Homework #9

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Number of Questions: 20

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Question 1: (5 points)

The specific characteristics that identify most quasars are

1. that they look like elliptical galaxies, but with high spectral redshifts.
2. bright, starlike appearance and very high spectral blueshift, indicating that they are approaching the Sun very fast, and rapid intensity fluctuations, indicating small intrinsic size.
3. bright, starlike appearance with very high redshifts and hence very large distances, indicating very energetic sources.
4. spiral galaxy appearance and very high spectral blueshift, indicating that they are coming toward the Sun at high speed.

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Question 2: (5 points)

The extreme redshifts of quasar spectra are caused by

1. very high recession speeds of the sources away from our Galaxy.
2. absorption of all but the red parts of the quasar spectrum by intergalactic matter.
3. Zeeman effects from the very intense magnetic fields in the vicinity of the source.
4. high gravitational fields at the surfaces of these quasars (gravitational redshift).

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Question 3: (5 points)

What observations convince us that the energy source of a quasar is physically very small?

1. Rapid fluctuations in brightness, since variations over one day mean that the source must be less than one light-day across.
2. The instant disappearance of the quasar when occulted by the Moon's edge as the Moon moves in front of a quasar, indicating a very small source size.
3. The sharpness of the emission lines in their optical spectra, since motions within a large

source would smear out the line shapes.

4. The extremely small size of the image of a quasar, even from Hubble Space Telescope images and radio interferometry measurements.

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Question 4: (5 points)

The surprising observational fact about quasars is that they appear

1. to be the largest known structures in the universe, although they produce only modest amounts of energy.
2. to produce the energy output of greater than 100 galaxies in a volume similar to that of our planetary system.
3. to be associated with ancient supernova explosions.
4. to be moving rapidly toward us, while emitting large amounts of energy.

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Question 5: (5 points)

Which of the following objects is NOT classified as an active galaxy?

1. A Seyfert galaxy.
2. A BL Lacertae object.
3. A quasar.
4. A barred spiral.

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Question 6: (5 points)

The mechanism that appears to generate two extensive regions of radio emission near active galaxies is

1. two very hot gas clouds, suspended by magnetic fields above the rotation axis of a galaxy, emitting 21-cm radio waves.
2. a radio source split by a dark absorbing disk across its center as seen from Earth.
3. the double image of a single source behind the galaxy, produced by gravitational lensing by the galaxy.

- 4. two oppositely directed jets of energetic particles that collide with intergalactic gas.

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Question 7: (5 points)

What appears to be the central energy-generating system, "engine", or Monster that is producing prodigious amounts of energy in the centers of galaxies, active galaxies, and quasars?

- 1. A steady series of supernova explosions, the late evolutionary stages of massive stars.
- 2. A very rapidly rotating core of matter, where friction between it and the surrounding matter causes tremendous heat and energy output.
- 3. A supermassive black hole, where matter is compressed upon falling into the hole and heated to extremely high temperatures.
- 4. There is no central "engine" in these sources. Their high gravity has focused radiation from many sources beyond them by gravitational lensing and they thus appear to be very bright.

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Question 8: (5 points)

I thought black holes gobbled up matter! If the central engine of a double-lobed radio source is a black hole swallowing matter from an accretion disk, where do the jets of matter come from that we see traveling OUTWARD from the galaxy?

- 1. They are accelerated in the ergoregion of the rotating black hole and ejected outward in the black hole's equatorial plane.
- 2. They are composed of material that has been accelerated from two hemispheres toward the black hole with such speed that it escapes again on two opposite sides of the black hole.
- 3. The jets arise in the weak galactic magnetic field, not in the region near the black hole.
- 4. They are squirted out by high pressure in the accretion disk before the matter reaches the black hole.

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Question 9: (5 points)

In the "unified model" of active galaxies, the main difference between quasars, BL Lacertae objects, and radio galaxies appears to be that

- 1. we see the accretion disk around the central black hole from a different angle in each case—face-on for BL Lacertae, edge-on for radio galaxies, and in between for quasars.

- 2. the rate at which matter is falling into the central black hole is different in each case—largest in quasars, less in BL Lacertae objects, and least in radio galaxies.
- 3. the mass of the central black hole is different in each case—largest in quasars, less in BL Lacertae, and least in radio galaxies.
- 4. the galaxy type with which they are associated is different in each case—spiral for BL Lacertae, elliptical for quasars, and irregular for radio galaxies.

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Question 10: (5 points)

What is the observed distribution of gamma-ray bursters in the sky?

- 1. Concentrated primarily along the plane of the Milky Way, indicating an origin within our Galaxy.
- 2. Uniform over the entire sky, indicating an origin at "cosmological" distances.
- 3. Clumpy, but not coinciding with any known galaxy clusters, indicating an origin in a new kind of astronomical object.
- 4. Clumpy, approximately coinciding with large clusters of galaxies such as the Coma cluster.

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Question 11: (5 points)

Where are we?

- 1. At the exact center of an expanding universe, as shown by the universal expansion away from us in all directions.
- 2. Near the edge of an expanding universe, as shown by the microwave radiation coming to us from the edge.
- 3. Near, although probably not right at, the center of the universe, as shown by the fact that the edge is so far away.
- 4. Somewhere in an expanding universe, but not in any special part of it.

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Question 12: (5 points)

Because of the general expansion of space, all distant galaxies appear to be moving away from the Earth, with speeds that increase with distance from our Galaxy. What would an observer in one of these distant galaxies see?

1. The same that we see: all galaxies moving away from her, with more distant galaxies moving faster.
2. All galaxies moving toward her, with more distant galaxies moving faster.
3. All galaxies moving away from her, with closer galaxies moving faster.
4. All galaxies on one side of the sky moving toward her and all galaxies on the other side moving away, with more distant galaxies moving faster.

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Question 13: (5 points)

Why is the universe expanding?

1. Because the energy from all the stars is heating the universe, making it expand like a gas that is heated.
2. Because spacetime itself is expanding, carrying the galaxies (or superclusters of galaxies) with it.
3. It's not expanding—it is we who are getting smaller, making the universe seem bigger and bigger.
4. Because an infinitely dense clump of matter exploded, sending the galaxies (or superclusters of galaxies) hurtling out through space.

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Question 14: (5 points)

What is the "cosmological redshift"?

1. The stretching of the wavelengths of photons as they travel through expanding space.
2. The stretching of the wavelengths of photons by the Doppler shift, because they are emitted by galaxies that are moving away from us.
3. Photons lose energy by interacting with virtual particles in the vacuum, so their wavelength gradually increases as they travel toward us through space.
4. The stretching of the wavelengths of photons as they pass through absorbing matter in galaxies between us and the emitting galaxy.

Save answer

Question 15: (5 points)

In the expansion of the universe, the expansion takes place

1. only between objects separated by vacuum; as a result, our bodies do not expand but the Earth-Moon system does.
2. between all objects, even between the atoms in our bodies, although the expansion of a person is too small to be measured reliably.
3. only over distances about the size of a galaxy or larger; consequently, our Galaxy expands but the solar system does not.
4. primarily in the huge spaces between clusters of galaxies; "small" objects like galaxies or the Earth do not expand.

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Question 16: (5 points)

What caused the Big Bang and the expansion of the universe?

1. The separation of the strong nuclear force as a distinct force.
2. The decoupling of radiation from matter.
3. No cause has yet been found, but expansion started suddenly and has continued to this time.
4. A universal repulsive force, stronger than the gravitational attraction between matter in the universe.

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Question 17: (5 points)

The cosmic background radiation is

1. the flux of visible radiation in empty space, contributed by all visible stars in the universe.
2. the radio noise generated by Earth-bound transmitters, spreading out into space since about 1920.
3. the beam of atomic nuclei known as cosmic rays that continuously rain down upon the Earth from all directions in space.
4. low-intensity radio noise, with a 3 K blackbody temperature, almost uniform in intensity in all directions.

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Question 18: (5 points)

What do we mean when we say that the universe is homogeneous?

- 1. At any given time, the universe looks the same at all locations.
- 2. There are no mass concentrations anywhere in the universe.
- 3. The universe is static and unchanging.
- 4. At any given time, the universe looks the same in all directions.

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Question 19: (5 points)

What do we mean when we say that the universe is isotropic?

- 1. At any given time, the universe looks the same at all locations.
- 2. There are no mass concentrations anywhere in the universe.
- 3. The universe is static and unchanging.
- 4. At any given time, the universe looks the same in all directions.

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Question 20: (5 points)

Where was most of the helium in the universe created?

- 1. By nuclear reactions in the cores of stars, and was then thrown out into space by supernovae.
- 2. By high-energy processes during the collapse of pregalactic clouds during the formation of galaxies.
- 3. By nuclear reactions during the Big Bang.
- 4. By the collision of cosmic rays with hydrogen nuclei in interstellar gas clouds.

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