NMSU ASTRONOMY CUME 465, November 2022 **Jon Holtzman**

Read the paper "Variation in the Stellar Initial Mass Function from the Chromospheric Activity of M Dwarfs in Early-type Galaxies" by van Dokkum and Conroy (ApJ 923, 43, 2021). **You can skip the highlighted/greyed-out sections (Sections 3 and 4)**; concentrate on a firm understanding of the rest of the paper.

Answer the following questions.

I expect a passing grade will be 70-75 percent.

1 solar mass = 2×10^{33} gm. 1 solar luminosity =$3.8 \times 10^{33} ergs/s$. 1 pc = 3.086×10^{18} cm. $G = 6.67 \times 10^{-8} cm^3 gm^{-1} s^{-1}$.

1. (19 points) Initial mass function
   (a) (3) Describe in your own words what the initial mass function is (1-3 sentences).
   (b) (3) Considering the upper end of the initial mass function, say at masses greater than two solar masses. What implication would variations in this section of the initial mass function have on galaxy evolution studies? (1-3 sentences)
   (c) (3) Considering the lower end of the initial mass function, say at masses less than a solar mass. What implication would variations in this section of the initial mass function have on galaxy evolution studies? (1-3 sentences)
   (d) (5) In your own words (and in 1-5 sentences), state the main problem being addressed by the paper.
   (e) (5) In your own words (and in 1-5 sentences), state the main conclusion of the paper.
2. (16 points) Parameterizing the initial mass function
   (a) (5) Make a log-log plot that shows both a Salpeter IMF and a Kroupa IMF, roughly normalized so that the populations they represent would have the same total amount of *light*. Label the axes with names and numbers.
   (b) (5) In a Salpeter IMF with a lower mass cutoff of 0.1 solar masses and a upper mass cutoff of 100 solar masses, at what mass would a population have half the **mass** below and half the **mass** above? If you can't get to an answer, try to at least formulate the problem!
   (c) (3) In the solar neighborhood, why is there a difference between the *present day* mass function and the initial mass function? Make a sketch showing qualitatively how the two might compare, again labelling the axes.
   (d) (3) The paper defines an IMF parameter, α_{IMF}, using words (p3, bottom left column). Translate these words into an equation that defines α_{IMF}.
3. (10 points) Mass-to-light ratios
   (a) (2) Using normal convention, what is the mass-to-light ratio of the Sun?

(b) (5) Quantitatively estimate the mass-to-light ratios of an O star and an M star, given what you might know about scaling relations for main sequence stars. If you don't know anything about such relations, try to make up a plausible parameterization with a free parameter.

(c) (3) Which would you expect to be larger, the stellar mass-to-light ratio of a typical spiral galaxy or a typical elliptical galaxy? Why? Roughly what are the expected mass-to-light ratios?

4. (15 points) Population synthesis

(a) (5) Describe what is being shown in Figure 4 of the paper (perhaps concentrating on the right panel), highlighting the relation of this information to the main premise of the paper.

(b) (5) Why do the authors use the flux ratio $W^i_{Ly\alpha}$, rather than just the $Ly\alpha$ flux?

(c) (5) Does the main result of the paper depend on the population synthesis modeling described here? Why or why not?

5. (5 points) Initial mass function in elliptical galaxies

(a) (5) It has been suggested that ellipticals with the highest velocity dispersions form from dissipationless ("dry") mergers of smaller systems. Is the conclusion of this paper consistent with this hypothesis? Why or why not?