

Left	Side	Left	Side	Right	Side	Right	Side
Last Name	First Name			Last Name	First Name		
<b>LA</b>		<b>LE</b>		<b>RA</b>		<b>RE</b>	
Smith	Jaihan	Green	Kailey	Oconnor	McKenna	Chabino	Conner
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Rosentreter	Riley	Evans	Hannah	Stringer	Jason	Sauceda	Emma
Quinn	Jamie			Ellis	Alexander	Pike	Alena

"The world will end in 5 minutes. Please log out."

Anonymous

HW4 is due on Monday  
Group Project due on Apr 26.  
Quizzes 15, 16, & 17 still to do.

Total pre-last-test points posted by May 1  
On blackboard (total points column at the end)

NOTE: blackboard's “%” and “Total points”  
at the top will be incorrect but your individual  
grades and point total column I'm adding at  
the bottom should be correct.

Total in-class points: 690

Lab points: 230

Total Points: 920

A: 920-824, B:823-732, C:731-639

# Cosmology.

**Cosmology is the study of the Universe as a whole. It is about objects larger than individual galaxies and the evolution of the Universe and its contents.**

## Summation:

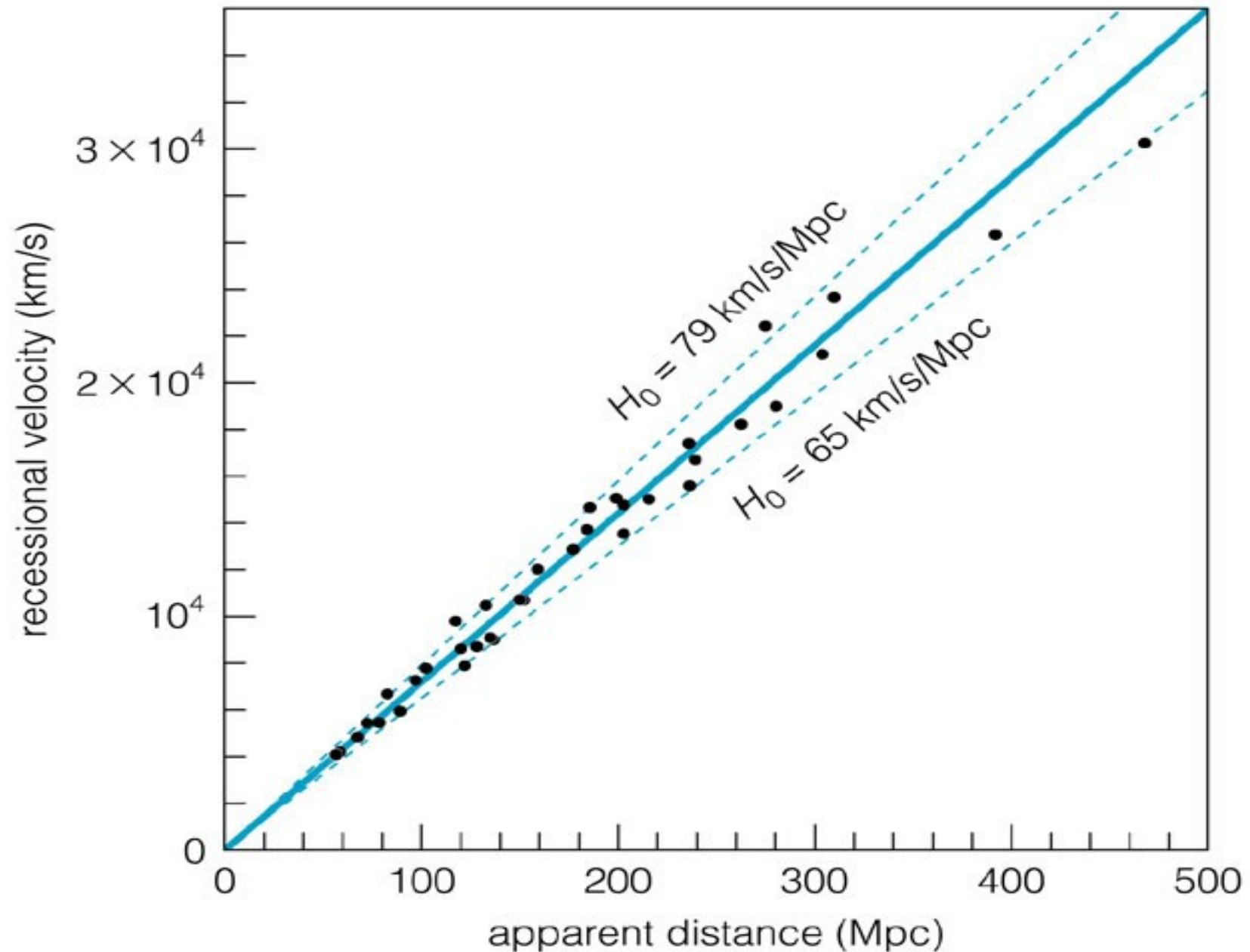
Most galaxies are in groups or clusters.

On large scales, the universe consists of superclusters and concentrations of galaxies, and voids, where there are few galaxies.

On scales larger than 200Mpc ( $\sim 600$ Mly), the universe is **homogeneous and isotropic** (the same everywhere).

Hubble plotted galaxy redshifts against their distances.

**These are not random!**



# Expanding Universe

As we look farther away from us, galaxies are moving away from us faster.

# Expanding Universe

What if we run the clock backwards?

Sometime in the past, the galaxies were at the same spot, at the same time!

What does this mean?



The Big Bang!

# The Big Bang

All that we know as our Universe came from a single point.

But first....

$$H_0 = v/D$$

Can we rearrange this to be something interesting?

But first....

$H_0 = v/D$  becomes

$$D = v/H_0$$

Why do we care?

But first....  
 $H_0 = v/D$  or  $D = v/H_0$

So if you know  $H_0$ , you can always measure  $v$  from spectral lines and get  $D$ .

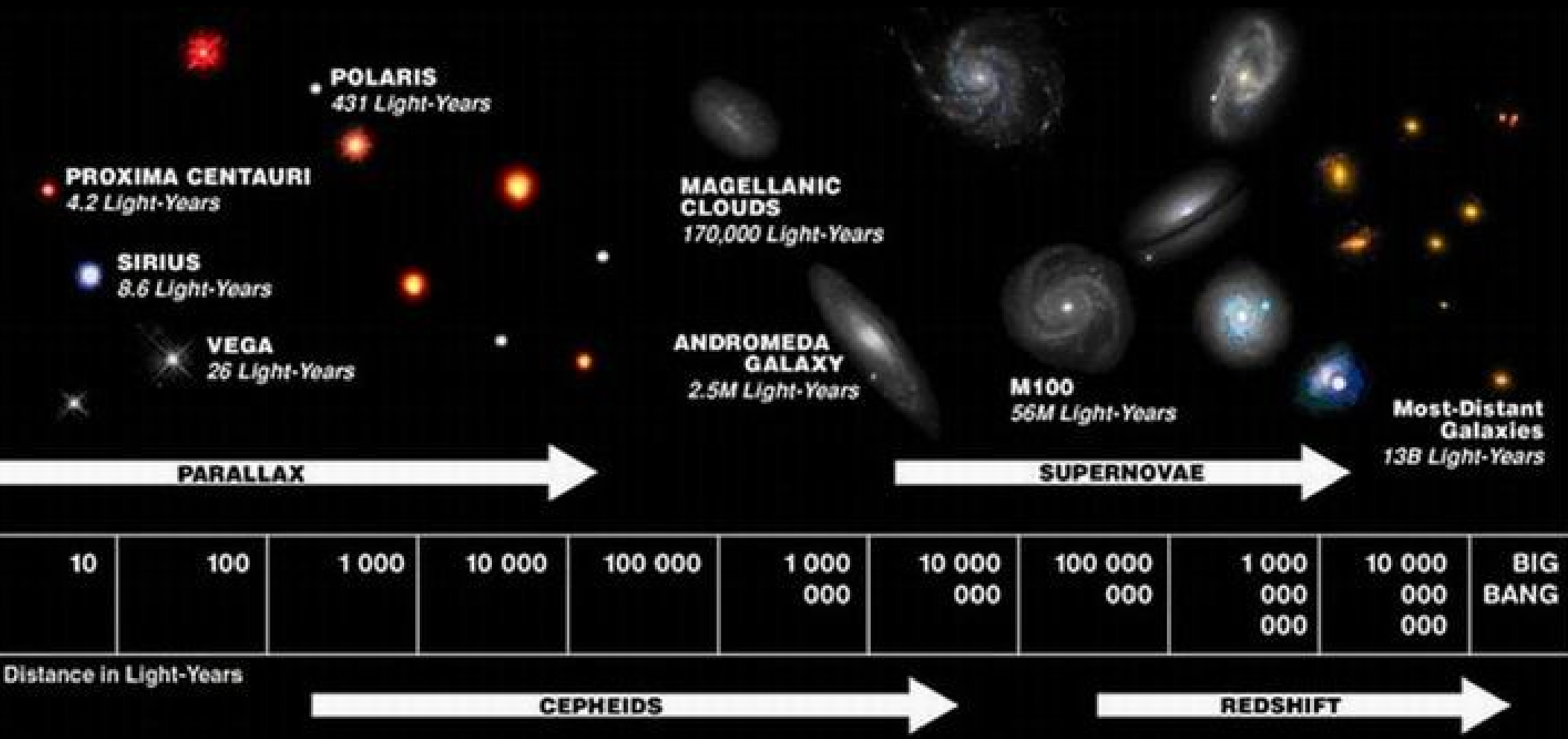
What a great distance indicator!!!!

The currently best value:

$$H_0 = 73.8 \pm 2.4 \text{ km/s/Mpc}$$

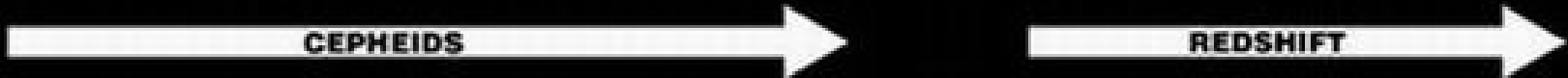
This is “redshift” in our distance ladder.

# Another example of a distance ladder



10	100	1 000	10 000	100 000	1 000 000	10 000 000	100 000 000	1 000 000 000	10 000 000 000	BIG BANG
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Distance in Light-Years



# Example

$D=v/H_0$  using  $H_0=73.8$  km/s/Mpc

What is  $D$  if  $v=32,000$  km/s?

- A) 74 Mpc
- B) 434 Mpc
- C) 2,350 Mpc
- D) 2,36,000 Mpc

# Example

$D=v/H_0$  using  $H_0=73.8$  km/s/Mpc

What is  $D$  if  $v=32,000$  km/s?

A) 74 Mpc

**\*\*B) 434 Mpc**

C) 2,350 Mpc

D) 2,36,000 Mpc



# Look Closer

What if we switch it a little bit?

$$H_0 = 1/s \text{ or } 1/\text{time:}$$

$$1/H_0 = \text{time.}$$

What does this time mean?

**It is the age of the Universe!**

**About 14 billion years.**

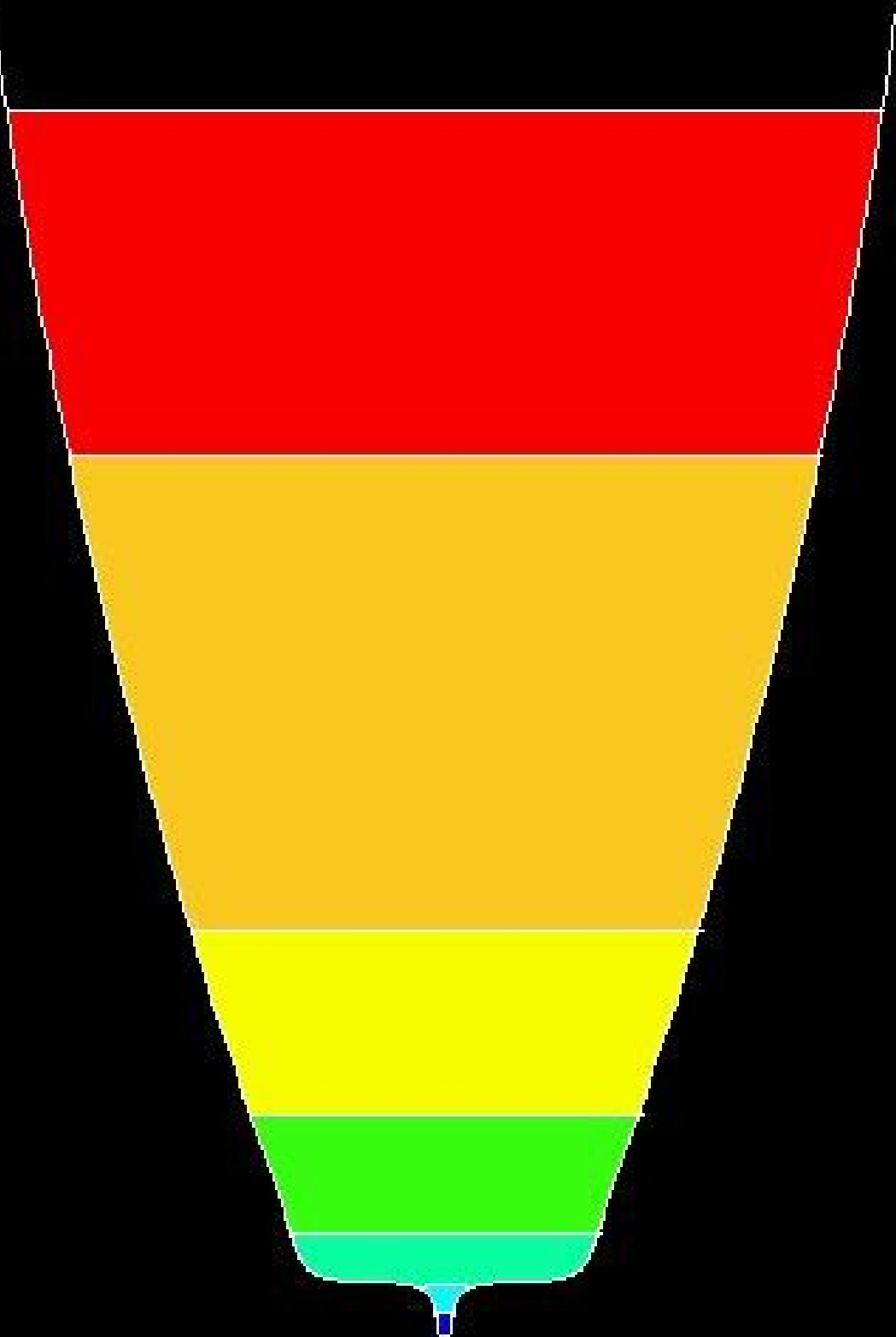
# The Scientific Principle

So let's first discuss the Big Bang idea and then see if there are other things that can be observed to confirm/deny/modify it.

(Summary slides along the way)

Here is a simplified picture of our Universe.

Size is its width, Age is its height- starting at the bottom.



The Universe at the Big Bang  
Shown actual size.



# In the beginning....

The Big Bang was an expansion from a quantum singularity. What does that mean?

# In the beginning....

The Big Bang was an expansion from a quantum singularity. What does that mean?

It means the Universe came into existence from 1 point, whose size is too small to be described.

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Group Project 2 work time.

Please remember that this is a science class  
and not a science fiction class.