December 3, 2004 Name:_____

Astronomy 102: Stars and Galaxies

Exam 4

Instructions: Write your answers in the space provided; indicate clearly if you continue on the back of a page. No books, notes, or assistance from anyone is allowed. You are allowed to use, and will need, a calculator. The exam has six questions, each with equal weight. Be brief, and to the point.

Possibly Useful Constants and Formulae

Earth-Sun Distance: 1.000 AU

Baryonic Products of Big Bang: 75% H, 25% He

Heavy Elements: Everything not H or He

Lifetime of 8 $M_\odot$ star: 80 million years

Age of Universe: 13.6 billion years.

$$L = A\,\sigma\,T^4$$

$$L = 4\pi\,R^2\,\sigma\,T^4$$

$$B = \frac{L}{4\pi\,d^2}$$

$$F = \frac{G\,M_1\,M_2}{d^2}$$

$$v = H_0\,d$$

$$t_H = \frac{1}{H_0}$$

$$E = m\,c^2$$

$$c = 3.00 \times 10^8\,\mathrm{m\,s^{-1}}$$

$$G = 6.67 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$$

$$1\,\mathrm{W} = 1\,\mathrm{J\,s^{-1}}$$

$$z = \frac{\lambda_{\mathrm{obs}} - \lambda_{\mathrm{emit}}}{\lambda_{\mathrm{emit}}} = \frac{\Delta\lambda}{\lambda}$$

$$z = \frac{v}{c} \quad (\text{for } v \ll c)$$

$$(1+z) = \frac{\text{Size Now}}{\text{Size Then}}$$

1. A major goal of cosmology right now is to find and understand the "first stars."

(a) What would the heavy element abundance of the first stars be?

(b) Stars in globular clusters have some heavy elements, though a lower abundance than those in the disk. Globular clusters can be as old as 13 billion years. What, if anything, does this tell you about how long after the Big Bang the first stars formed?

(c) Explain how can astronomers hope to observe the first stars given your answer to part (b).

2. **(a)** Looking through all of the stars in our Galaxy and in nearby galaxies, astronomers have never found a star with the heavy element abundance of a first star. What does this, together with your answers to question 1, tell you about the likely masses of the first stars?

(b) Might any remnants of those first stars still be hanging around in our galaxy? If so, what would the nature of those remnants be?

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3. Stars are held in equilibrium by the conflict of gravity and motion (pressure). Give two examples from stellar evolution evolution of cases where either gravity or pressure wins, at least for a short while. For each case, explain how one or the other wins, and describe what happens.

4. Give two reasons why we are sure that nuclear fusion is what powers the Sun.

5. Sketch a plot. The horizontal axis should be time, going from zero to 160 million years. The vertical axis should be number of stars.

Consider a star cluster. Draw two curves (clearly labelled) on your sketch. The first should be the number of neutron stars present in the star cluster. The second should be the number of white dwarves present in the star cluster. (Don't worry about scaling the absolute heights of the lines together. In other words, the range of the y-axis can be different for the neutron star line and the white dwarf line.)

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6. Binary stars generally form together, at the same. Tatooine (Luke Skywalker's home planet) orbits a binary star system; both stars are approximately the same luminosity. One is orange, one is blue.

(a) Suggest at what stage of stellar evolution each star must be to match this description. Which star must be more massive?

(b) As depicted in *Star Wars*, the two stars appear the same size. Is this realistic? Justify your answer.

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