

Big Bang, Black Holes, No Math

ASTR/PHYS 109

Dr. David Toback
Lecture 2 & 3

Prep For Today (is now due) - L3

- Reading (should already have been completed)
 - Required: BBBHNM: Chapter 1-4
- Pre-Lecture Reading Questions (PLRQ)
 - All 6 PLRQ quizzes in eCampus
 - 4 written questions to be turned into CPR (due Monday) - Stage 1
- End-of-Chapter Quizzes
 - None (haven't finished Chapter 2)
- Papers
 - None assigned
 - First one will be assigned when we do Chapter 6

Stage I and Stage II in CPR

Stage I: (Typically due before the first class of the Unit)

- Write 4 questions and turn them into CPR (online)
- Make sure to use HTML formatting (do a Preview to check)
 - Use the <p> or
 lines after your paragraph or question.

Stage II: (Typically due before the following lecture)

- Three-Parts
 1. **Calibrations (learning to use the Rubrics)**
 - Read an example submission and use the grading rubric to assign a score. Grade the three example submissions (get only one free try to pass the grading rubric)
 2. **Reviews (Grade three other submitted submissions)**
 - Ignore that it says you have only 5 minutes for this. I have set it so you can start the reviews right after you finish your calibrations
 3. **Self-Assessment (Grade your own submission)**

Note: You get a separate score for each of the 4 parts (text, calibrations, Reviews and Self-Assessment)

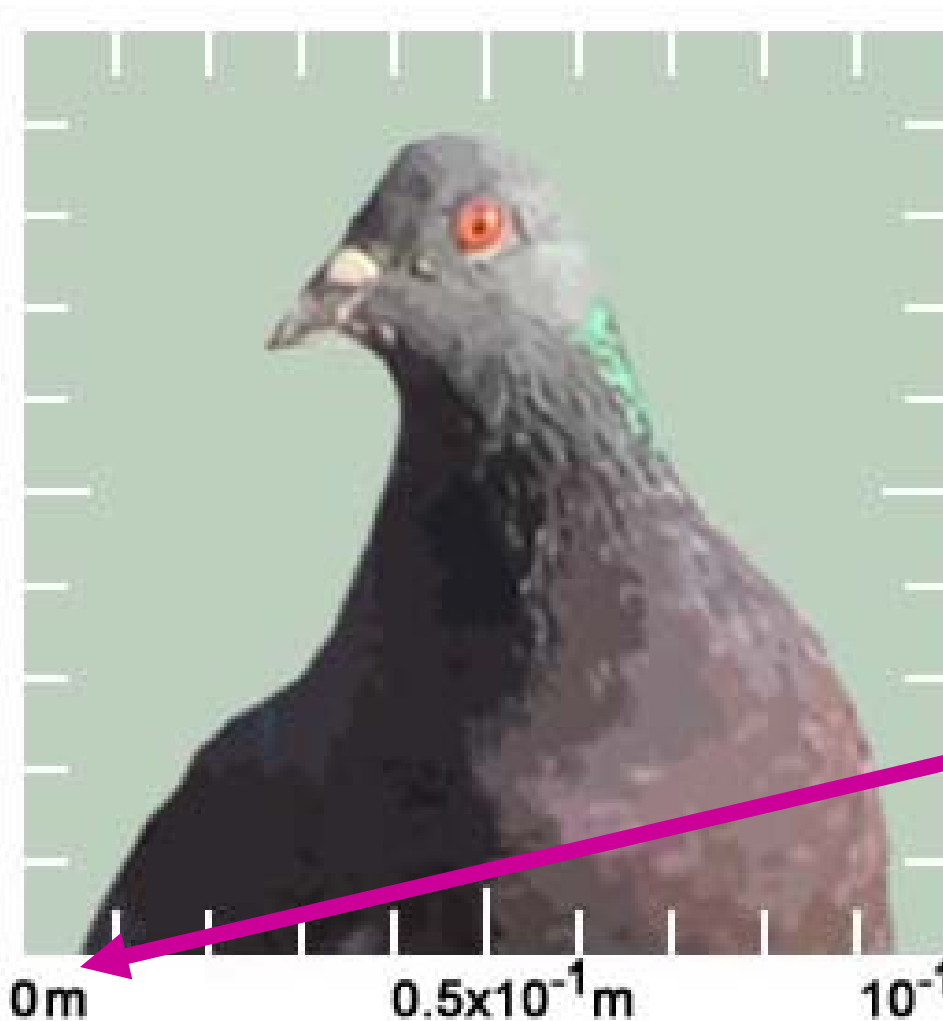
Going Big - Chapter 2

- You have to get started somewhere
- Start by looking at the various things in the universe
 - Go from sizes we know to the VERY big
- After that we'll do the very small
 - Chapter 3

The Very Big: *Why Start Here?*

- If we want to understand the universe and where it comes from (and what's going to happen to it) we need to know:
 1. What's in it
 2. What it's made of
- Said differently, *"What are we trying to explain?"*
 - If we were detectives trying to explain what happened, we'd need to gather evidence: *What's the evidence we can gather by looking at the scene of the crime?*

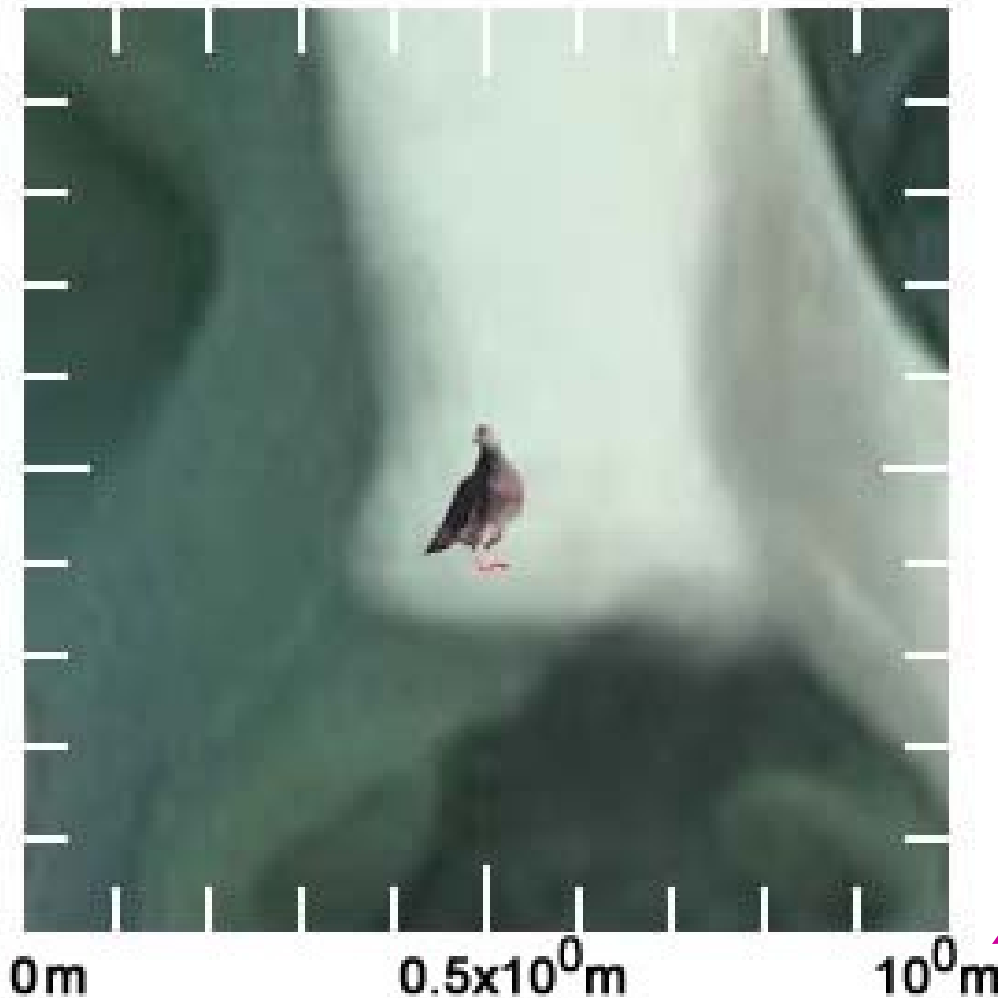
Starting out...



Just starting out...
A size we know:
The nose in front
of your face
(well... someone's
face)

10 centimeters,
or 0.1 meters, or
 10^{-1} meters.
About 3 inches

Look from father away...



Moving out,
but still
staying at
sizes we
know and
love

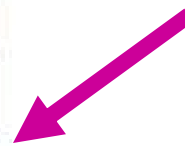
1 meter (or
about 3 feet)

Bigger still...



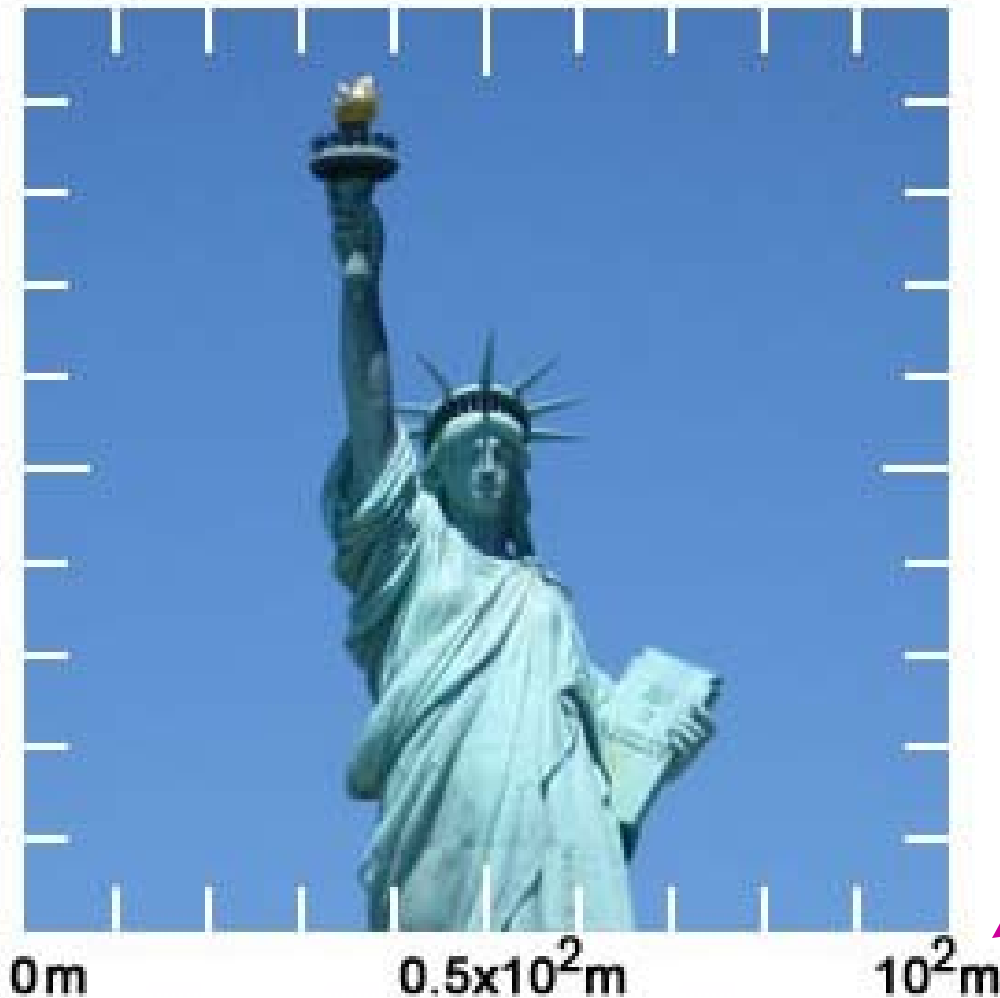
The Statue
of Liberty
in New
York

10 meters
(or about 30
feet)



0m $0.5 \times 10^1 \text{m}$ 10^1m

Keep going...

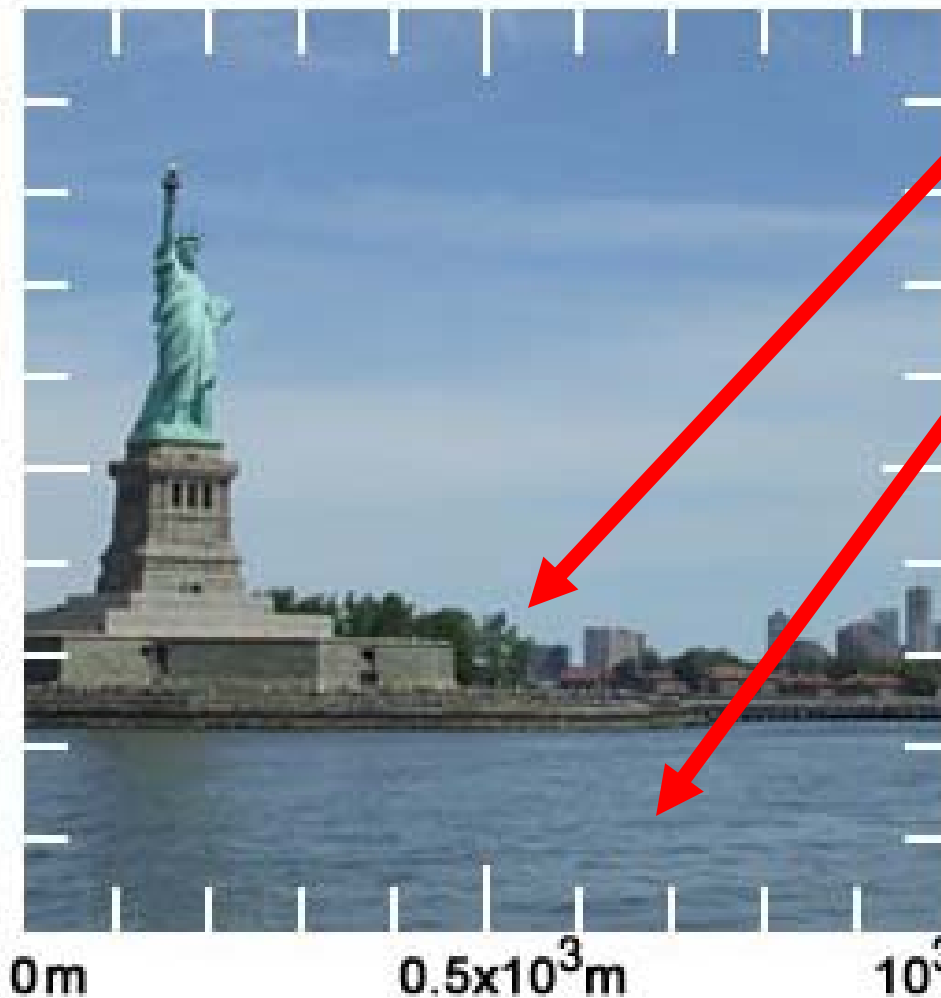


100 meters or
about a
football field,
or 10^2 meters

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Introduction
Topic 2: Going Big

Starting to get out there...



Manhattan and
the Hudson
river

1 kilometer or
 10^3 meters

Even bigger... use an airplane



0m $0.5 \times 10^4 \text{ m}$ 10^4 m

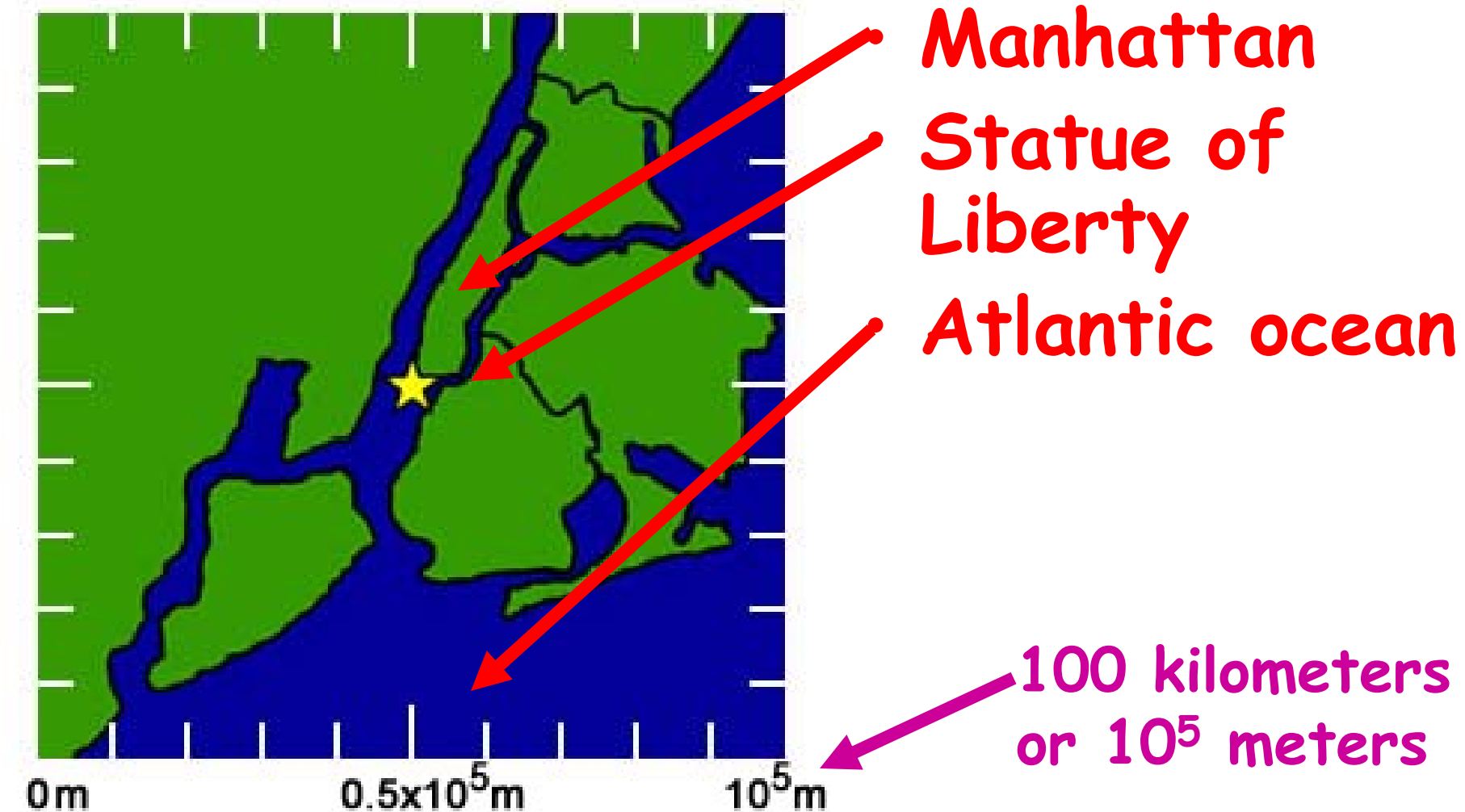
- Can see the grid structure of Manhattan

- *Important to the story?*

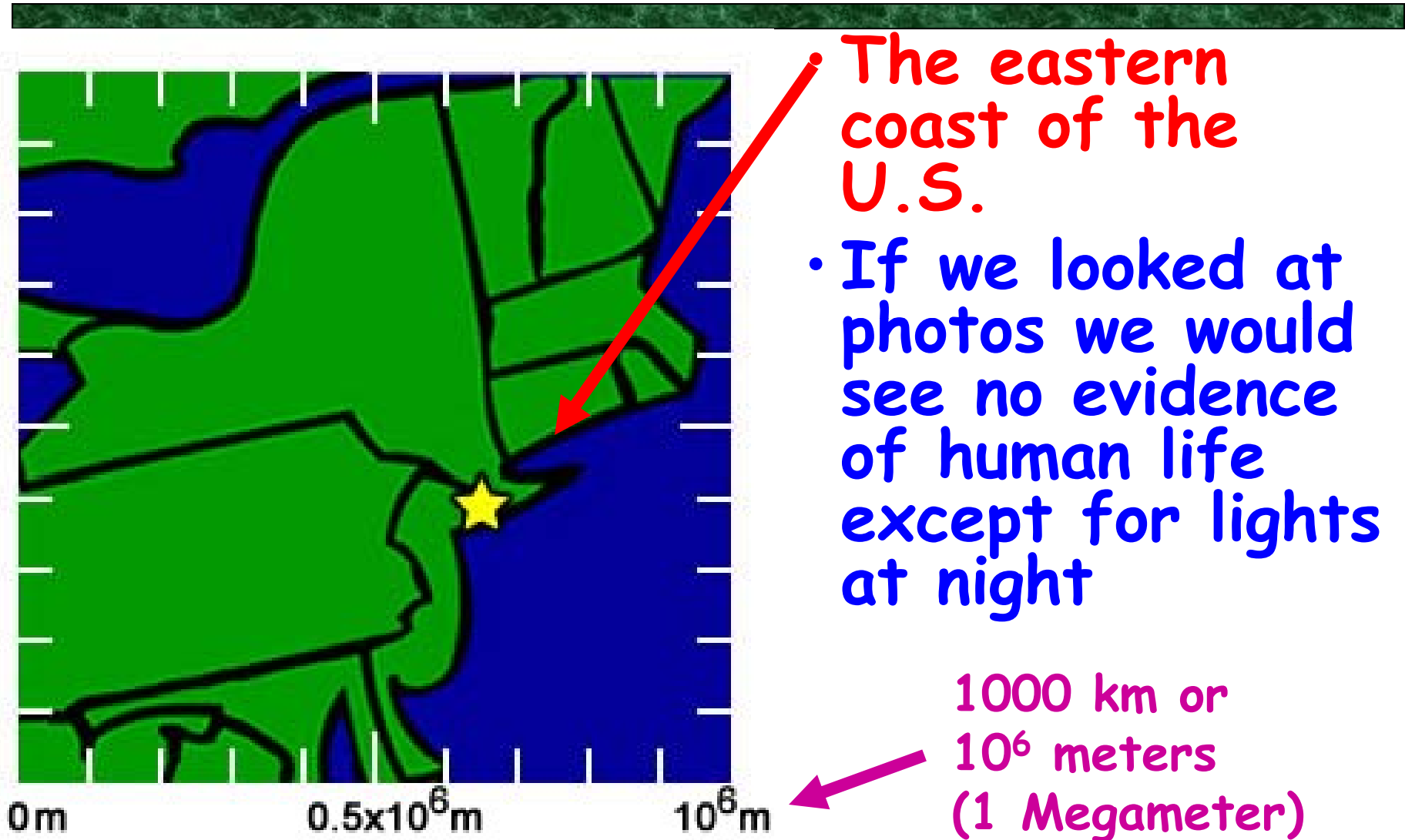
→ *Yes! Can tell us a LOT about how New York City was constructed!*

10 kilometers
or 10^4 meters

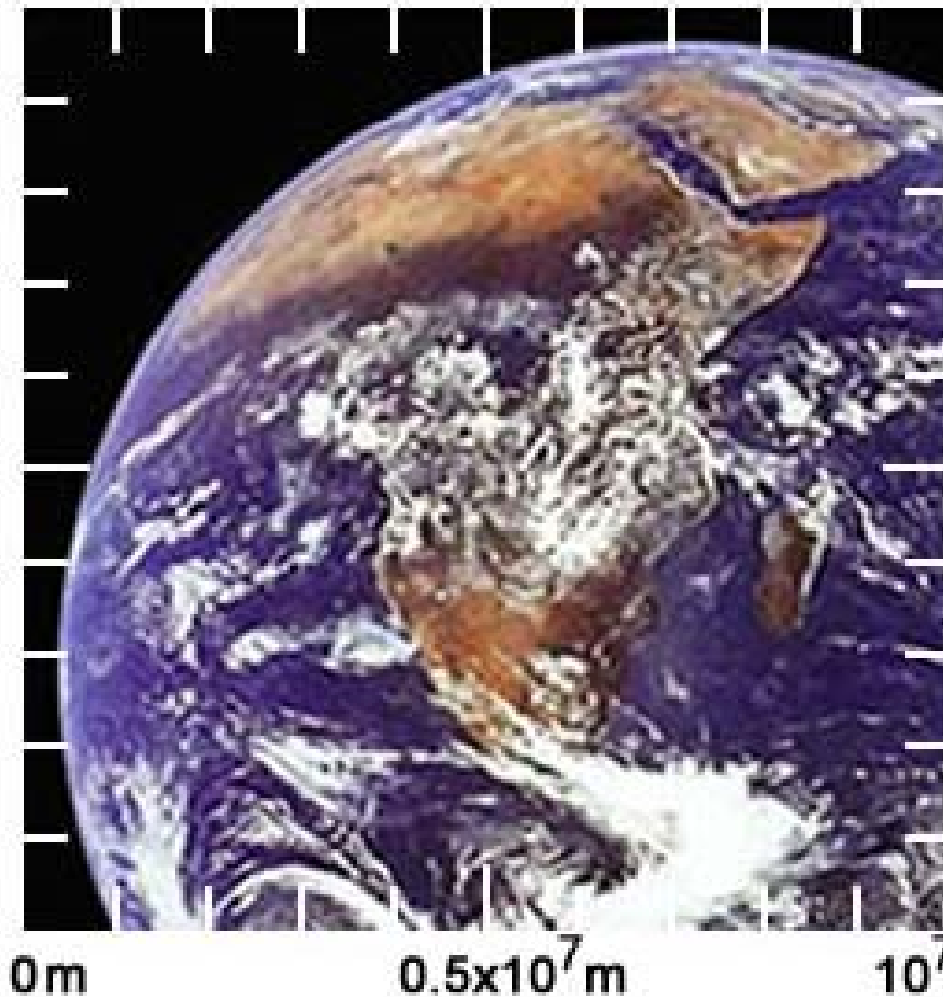
Go to Drawings



Yet bigger...



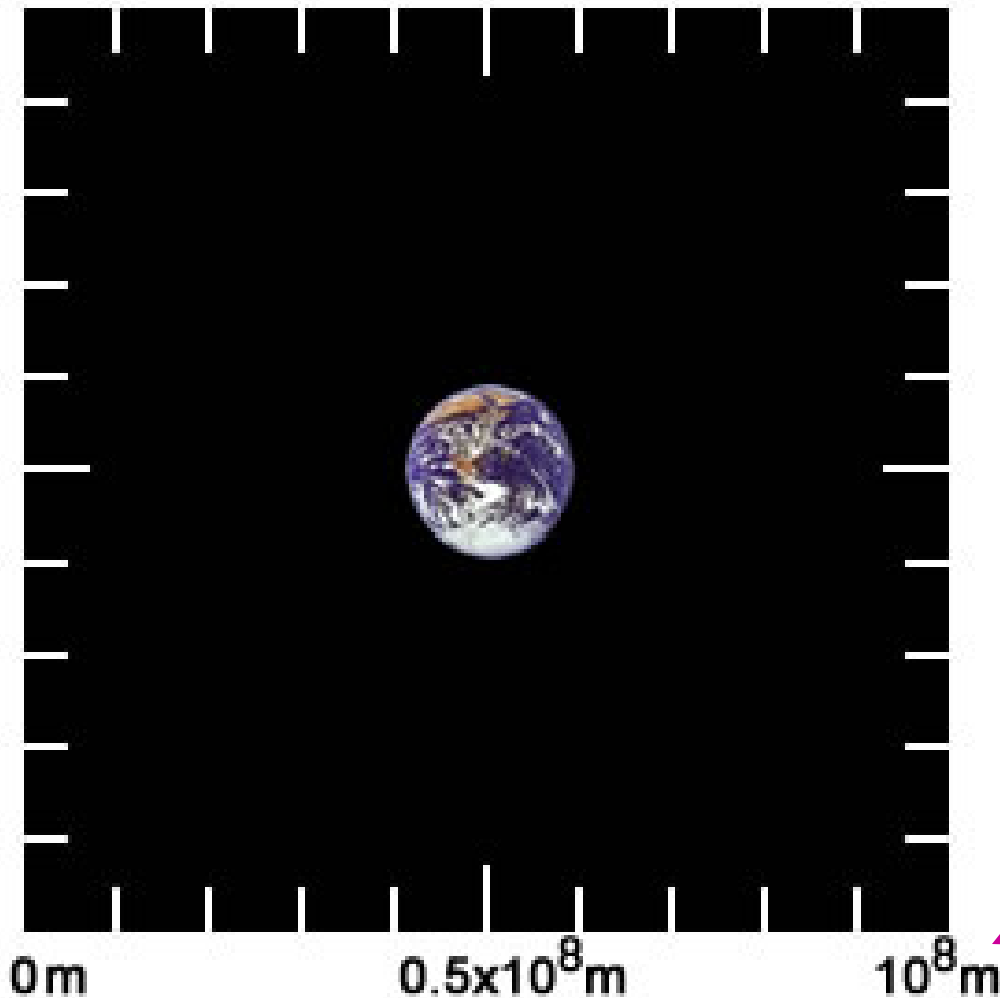
The Earth from Space



Now we can
see most of
the Earth,
but we can't
see the
streets

10⁷ meters!

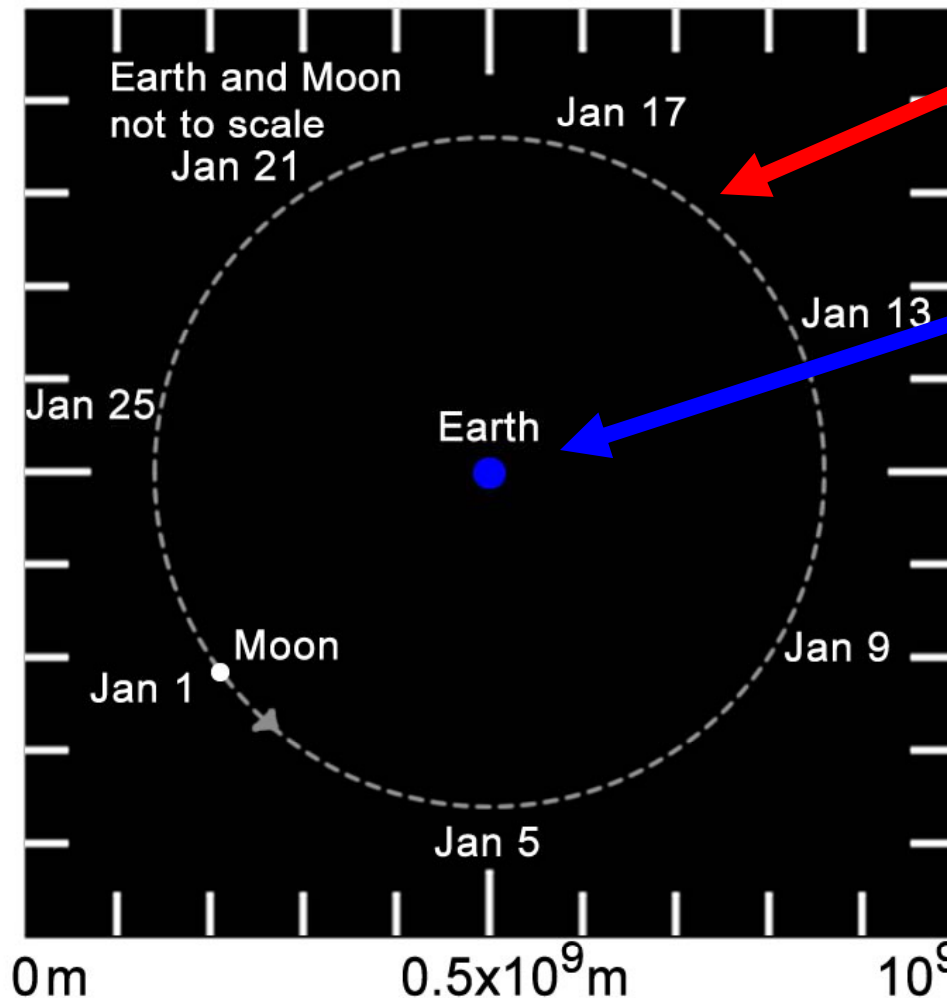
More Earth



The Earth is
a sphere in
space

10^8 meters!

More Drawings

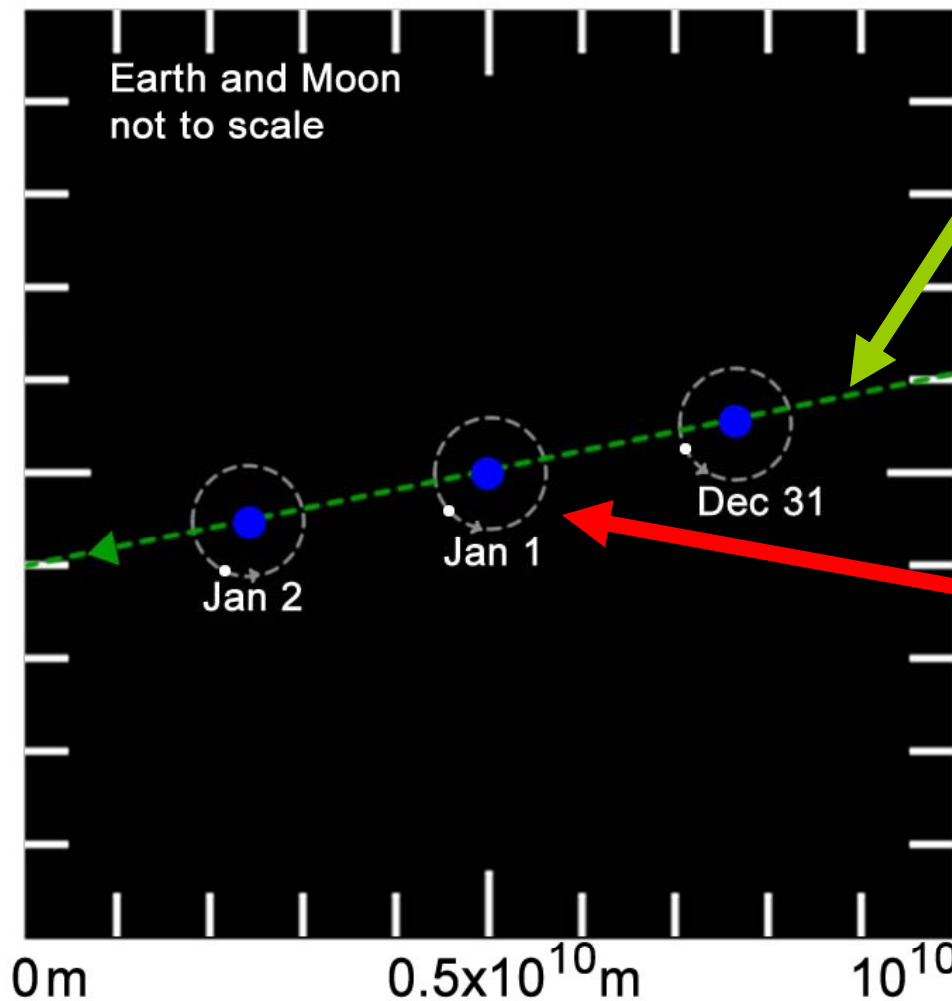


Orbit of the Moon
(27.3 days)

The Earth

10^9 meters, a
billion meters (a
gigameter), a
million miles

The Earth orbiting the Sun

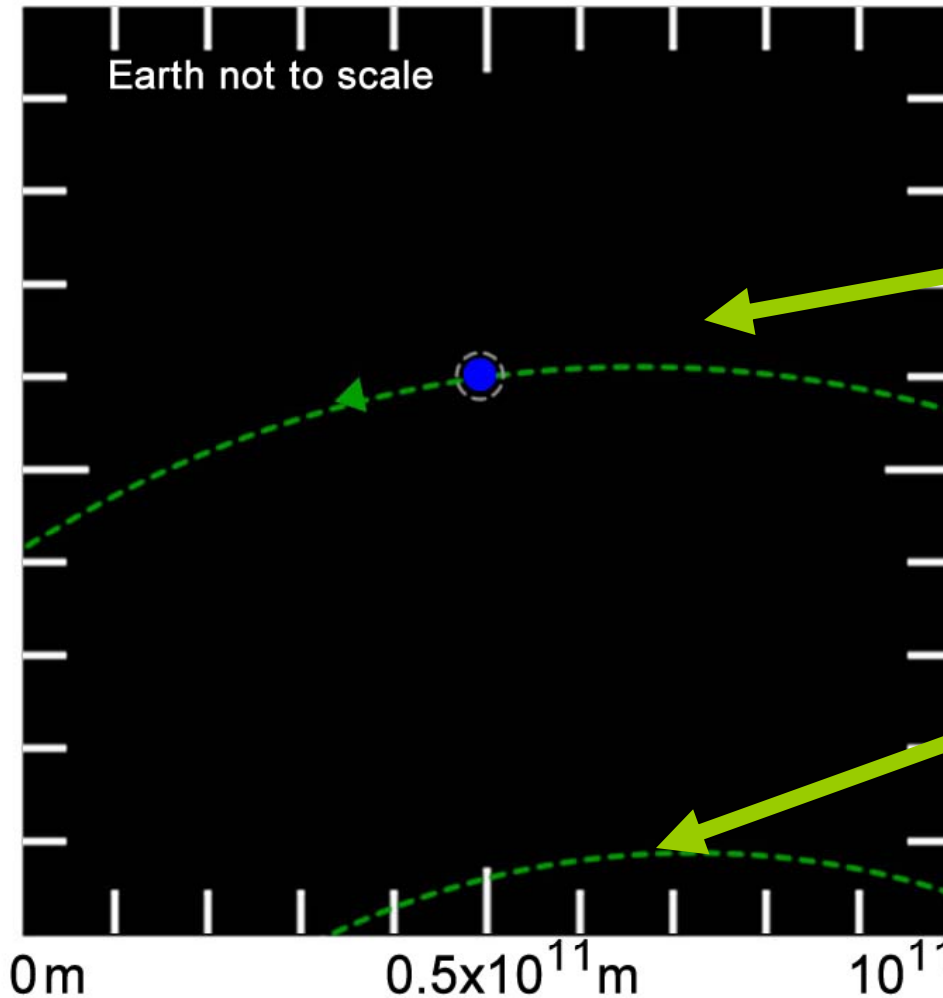


The Earth on its
trajectory around
the sun

The Moon going
around the Earth

10¹⁰ meters!

Earth around the Sun



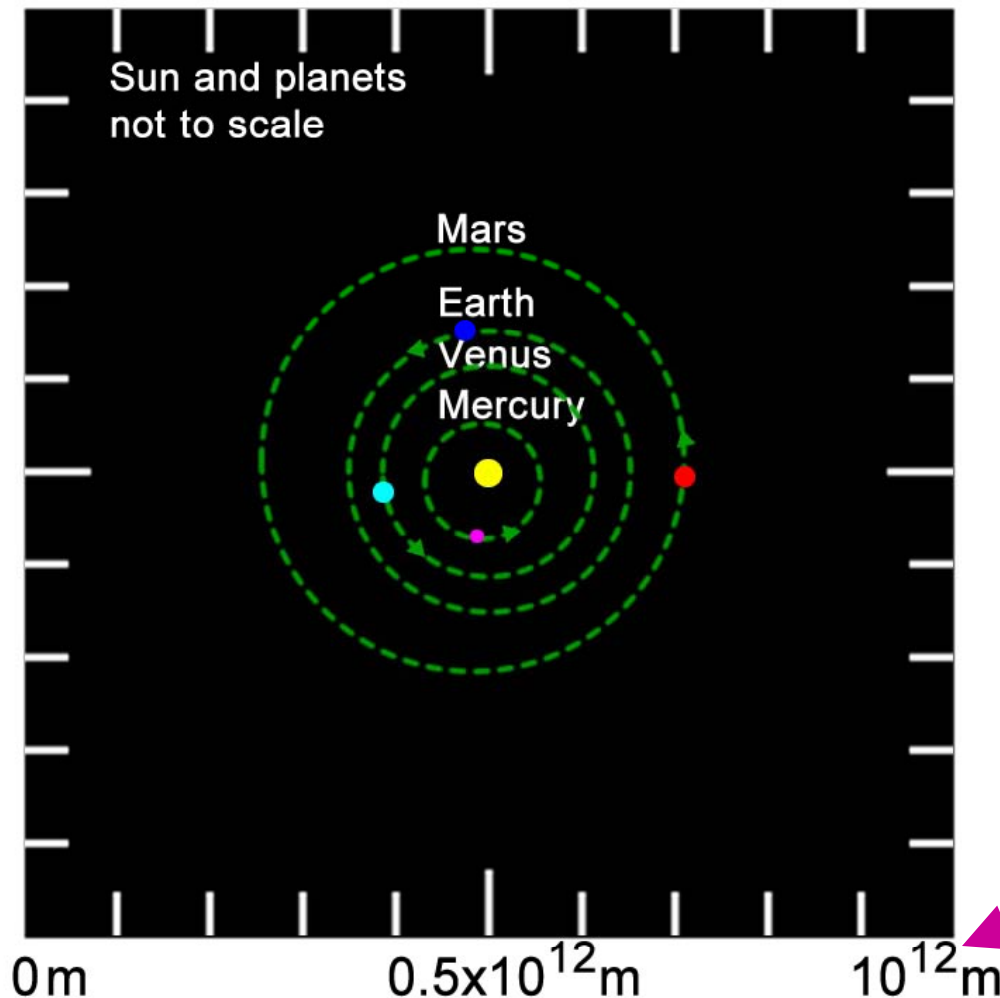
Orbit of the Earth

- Yellow circle is the Moon's orbit

Orbit of Venus

10^{11} meters!

The Inner Planets



- Mars, Earth, Venus and Mercury orbiting the Sun
- All the planets move in the same direction (counterclockwise in this picture)
- *A clue?*

10^{12} meters!
~A billion miles!

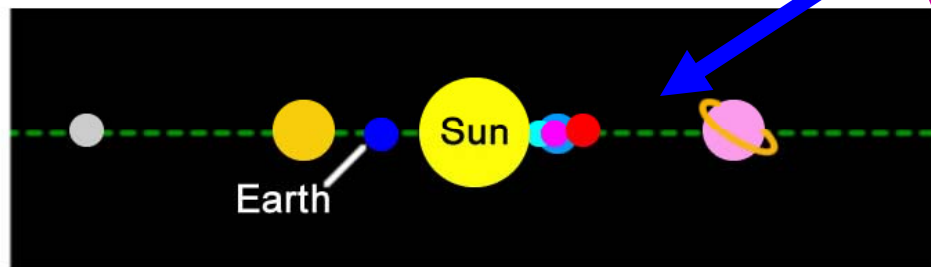
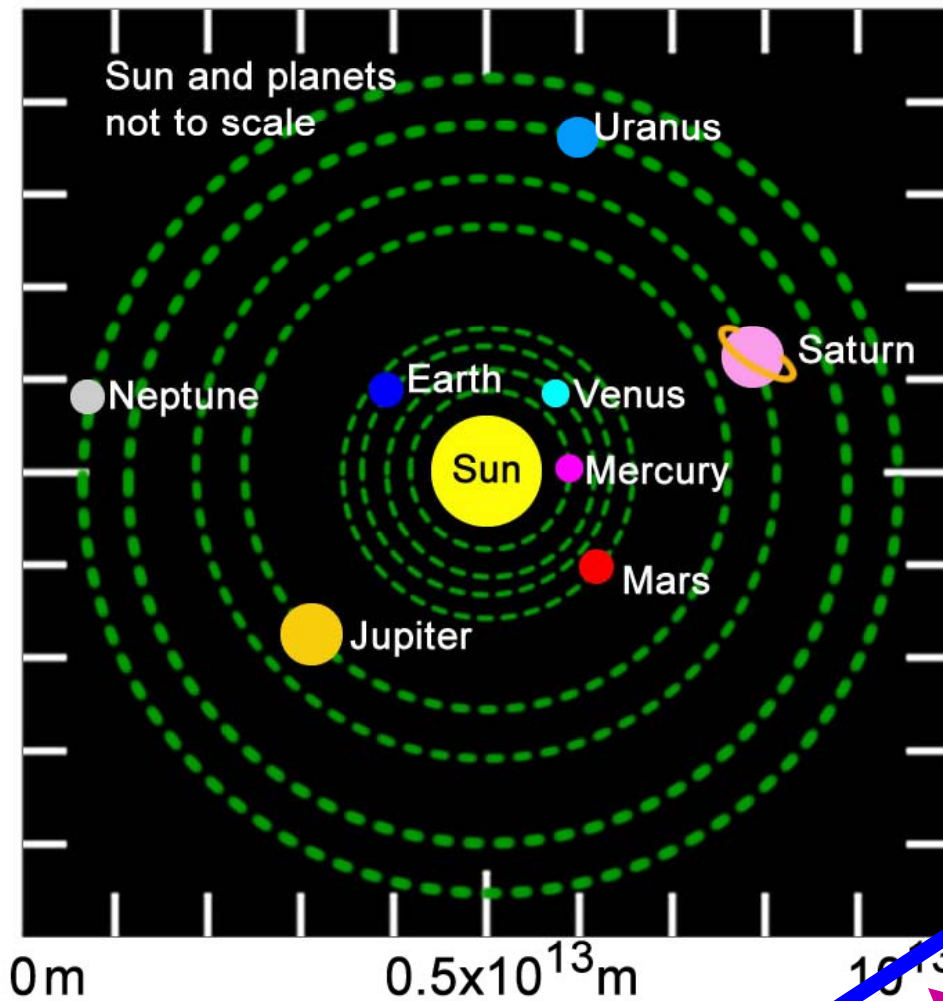
The Outer Planets

- Jupiter, Saturn, Uranus and Neptune

- Again all move in the same direction!

Look from the side: All move in the same plane!
Another clue?

10^{13} meters!

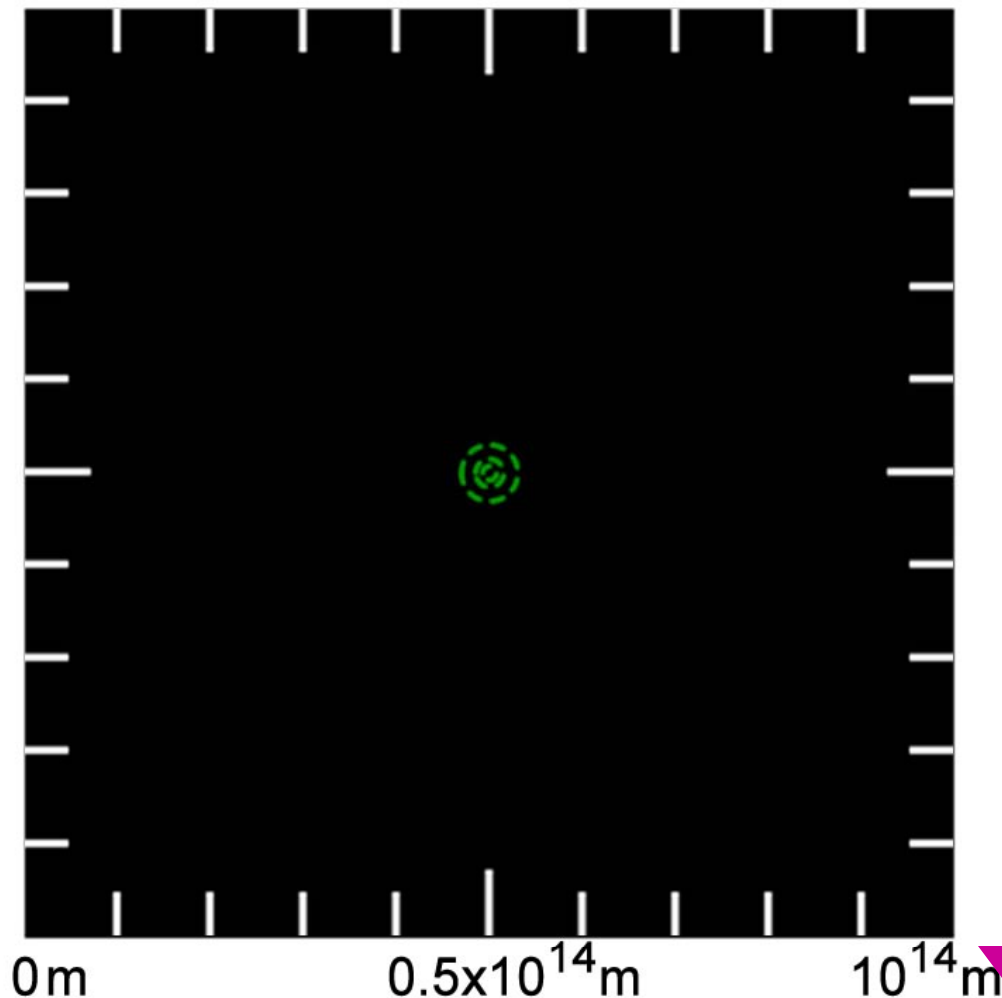


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Topic 2: Using Big

Notes, No Math

The Whole Solar System



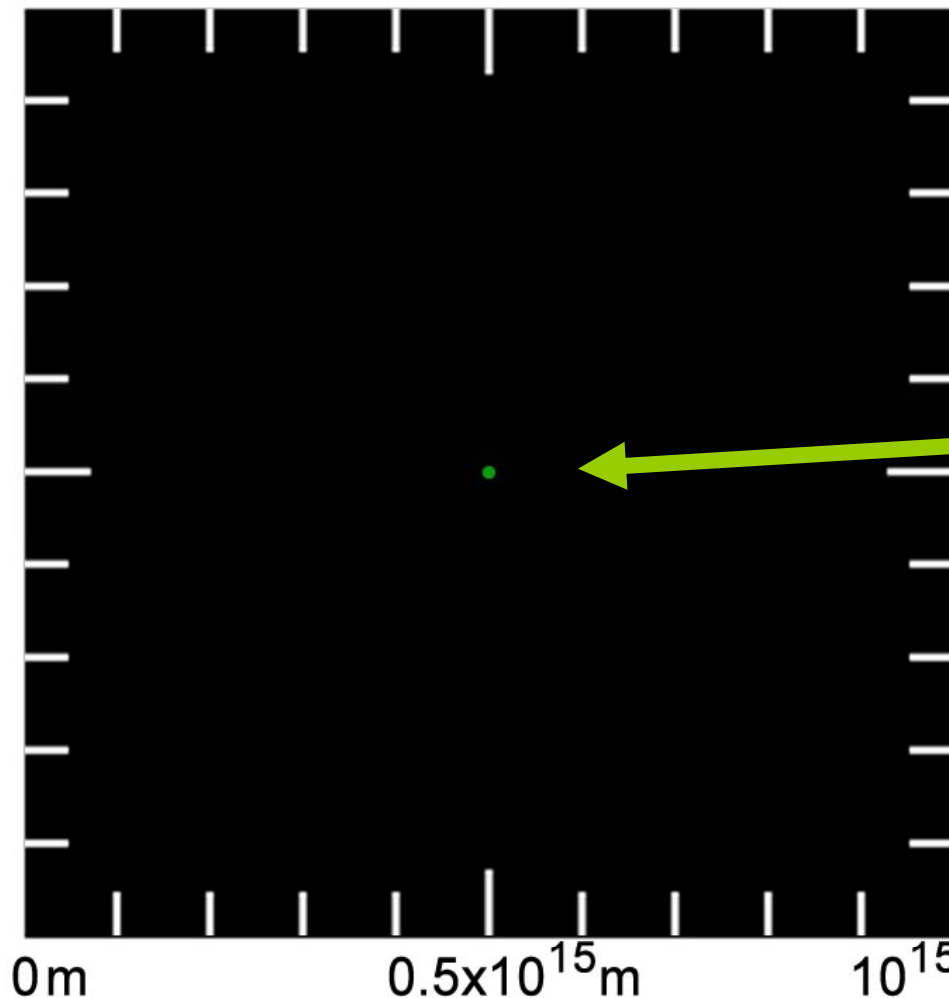
- Mostly empty space, but some stuff
- Typically only 1 hydrogen atom per cubic centimeter (size of a standard die)
- There is other stuff we'll talk about like cosmic background radiation and dark matter

Big Bang, Black
Holes, No Math

Introduction
Topic 2: Going Big

10^{14} meters!

Mostly Empty Space

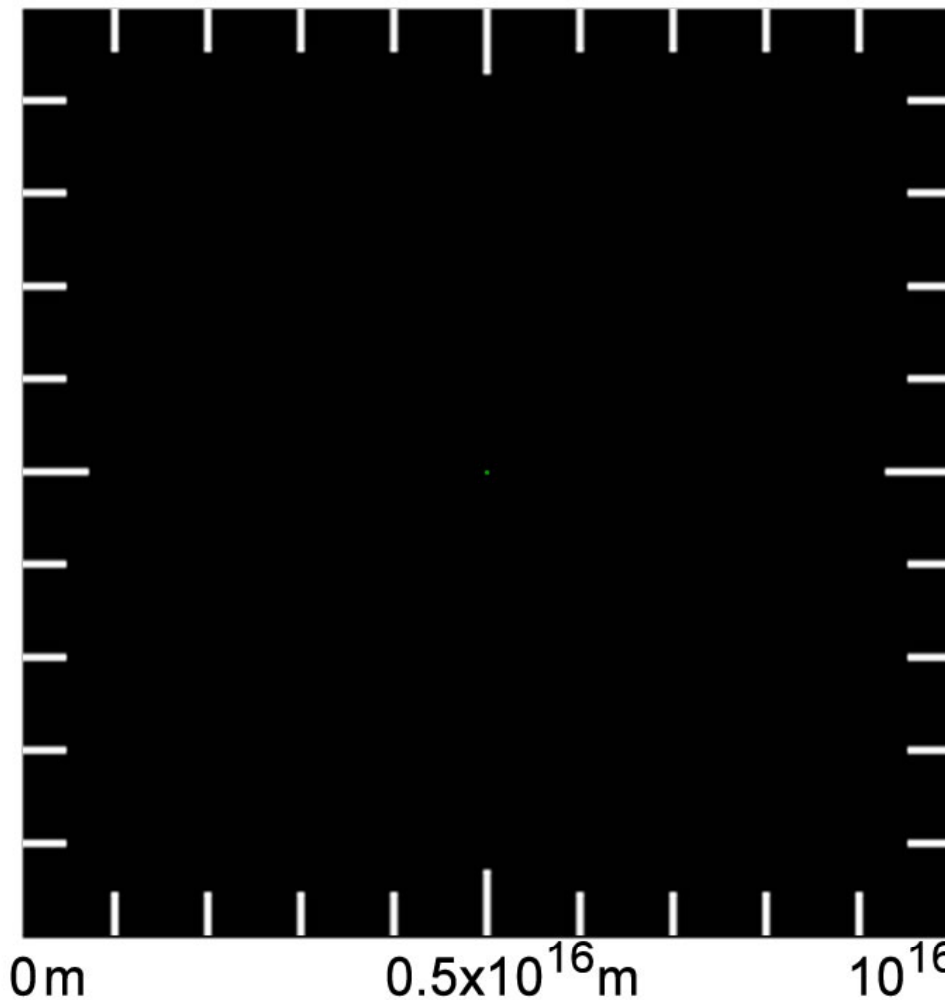


- More interstellar space

The small circle is the orbit of Pluto

10^{15} meters!
~trillion miles

More Empty Space



On this scale the
solar system is a
tiny dot

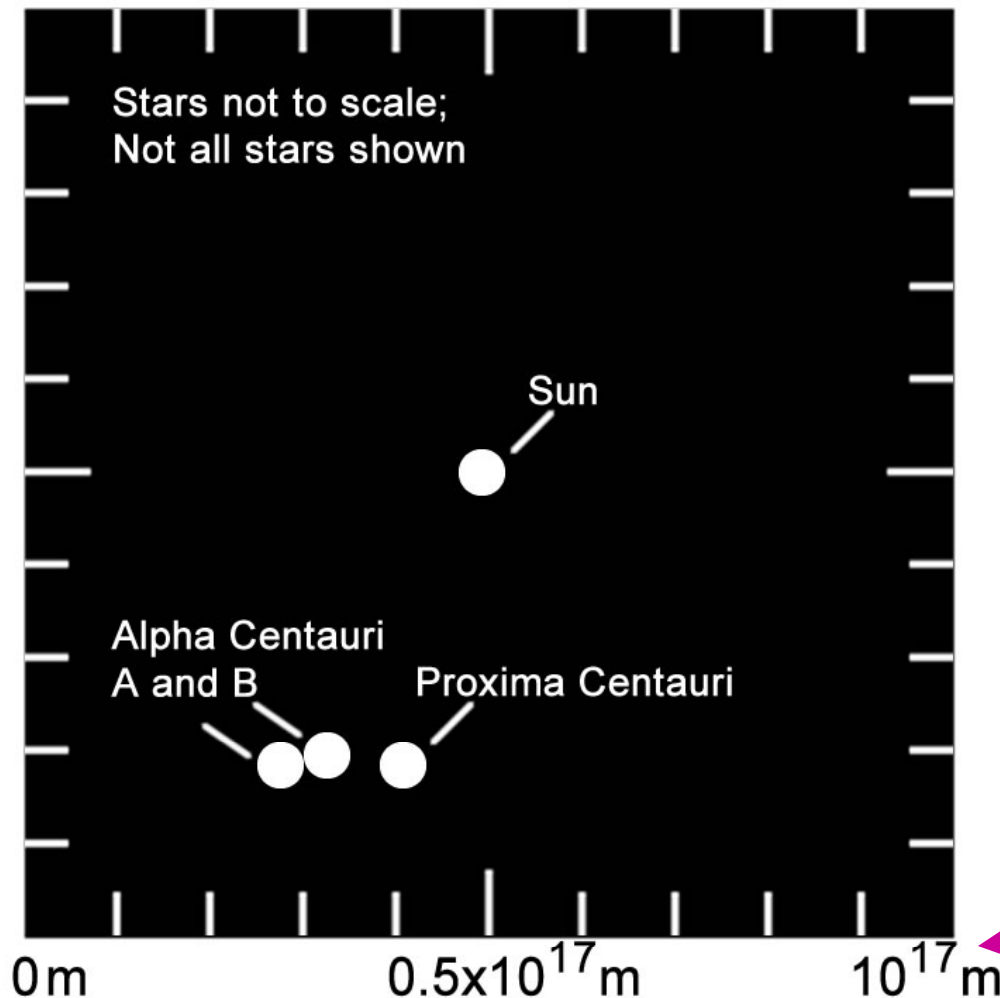
10¹⁶ meters!

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Introduction
Topic 2: Going Big

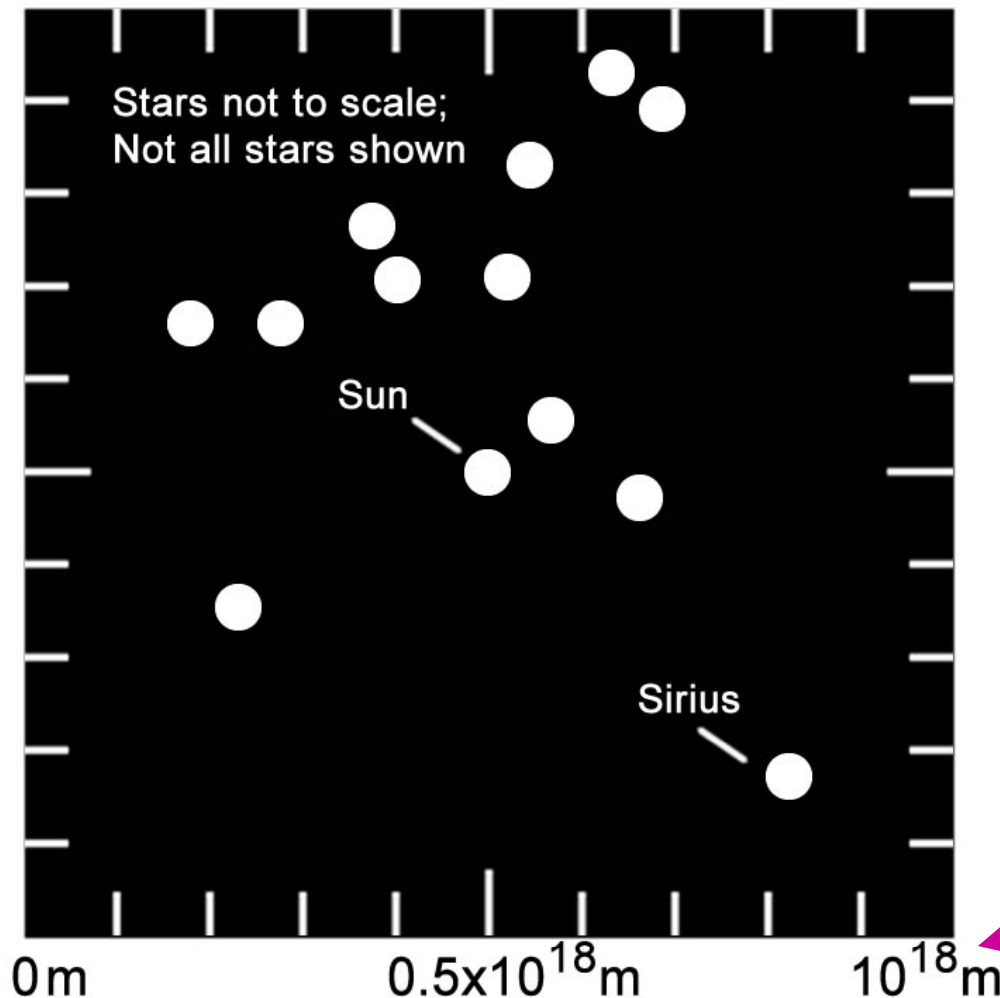
The Nearest Stars



- Alpha Centauri A, Alpha Centauri B and Proxima Centauri
- Proxima Centauri is the closest at 4.0×10^{16} meters from the sun
- Same as 4.2 light-years away
 - (it takes light 4.2 years to get there)
 - 1 light-year is about a trillion miles

10^{17} meters!

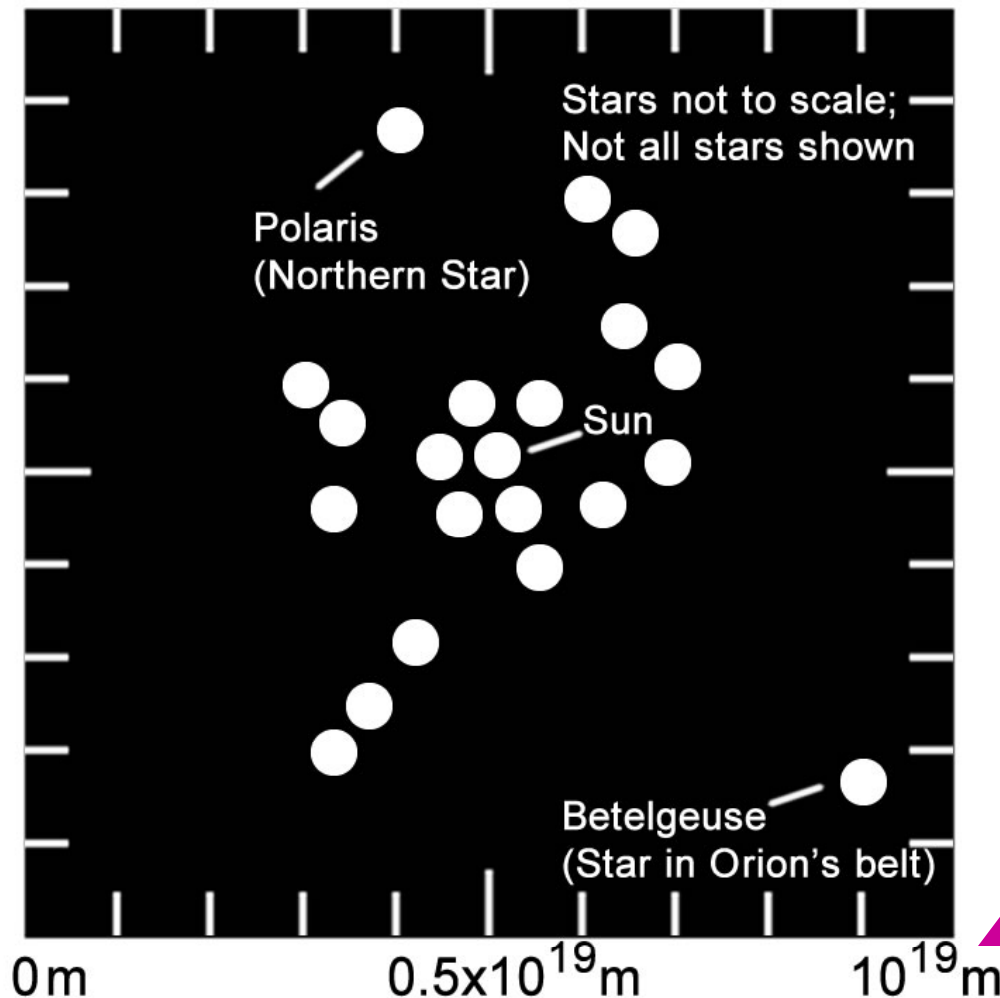
The Brightest Stars in Our Sky



- Only the brightest stars are shown
- Almost 2000 in reality

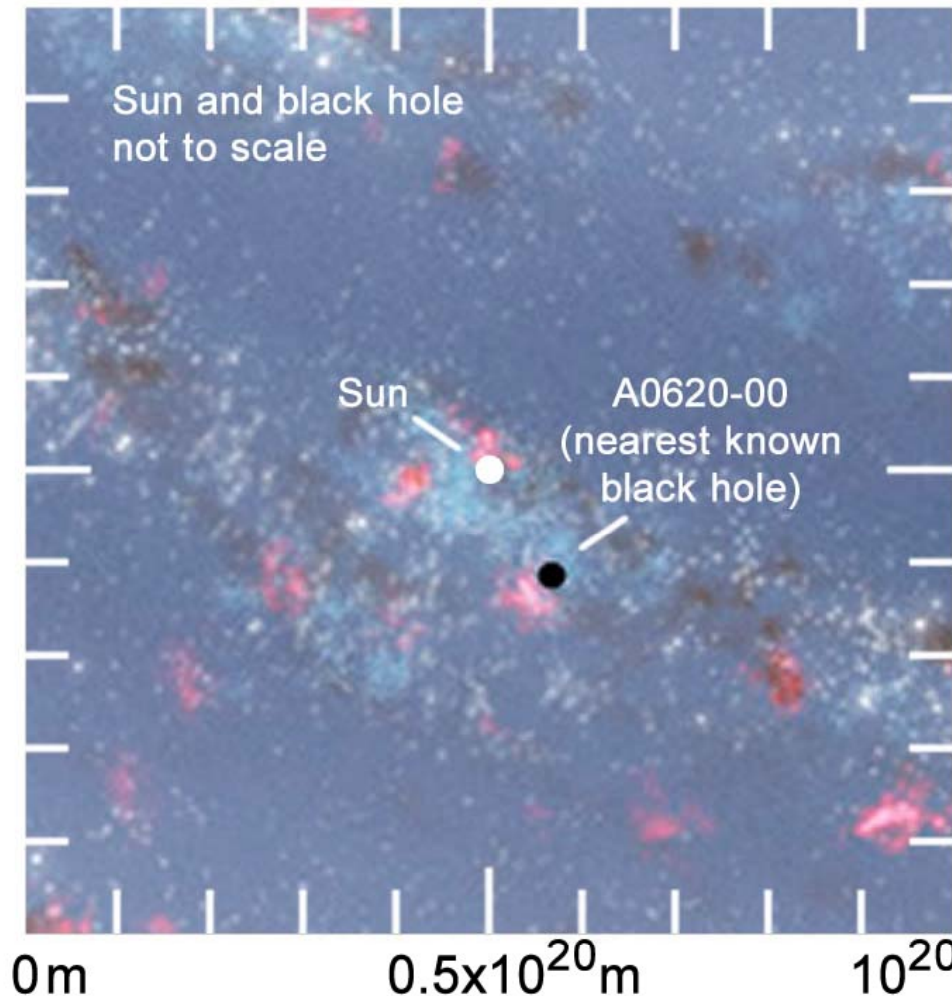
10^{18} meters!

Next Round...



- Again, only the brightest
 - ~2 million total in this space
- 10^{19} meters!

The Milky Way



So many stars that they appear to be "clouds" of stars

Much of the space between stars contains "Dark Matter" we can't see directly

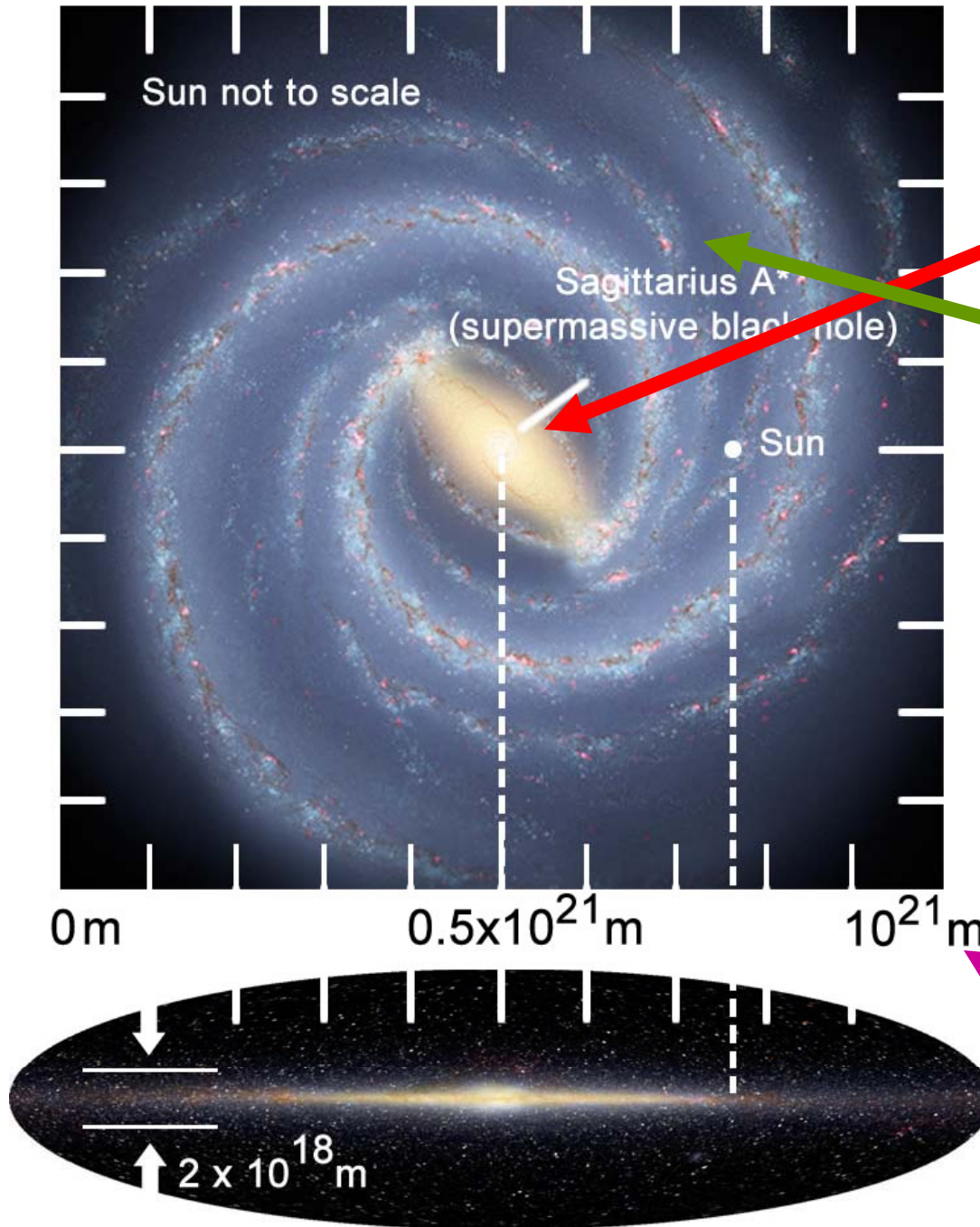
- About 5 times more mass in Dark Matter than the stars

10²⁰ meters!

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Introduction
Topic 2: Going Big

Our Galaxy



- **Central Bulge**

- **Spiral arms**

- The sun is in one of the spiral arms, ~1/3 of the way inward from edge of the disk towards the center

10^{21} meters!

on
Big

Prep For Next Time - L3

- **Reading: (Already due)**
 - Required: BBBHNM Unit 1 (Chapter 1-4)
 - Recommended Reading:
 - BHOT: Chap. 1-3
 - SHU: Chap. 1-2
 - TOE: Chap. 1
- **Pre-Lecture Reading Questions (some were due already)**
 - CPR/PLRQ quizzes in eCampus
 - Stage 1 in CPR (enter your 4 questions)
 - Remember to use HTML formatting
 - Due Monday Feb 2, BEFORE class (won't usually give 1 week)
 - Stage 2 will be due before class on Wednesday, Feb 4
- **End-of-Chapter Quizzes**
 - If we finished Chapter 2 then end-of-chapter quiz 2
- **Papers**
 - None assigned
 - First one will be assigned when we do Chapter 6

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Holes, no matrix Topic 2: Going Big

Full Set of Readings So Far

- Required: BBBHNM: Chap 1-4
- Recommended:
 - BHOT: Chap. 1-3
 - SHU: Chap. 1-2
 - TOE: Chap. 1