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Answer Key: Cosmic Forensics: Senior Seminar on Galactic Evolution

Evaluate the complex dynamics of dark matter halos and baryonic feedback through high-level synthesis and quantitative analysis of extragalactic phenomena.

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1. When analyzing the 'missing baryon problem' in the circumgalactic medium (CGM), which mechanism is currently considered the primary driver for preventing the overcooling of gas in massive galactic halos?

Answer: B) Kinetic and thermal feedback from Active Galactic Nuclei (AGN)

AGN feedback, through relativistic jets and radiation pressure, provides the necessary energy injection to counteract radiative cooling, maintaining the CGM in a hot, diffuse state and regulating star formation.

2. The Tully-Fisher relation specifically correlates the luminosity of elliptical galaxies with their central velocity dispersion to determine distance.

Answer: B) False

The Tully-Fisher relation applies to spiral galaxies, linking rotational velocity to luminosity. The correlation described (luminosity/velocity dispersion) for elliptical galaxies is known as the Faber-Jackson relation.

3. In the context of the Lambda Cold Dark Matter (ΛCDM) model, identify the phenomenon that best explains why dwarf galaxies appear less abundant than predicted by N-body simulations.

Answer: C) Supernova-driven gas expulsion (The Missing Satellites Problem)

Baryonic processes, such as supernova feedback, can blow gas out of small dark matter halos, making them 'dark' or under-luminous, which addresses the discrepancy between theoretical dwarf galaxy counts and observations.

4. The _____ _____ represents the maximum mass of a white dwarf star (~1.4 solar masses), a critical value used in calibrating Type Ia supernovae as standard candles for measuring universal expansion.

Answer: B) Chandrasekhar Limit

The Chandrasekhar Limit is the theoretical threshold above which electron degeneracy pressure can no longer support a white dwarf, leading to a supernova and providing a consistent peak luminosity.

5. What does the observation of 'red nuggets' at high redshifts (z ~ 2) imply about the evolutionary path of massive elliptical galaxies?

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Answer: B) They are the progenitors of modern giant ellipticals that grew through dry mergers.

Red nuggets are compact, quiescent galaxies. Their evolution into today's larger ellipticals likely occurred through numerous 'dry' (gas-poor) minor mergers that increased their size without triggering significant new star formation.

6. The _____-_____ effect describes the spectral distortion of the Cosmic Microwave Background (CMB) as photons inverse-Compton scatter off high-energy electrons in hot galaxy cluster gas.

Answer: B) Sunyaev-Zeldovich

The Sunyaev-Zeldovich (SZ) effect is a powerful tool in observational cosmology for detecting galaxy clusters and measuring the Hubble constant independently of the distance ladder.

7. The 'Great Attractor' is a gravitational anomaly located within the Laniakea Supercluster that demonstrates the influence of dark matter on peculiar velocities across hundreds of millions of light-years.

Answer: A) True

The Great Attractor is a massive concentration of matter whose gravity affects the motion of galaxies, including our own, revealing the large-scale structure and mass distribution of the local universe.

8. Which specific observation provides the most robust evidence that the universe shifted from a matter-dominated epoch to a dark energy-dominated epoch roughly 5-6 billion years ago?

Answer: C) The transition from deceleration to acceleration in the expansion rate ($z \sim 0.6$)

Supernova surveys show that the expansion of the universe was slowing down due to gravity until dark energy became the dominant density component, causing the expansion to accelerate.

9. The _____ profile is a widely used mathematical model that describes the mass density distribution of dark matter halos as determined by N-body cosmological simulations.

Answer: D) Navarro-Frenk-White

The Navarro-Frenk-White (NFW) profile is the standard model for the spatial distribution of dark matter, characterized by a 'cuspy' central density.

10. Baryon Acoustic Oscillations (BAO) act as a 'cosmic ruler' because they provide a fixed length scale based on the distance sound waves traveled in the photon-baryon plasma before recombination.

Answer: A) True

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BAO provide a standard ruler that allows cosmologists to measure the expansion history of the universe by looking at the preferred separation scale of galaxies.