(1) An observer studies a cluster containing several Sun-like (G2V) stars. If an extinction of $A_v = 1$ mag is measured toward the cluster and the Sun-like stars have an observed apparent magnitude of $m_v = +10.0$, what is the true distance to the cluster?

(2) If the Sun is moving 250 km/s at 8.5 kpc from the center of the Milky Way, calculate the rotation period of the Sun around the Galaxy (assume $e=0$). Estimate the mass of the Galaxy interior to the Sun’s orbit. How many orbits has the Sun made around the Galaxy over its 4.5 billion year lifetime?

(3) In the 1930s, Fritz Zwicky measured the mass of the Coma Cluster using the observed radial velocity dispersions of the galaxies ($<v_r> = 700$ km/s). (a) What is the 3-dimensional velocity dispersion? (b) If the cluster radius is approximately 3 Mpc, calculate the mass of the Coma Cluster using the Virial Theorem. (c) If the observed total luminosity of Coma galaxies is $3 \times 10^{13} L_{\odot}$, what is the M/L ratio for the Coma Cluster. (d) Compare this number to the observed M/L ratio in the solar neighborhood of the Milky Way ($M/L \sim 3 M_{\odot}/L_{\odot}$). This classic calculation was the first evidence for Dark Matter!

(4) An observer wants to observe the CO molecule (to constrain the star formation rate) in the distant quasar J1148+5251 ($z = 6.419$) with the VLA. If the rest frequency of the CO $J=2-1$ rotational line is 230.538 GHz, what frequency should the VLA observer tune to observe the quasar?

(5) The H$\alpha$ line is identified in a Galaxy spectrum at a wavelength of 6740.3 Angstroms. If the H$\alpha$ rest wavelength is 6562.8 Angstroms, what is the redshift, velocity (km/s), and distance (Mpc) to the Galaxy?