

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?