

# The Growing Darkness and the Ultimate Fate of the Everything

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Mitchell Chair in Astronomy

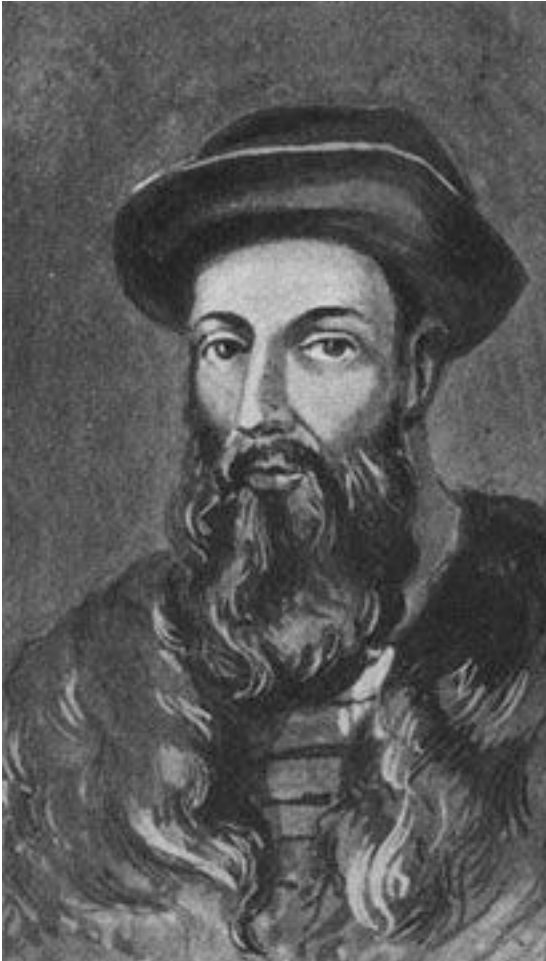
Department of Physics

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30 January 2009



# Ferdinand Magellan (1519-1521)



Magellan's voyage around the world

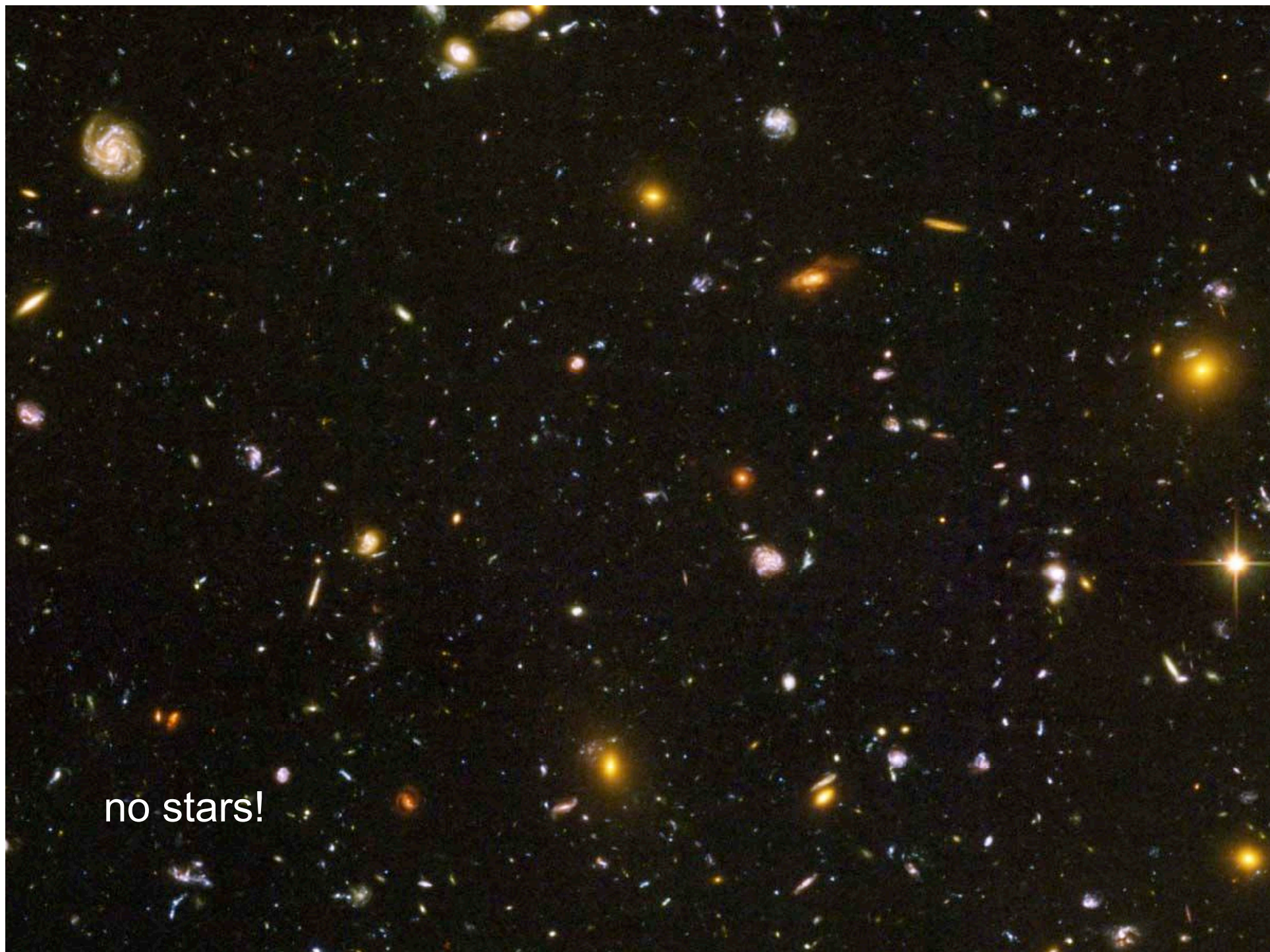


# Why is the sky black?



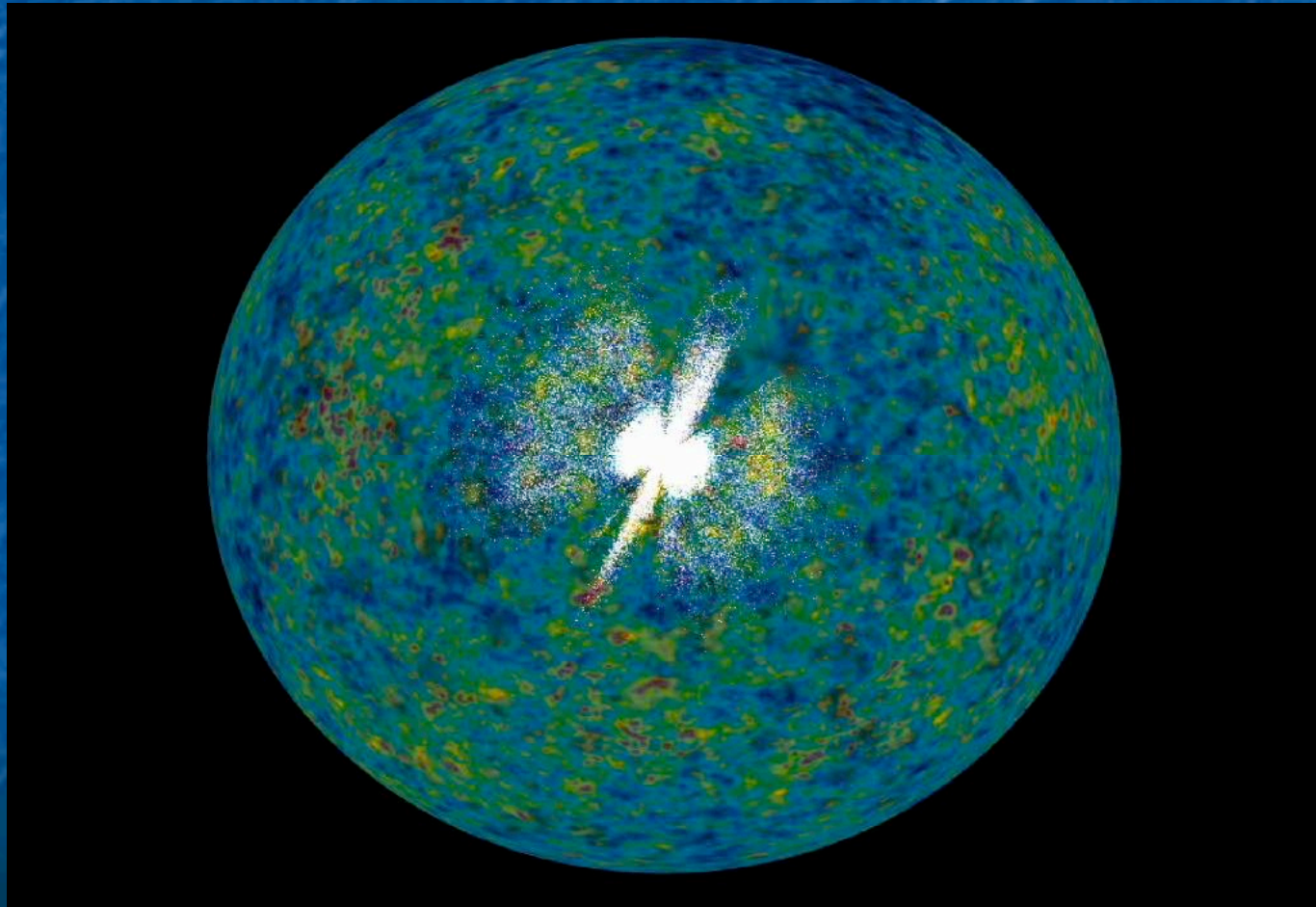
Oblers' paradox







# Our Universe



# Einstein





# Quickie Class in General Relativity

$$G_{\mu\nu} + g_{\mu\nu}\Lambda = 8\pi G T_{\mu\nu} / c^4$$

# Quickie Class in General Relativity

or...

*mass bends space*

*and*

*bent space tells mass how to move*



# Quickie Class in General Relativity

$$G_{\mu\nu} + g_{\mu\nu}\Lambda = 8\pi G T_{\mu\nu} / c^4$$



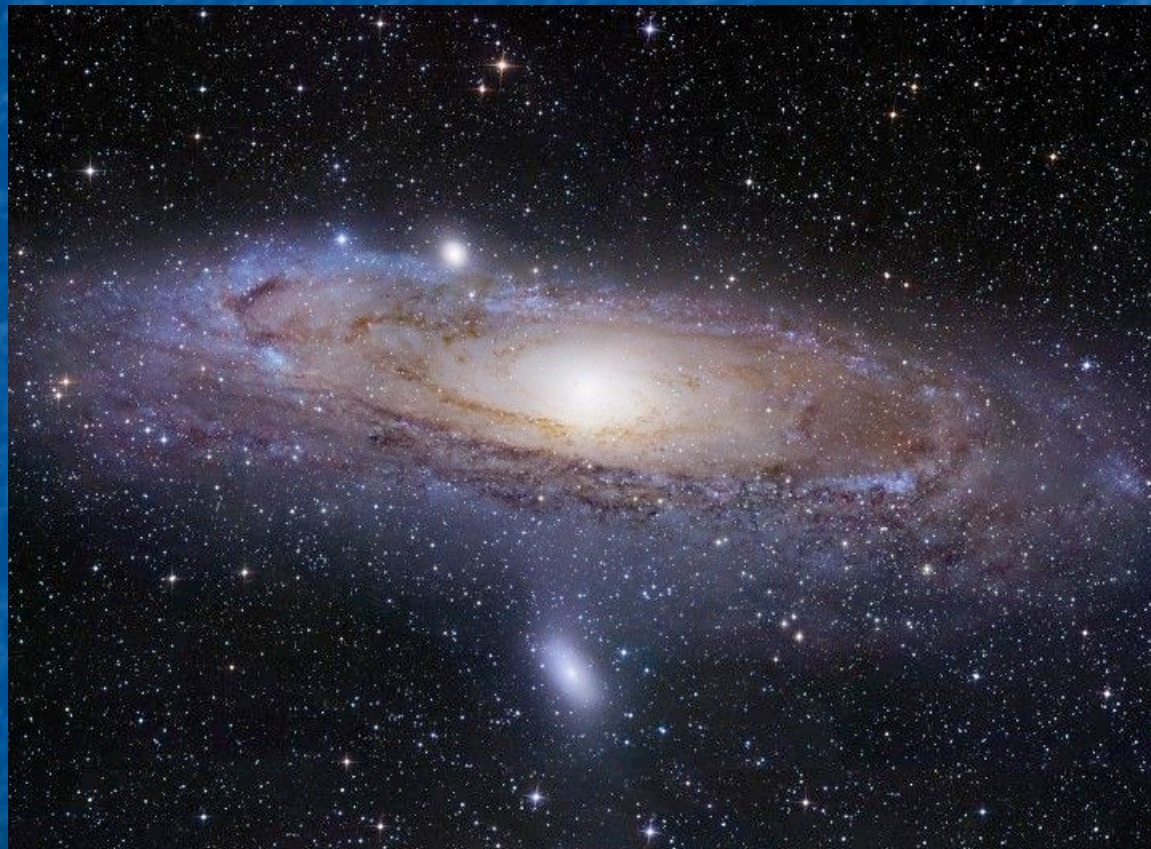
static universe

“cosmological  
constant”

*Einstein*

*“my biggest blunder”*

# Dark Matter





# What is Dark Matter?

We have no idea. Or perhaps, we have too many ideas. It is hard to tell.

# The Runaway Universe

*But the Universe is even much stranger than this.*



# Dark Energy



# Distant supernovas are too faint!

→ they are farther away  
than expected

→ the local Universe is larger  
than expected

→ the local Universe has  
*accelerated* away from the  
gravitational frame



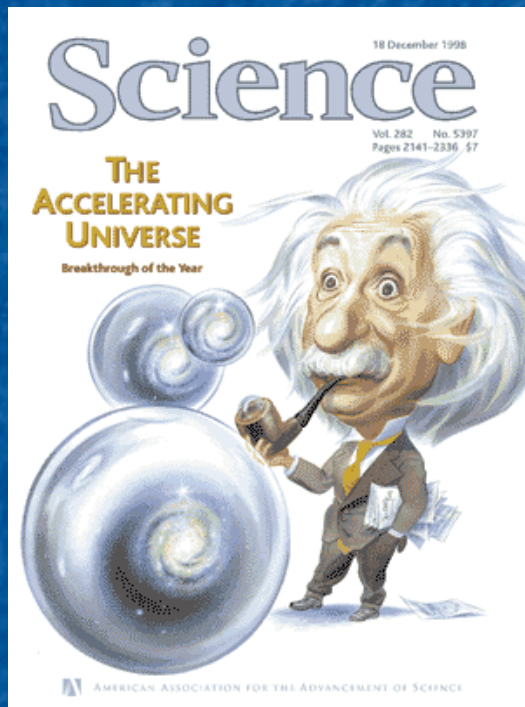
# Einstein's "Biggest Blunder"

The "Cosmological Constant", a negative gravity created to make the Universe static. In his form, it was a mathematical error. But it doesn't have to be.

We now call it Dark Energy.

It is negative gravity - produced by nothing!

Perhaps the strangest result in physics in 80 years.



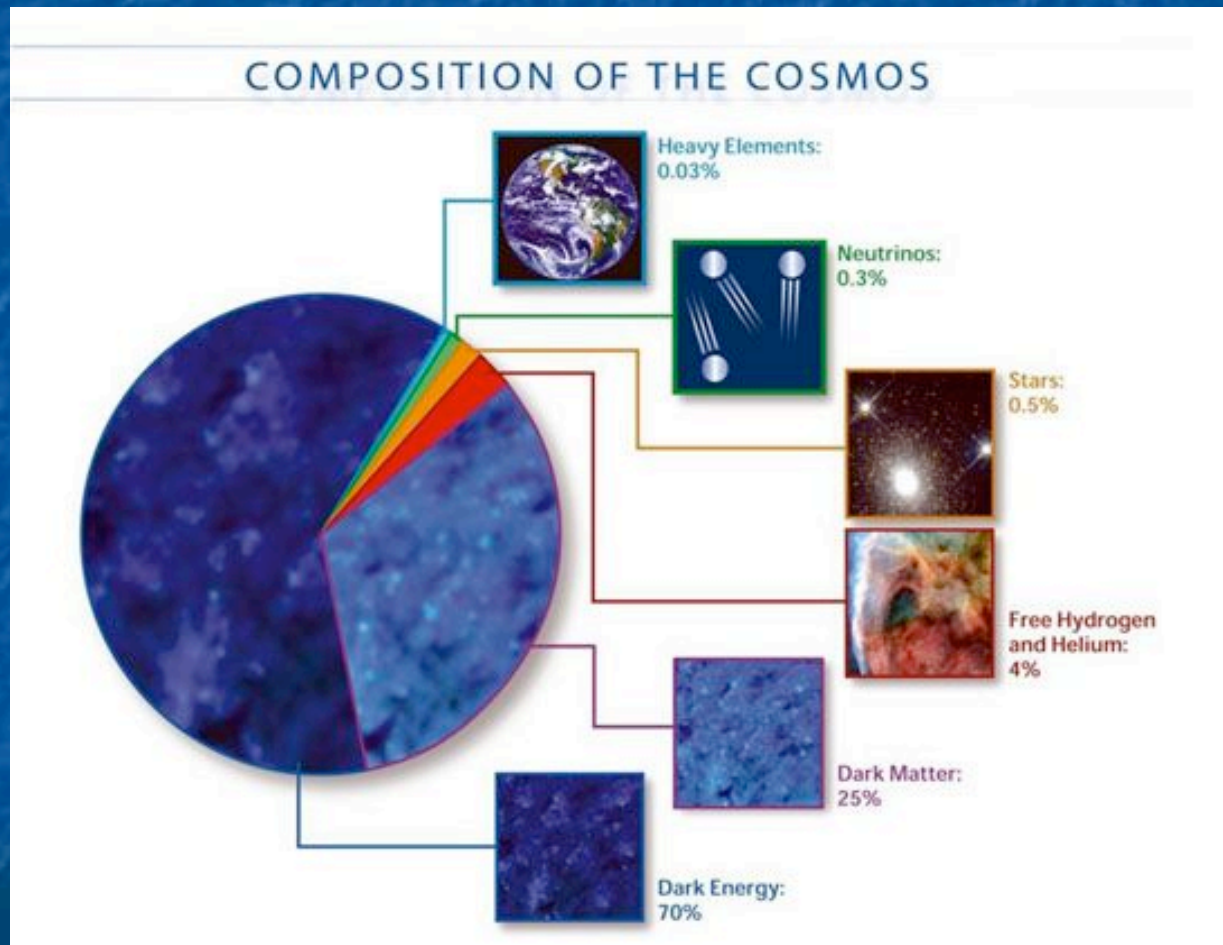
Science Magazine  
Scientific Breakthrough  
of the Year - 1998



Gruber Prize in  
Cosmology - 2007



# The Universe in 2009



# The Ultimate Death of the Cosmos

This makes for a very weird future for our Universe. We are being driven into exponential acceleration. Right now, the edge of the Universe is set by the *edge in time* given by the age of the Universe of  $\sim 13.7$  Gyrs – that is, we can't see farther than 13.7 billion light years away.

But we are now living in an epoch where the most distant points of the Universe are disappearing because they are going faster than the speed of light.



# Our Exponential Death

- In 150 billion years, the 30,000,000,000 galaxies will disappear except the few close ones. The sky will be very dark.
- If the dark energy is slightly stiffer than what Einstein predicted, not only will the galaxies disappear, but all matter will rip itself apart.

# Exponential Death

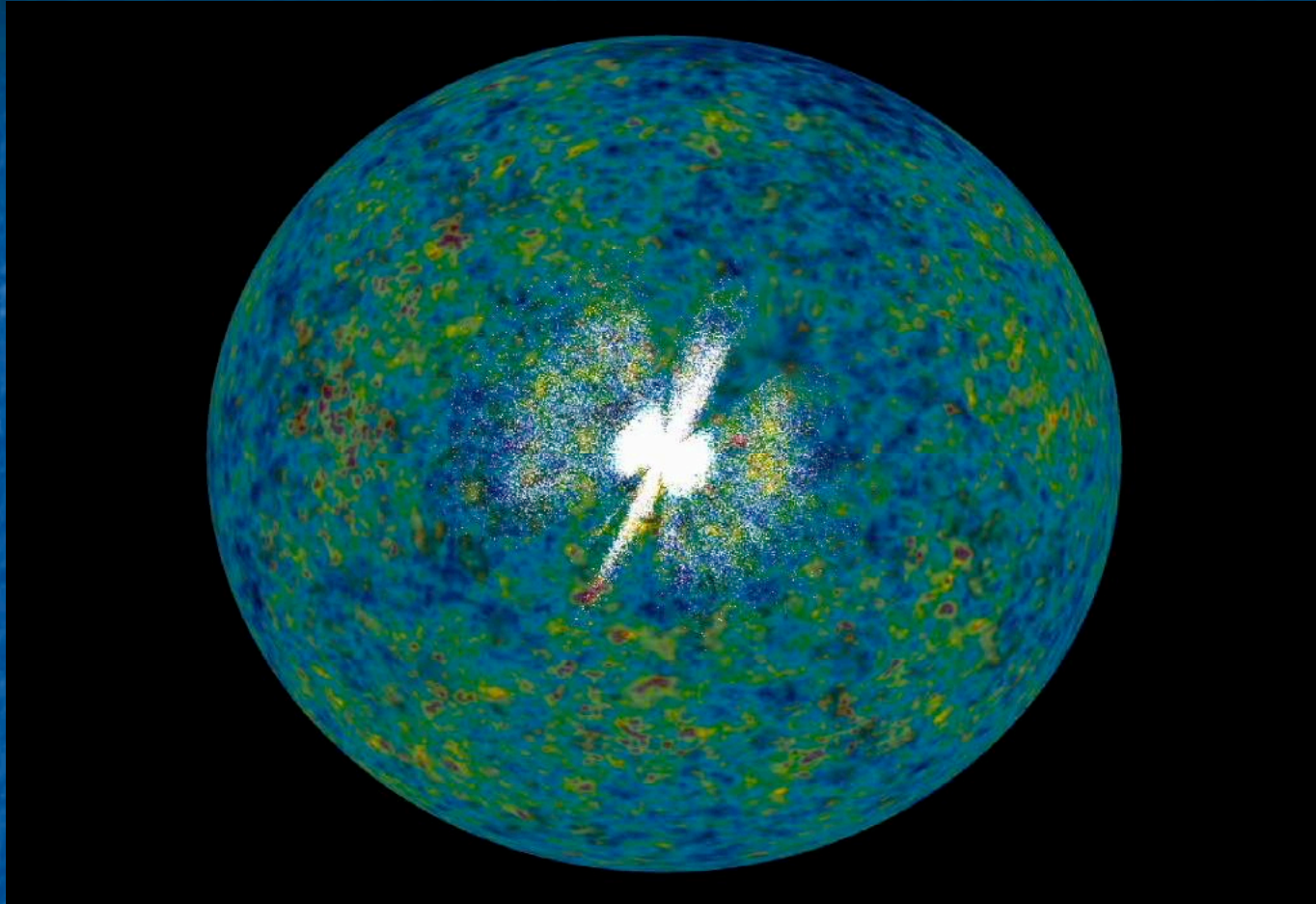
This is an awful Universe!

However, don't despair. We have no way of predicting the future evolution of dark energy. It could suddenly go away, or even go negative and cause the Universe to suddenly Crunch. There is no way of knowing the future evolution of the vacuum field. In the mean time, we can worry about:

- Killer asteroids every 250Myrs
- Brightening of the sun in the next 1-2 billion years which will fry the earth unless we move the orbit out. But we can move the Earth.



# Our Universe - 99.5% missing



" We are very lucky to live in an age in which we are still making discoveries. It is like the discovery of America - you only discover it once. " Richard Feynman



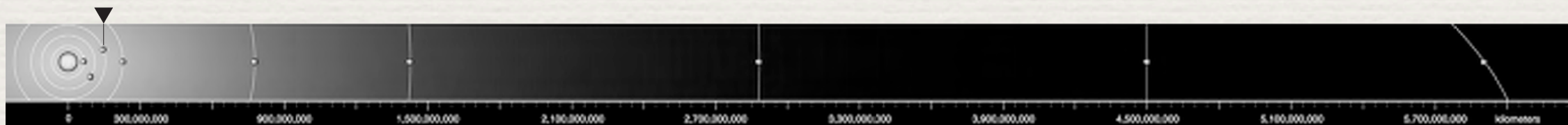
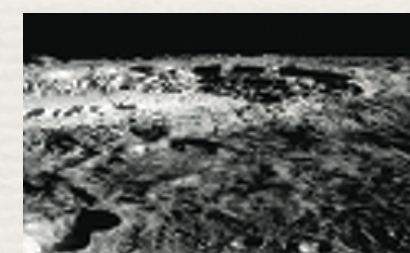
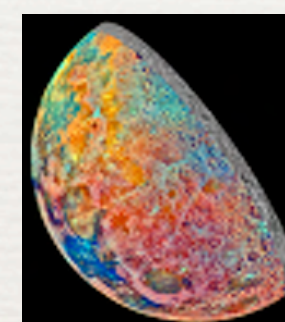
# IYA - 2009

- ♦ 2009 is the International Year of Astronomy
- ♦ US IYA website: <http://astronomy2009.us/>
- ♦ Examples of IYA projects:
  - ♦ IYA Discovery Guides - each month focuses on different objects to observe, along with specific activities - many great for classrooms - [www.astrosociety.org/iya/guides.html](http://www.astrosociety.org/iya/guides.html)
  - ♦ Example - February = “Our Solar System”, featured observing object = Moon
  - ♦ Additional activities & demos to complement Discovery Guides
  - ♦ Other Activities & Resources such as - 100 hours of Astronomy 1<sup>st</sup> weekend of April 2009, “IYA movie” trailer, PBS documentary on 400 years of the Telescope, all on IYA website.





## Earth's Moon





# More IYA Activities:

## Spotting Craters

Why is the Full Moon a Poor Time to Observe the Moon?

### About the Activity

Use a model of the surface of the Moon to show how shadows show more details than direct light. Participants see the difference between a full Moon and a partially dark Moon.



### Materials Needed

- Packet of powdered hot cocoa mix
- Aluminum pan
- 5 pounds of flour
- Several small rocks
- Flashlight covered with a paper towel to diffuse the light
- Newspaper, if doing activity inside
- Plastic "moon" ball on a toothpick or skewer stick



### Topics Covered

- Why shadows make viewing the Moon more spectacular.
- What do we see when looking at the Moon?

### Participants

Use this activity with families, the general public, and school or youth groups ages 7 and up.

### Location and Timing

This activity takes about 10-15 minutes and can be used at night or in a classroom that can be darkened. Not recommended for a windy night.



### Included in This Activity

Preparation Instructions  
Detailed Activity Description  
Background Information  
Helpful Hints



© 2008 Astronomical Society of the Pacific [www.astrosociety.org](http://www.astrosociety.org)

Copies for educational purposes are permitted.

Additional astronomy activities can be found here: <http://nightsky.jpl.nasa.gov>



- ♦ Galileoscope - Key Cornerstone project of IYA to distribute 1 million telescopes to school children, similar to design used by Galileo 400 years ago (but better) <http://astronomy2009.us/optics/galileoscope/>





# Globe at Night:

**GLOBE at Night**

**Observation Sheet March 16-28, 2009**

To observe, go outside at least 1 hour after sunset to a dark area and wait 10 minutes for your eyes to dark-adapt. Then look to the west to locate the constellation Orion and compare it to the magnitude charts below. Submit this sky quality reading online to get your neighborhood on a global map of sky quality readings.

[www.globe.gov/globeatnight](http://www.globe.gov/globeatnight) Only fields marked by \* are required.

\*Date: March \_\_, 2009

\*Observation Time: \_\_: \_\_ PM local time (HH:MM)      \*Country: \_\_\_\_\_

\*Latitude (in deg/min/sec or decimal degrees): \_\_\_\_ deg \_\_\_\_ min \_\_\_\_ sec (North / South)

\*Longitude (in deg/min/sec or decimal degrees): \_\_\_\_ deg \_\_\_\_ min \_\_\_\_ sec (East / West)

Websites to help look up your position:  
[www.itouchmap.com/latlong](http://www.itouchmap.com/latlong)  
<http://maporama.com>

Comments on location: (e.g. There is one street light within 50 m that is shielded from my view.)

\*Match your nighttime sky to one of our magnitude charts :

☐ Cloudy Sky      ☐ Magnitude 1 Chart      ☐ Magnitude 2 Chart      ☐ Magnitude 3 Chart

☐ Magnitude 4 Chart      ☐ Magnitude 5 Chart      ☐ Magnitude 6 Chart      ☐ Magnitude 7 Chart

\*Estimate the cloud cover in the sky:  
☐ Clear      ☐ Clouds cover 1/4 of sky      ☐ Clouds cover 1/2 of sky      ☐ Clouds cover > 1/2 of sky

Comments on sky conditions: (e.g. a little haze to the north)

Report online at [www.globe.gov/globeatnight/report.html](http://www.globe.gov/globeatnight/report.html)

- ◆ “Globe at Night” - March 16-28<sup>th</sup>, 2009 - students & families participate in observing the constellation Orion at home.
- ◆ Report observations online: [www.globe.gov/GaN](http://www.globe.gov/GaN)
- ◆ 2008 had over 5000 participants world wide.



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\*Latitude (in deg/min/sec or decimal degrees): \_\_\_\_ deg  
\*Longitude (in deg/min/sec or decimal degrees): \_\_\_\_ deg

Comments on location: (e.g. There is one street light nearby)

\*Match your nighttime sky to one of our magnitude charts

☐ Cloudy Sky ☐ Magnitude 1 Chart

☐ Magnitude 4 Chart ☐ Magnitude 6 Chart

\*Estimate the cloud cover in the sky:  
☐ Clear ☐ Clouds cover 1/4 of sky

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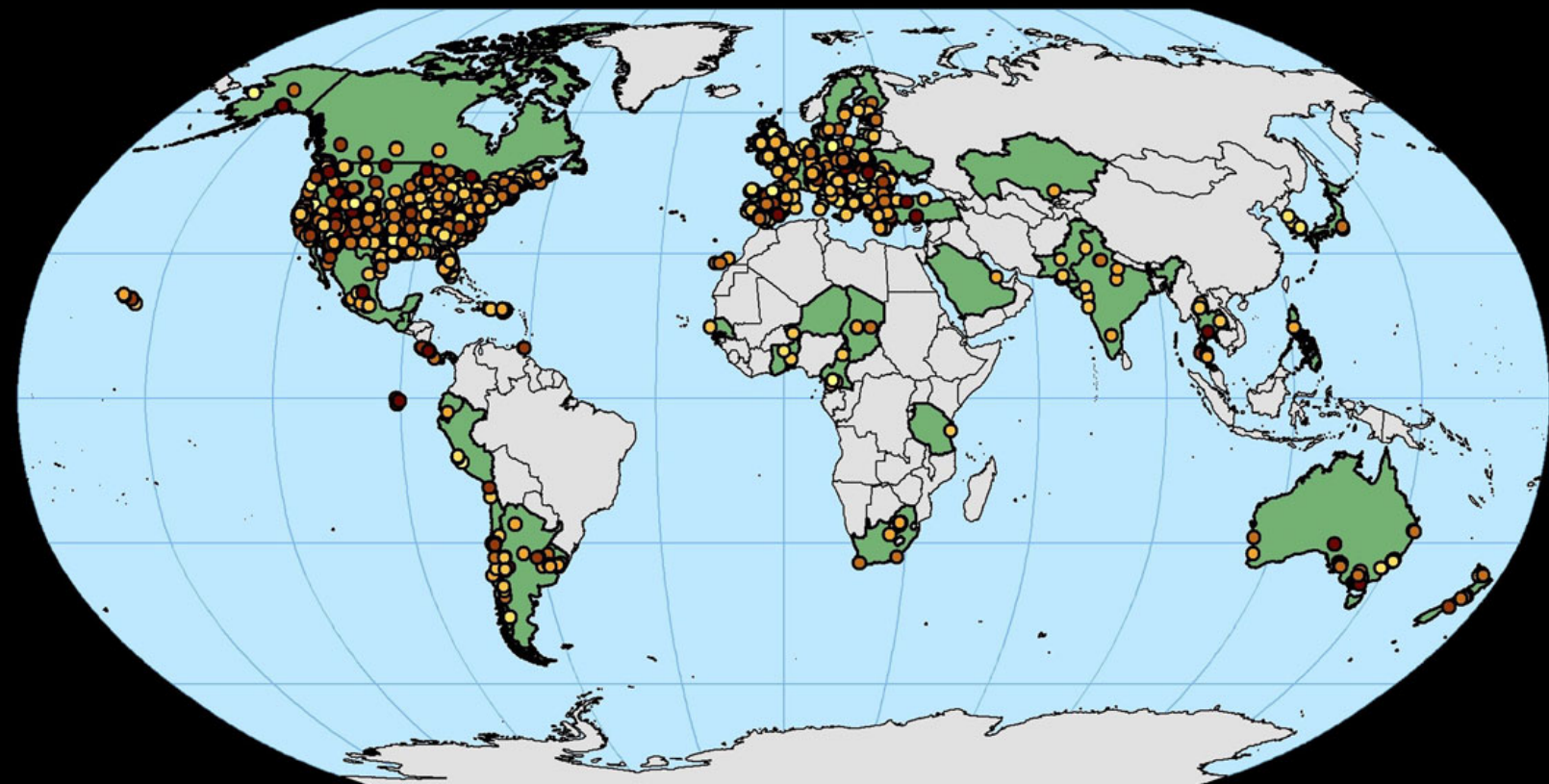
♦ “Globe at Night” - March 16-28<sup>th</sup>, 2009 - students & families participate in

## GLOBE at Night 2008 Results

**Legend**  
**2008 GLOBE at Night Magnitude**

Bright Skies > Dark Skies

- Limiting Magnitude 1
- Limiting Magnitude 2
- Limiting Magnitude 3
- Limiting Magnitude 4
- Limiting Magnitude 5
- Limiting Magnitude 6
- Limiting Magnitude 7





# More Astronomy Events:

- ♦ Astronomy Group at Texas A&M is planning a number of events to celebrate the IYA and bring more astronomy education & public outreach to the community and schools.
  - ♦ Events Coming Soon - Monthly Astronomy Open Houses at campus observatory - 1st event scheduled for Friday Feb. 27<sup>th</sup>
  - ♦ Visiting schools to give Astronomy talks/demos
  - ♦ Contact: Keely Finkelstein: (979) 862-1763, email: [keelyf@physics.tamu.edu](mailto:keelyf@physics.tamu.edu), or <http://people.physics.tamu.edu/keelyf> for more info about upcoming events
- ♦ “Physics & Astronomy Festival” - March 28<sup>th</sup> at George Bush Library, 10 am - 5 pm, <http://physicsfestival.tamu.edu/>
- ♦ Hands-On Science Activities, Lecture by Dr. Geoff Marcy - Extrasolar Planet Discoverer