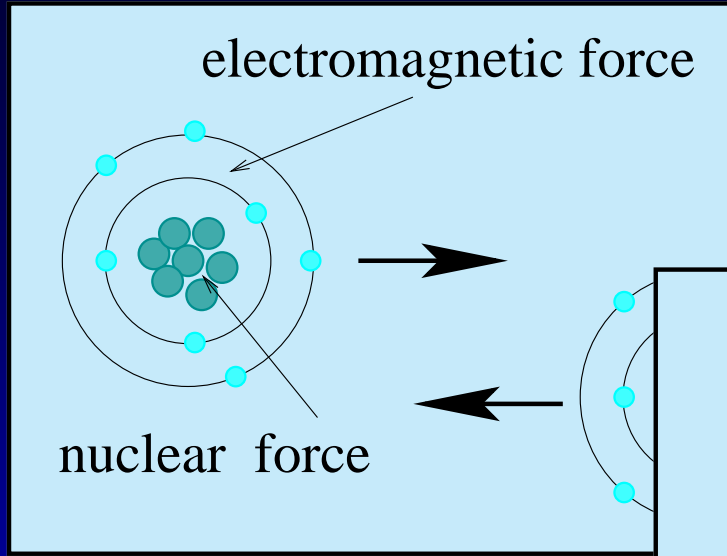
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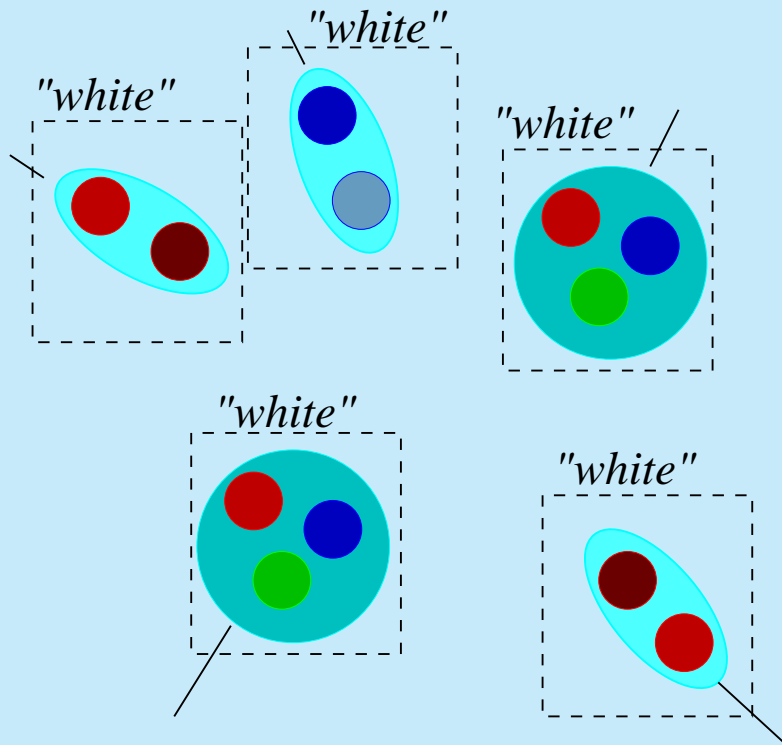
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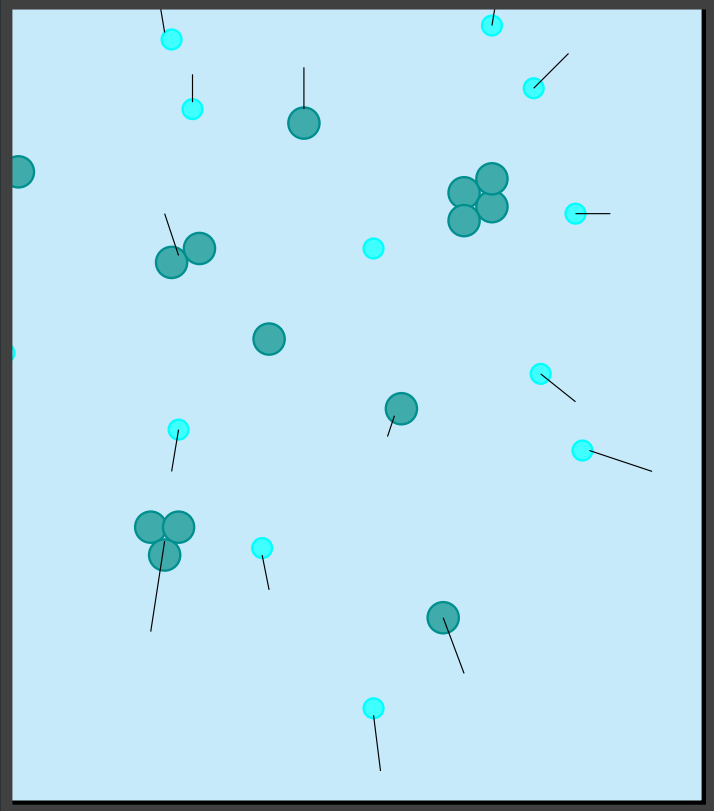
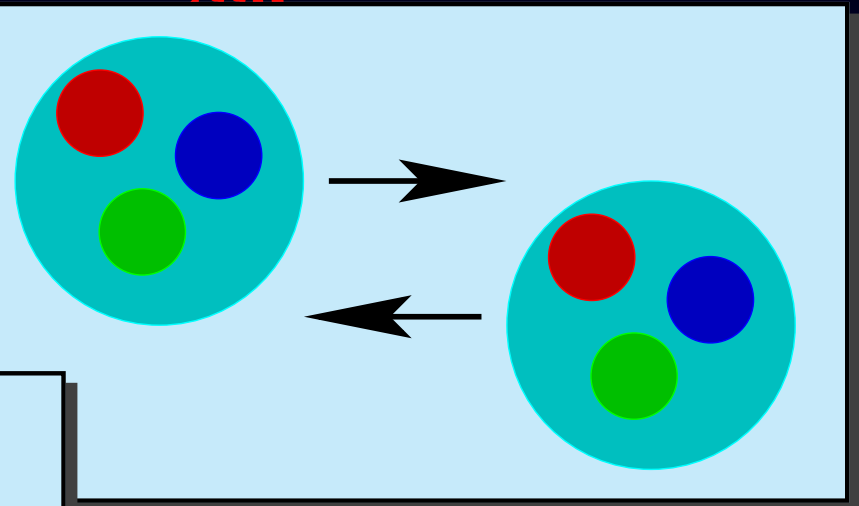
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## collision of atoms

electromagnetic force

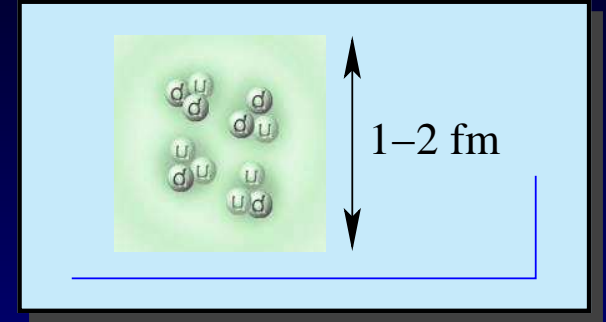


color confinement



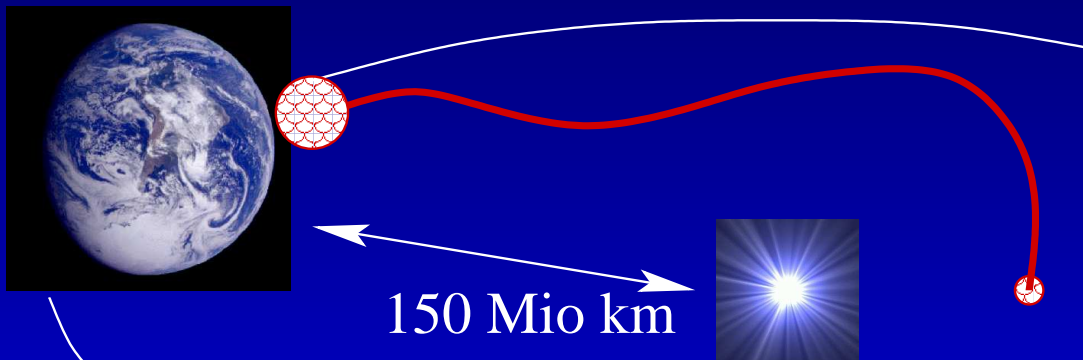
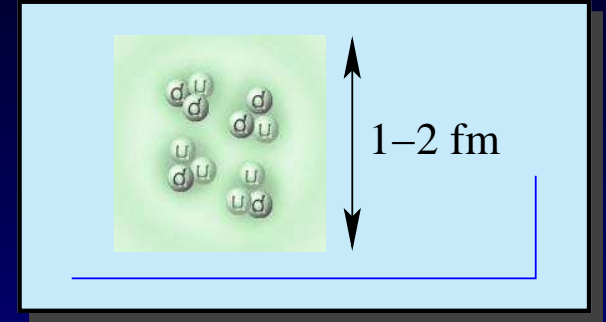
# What do we know about confinement?

- We only observe color singlets!



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- We only observe color singlets!
- We don't observe

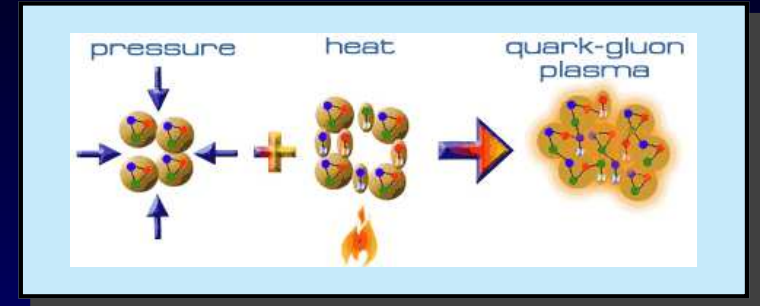


confinement scale

$$440 \text{ MeV} \hat{=} 0.5 \text{ fm}$$

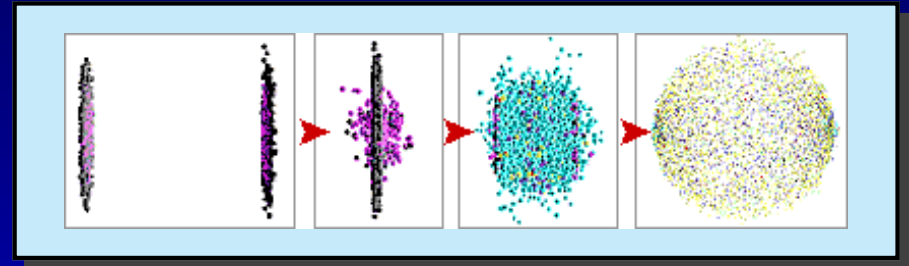
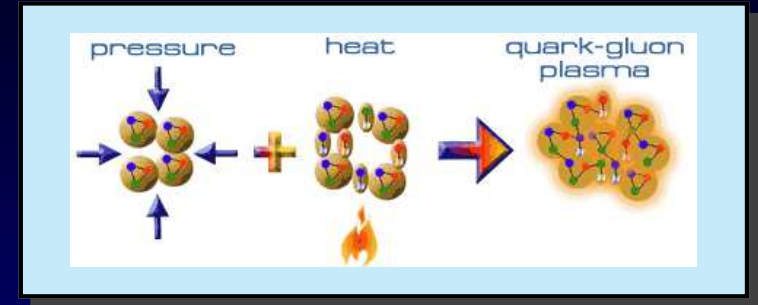
# What do we know about confinement?

- Loss of confinement under extreme conditions



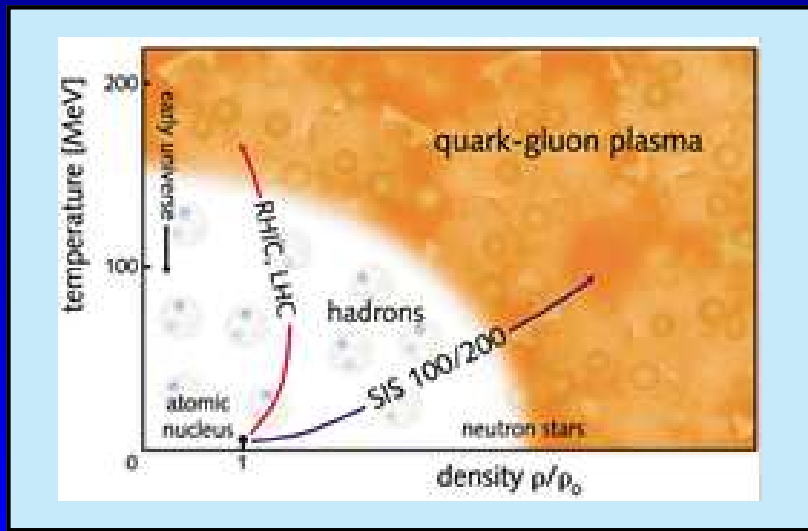
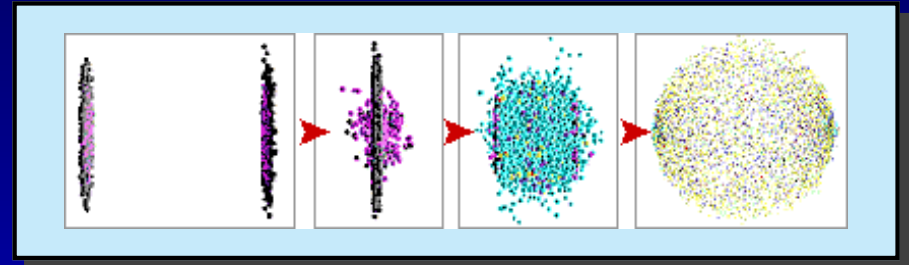
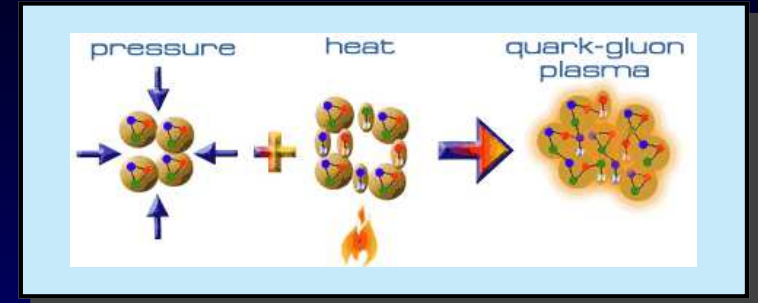
# What do we know about confinement?

- Loss of confinement under extreme conditions
- Many efforts (\$) to see the **QGP**  
RHIC, GSI, LHC, ...



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QCD phase diagram

# Why do we want to understand confinement ?

- dictates structure of matter

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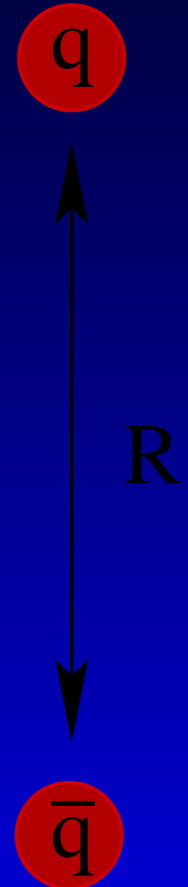
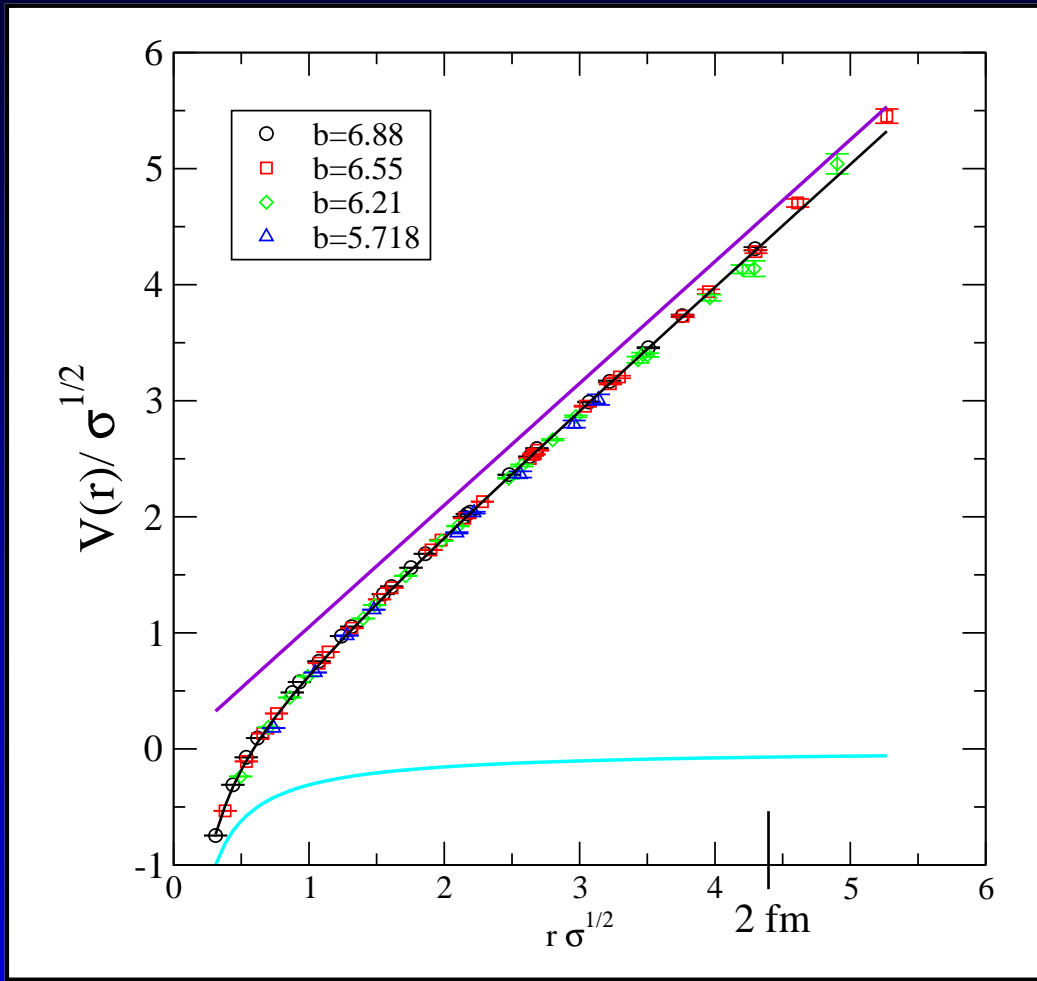
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- Nuclear binding energies:  $\approx \text{MeV/nucleon}$   
Confinement scale:  $\approx 1 \text{ GeV}$   
→ Nuclear forces are **subleading**

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- Nuclear binding energies:  $\approx \text{MeV/nucleon}$   
Confinement scale:  $\approx 1 \text{ GeV}$   
→ Nuclear forces are **subleading**
- **1.000.000 \$ Millenium problem:**  
Clay Mathematics Institute, Cambridge, Massachusetts  
**Existence of YM-Theory and  
proof of mass gap**

# Heavy quark anti-quark potential:

$$V(r) = \sigma r - \alpha/r$$



[KL, improved SU(3) action, hep-lat/0403018]