Astronomy UN2002 (Introduction to Astrophysics II)
Wed. Mar 11

Spring 2020
Prof. J. Halpern

Midterm Exam
(Due at 10:00am)

Do all four questions/problems. The have equal point value.

1. The Sun has absolute magnitude $M_V = +4.83$. Suppose that we lived in galaxy of uniform dust density such that the visual extinction is $A_V/d = 1$ mag kpc^{-1}, and the ratio R of total to selective extinction is 3.1.

   (a) What would be the apparent V magnitude of the Sun at a distance of 1 kpc, and at 2 kpc?

   (b) What would be the apparent B magnitude of the Sun at a distance of 1 kpc, and at 2 kpc?

2. Consider a globular cluster a distance of 3 kpc. consisting of 10^6 stars of average mass $0.5\,M_\odot$, and half-mass radius of 1 pc.

   (a) Estimate the radial velocity dispersion of the stars in the cluster.

   (b) Hypothetically, if a black hole of mass $1000\,M_\odot$ resides at the center of the globular cluster, estimate its radius of influence in pc, and in arcseconds.

   (c) What kind of observation could we make to infer the presence of such a black hole? Do you think it is feasible to obtain such evidence of the black hole?

3. Figure 11 on the next page shows that the ratio of intensities of emission lines from [O III] in nebulae

$$\frac{I(4959\,\text{Å} + 5007\,\text{Å})}{I(4363\,\text{Å})}$$

   depends on both electron temperature T_e and electron density n_e.

   (a) Explain qualitatively why the curves behave the way they do as a function of temperature and density.

   (b) Explain why Balmer-line intensity ratios in H II regions have very little dependence on temperature and density.

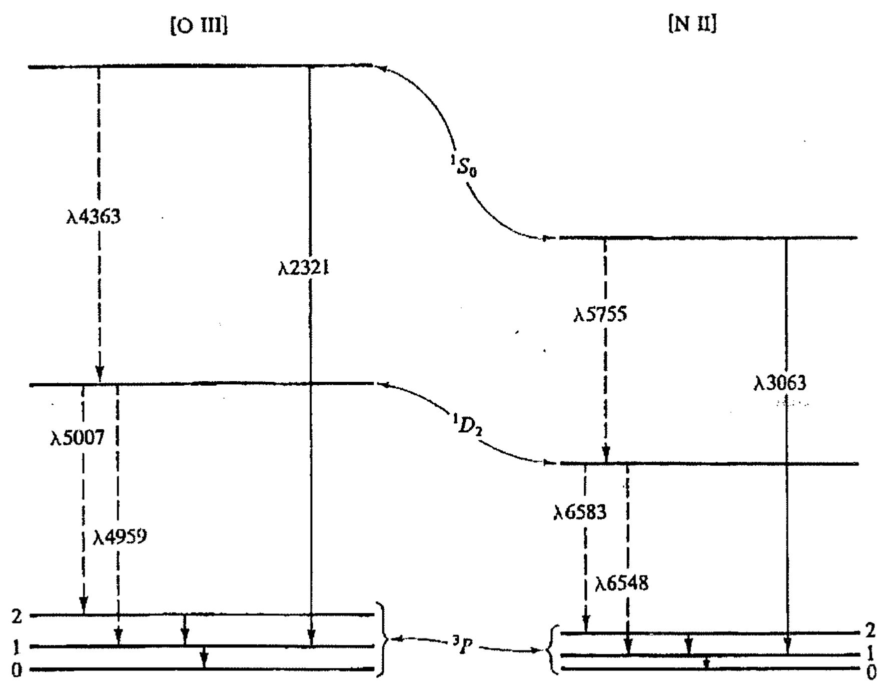

FIGURE 3.1
Energy-level diagram for lowest terms of [O III], all from ground $2p^2$ configuration, and for [N II], of the same isoelectronic sequence. Splitting of the ground ^3P term has been exaggerated for clarity. Emission lines in the optical region are indicated by dashed lines, and by solid lines in the infrared and ultraviolet. Only the strongest transitions are indicated.

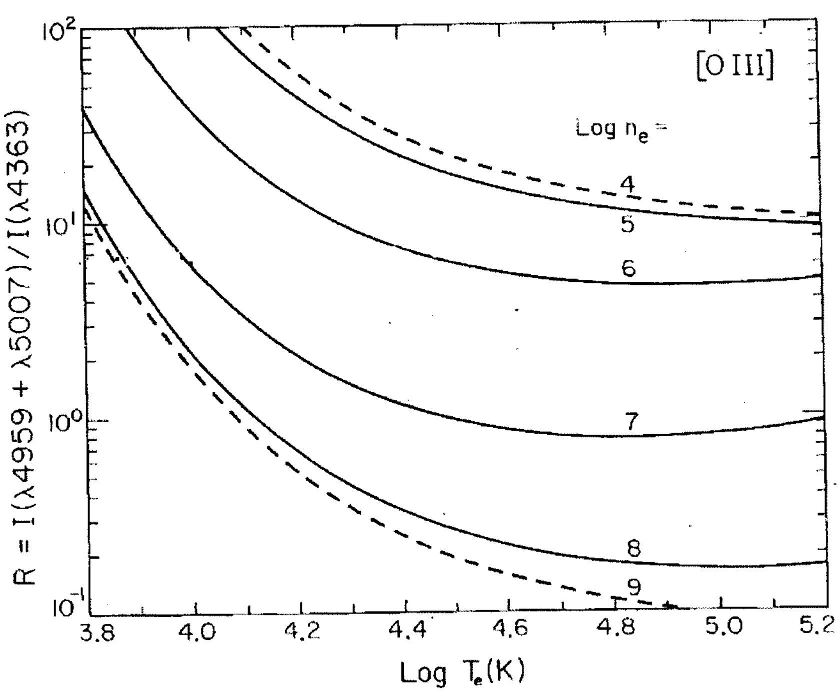

FIG. 11.—The theoretical intensity ratio of nebular to auroral [O III] emission (R) is plotted as a function of log T_e for a range of densities and zero reddening. Dashed lines approximate the low- and high-density limits.

4. A disk galaxy's major-axis rotation curve from Hα emission is depicted in the Figure below. The x-axis is labelled in arcseconds, and the y-axis is heliocentric velocity, the velocity with respect to the Sun. The galaxy's rotation axis is inclined at $i = 85°$ from the line of sight. Estimate the following properties of the galaxy (you may use $H_0 = 71$ km s^{-1} Mpc^{-1}):

   (a) Its distance.

   (b) Its visible diameter in kpc, corresponding to the extent of the data points plotted.

   (c) Its maximum rotation velocity.

   (d) Its mass in solar masses enclosed within its visible diameter from part (c).

   (e) Do you think this galaxy is more or less luminous than the Milky Way? Explain.