

RELATIVE SCALES IN THE UNIVERSE



 Earth From Space - Apollo 17
NASA Langley Research Center

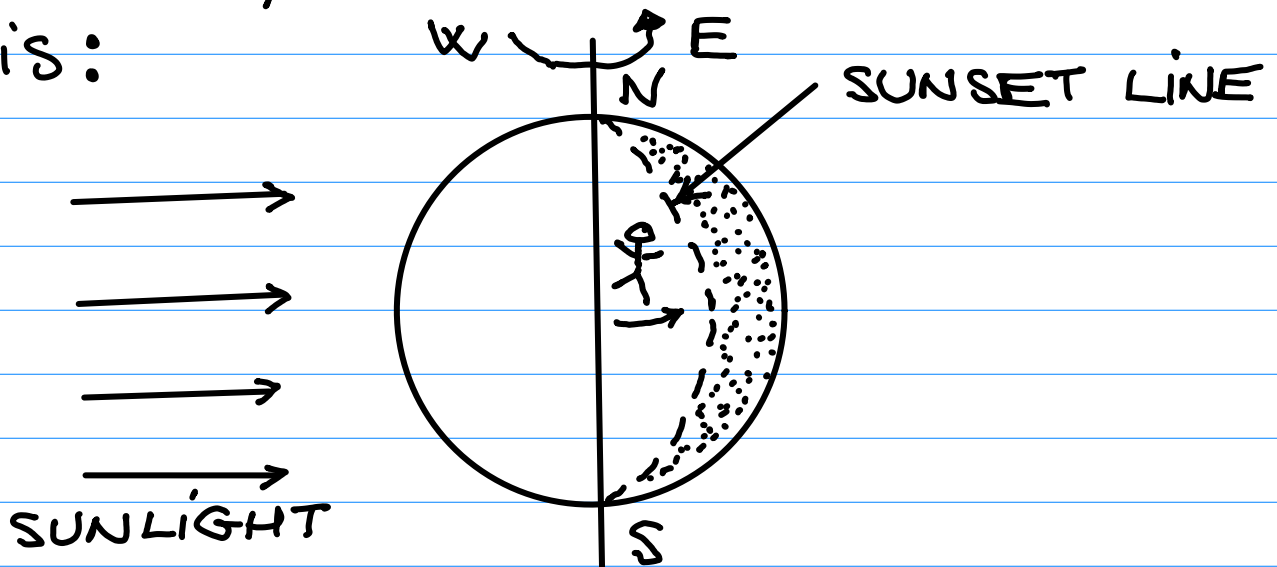
12/7/1972

Image # EL-1996-00155

EARTH

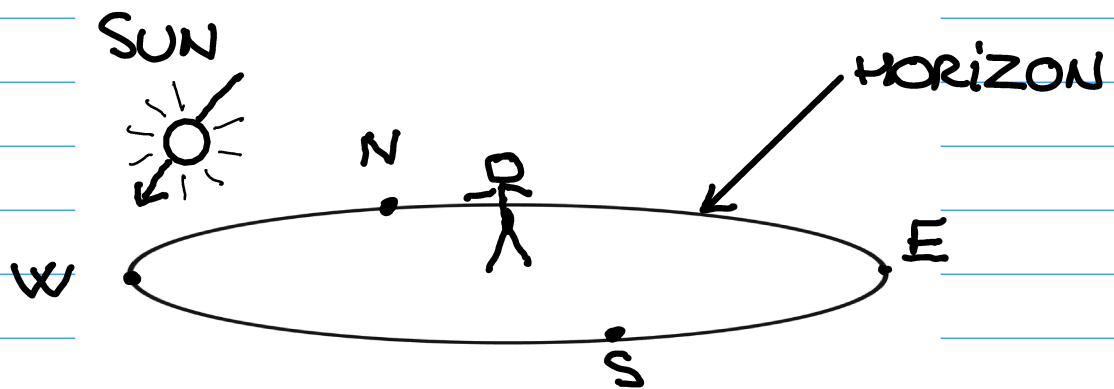
RADIUS \approx 6,400 km

IT SPINS/ROTATES AROUND NORTH-SOUTH
AXIS:



THE DIRECTION OF THE SPIN IS COUNTERCLOCKWISE (PROGRADE) AS ONE WOULD OBSERVE FROM ABOVE THE NORTH POLE - FROM WEST TO EAST.

AN OBSERVER ON EARTH WHO IS APPROACHING THE SUNSET LINE WOULD SEE:



THE SUN IS RISING IN THE EAST AND SETTING IN THE WEST BECAUSE THE EARTH IS ROTATING/SPINNING FROM WEST TO EAST.

THE EARTH SPINS ONCE IN ABOUT 24 HOURS.



THE EARTH-MOON SYSTEM
AS SEEN FROM THE DISTANCE
OF PLANET SATURN

THE EARTH-MOON DISTANCE IS 384,500 km.

HOW LONG DOES IT TAKE LIGHT REFLECTED
OFF THE MOON AND TRAVELING AT A
SPEED OF 300,000 km/s TO REACH
THE EARTH?

$$\text{TIME} = \frac{\text{DISTANCE}}{\text{SPEED OF LIGHT}} = \frac{384,500 \text{ km}}{300,000 \frac{\text{km}}{\text{s}}} = 1.28 \text{ s}$$

NOTE : THE GREATER THE DISTANCE,
THE LONGER IS THE LOOKBACK TIME.



THE AVERAGE EARTH-SUN DISTANCE IS 150 MILLION (1.5×10^8) km.

IT IS MORE NATURAL TO EXPRESS THE DISTANCES IN THE SOLAR SYSTEM IN TERMS OF THE EARTH-SUN DISTANCE.

A NEW UNIT OF DISTANCE :

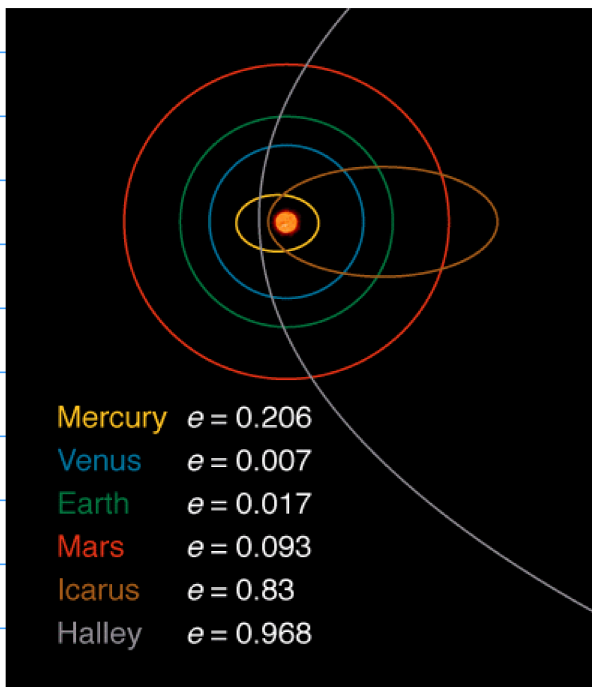
ASTRONOMICAL UNIT (AU) = THE AVERAGE
EARTH-SUN DISTANCE = 150,000,000 km

HOW LONG DOES IT TAKE LIGHT EMITTED BY THE SUN TO REACH THE EARTH?

$$\frac{150,000,000 \text{ km}}{300,000 \frac{\text{km}}{\text{s}}} = 500 \text{ s} = 8 \text{ min } 20 \text{ s} = \underline{8.3 \text{ min}}$$

ONE LIGHT-MINUTE (1min) IS THE DISTANCE LIGHT TRAVELS IN ONE MINUTE.

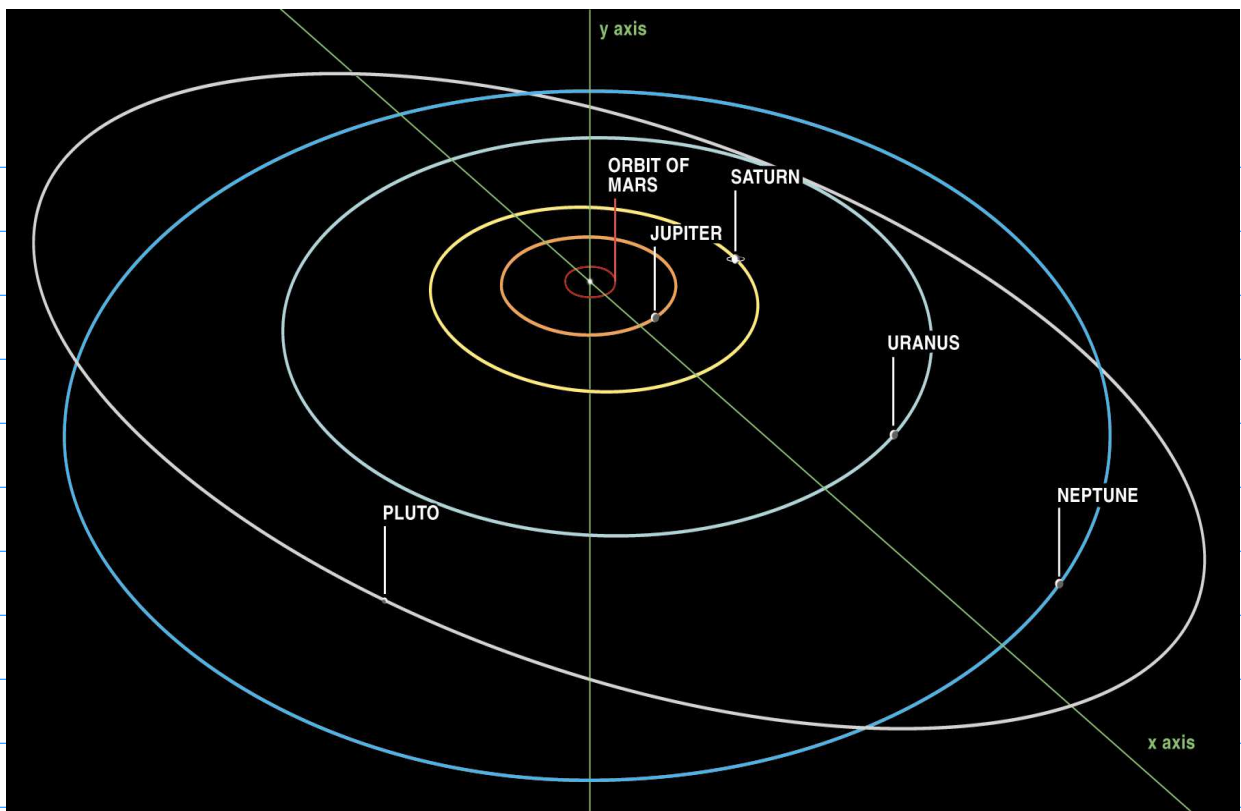
HENCE, $1 \text{ AU} = 8.3 \text{ 1min}$



<u>PLANET</u>	<u>AVERAGE DISTANCE (AU)</u>
MERCURY	0.39
VENUS	0.72
EARTH	1
MARS	1.52

e = ECCENTRICITY OF THE ORBIT

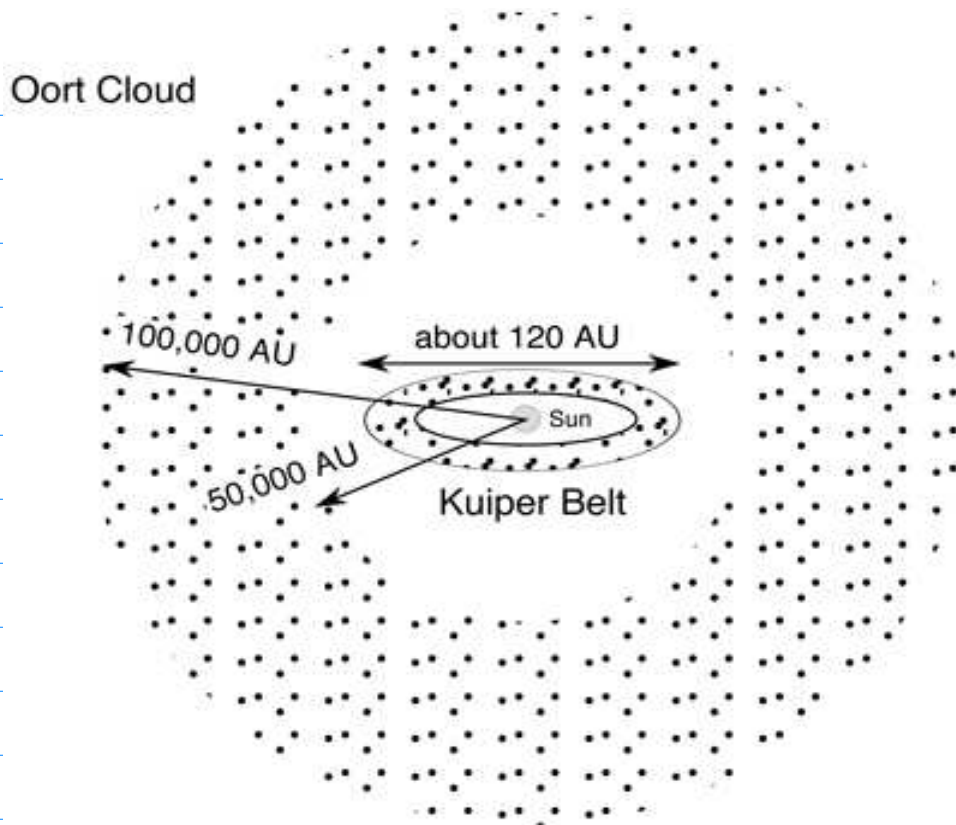
MERCURY, VENUS, EARTH, AND MARS ARE CALLED TERRESTRIAL (EARTH-LIKE) PLANETS.



<u>PLANET</u>	<u>AVERAGE DISTANCE (AU)</u>
JUPITER	5.2
SATURN	9.54
URANUS	19.18
NEPTUNE	30.06

THESE ARE JOVIAN (JUPITER-LIKE) PLANETS.

AS OF 2006 PLUTO IS CLASSIFIED AS A DWARF PLANET (AVERAGE DISTANCE FROM THE SUN IS 39.44 AU)



The Oort Cloud and Kuiper Belt (not to scale!). Extent of the two comet reservoirs are indicated. The nearest star is almost three times farther out than the Oort Cloud.

KUIPER BELT : 30 AU - 60 AU

IT CONTAINS NUCLEI OF SHORT PERIOD
COMETS



COMET NUCLEUS

OORT CLOUD : 50,000 AU - 100,000 AU

IT CONTAINS NUCLEI OF LONG PERIOD COMETS.

THE STAR CLOSEST TO THE SUN IS PROXIMA CENTAURI AT 270,000 AU.



HUBBLE SPACE
TELESCOPE IMAGE
OF PROXIMA CENTAURI

TO MEASURE THE DISTANCE TO A STAR
WE NEED A NEW UNIT OF LENGTH
(AU IS TOO SMALL A UNIT):

LIGHT YEAR = THE DISTANCE LIGHT
(ly) TRAVELS IN ONE YEAR

$$= 63,239.7263 \text{ AU}$$
$$= 9.4605284 \times 10^{12} \text{ km}$$

THE DISTANCE TO PROXIMA CENTAURI
IS 4.24 ly.

STARS OCCUR IN CLUSTERS:



OPEN CLUSTER M45

M45 IS AT A DISTANCE OF ABOUT 400 ly
AND ITS CORE RADIUS IS ABOUT 80 ly.



GLOBULAR CLUSTER M4

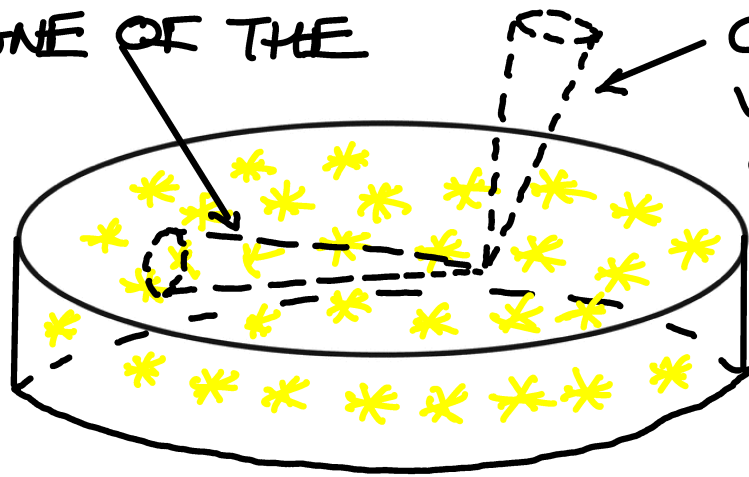
THE DISTANCE OF M4 IS 7,200 ly

THE STARS AND STAR CLUSTERS FORM OUR GALAXY — THE MILKY WAY (FROM VIA LACTEA IN LATIN). AWAY FROM LIGHT POLLUTION WE OBSERVE A DIFFUSE BAND OF LIGHT ACROSS THE SKY:



WE OBSERVE THIS BECAUSE WE
ARE LOCATED IN A DISK OF STARS:

CONE OF VISION IN
THE PLANE OF THE
DISK



CONE OF
VISION OUT
OF THE DISK

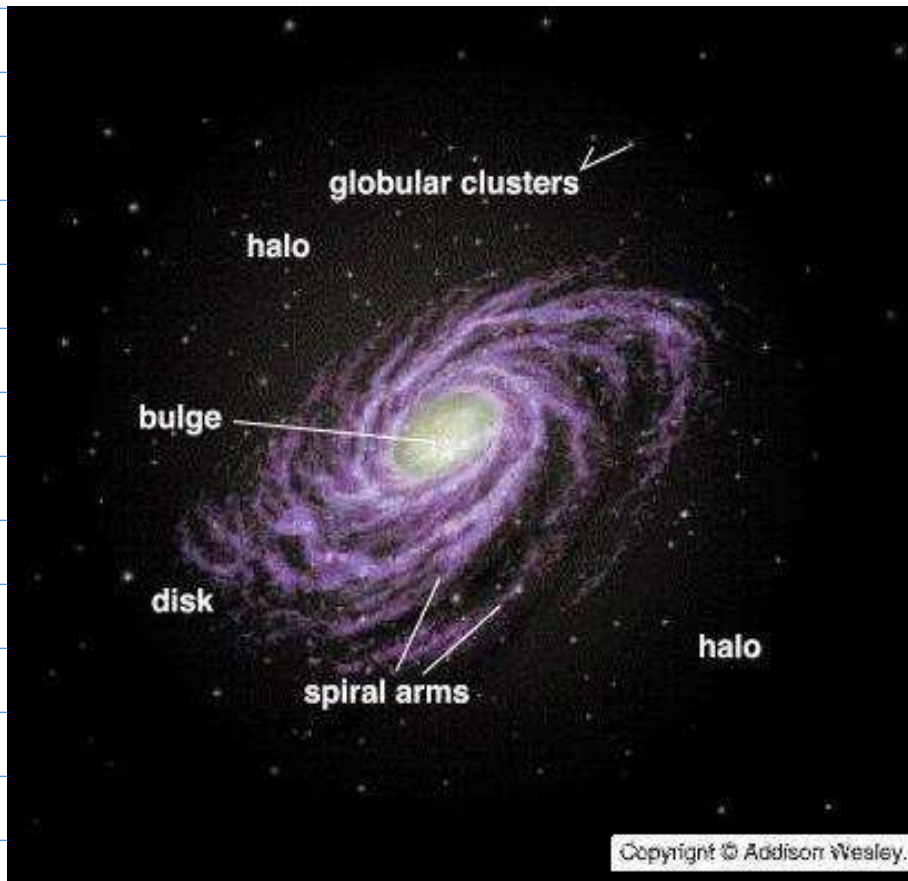
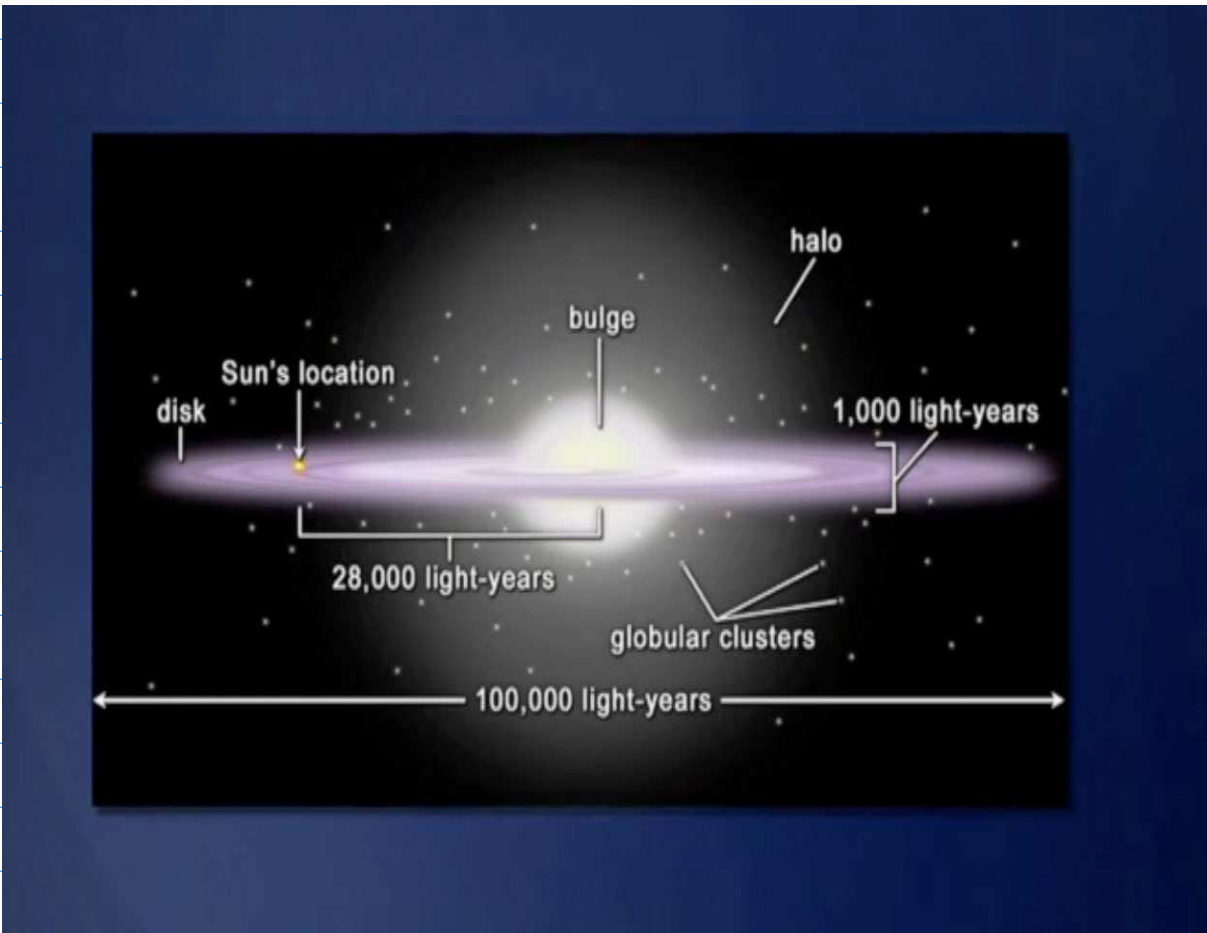
WHEN WE LOOK AT THE Milky Way
IN THE SKY WE ARE LOOKING ALONG
THE PLANE OF THE DISK AND WE SEE
MORE STARS.

WHEN WE LOOK AWAY FROM THE
Milky Way IN THE SKY WE ARE
LOOKING OUT OF THE PLANE OF THE
DISK AND WE SEE LESS STARS.

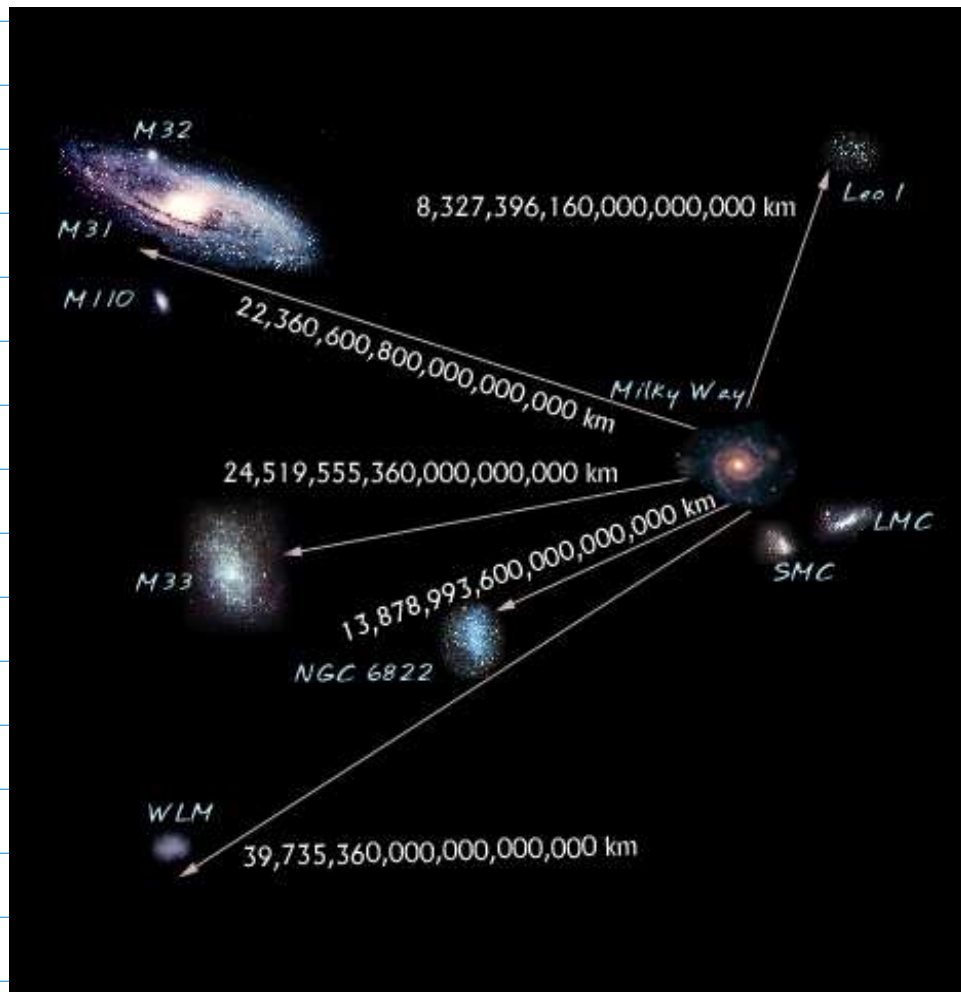
THE DIAMETER OF THE Milky Way IS
ABOUT 100,000 ly.

OUR DISTANCE FROM THE GALACTIC
CENTER IS ABOUT 30,000 ly.

THE SIZE AND STRUCTURE OF THE MILKY WAY:

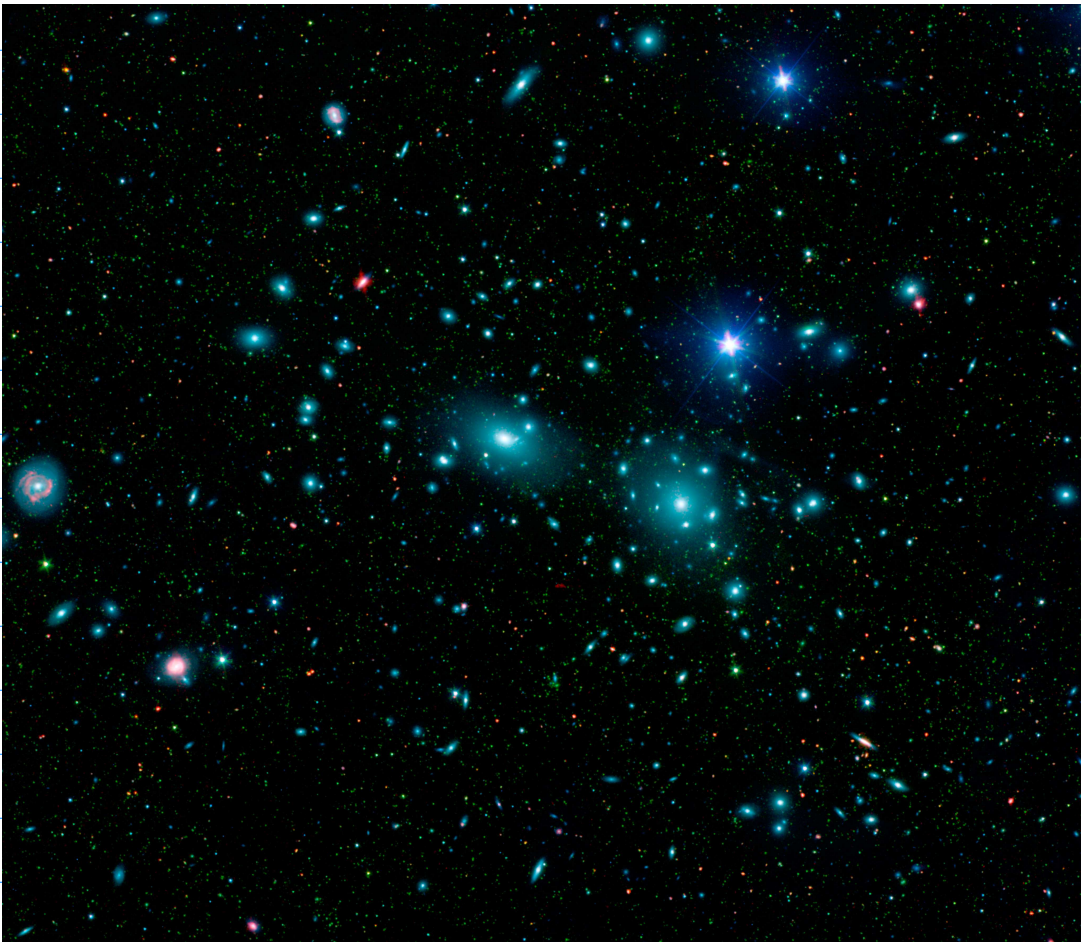


GALAXIES FORM CLUSTERS :



LOCAL GROUP - A CLUSTER OF GALAXIES WHICH CONTAINS THE MILKY WAY.

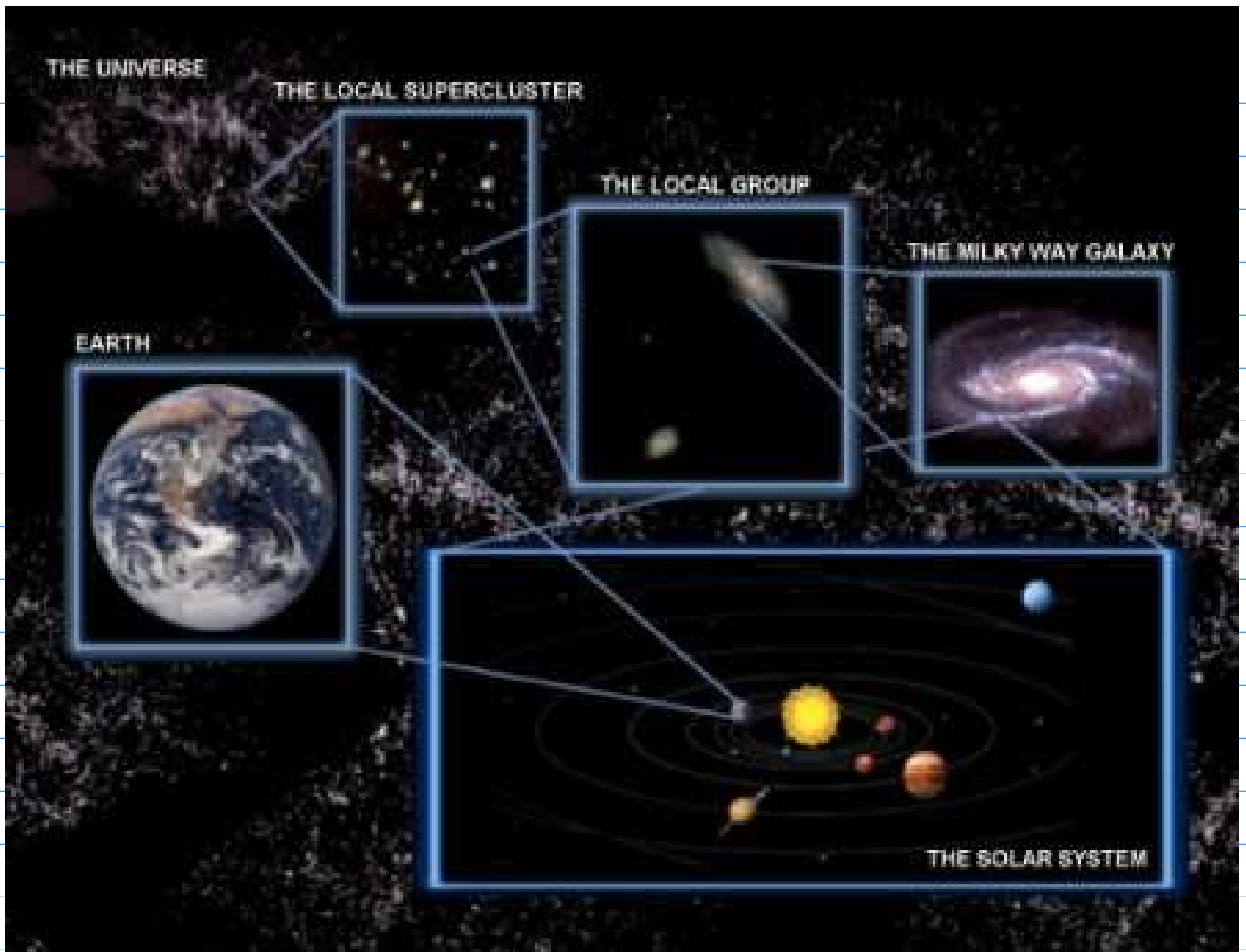
IT IS AN EXAMPLE OF A POOR GALAXY CLUSTER (LESS THAN 1000 GALAXIES).



COMA CLUSTER

COMA CLUSTER IS AN EXAMPLE OF A RICH GALAXY CLUSTER (MORE THAN 1000 GALAXIES).

GALAXY CLUSTERS FORM EVEN BIGGER STRUCTURES - THE SUPERCLUSTERS OF GALAXIES (I.E. THE CLUSTERS OF GALAXY CLUSTERS):



THE SUPERCLUSTER TO WHICH THE LOCAL GROUP BELONGS IS CALLED THE LOCAL SUPERCLUSTER.

THE SUPERCLUSTERS ARE LINKED FORMING LONG FILAMENTS :

