

Homework 4 Due May 3 All questions 10 points

1)

- a) Describe the AGN Zoo in a **few** sentences and what are the physical connections and patterns that drive the nomenclature.
- b) What are the implications of the unified model for the classifications.
- c) How are observations affected by geometry vs. intrinsic differences.

2) Calculate how long it takes a black hole to double its mass if it is accreting at the Eddington limit.

Use this calculation to estimate how long it takes to grow a $10^6 M_\odot$ black hole assuming one starts with a seed stellar mass black hole of $M=10 M_\odot$ and $1000 M_\odot$ -is there enough time if the seed is formed at $z=20$ (use

<http://www.astro.ucla.edu/~wright/CosmoCalc.html> or equivalent).

Comment on how one can produce a $10^9 M_\odot$ BH at a redshift of 6 when the universe was 950 million years old.

3)

- a) Are there any observational signatures of strong gravity (e.g.. relativistic effects are dominant) around a black hole?: if there are such signatures describe at least one and why it is indicative of strong gravity.
- b) How does the innermost stable orbit change with spin. quantitatively describe what differences between $a=0$ and $.994$. Based on your answer to (a) what is changing with spin. What happens to the event horizon radius when $a > M$?

4) a) Summarize the 'Soltan' argument for the growth of black holes and how it constrains the relation between how black holes grow and their present mass density in the universe- explain how the result does or does not depend on cosmology or the details of the growth rate of black holes.

b) How do black holes evolve across cosmic time. Sketch the luminosity function at 3 epochs What does this imply for the growth of black holes.

c) Give two ways black holes can grow - what is their relative importance based on the Soltan argument. How we will constrain (in the future) the relative importance?