Galaxies final exam, course 2005-2006

Please write down you name and your student ID on every page. You can answer the questions in English or in Dutch. Please explain clearly all the steps you have used to derive a result, and make sure your handwriting is readable.

1. Practical exercises for a total of 30 points. Explain clearly the steps you have used to derive the final results

   (a) Luminosity and surface brightness of galaxies

   - Write down the expression for the total luminosity of a galaxy whose surface brightness is given by $I(R)$.
   - Show that the total luminosity of an exponential disk profile $I(R) = I_0 e^{-R/R_0}$ is $2\pi I_0 R_0^2$.
   - Explain why the surface brightness is independent of distance

   (b) The motion of stars in disk galaxies

   - Find the rotation curve $V_c(r)$ inside a sphere of uniform density ρ_0. What can you say about the functional form of the angular velocity? What is the value of the Oort constant B in this case?
   - Assume that the sphere has a finite radius a. What is the circular velocity for $r > a$?
   - Plot the rotation curve in both regimes.

2. Answer briefly (a minimum of 4–5 sentences) the following questions (50 points in total)

   - What is the difference between absolute and relative distance indicators? List three distance indicators and describe when each is used.
   - What is the Local Standard of Rest? Explain the kinematics of stars in the Galactic disk. How can we derive their motions?
   - Describe the properties of elliptical galaxies. Mention three important differences between disk and elliptical galaxies.
   - Describe the evidence for the presence of large amounts of dark matter in the halos of galaxies. Your answer should include reference to an equation that relates the mass of a galaxy to observable properties of the galaxy.
   - Compare and contrast radio galaxies, Seyfert galaxies, QSOs and quasars. Describe the unification scheme. What is meant by the Eddington luminosity?

3. Mark with T for true or F for false the following statements (10 pt for 10 questions).

   (a) Faber-Jackson and Tully-Fisher relations show that the typical velocities of stars in elliptical and disk galaxies scale with the (approximately) 1/4 -power of luminosity L of the host galaxy.

   (b) The closed-box chemical enrichment model with zero initial metallicity solves the G-dwarf problem.

   (c) From the principle of angular momentum conservation it follows that the vector of angular momentum of a star in an axisymmetric galaxy is constant in time.

   (d) An average star has a very small chance of colliding with another star in the Galaxy during one Hubble time.

   (e) After one relaxation time of a globular cluster, which may be as short as 10^9 years, the cluster changes direction of motion in the galaxy by 90 degrees (on the average).

   (f) We can determine the distance to a galaxy that contains Cepheid variables by using the period-mass relation.

   (g) Population II stars have relatively small amounts of heavy elements because they are too young to have made them yet.

   (h) One scenario for the formation of some elliptical galaxies involves collisions between spiral galaxies.

   (i) Elliptical galaxies contain relatively little interstellar material and many cool red giants.

   (j) All elliptical galaxies have the same intrinsic shape.

4. Choose for each question the *best* answer (10 pt for 10 questions)

   - Where does the Sun lie within the Milky Way?
     (a) in the galactic halo
     (b) in the galactic bulge
     (c) in the galactic disk, about 8 kpc from the galactic center
     (d) above the galactic disk, about 8 parsecs from the galactic center
   - What two quantities allow one to determine the amount of mass in our Galaxy that lies inside the Sun's orbit?
     (a) the Sun's mass and rotation rate
     (b) the Sun's age and distance from the galactic center
     (c) the Sun's radius and mass
     (d) the Sun's orbital velocity and distance from the galactic center
   - The majority of stars in the sky are
     (a) supergiants
     (b) main sequence stars
     (c) red giants
     (d) high mass stars
   - What property of halo stars in our Galaxy is consistent with the belief that they formed long ago from primordial material that had not been processed through previous generations of stars?
     (a) the halo stars have large random motions
     (b) the halo stars have low abundances of heavy elements
     (c) the halo stars are mainly high mass O and B stars
     (d) the halo stars are rich in iron
   - Where would you most likely find young high-mass O and B stars?

(a) in the galactic halo
(b) in the galactic disk
(c) in globular clusters
(d) all of the above

- What do rapid changes in the total energy output of an "active" galaxy imply?
  (a) Type II supernovae are occurring at high rates in active galaxies
  (b) the source of energy in the galaxy's nucleus is rotating rapidly
  (c) the source of energy in the galaxy's nucleus must be relatively small
  (d) the galaxy is moving rapidly
- How do we know that stars in the galactic disk are rotating about the center of our Galaxy?
  (a) by measuring the apparent magnitudes of stars lying in different directions from us
  (b) by using Hubble's Law to measure the velocities of stars in the galactic disk
  (c) by measuring the Doppler shifts of galactic disk stars lying in different directions from us
  (d) by measuring the luminosities of galactic disk stars lying in different directions from us
- Stars in the galactic halo are generally
  (a) very massive
  (b) accompanied by clouds of gas and dust.
  (c) very old.
  (d) very young.
- Classification of spiral galaxies into subtypes is based on
  (a) grouping of stars into globular clusters.
  (b) the number of stars contained in the galaxy.
  (c) how tightly wound the spiral arms are.
  (d) the size of the dust lane.
- What type of galaxy is often found at the center of a galaxy cluster?
  (a) a giant elliptical galaxy
  (b) a normal barred spiral galaxy
  (c) no particular type of galaxy is preferentially found
  (d) a giant spiral galaxy