Last of the Three Astronomy Exams

June 18, 2021

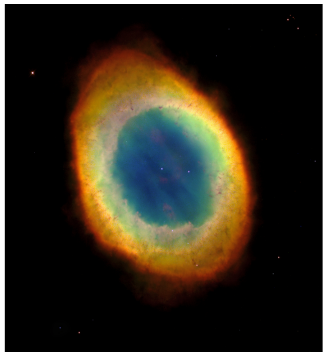
1. Death of Stars

One or more of the following statements three statements are true. Cross out any statements that are wrong.

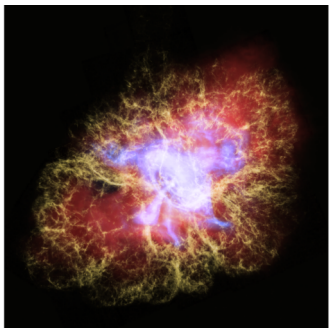
(A) When a star turns nova, it spreads some of the elements it has made into a “planetary nebula”
(B) A star turns supernova due to an exotic kind of fusion where protons and electrons fuse to become neutrons.
(C) When a star turns supernova, elements heavier than iron (like lead, gold and uranium) are made and pushed out as a nebula

Some nice examples of nova and supernova remnants are below.

Ring Nebula (a nova remnant):



Crab Nebula (a supernova remnant):



2. Death of Stars

A star with the same mass as our Sun finishes its life:

(A) by shrinking to a white dwarf and then enlarging to a red giant
(B) by enlarging to a red giant and then becoming a nova, leaving a white dwarf
(C) by enlarging to a red supergiant and then becoming a supernova, leaving a black hole

3. Death of Stars

A star with 10 times the mass of our Sun finishes its life:

(A) by shrinking to a white dwarf and then enlarging to a red giant
(B) by enlarging to a red giant and then becoming a nova, leaving a white dwarf
(C) by enlarging to a red giant and then becoming a supernova, leaving a neutron star

4. Death of Stars

One or more of the following statements three statements are true. Cross out any statements that are wrong. Features of Type 1a Supernova are:

(A) Unlike Type II supernovae, it has little or no Hydrogen in its spectrum
(B) It is caused by the accretion of a large star onto a white dwarf
(C) It occurs when the white dwarf grows to a special size known as the Chandrasekhar limit
(D) They have consistent and intense peak brightness, making them useful as a “standard candle.”

5. Stellar Mass Black Holes

If you are near a black hole (or any large mass), then time runs _____ it does for people who are far from the large mass.

(A) slower for you than
(B) the same for you as
(C) faster for you than

6. Supermassive Black Holes

Active galactic nuclei contain supermassive black holes that are drawing in matter around them. Explain in a short sentence why the center of our galaxy is not currently active:

_____

7. Supermassive Black Holes

The supermassive black hole at the center of the Milky Way is about 4 million times the mass of the Sun. Explain in a short sentence what method is used to determine its mass:

_____

8. Galactic Rotation Curves

If all the mass in the galaxy were concentrated at the center of the galaxy, then for a star orbiting the center of the galaxy at radius R you'd expect the speed v to be $v = \sqrt{\frac{G\, m_{\text{Galaxy}}}{R}}$.

So you'd expect that stars closer than our Sun to the center of the galaxy would be going _____, and stars further than our Sun would be going _____, but in the real data they are all _____.

HINT: for the first two blanks, I am just looking for "faster" or "slower," and for the third I am looking for a rough description of our galaxy's rotation curve.

9. Galactic Rotation Curves

Our Sun is about 8 kpc from the center of the Milky Way. At this distance, while going 200 km/sec, the material in our part of our spiral arm should have gone around about 50 times. If the material at 4 kpc is going around at the same speed, it should have gone around about _____ times. If the material at 16 kpc is going around at the same speed, it should have gone around about _____ times. The great difference should have destroyed the spiral arm, this is called the _____ problem, and the leading solution to the fact that the spiral arms are not all wound up is the density wave theory.

10. Quasars

One of more of these statements about quasars is false. Cross them out:

(A) Galaxies are more likely to be quasars if we look back billions of years in time.
(B) Quasars typically have enormous blue shifts.
(C) Quasars are powered by matter falling into a black hole, and about 10% of the rest mass of the infalling matter can be converted to energy.
(D) The jets of a quasar can appear (from our perspective) to have superluminal velocities.
(E) Quasars are our most accurate standard candle at large distances.

11. The Big Bang

Below is the plot from Hubble's 1929 paper.

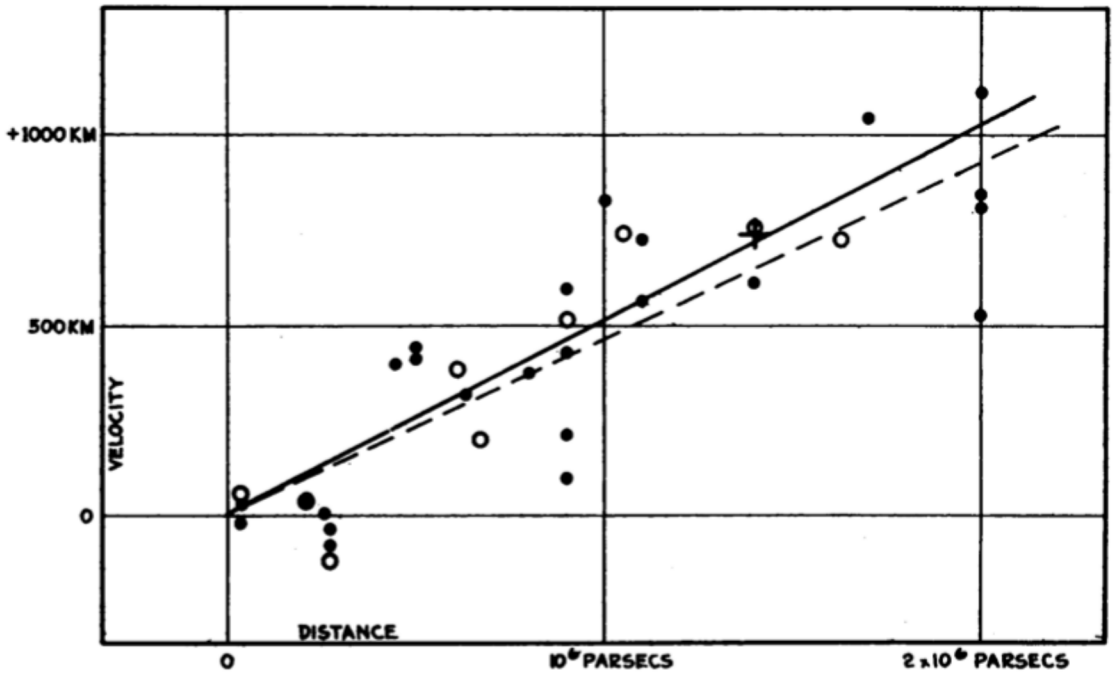


FIGURE 1

Velocity-Distance Relation among Extra-Galactic Nebulae.

The vertical axis should read 500 km/s and 1000 km/s, not 500 km and 1000 km.

Studying this plot, what value do you calculate for the Hubble constant? _____. One significant figure will do. The modern value is about 70km/s/Mpc.

12. The Big Bang

As we look back in distance, we are looking back in time. If the Hubble plot got steeper as we look back, that would say that in the far past, the universe was expanding

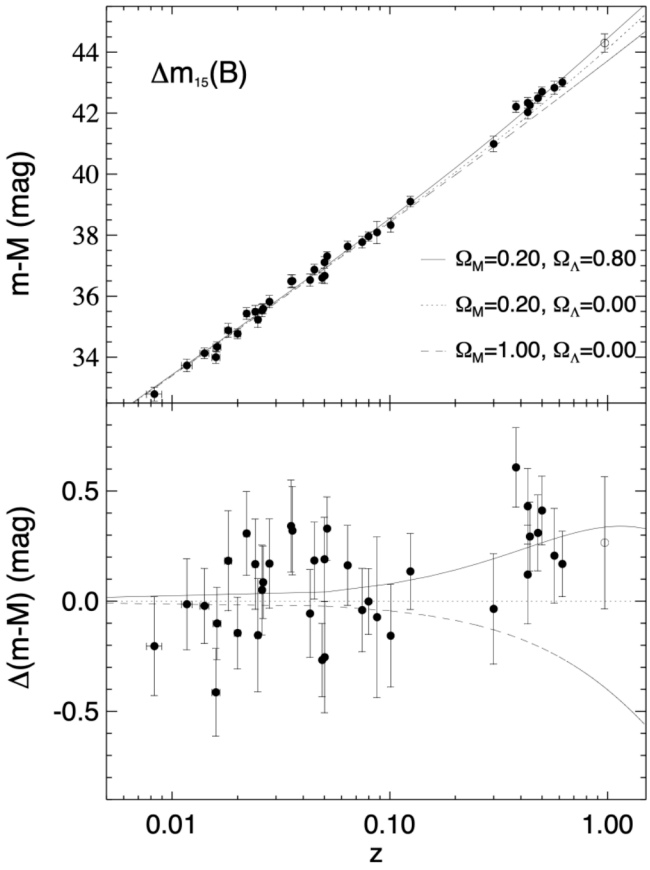
(A) more quickly than today (the universe's expansion is decelerating)
(B) less quickly than today (the universe's expansion is accelerating)

13. The Big Bang

Because gravitation attraction among matter tends to slow expansion, we would expect

(A) the universe to be decelerating
(B) the universe to be accelerating

14. The Big Bang

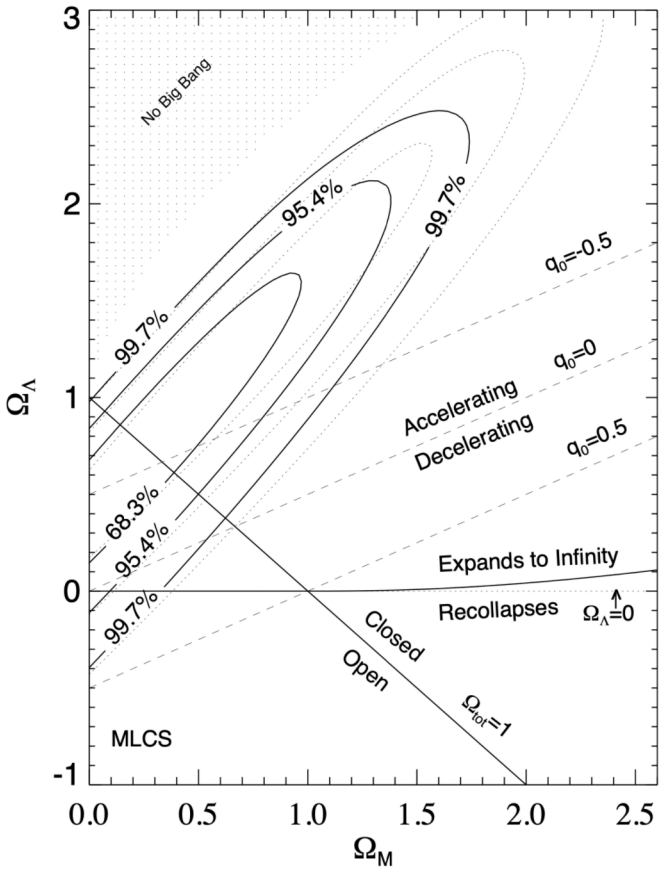


Above is a plot from Riess et al, 1998. The graph gets subtly steeper as you go far into the past. Yet Riess et al say that the universe is accelerating.

In a short sentence, reconcile this with your answer to Problem 12.

HINT: We discussed this in class. There is something fundamentally different about the graph in Riess et al, 1998, vs the one in Hubble, 1929. What do the axes represent?

15. The Big Bang



The center of the ellipses is the paper's best estimate of the parameter values that determine the expansion rate and fate of the universe.

Read off (one sig fig is fine), the best estimate for the value for Ω_Λ: _____. Read off (one sig fig is fine), the best estimate for the value for Ω_M:_____.

16. The Big Bang

Here is one extra problem so that you can get one wrong and still get a perfect 15/15.

The fact that $\Omega_\Lambda > \Omega_M$ says that today

(A) visible matter
(B) dark matter
(C) dark energy

dominates the universe.