



# Phys 576

# Particle II

Prof. Noronha-Hostler  
January 18th, 2023

<https://courses.physics.illinois.edu/phys576/sp2023/index.html>

# Introductions



Prof. Jaki Noronha-Hostler

High-energy nuclear theory  
Quantum Chromodynamics

Pronouns: she/her



Jordi Salinas san Martin

High-energy nuclear theory,  
QCD, hydrodynamics, EIC

Pronouns: he/him

# Grades

Homework\* (~every 2 weeks): 700 points

Abstract (midterm): 50 points

Final Presentation: 250 points

Total possible points: 1000 points

\*Drop lowest homework

# Grade Breakdown

Final Grade	Minimum Percentage
A+	970
A	930
A-	900
B+	870
B	830
B-	800
C+	770
C	730
C-	700
D+	670
D	630
D-	600
F	< 600

# Homeworks

- \* Gradescope: [gradescope.com](https://www.gradescope.com) Entry Code:JKDX5N
- \* Time period: ~2 weeks to complete
- \* Late: Students will be able to turn in assignments after the due date for 75% of credit up to 1 weeks after the deadline
- \* Medical exceptions may be possible

# Homeworks cont.

- \* Some later homework may require coding, you can use whatever language you prefer BUT I know Mathematica and c++ the best. I won't check your python code for errors.
- \* Write clearly, explain your work, etc.
- \* Lowest homework grade is dropped.
- \* Talk to me if you get behind, don't wait until the last week!

# Schedule

[Home page](#)

[Schedule](#)

[Gradebook](#)

[GradeScope](#)

[Lecture Zoom Links](#)

[Office Hour Zoom Links](#)

[Recorded Lectures](#)

[Course Slack Channel](#)

[Course Description](#)

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## PHYS 570 Fall 2020



### Schedule

If you have any issues logging in to view any of the secured documents below, please try adding "uofi" (without the quotes) in front of your netid.

Week	Date	Lecture	Reading	Homework
1	Monday 8/24/2020	Lecture 1		
	Tuesday 8/25/2020			
	Wednesday 8/26/2020	Lecture 2		
	Thursday 8/27/2020			
	Friday 8/28/2020			
2	Monday 8/31/2020	Lecture 3		Survey Due!
	Tuesday 9/1/2020			
	Wednesday 9/2/2020	Lecture 4		
	Thursday 9/3/2020			
	Friday 9/4/2020			Homework 1 Due

# Lectures

- \* Ask lots of questions!
- \* Be respectful of others, be on time
- \* May sometimes have questions/work in class
- \* If class is virtual, zoom link: <https://illinois.zoom.us/j/84711603841?pwd=a1B5UVZZZDIFbVVxMDVmM09IRnVSdz09>
- \* May have a possible virtual lecture, if I'm traveling



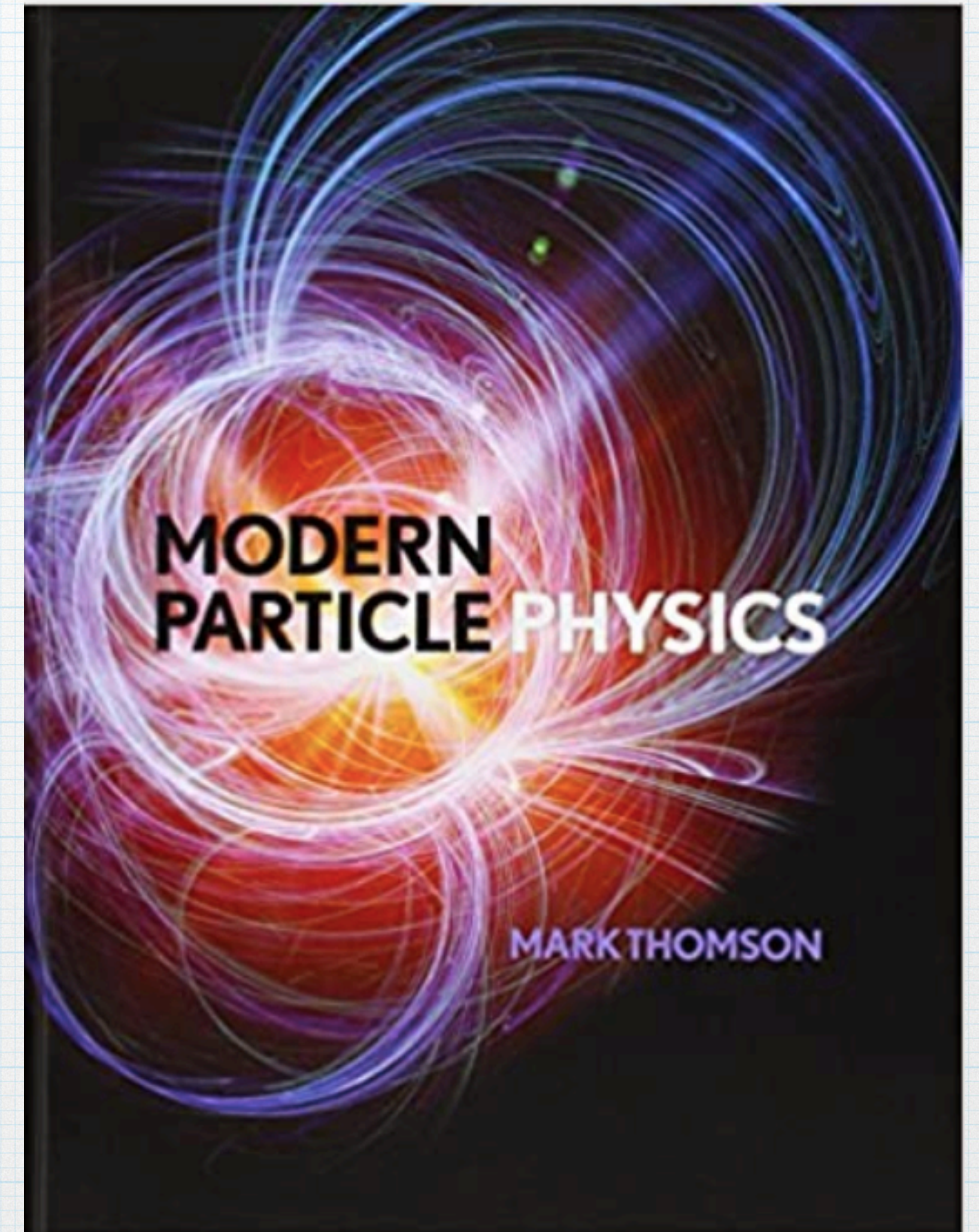
# Final Presentation

- \* You pick a paper on either particle or nuclear physics and present it to the class (discuss with me first!).
- \* 10 points= I must approve paper FIRST
- \* 40 points= writing a 250 word summary (in your own words!)
- \* 250 points, 10 minute presentation + questions at the end of the semester

# (Optional) Book

Modern Particle Physics  
by Mark Thomson

<https://www.amazon.com/Modern-Particle-Physics-Mark-Thomson/dp/1107034264>



# Other Resources

- \* Particle Data Group: <https://pdglive.lbl.gov/Viewer.action>
- \* Introduction to Elementary Particles by David Griffiths
- \* Quantum Field Theory in a Nutshell by Anthony Zee
- \* Finite Temperature Quantum Field theory by Gale and Kapusta
- \* Introductory Nuclear Physics by Kenneth S. Krane
- \* Various articles (will provide in class)

# Office Hours

- \* Jordi: Monday 3:00-4:00pm (Central time),  
Loomis 443
- \* Jaki: Monday 3:00-4:00pm (Central time),  
Loomis 427

# Academic Integrity

- \* cheating, plagiarism, fabrication,
- \* facilitating infractions of academic integrity,
- \* academic interference,
- \* computer-related infractions (e.g. posting problems on Chegg),
- \* unauthorized use of university resources,
- \* sale of class materials or notes

# Disability services

<https://www.disability.illinois.edu/academic-support/instructor-information/examples-disability-statements-syllabus>

The Department of Physics is committed to being an open and welcoming environment for all of our students. We are committed to helping all of our students succeed in our courses. To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible: call 333-4603 or e-mail [disability@illinois.edu](mailto:disability@illinois.edu). If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available on campus that can help diagnosis a previously undiagnosed disability by visiting the DRES website and selecting Sign-Up for an Academic Screening at the bottom of the page

# Mental Health Resources

Counseling Center, 206 Fred H. Turner Student Services Building, 7:50 a.m.-5:00 p.m., Monday through Friday Phone: 217-333-3704,

McKinley Mental Health, 313 McKinley Health Center, 8:00 a.m.-5:00 p.m., Monday through Friday Phone: 333-2705, McKinley Health Education offers individual consultations for students interested in learning relaxation and other stress/time management skills, call 217-333-2714

# Topics

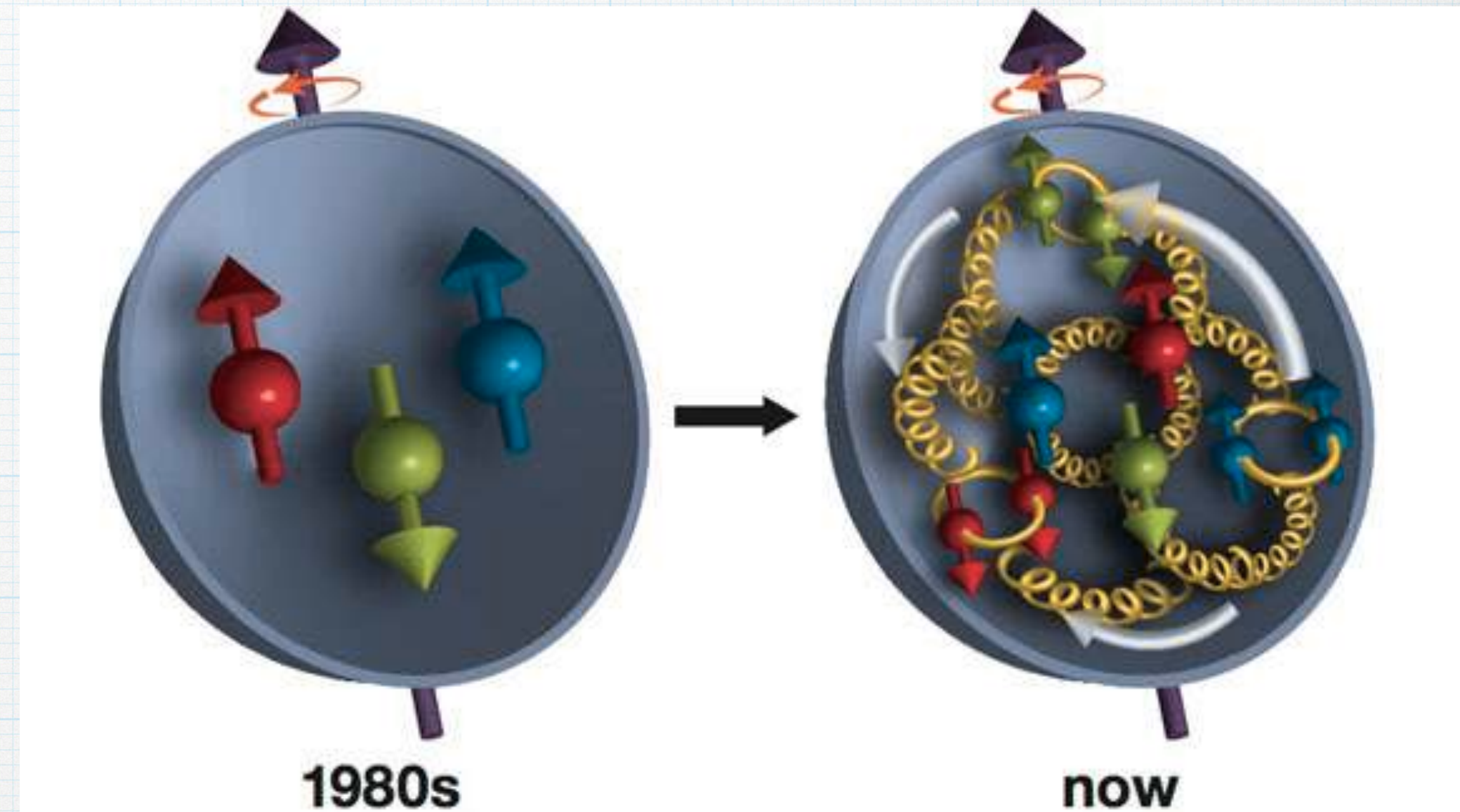
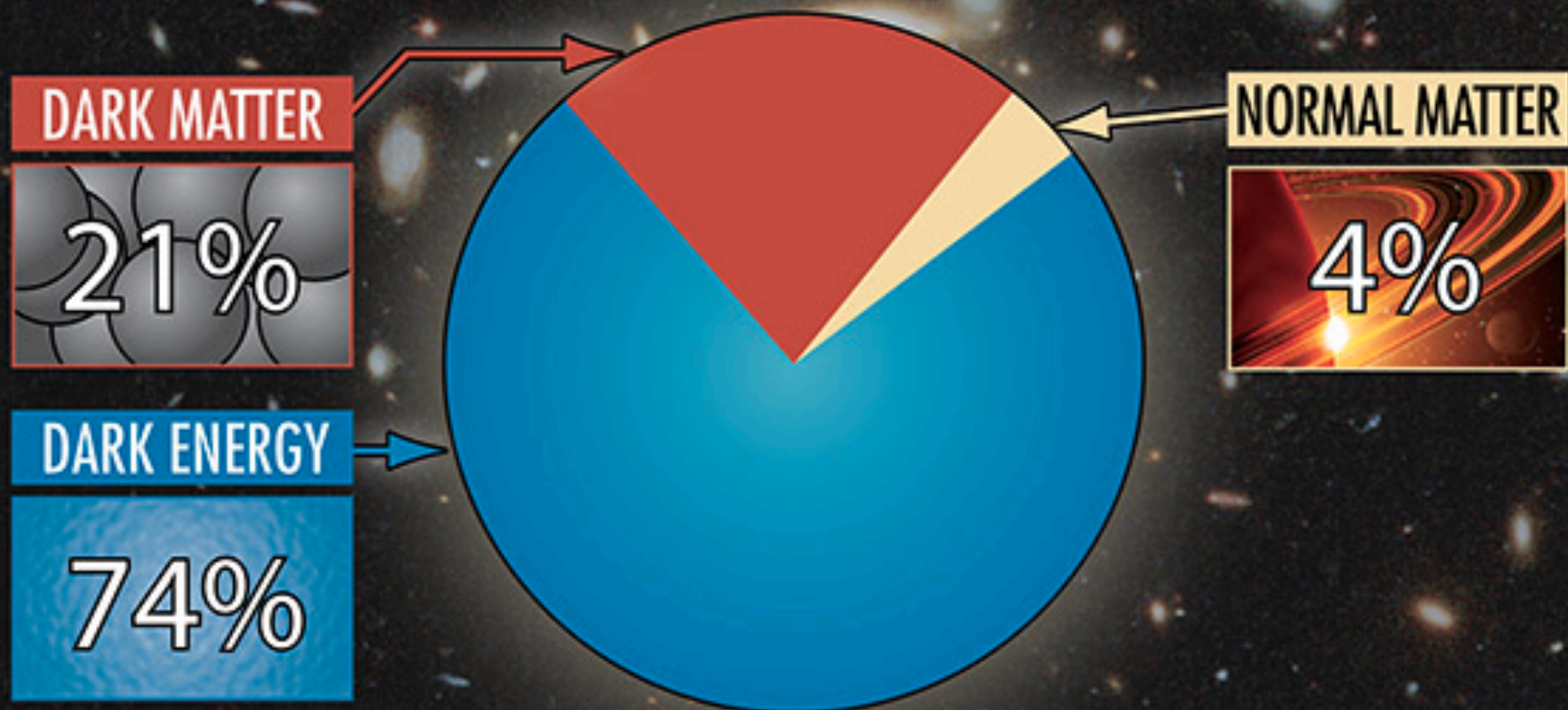
- \* Basics of Quantum Chromodynamics (QCD)
- \* Feynman diagrams (QCD)
- \* Perturbation Theory
- \* CPT, chirality
- \* Lattice QCD
- \* Heavy-ion collisions
- \* Deep Inelastic Scattering/Electron Ion Collider



# Why do we care?

Need to understand the standard model before we can look for beyond standard model physics

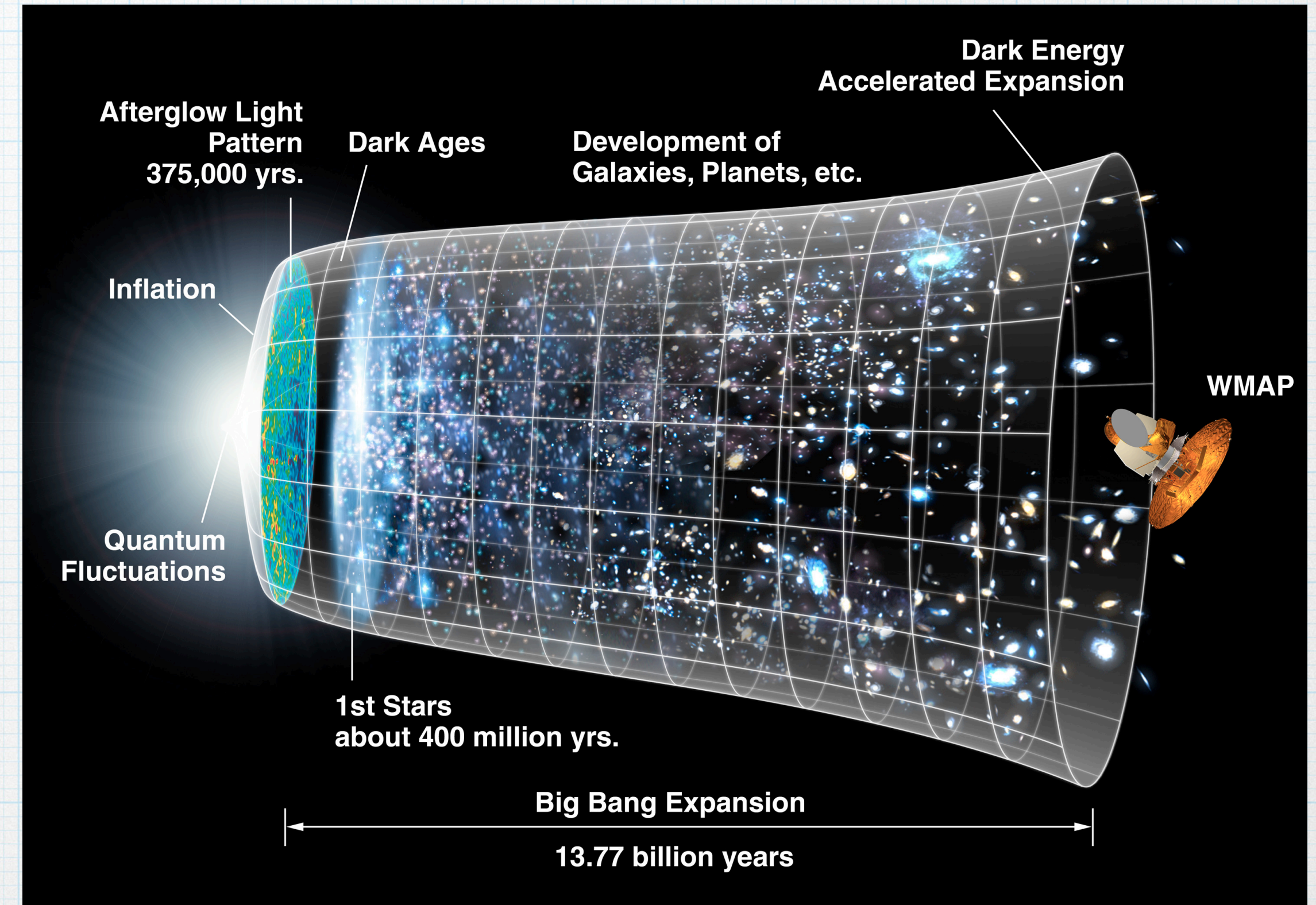
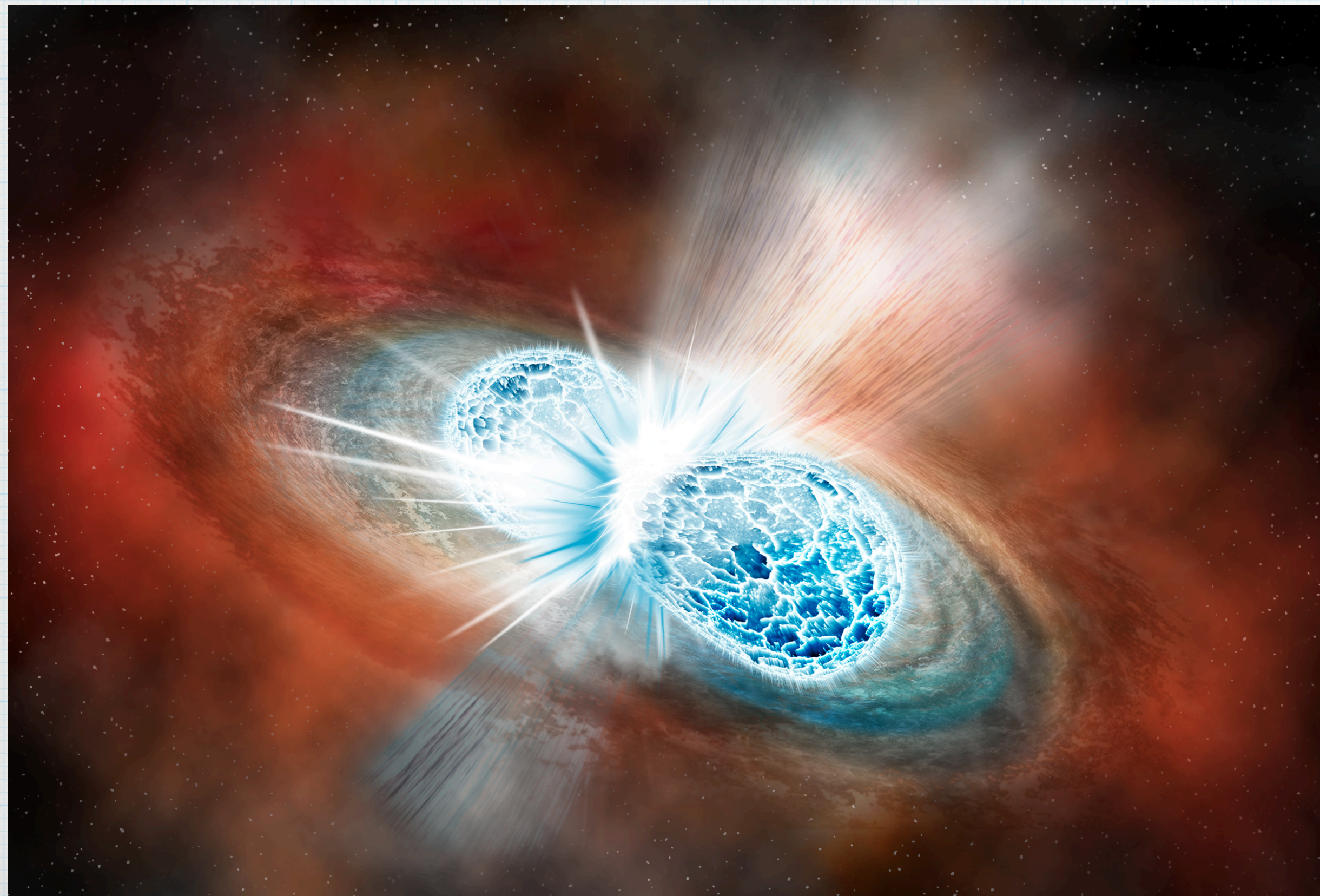
## What The Universe Is Made Of



Proton is infinitely more complicated than we ever imagined. We're barely scratching the surface of physics to learn from quarks & gluons.

# Astrophysics+particle/nuclear

Neutron star mergers require nuclear physics input: properties of nuclei, interactions, equation of state, etc



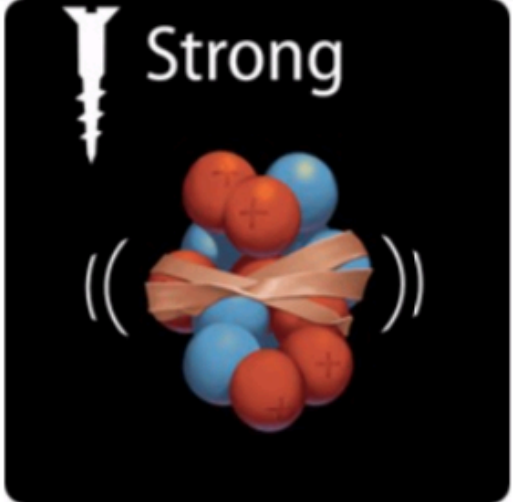
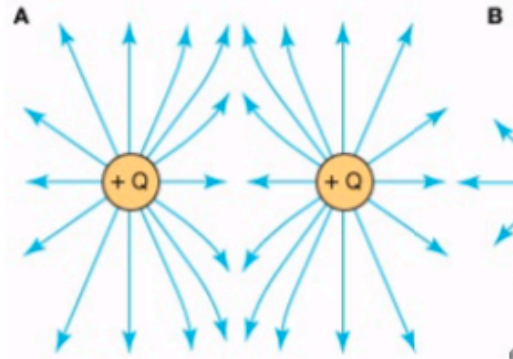
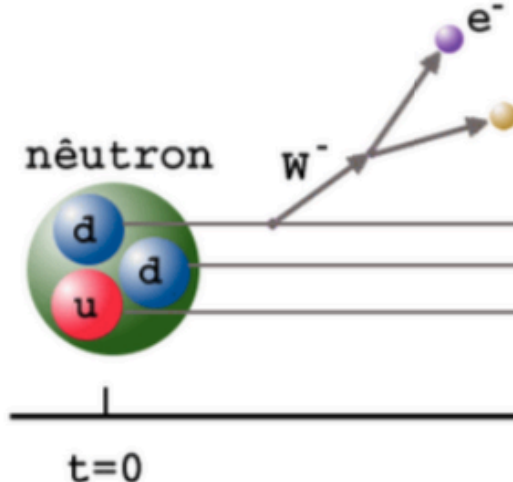
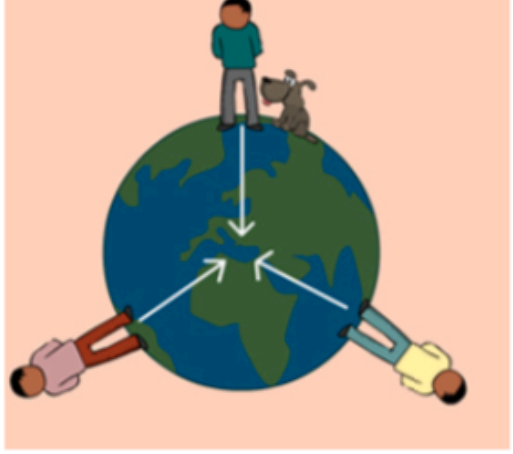
Miniature versions of the early universe can be created in the laboratory using heavy-ion collisions

# Why do we care?



Origin of the mass in the universe: Higgs vs. Quantum Chromodynamics.

# Strongest Force

Force	Image	Strength	Range (m)
Strong		1	$10^{-15}$ (size of nucleus)
Electromagnetic		$\frac{1}{137}$	$\infty$
Weak		$10^{-6}$	$10^{-18}$ (0.1% of the proton)
Gravity		$6 * 10^{-39}$	$\infty$

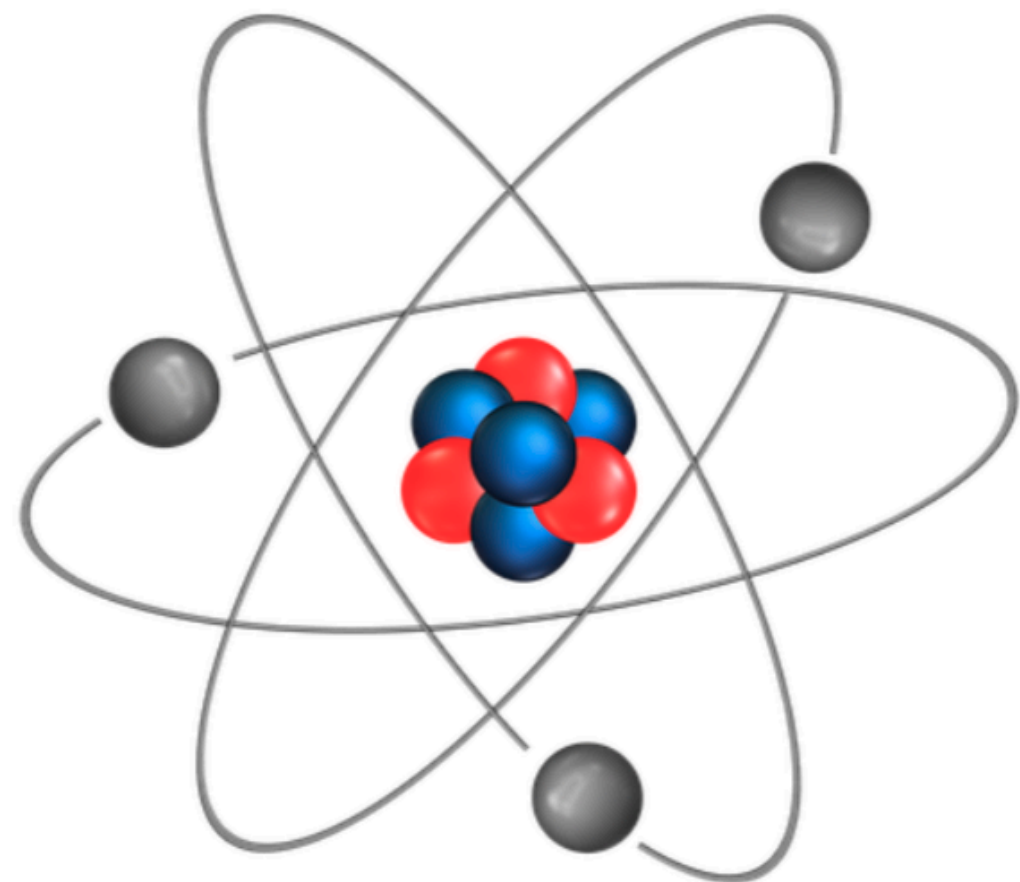
# Scales of the universe

## Atom

**Scale**  $\sim 10^{-10}$  meter

**Discovered by humans**  
 $\sim 1800$ 's

**Experiment** Chemistry

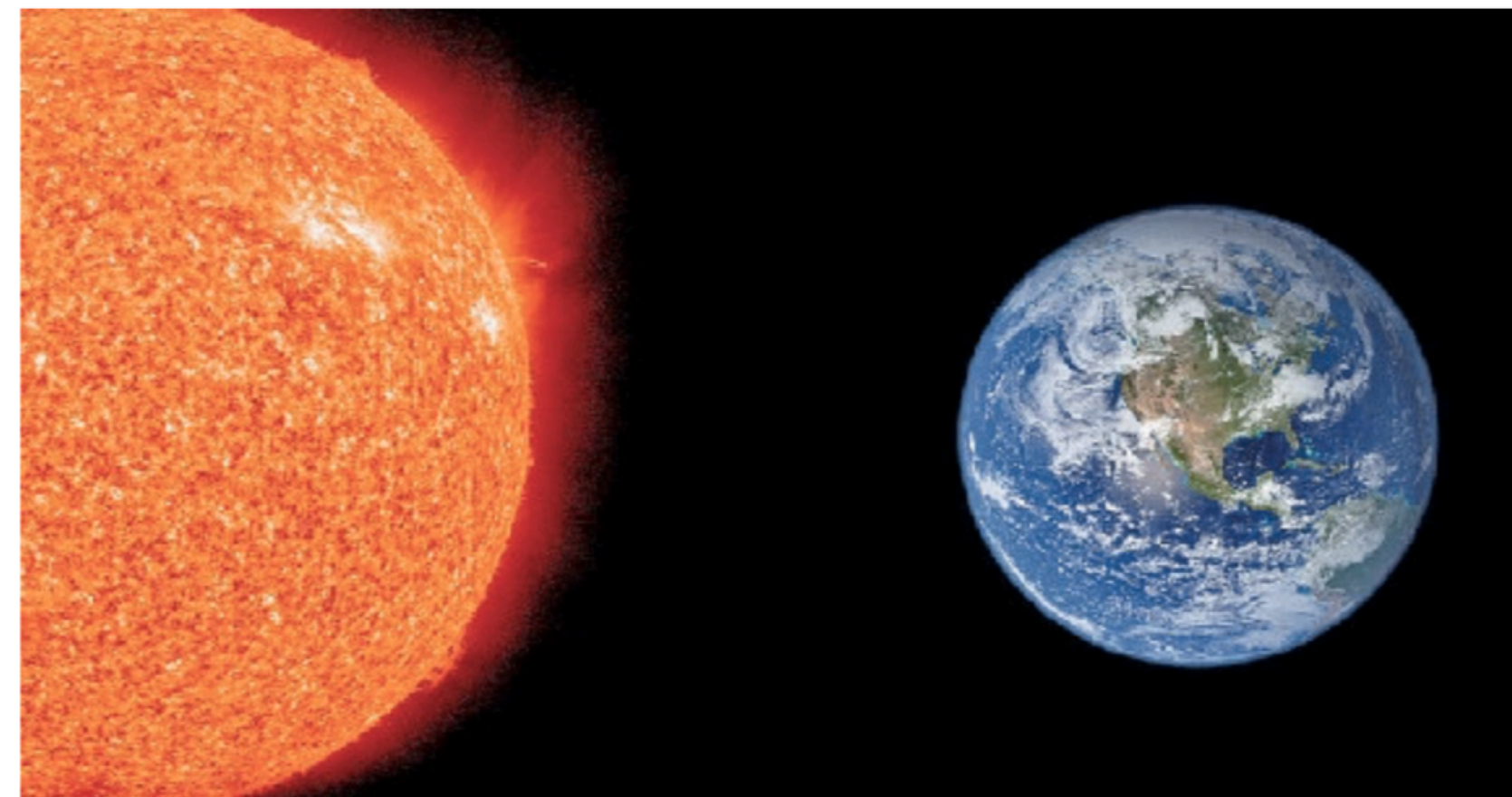


## Distance Earth to Sun

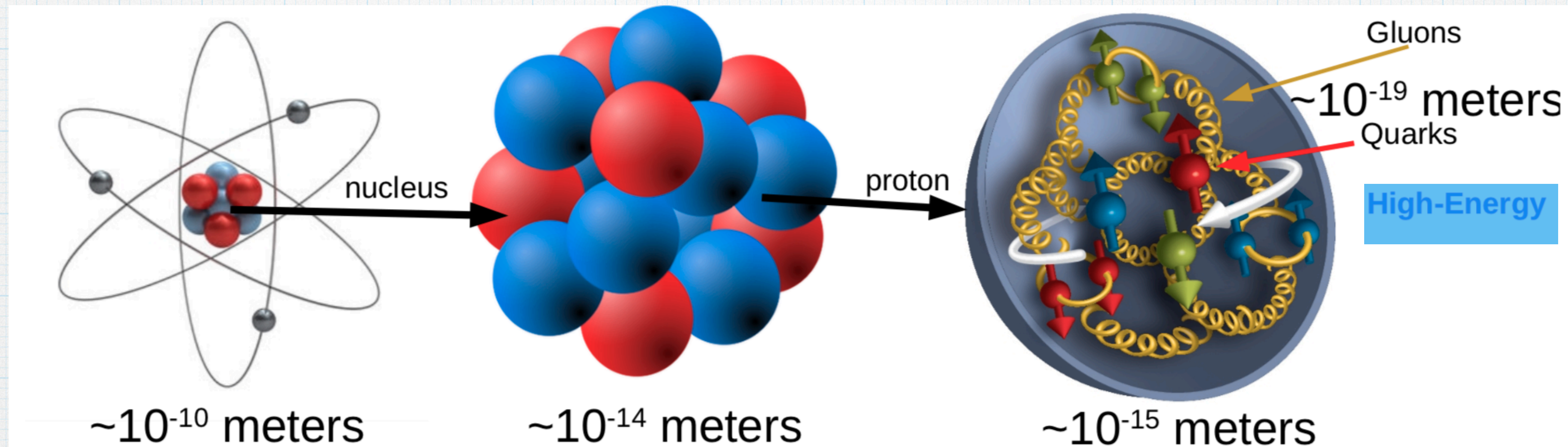
**Scale**  $\sim 10^{11}$  meter

**Discovered by humans**  $\sim 250$   
BC

**Experiment** various



# Scales of the strong force



Distance to nearest star (Alpha Centauri system)  $\sim 10^{16}$  m

Natural Units:  $\hbar = c = 1$  i.e.  $E = Mc^2 \rightarrow E = M$

**Length** 1 Femtometer [fm] =  $10^{-15}$  [m]

**Temperature** 1000 Megaelectron-volt [MeV] = 11 billion [K]

**Mass** 1 [MeV] =  $1.79 \times 10^{-30}$  [kg]