# Physics of Galaxies 2019/2020

## Mock Exam

**This exam will be evaluated on a scale 0-10, and the overall mark will count 70% of the course final grade. This exam is strictly individual, so any interchange of material with other people is forbidden. You can consult your own notes and books and use a scientific calculator.**

**Please upload your answers, including your intermediate calculations, to your Dropbox folder in the Student Portal by the exam end time.**

**PART I:**

**There are 10 questions in this first part of the exam, each with a maximum grade of 0.5 points. Your reply to each question should be brief, containing only 1-3 short sentences.**

1. Explain briefly Hubble's classification for late-type galaxies.

2. What type/sub-type of supernovae can be used to measure distances to a nearby galaxy? Why? Explain briefly.

3. What is the Initial Mass Function (IMF) of a stellar population?

4. What are the main (UV/optical) spectral differences between a young star-forming galaxy and an old galaxy with no on-going star formation?

5. How would the presence of intrinsic dust affect the UV/optical spectrum of a star-forming galaxy?

6. What is the main difference between the compositions of the Milky Way's thin and thick discs?

7. What are the two main components in which one can separate a galaxy gravitational potential?

8. Explain the phenomenon of gravitational lensing in only one sentence.

9. What is the factor relating the emitted and observed wavelengths in any galaxy at $z > 0$?

10. What is the main difference between active galactic nuclei (AGN) of types 1 and 2?

**PART II:**

**There are 4 short problems in this second part of the exam, each with a maximum grade of 1.25 points. Your intermediate calculations must be delivered along with the final answer. These intermediate calculations can be appended at the end of the exam, or uploaded in a separate file.**

11. Consider a galaxy solely composed of a bulge with a radius $R_{\rm bulge} = 1\,{\rm kpc}$. The stellar density in the bulge is described by

$$\begin{aligned} \rho_{\rm bulge} &= \rho_0 = \text{constant} && \text{if } r < 0.1\,{\rm kpc} \\ &= \rho_0\,(R_{\rm bulge}/r) && \text{if } 0.1 \leq r \leq 1\,{\rm kpc}, \end{aligned}$$

with $\rho_0 = 4{\rm M}_\odot/{\rm pc}^3$. Compute the stellar mass of the bulge.

12. Consider a globular cluster with age 11 Gyr. Its stellar number density is $n = 100\,{\rm pc}^{-3}$ and the average individual star mass is $0.5\,{\rm M}_\odot$. The radial velocity dispersion of the cluster core is $\sigma_r = 5\,{\rm km/s}$. Assume the Coulomb parameter to be 1 for practical reasons. What is the relaxation time of this cluster? Your answer should be a number.

13. Consider a spheroidal galaxy with a constant and isotropic velocity dispersion $\sigma_r = 100\,{\rm km/s}$. The stellar mass of this galaxy is $M = 5 \times 10^{10}\,{\rm M}_\odot$. The $M/L$ ratio is constant throughout the galaxy, and the amount of dark matter in it is negligible. Compute the kinetic energy of the galaxy. Give your answer in Joules (J).

14. Consider the formation of a disc galaxy from a gas cloud. At $t = 0$ the system has $M_{\rm gas}(0) = 10^{10}\,{\rm M}_\odot$ and no stars, i.e., $M_{\rm stars}(0) = 0$. The time evolution of gas consumption can be described as

$$M_{\rm gas}(t) = M_{\rm gas}(0) \times \exp(-t/\tau_0), \tag{1}$$

where $\tau_0$ is a constant. Ignore the presence of dark matter in all this problem.

Assuming a closed-box model, give an expression for the evolution of metallicity with time, i.e., $Z(t)$, assuming a constant metal yield $p = 0.1$. The final expression $Z(t)$ should only depend on $t$ and $\tau_0$.

**List of constants and conversion factors that may be useful for this exam:**

Speed of light: $c \approx 3 \times 10^5\,\mathrm{km\,s^{-1}}$

Solar luminosity: $\mathrm{L_\odot} = 3.83 \times 10^{33}\,\mathrm{erg\,s^{-1}}$

Solar mass: $\mathrm{M_\odot} = 1.99 \times 10^{30}\,\mathrm{kg}$

(Current value of) Hubble constant: $H_0 = 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$

Gravitational constant: $G = 6.67 \times 10^{-8}\,\mathrm{cm^3\,g^{-1}\,s^{-2}}$

AB zero point $= 3.63 \times 10^{-20}\,\mathrm{erg\,cm^{-2}\,s^{-1}\,Hz^{-1}}$

1 Mpc $= 3.086 \times 10^{24}$ cm