

ARTHUR C CLARKE CENTER FOR HUMAN  
**IMAGINATION**

**PRESENTS**

# **MATH AND THE BODY AND THE MIND**

**RAFAEL NÚÑEZ**  
UC SAN DIEGO COGNITIVE SCIENCE

**CINDY LAWRENCE**  
THE NATIONAL MUSEUM OF MATHEMATICS

**GLEN WHITNEY**  
THE NATIONAL MUSEUM OF MATHEMATICS

Join cognitive scientist Rafael Núñez along with Cindy Lawrence and Glen Whitney, Co-Directors of the National Museum of Mathematics as they discuss the interplay between physical experience and mathematical cognition and intuition. Is mathematics a purely symbolic exercise, or can it be experienced and processed physically? How do mathematical ideas originate? What role do fun, creativity, and exploration play in the learning and doing of mathematics?

**OCTOBER 16, 2013 5:30PM TO 7:30PM**  
AT UC SAN DIEGO'S ATKINSON HALL AUDITORIUM

LIGHT REFRESHMENTS SERVED FROM 5:30 TO 6:00  
**FREE TO THE PUBLIC**  
RSVP [INFO@IMAGINATION.UCSD.EDU](mailto:INFO@IMAGINATION.UCSD.EDU)

Thanks to the James B. Ax Family Foundation for underwriting this event.

**UC San Diego**

**ViaSat**

Founding Partner of the Clarke Center

# MfA Math for America San Diego

Math for America San Diego's Third Annual Fundraiser

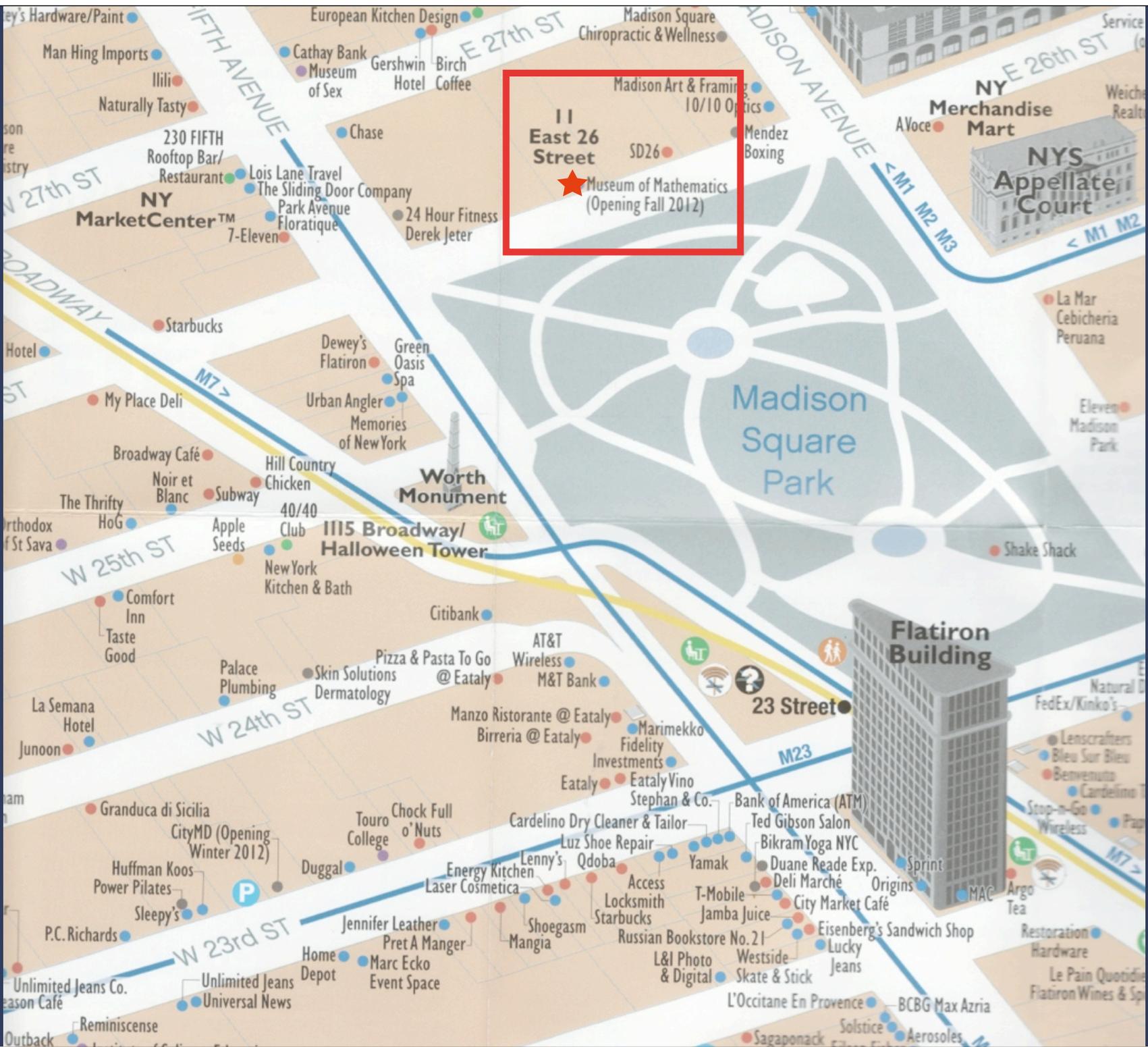
## **The Changing Face of Mathematics**

Scripps Institution of Oceanography

Thursday, Oct. 17, 2013 ~ 5 - 7 p.m.



invite only:  
[bkeating@ucsd.edu](mailto:bkeating@ucsd.edu)



11 East 26 Street  
★ Museum of Mathematics (Opening Fall 2012)

NYS Appellate Court

Flatiron Building

Madison Square Park

Worth Monument

1115 Broadway/  
Halloween Tower

23 Street

W 23rd ST

W 25th ST

W 24th ST

E 27th ST

E 26th ST

NY MarketCenter™

NY Merchandise Mart

Man Hing Imports  
Ilii  
Naturally Tasty

230 FIFTH Rooftop Bar/Restaurant

7-Eleven

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

Granduca di Sicilia

CityMD (Opening Winter 2012)

Huffman Koos

Power Pilates

Sleepy's

P.C. Richards

Cathay Bank  
Museum of Sex

Chase

Lois Lane Travel  
The Sliding Door Company

Park Avenue Floratique

7-Eleven

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

European Kitchen Design  
Gershwin Hotel

Birch Coffee

Chase

Lois Lane Travel  
The Sliding Door Company

Park Avenue Floratique

7-Eleven

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

Madison Art & Framing  
10/10 Optics

SD26

Mendez Boxing

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

Granduca di Sicilia

Madison Square Chiropractic & Wellness

Madison Art & Framing  
10/10 Optics

SD26

Mendez Boxing

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

NY Merchandise Mart

AVoCe

NYS Appellate Court

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

Granduca di Sicilia

Service

NY Merchandise Mart

NYS Appellate Court

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

Granduca di Sicilia

Weiche Realty

AVoCe

NYS Appellate Court

Starbucks

My Place Deli

Broadway Café

Noir et Blanc

The Thrifty HoG

Apple Seeds

Comfort Inn

Taste Good

La Semana Hotel

Junoon

Granduca di Sicilia



# Museum of Mathematics



string  
product



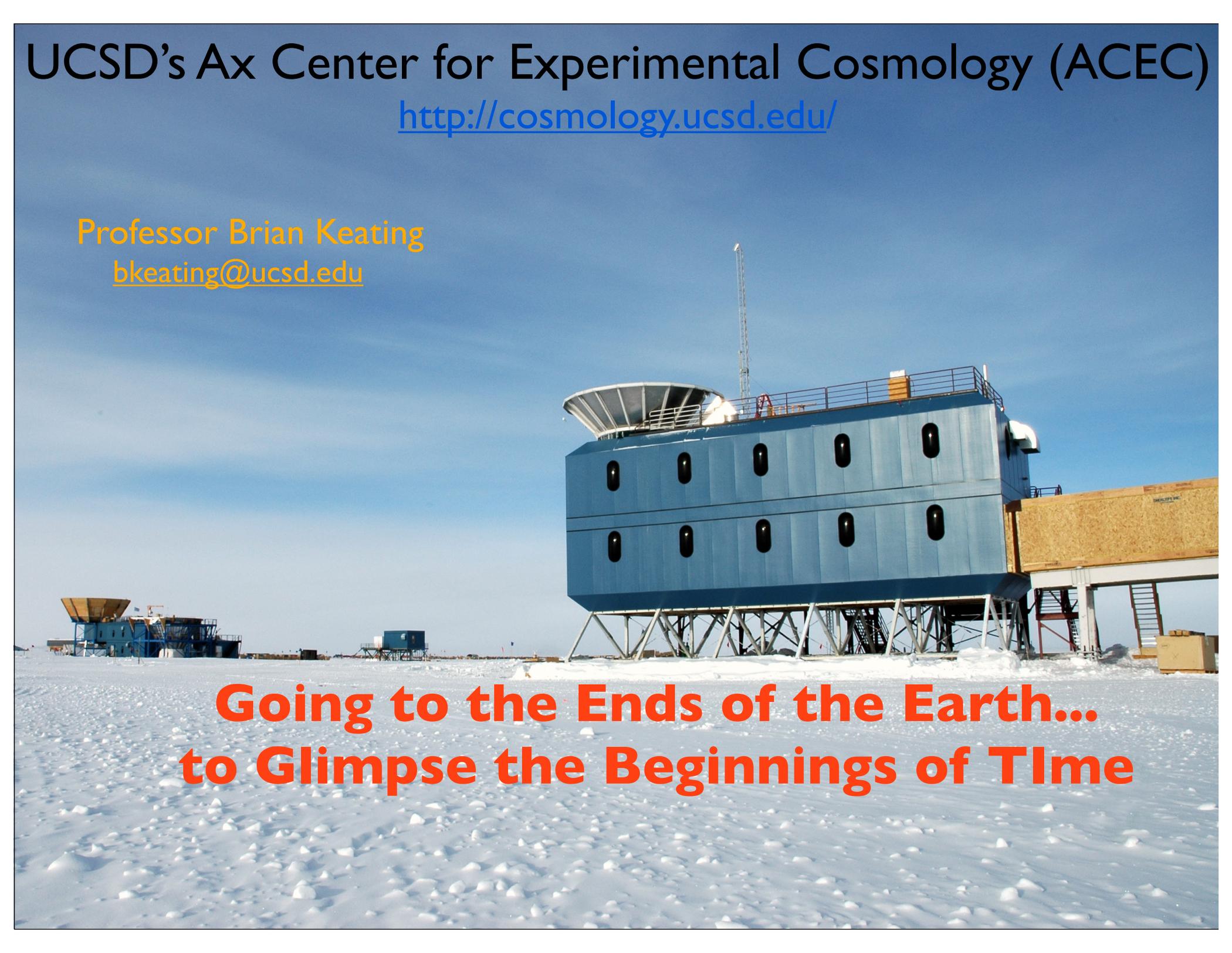


# UCSD's Ax Center for Experimental Cosmology (ACEC)

<http://cosmology.ucsd.edu/>

Professor Brian Keating

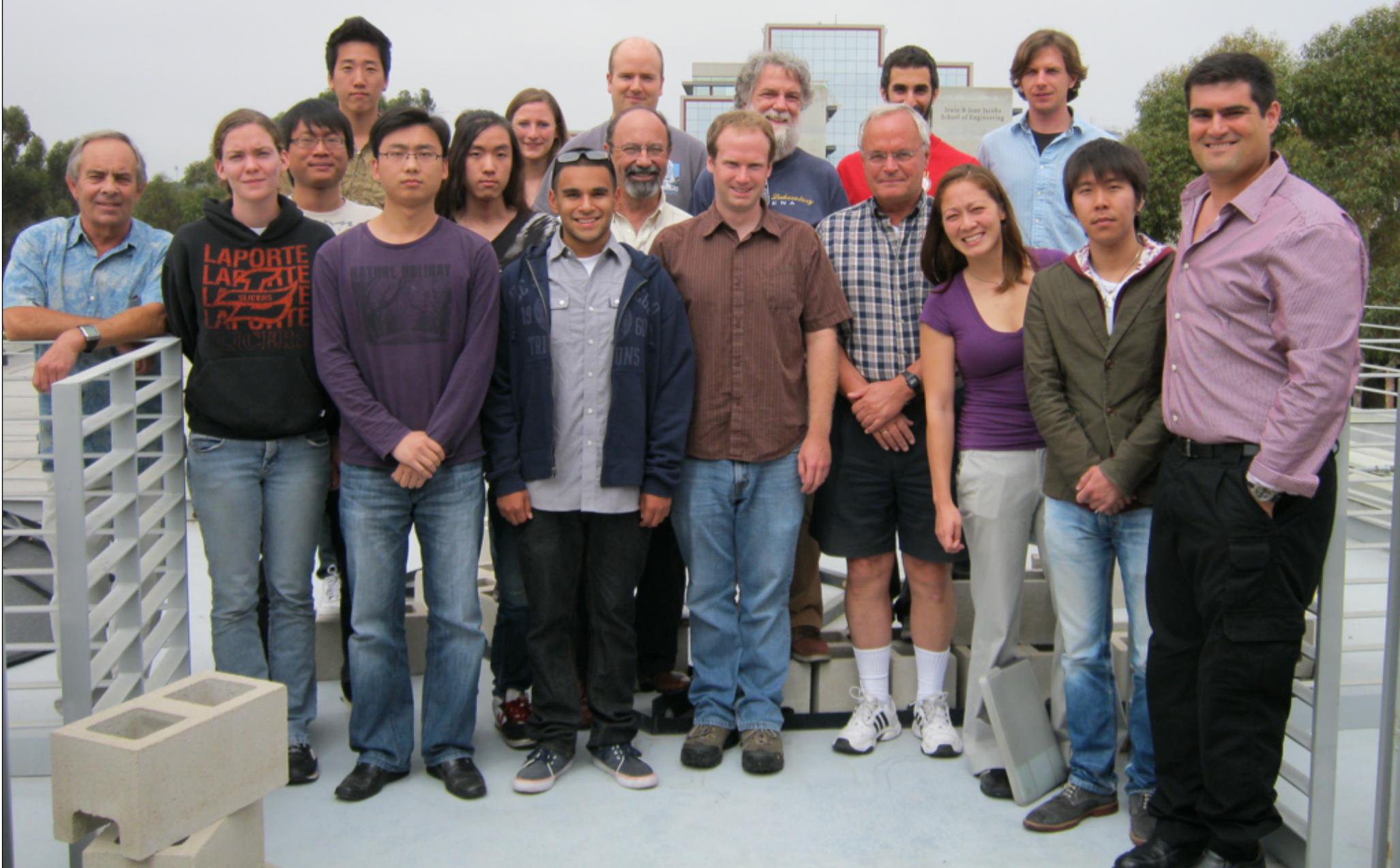
[bkeating@ucsd.edu](mailto:bkeating@ucsd.edu)

A large, blue, modular building with a satellite dish on top, situated on a snowy field. The building has two levels of windows and is supported by a metal frame. In the background, other similar structures and a clear blue sky are visible.

**Going to the Ends of the Earth...  
to Glimpse the Beginnings of Time**

<http://cosmology.ucsd.edu/>

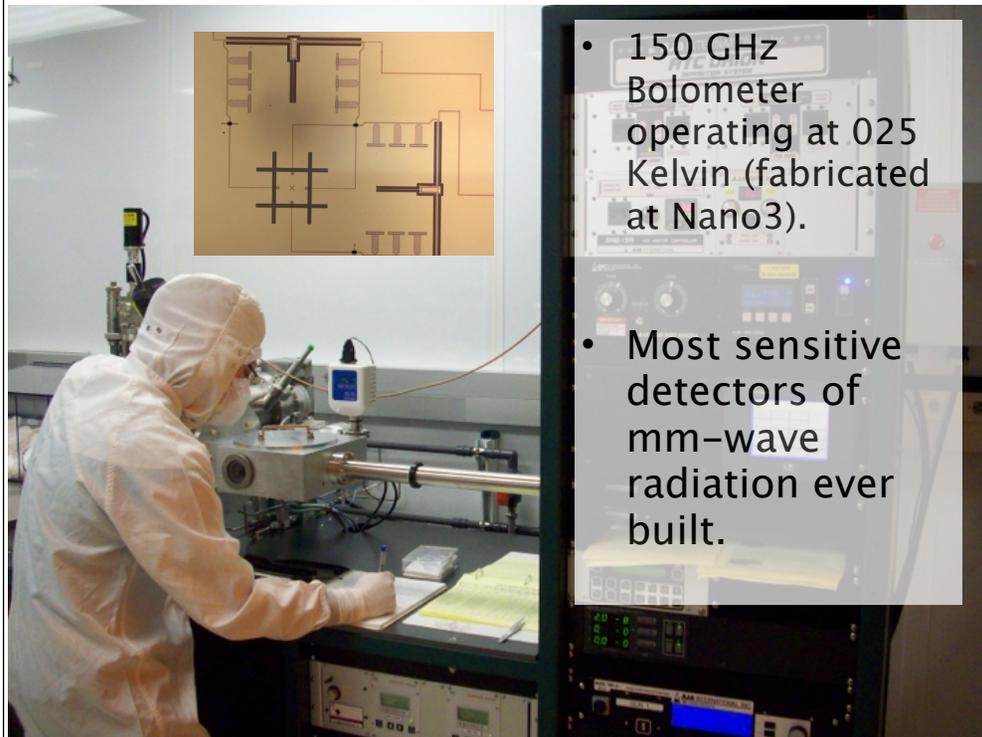
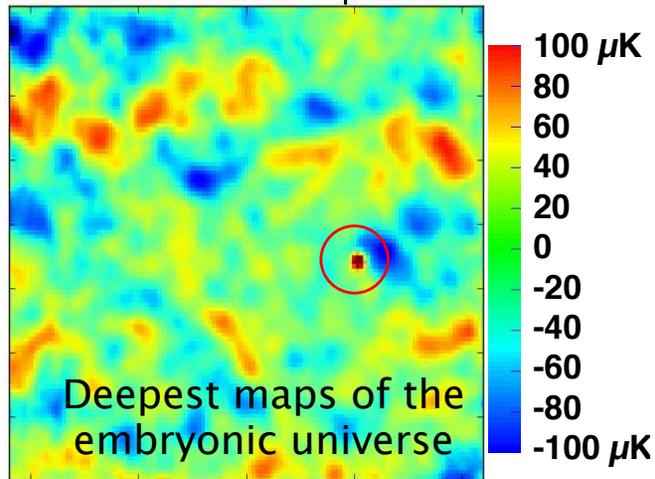
 @ucsdcosmology



# The POLARBEAR Cosmic Microwave Background Telescope

## UCSD, Berkeley, Colorado, Japan

- Measure the mass of neutrinos
- Measure physics at the GUT scale immediately after the Big Bang  $10^{-35}$ s

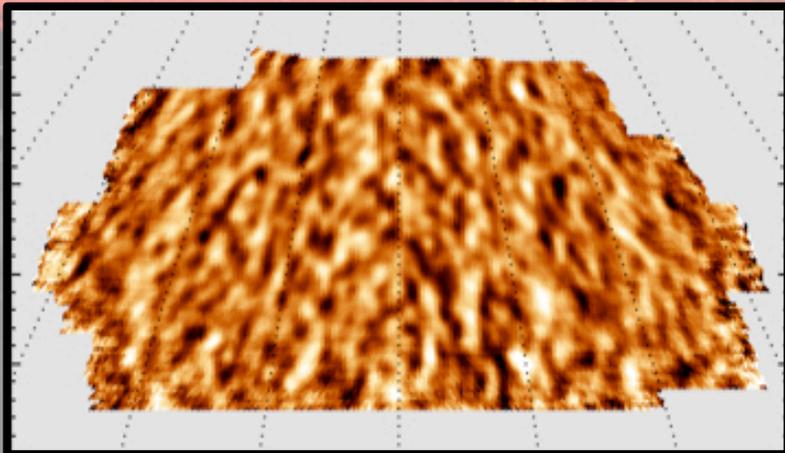
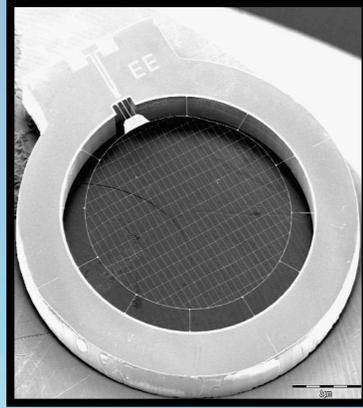


# Grading

- Homework 30%
- **Midterm Exam 20%, 11/06/2013 in class**
- Class Participation 10%, in class, every class!
- **Final Exam 40% (on 12/10/2013 at 11am-2:30p)**
- For both homework and exams (and class participation) I give lots of partial credit!
- For homework, you may obtain help from any source (except solutions to the homework!) .You must write up your submission.
- **A crib sheet (size 8.5"x11") in your own handwriting may be used at the mid-term and final examinations, which are, otherwise, closed book.**
- UCSD's Policy on Academic Integrity must be observed. See: <http://senate.ucsd.edu/manual/appendices/app2.htm>
- Course Text: David Griffiths, Introduction to Quantum Mechanics, (Pearson Prentice Hall, Upper Saddle River, NJ, 2005), 2nd edition. Most of the homework problems will be assigned from Griffiths.



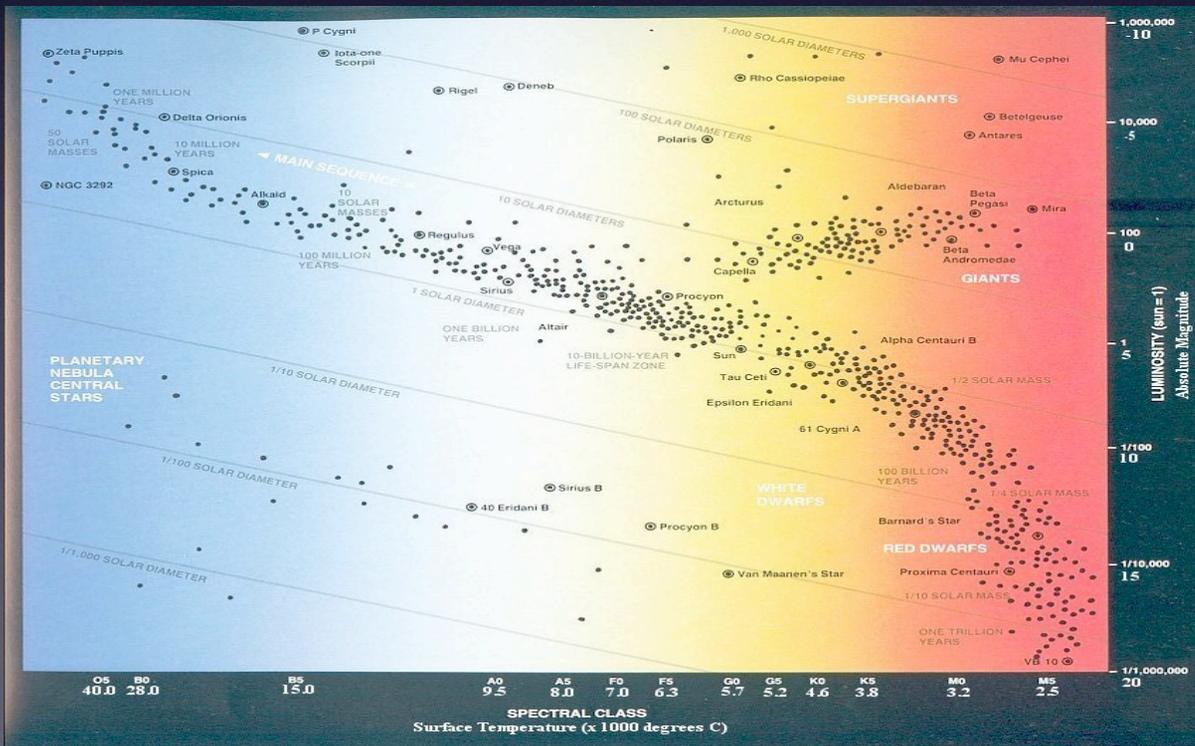
# We study the **Cosmic Microwave Background (CMB)**



- We build high-precision optics, detectors and cryogenics.
- We deploy them to cool places (literally) such as the South Pole, Chile's Atacama Desert & outer space.
- We take the Universe's "Baby Picture"!

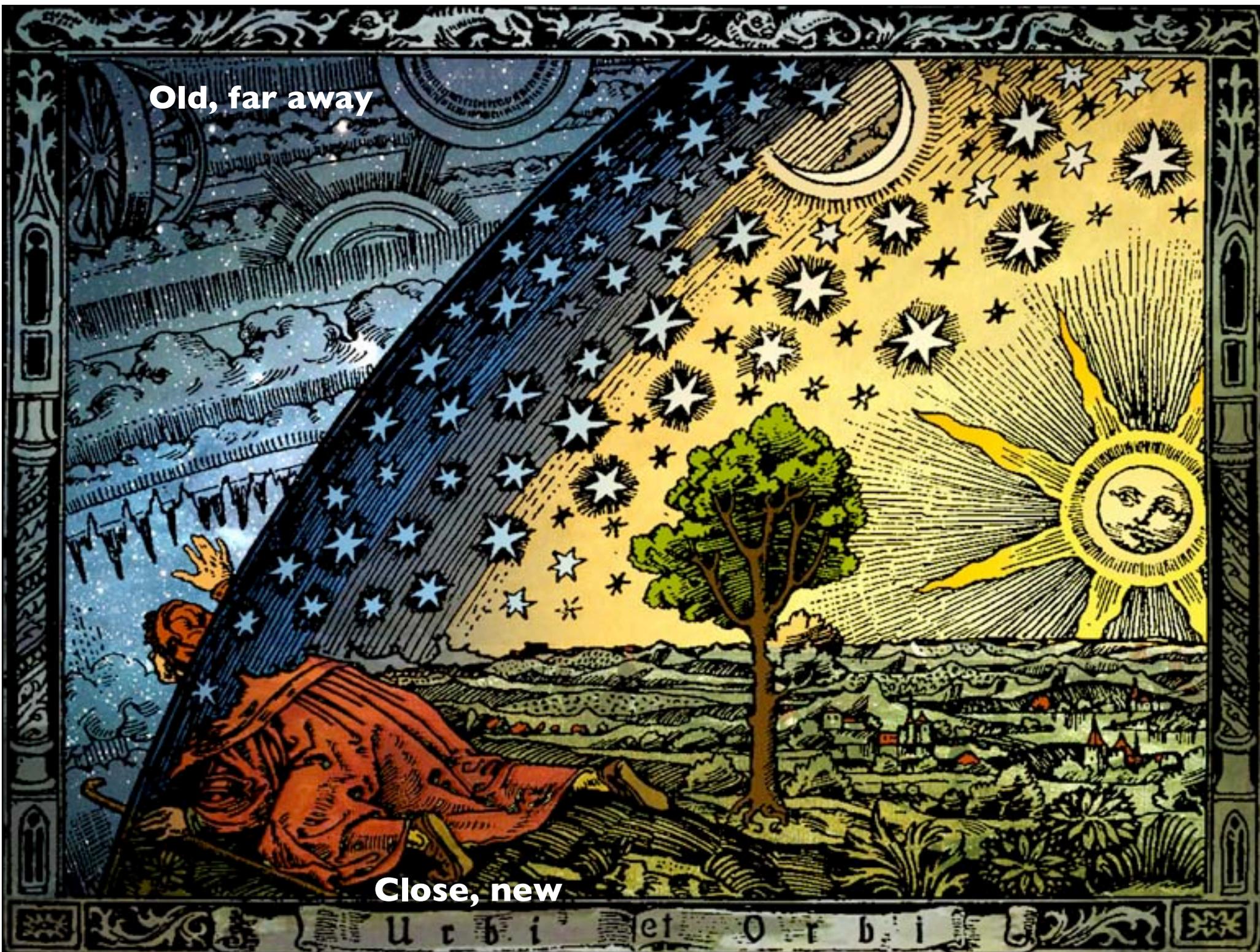
# Astronomy is *taxing*...Cosmology can be harder

- It's impossible to do true experiments: "What would happen to our galaxy if we turned up the temperature of each star?"
- At least astronomy has statistics: many sets of stars, galaxies, galaxy clusters...



Old, far away

Close, new



U t b i et O r b i

**Old, far away**

**INFLATION**

**fraction  
of a second**

**CMB  
last scattering**

**380,000  
years**

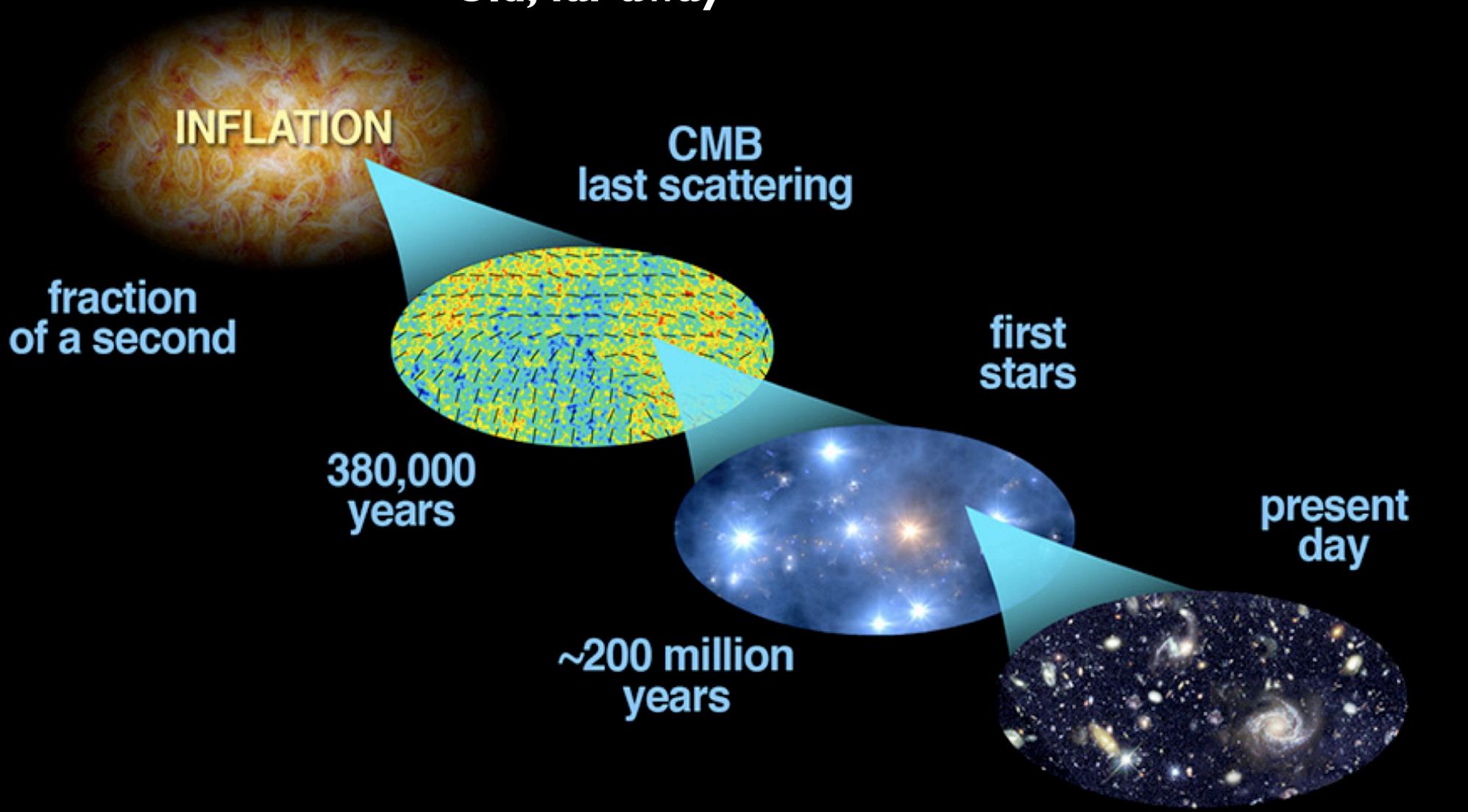
**first  
stars**

**~200 million  
years**

**present  
day**

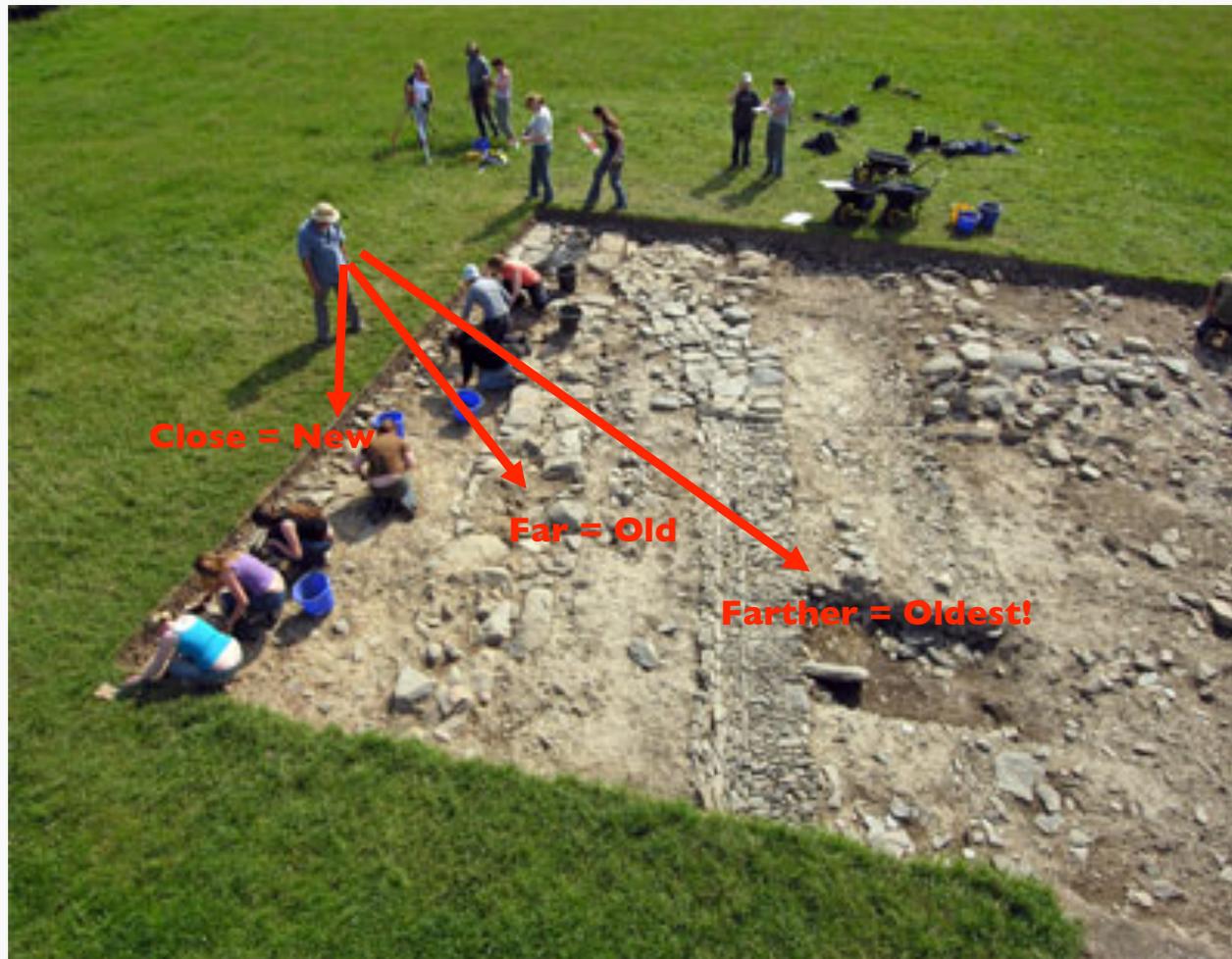
**13.7 billion  
years**

**Close, new**



# Time and Distance

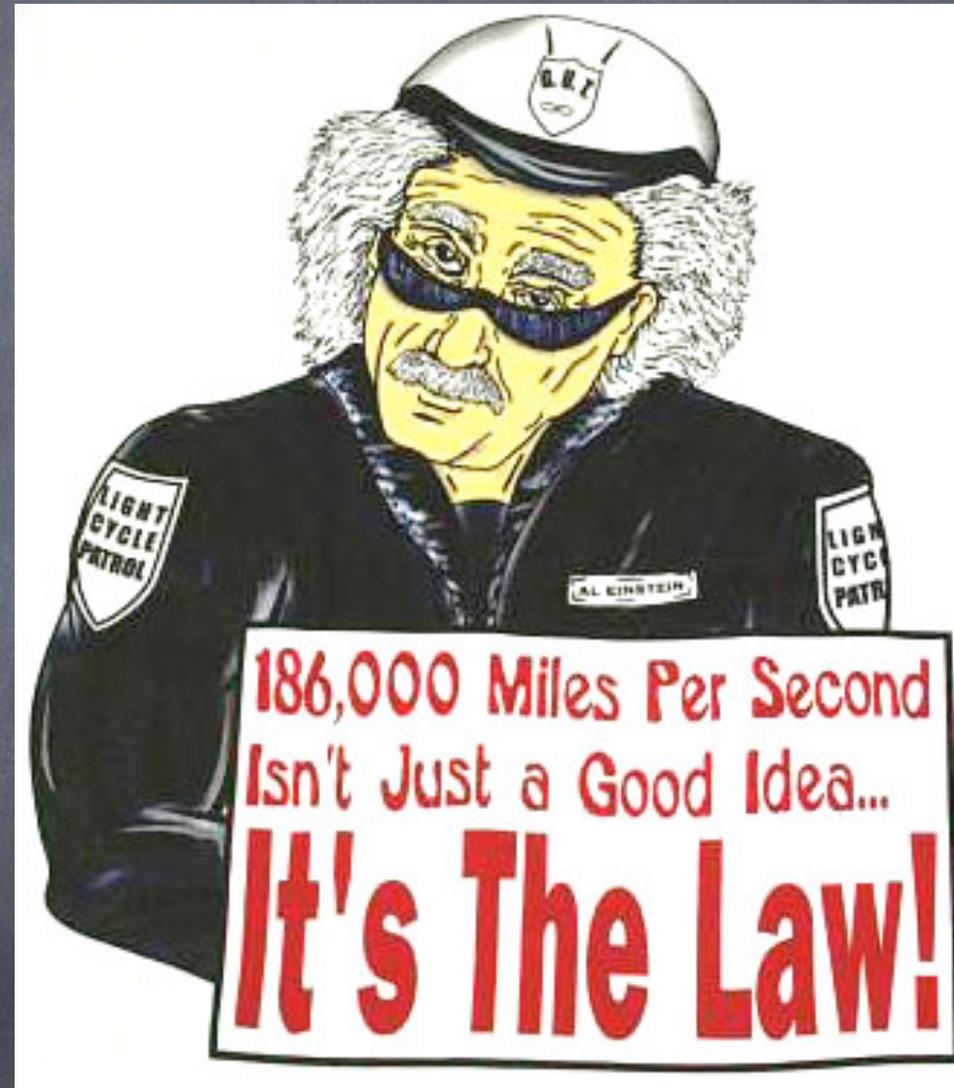
Just like digging for fossils, the farther away something is the older it is...



Telescopes are time-machines!!

The speed of light  
( $c$ ) is large but finite.

$c = 300,000$  km/sec  
(186,000 miles/sec).



- The **speed of light** is 1 Billion **feet** per second.
- How far away is 1 Billion feet? About 186,000 miles.
- The moon is approximately 250,000 miles away from earth.
- How long does it take for light from the moon to reach earth? About 1.5 seconds.

Sun

# Sun to the Earth, Earth to Moon

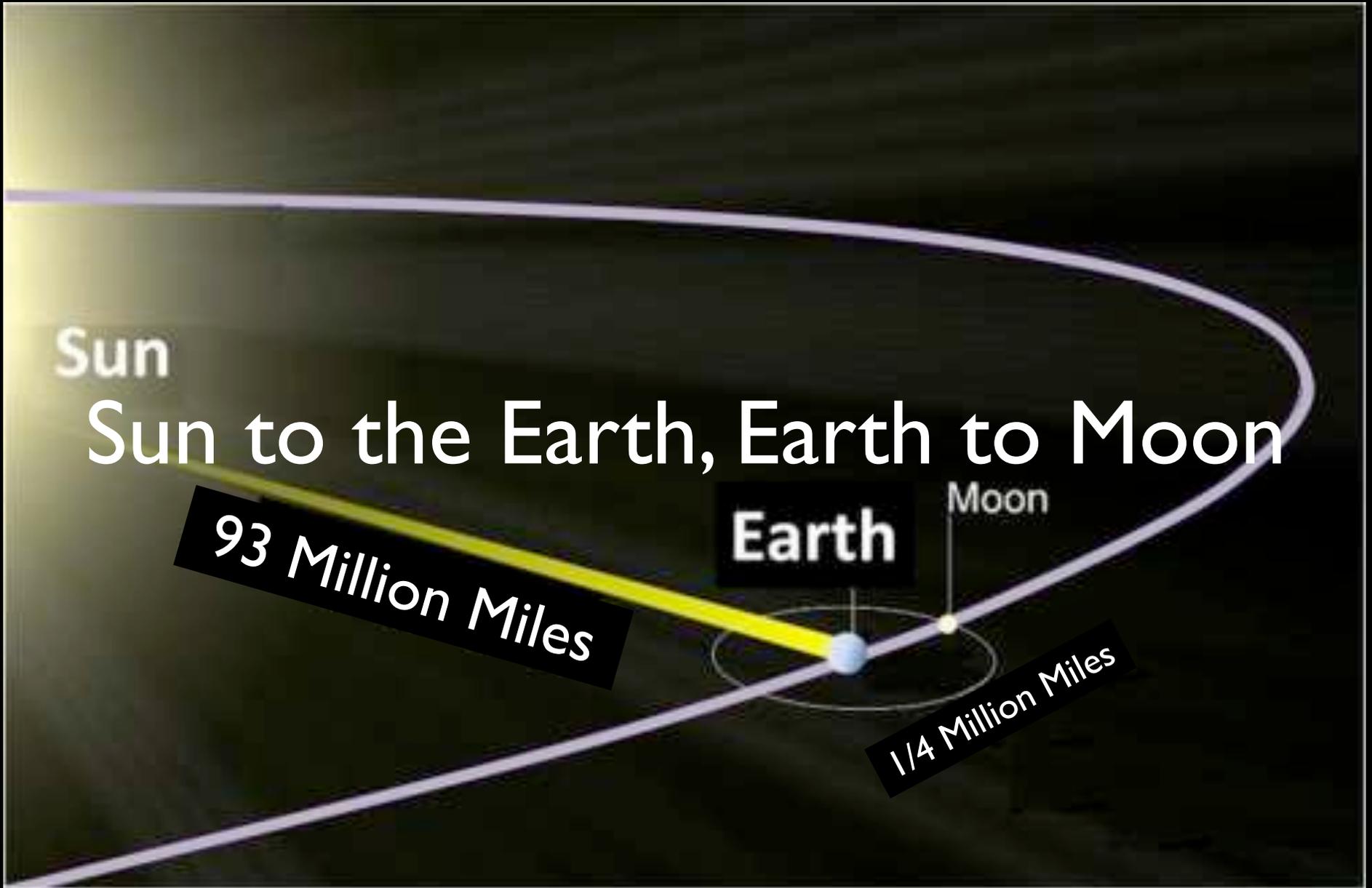
93 Million Miles

Earth

Moon

1/4 Million Miles

Which takes longer?



# Consider the Mayfly...

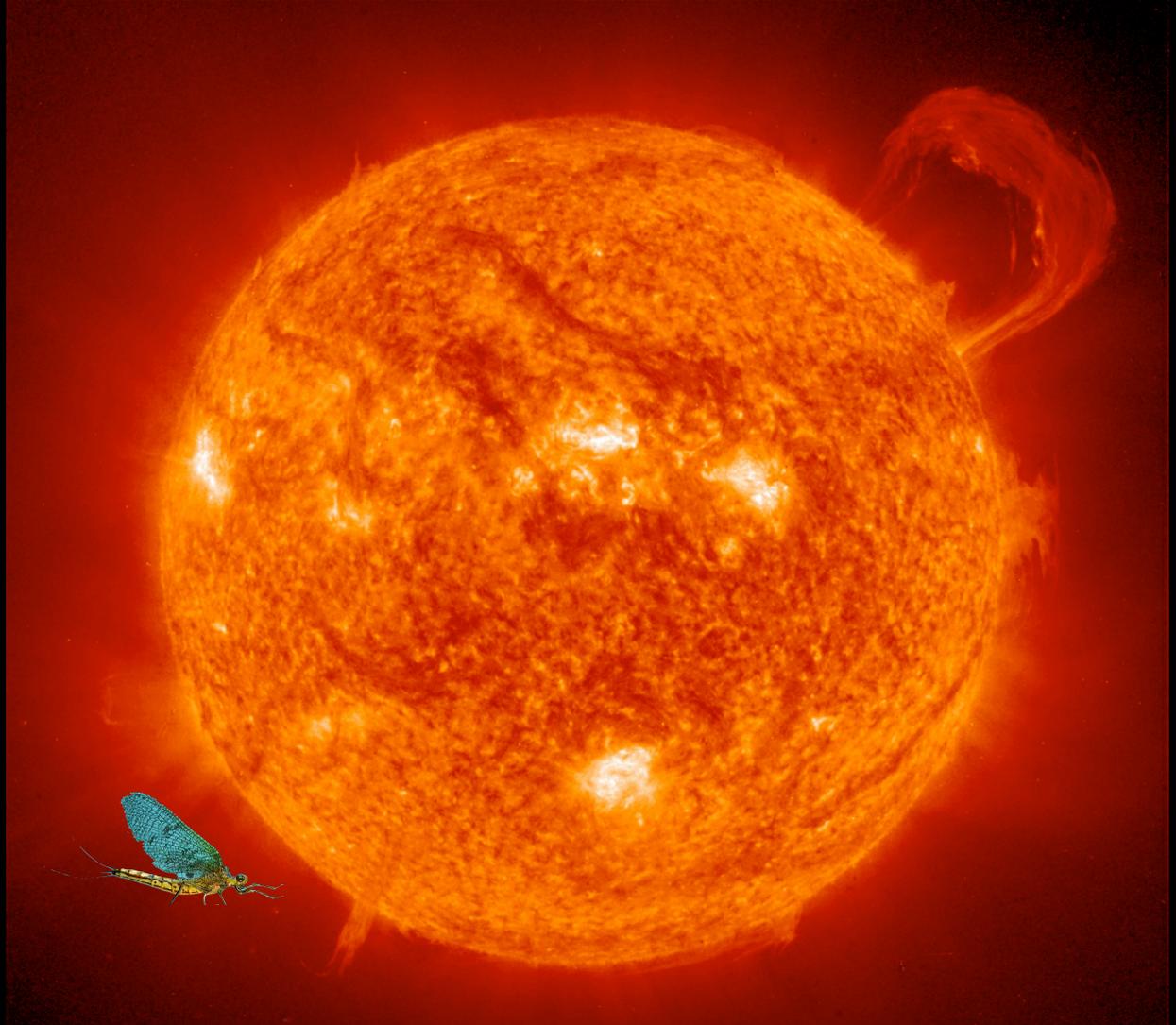


## *Baetis tricaudatus*

The lifespan of an adult mayfly is very short and varies depending on the species. The primary function of the adult is reproduction; the mouthparts are [vestigial](#), and the digestive system is filled with air.

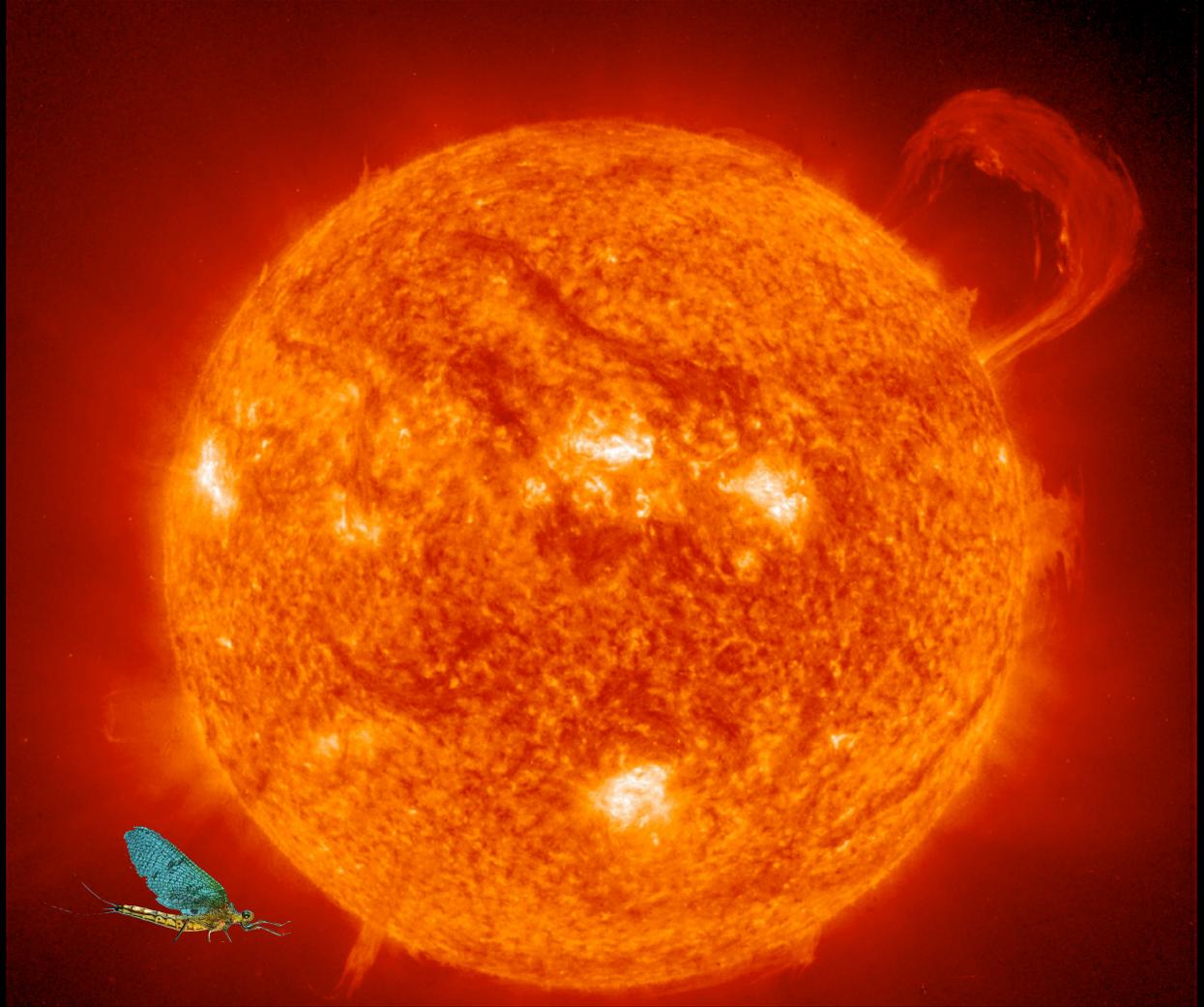
**Some male mayflies live only about 8 minutes!**

Now consider two Mayflies, born at the same time,  
but *separated* at birth:



It takes 8.3 minutes for light from the Sun to reach Earth

Now consider two Mayflies, born at the same time,  
but *separated* at birth:



If you see the one on the Sun alive, the one on the Moon will  
be dead! Farther away things are seen as being younger.