

Long theoretical questions

1. A transit of duration 180 minutes was observed for a planet which orbits the star HD209458 with a period of 84 hours. The doppler shift of absorption lines arising in the planet's atmosphere was also measured, corresponding to a difference in radial velocity of 30 km/s (relative to Earth) between the beginning and the end of the transit. Assuming a circular orbit exactly edge-on to the observer, find the approximate radius and mass of the star and the radius of the orbit of the planet.
2. Within the field of a galaxy cluster at a redshift of $z = 0.500$, a galaxy which looks like a normal elliptical is observed, with an apparent magnitude in the B filter $m_B = 20.40$.

What is the absolute magnitude of this galaxy in the B filter?

Can it belong to this cluster? (write YES or NO alongside your final calculation)

The luminosity distance corresponding to a redshift of $z = 0.500$ is $d_L = 2754$ Mpc.

The spectral energy distribution (SED) of elliptical galaxies in the wavelength range 250 nm to 500 nm is adequately approximated by the formula:

$$L_\lambda(\lambda) \propto \lambda^4$$

(i.e., the spectral density of the object's luminosity, known also as the monochromatic luminosity, is proportional to λ^4 .)

Hint: Try to establish a relation that describe the dependence of the spectral density of flux on distance for small wavelength interval.

3. The planetarium programme 'Guide' gives the following data for particular stars:

Star	1	2
Right Ascension	$14^{\text{h}} 29^{\text{m}} 44.95^{\text{s}}$	$14^{\text{h}} 39^{\text{m}} 39.39^{\text{s}}$
Declination	$-62^\circ 40' 46.14''$	$-60^\circ 50' 22.10''$
Distance	1.2953 pc	1.3475 pc
Proper motion in R.A.	-3.776 arcsec / year	-3.600 arcsec / year
Proper motion in Dec.	0.95 arcsec / year	0.77 arcsec / year

Based on these data, determine whether these stars form a gravitationally bound system. Assume the stars are on the main sequence. Write YES if bound or NO if not bound alongside your final calculation.