Physics of Galaxies 2019/2020

Problem Set 1

1. Compute the diffraction limit of the *Hubble Space Telescope (HST)*, which is a 2.4 m telescope, in the V band. Consider the V band to be centred at 5000 Å.

2. Show that the Sun produces 10,000 times less energy per unit mass than an average human giving out $1\,\mathrm{W\,kg^{-1}}$.

3. Estimate the solar radius $R_\odot$ from its luminosity and effective temperature. Show that the gravitational acceleration g at the surface is about 30 times larger than that on Earth.

4. a) Show that, if two stars of the same luminosity form a close binary pair, the apparent magnitude of the pair measured together is about 0.75 mag brighter than either star individually.

b) How much brighter than each individual star in a) would the pair be if one of the stars had the same luminosity as in a), and the other were 50% more luminous?

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Problem Set 2

1. Show that, when an astronomical source is dimmed by an amount $e^{-\tau_\lambda}$, then its apparent magnitude *increases* by an amount $A_\lambda = 1.086\,\tau_\lambda$. Note that A_λ is called the *extinction* at wavelength λ.

2. Assume a galaxy pair at $z \approx 1$. The spectra taken for each galaxy shows that the [OII] line emitted at $\lambda_{\rm rest} = 3727\,$Å is redshifted to 7454 Å for one of the galaxies and to 7455 Å for the other. What is the relative radial velocity between the two galaxies in the pair?

3. Consider a disk galaxy whose light profile has a Sérsic index $n = 1$ and which has a surface brightness $\mu_0 = 21.7\,{\rm mag/arcsec^2}$ and a characteristic scale length of 2 arcsec. If this galaxy is at redshift $z = 0.1$, what is its absolute magnitude? Assume $H_0 = 100\,{\rm km\,s^{-1}Mpc^{-1}}$.

4. Search for the following galaxies on the web:

M 51, M 99, NGC 1232, NGC 1407, NGC 1507, NGC 1550, NGC 1700, NGC 1752, NGC 1832, NGC 1888, NGC 1954, NGC 2339, NGC 2344, NGC 2424, NGC 2486, NGC 2487, NGC 2493, NGC 2500, NGC 3003, NGC 3077, NGC 4125, NGC 4038, NGC 4536

Inspect their optical and near-IR images (if both available), preferably from SDSS/HST and 2MASS. Classify their morphologies according to the Hubble sequence. Explain briefly why you chose that classification in each case. When optical and near-IR images are both available, briefly describe the differences for the same galaxy at the two wavelength ranges.