Final exam:

- Wednesday, May 6 from 7:30 pm – 10:30 pm.
- Regular office hours through next Monday. Expanded office hours for next Tuesday and Wednesday.
- Optional review session for Unit 4 on Sunday, May 3 from 7:00–8:00 pm, here in Olin 268.
- The final exam is 200 points.
- You may bring your previous 3 cards and a fourth card for Unit 4.
- We will provide the particle tables, all constants, and spin state relations.

Evaluations for Lecture:

You can use a computer, tablet, or cell phone.

To access the form, either

- click on link at the top of the PHYS 212 web page, or
- use this QR code:

Your feedback about this course is useful for evaluating whether the assignments, activities, instruction and other aspects of this course helped you meet the learning goals. We therefore appreciate your thoughtful responses to these questions.

Please be aware of the potential for bias while responding to questions. You are not evaluating the instructor on their expertise, their appearance, or aspects of their identity. Your responses will not be seen by the instructor until after grades are submitted, and all responses will remain anonymous. Please do not collaborate with others on your responses.

Please join
Physics & Astronomy Professors Jackie Villadsen and D. Iyer along with student researchers Aura Hernandez '27 and Meshkat Alam '28 to discuss:

Physics and astronomy have historically supported colonization (navigation, war, mining) and an ethos of the supremacy of western "civilization." In this project, we explore the modern ways in which astronomy benefits from and perpetuates its colonial past. This includes building telescopes on sacred indigenous lands, despite systematic opposition from indigenous groups. As we discuss these connections, we reflect on our own values and what we have learned.

Thursday April 30th at noon in OLIN 268

Pizza will be served

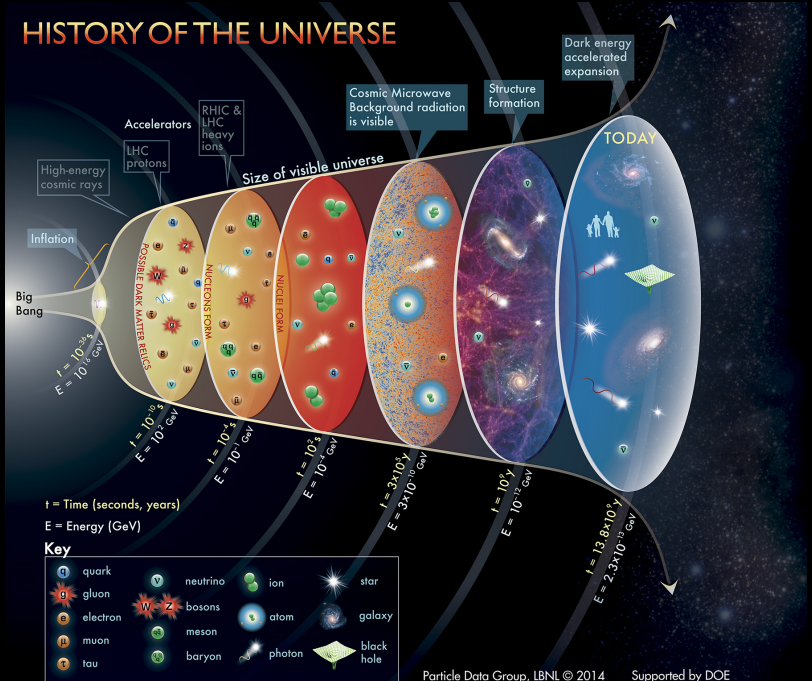
[S] Science on Screen

An initiative of the COOLIDGE CORNER THEATRE with major support from the ALFRED P. SLOAN FOUNDATION

Saturday, MAY 2ND at 7:00 PM

"Unseen and Underestimated: The Intersection of Race, Gender, and Identity in STEM" with special guests **JiaJia Dong & Adam Mair**

CAMPUS THEATRE
EST. 1941

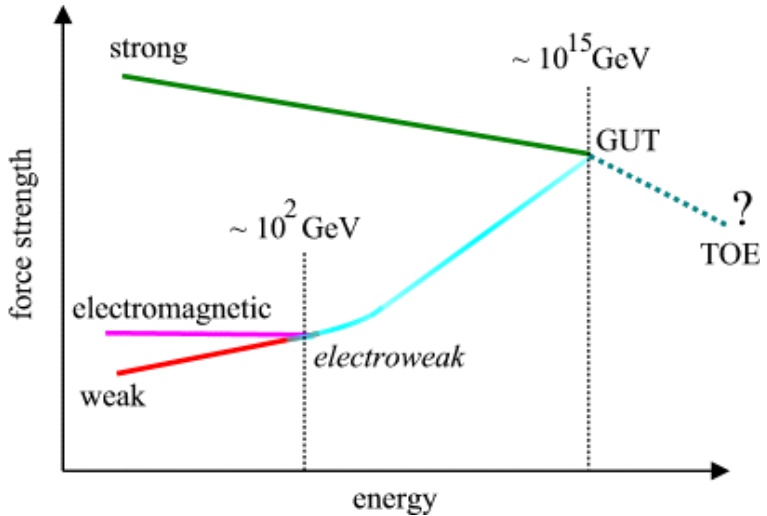

HISTORY OF THE UNIVERSE
Dark energy accelerated expansion
Cosmic Microwave Background radiation is visible
Structure formation
TODAY
Accelerators
RHIC & LHC heavy ions
LHC protons
High-energy cosmic rays
Size of visible universe
Inflation
Big Bang
POSSIBLE DARK MATTER RELICS
NUCLEONS FORM
NUCLEI FORM
t = 10^-35 s
E = 10^15 GeV
t = 10^-10 s
E = 10^2 GeV
t = 10^-4 s
E = 10^-1 GeV
t = 10^2 s
E = 10^-4 GeV
t = 3x10^5 y
E = 3x10^-10 GeV
t = 10^9 y
E = 10^-12 GeV
t = 13.8x10^9 y
E = 2.3x10^-13 GeV
t = Time (seconds, years)
E = Energy (GeV)
Key
quark
gluon
electron
muon
tau
neutrino
W Z bosons
meson
baryon
ion
atom
photon
star
galaxy
black hole
Particle Data Group, LBNL © 2014
Supported by DOE

Lecture 25 — Concept Test 1

How long after the Big Bang did the temperature of the universe cool down to $10\,000$ K?

1. 10^{12} s
2. 10^{6} s
3. $10\,000$ s
4. 10^{-4} s
5. 10^{-6} s
6. 10^{-12} s

Thermal energy: $E \approx k_B T \approx \dfrac{10^6}{\sqrt{t}}$ (eV)

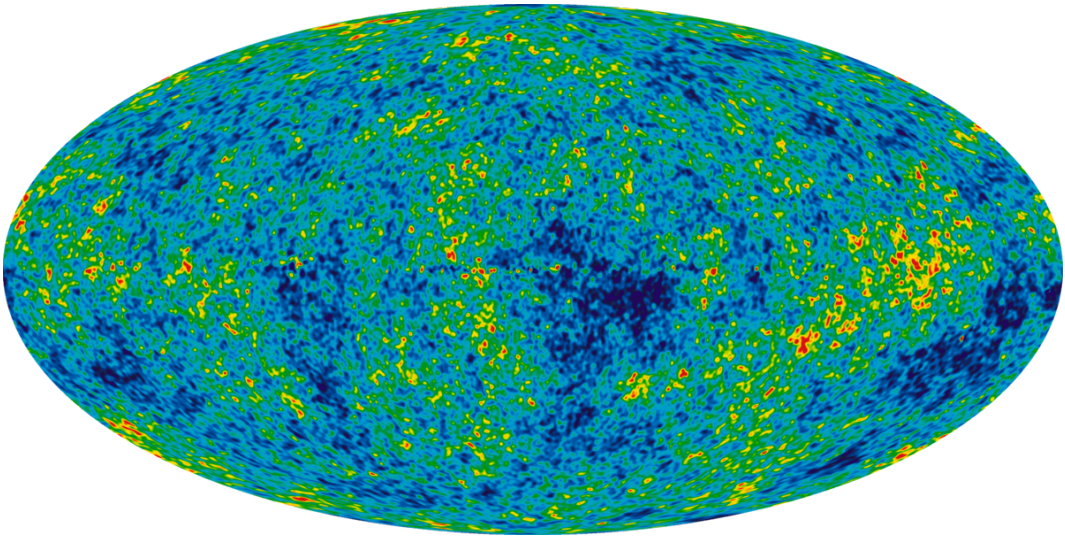


Lecture 25 — Concept Test 2

Roughly how long after the Big Bang did hydrogen atoms start to form? Recall that the energy of an electron in a hydrogen atom is $E_n = -13.6$ eV. For simplicity, assume that the binding energy is about 10 eV for hydrogen.

1. 10^{-10} s
2. 10^{-5} s
3. 100 s
4. $10\,000$ s
5. 10^{5} s
6. 10^{10} s

Cosmic Microwave Background Radiation



Credit: NASA / WMAP Science Team