Written re-exam for the course "Observational Astrophysics I" 2020

To pass you need 19 correct answers **including** at least **one** problem solved.

1. Telescopes

1.1. At what rate the field-of-view rotates for the equatorial and alt-azimuthally mounted telescopes? Is there a difference for alt-az telescopes in Southern and Northern hemispheres? What are the advantages and drawbacks of the two types of mounts?

1.2. What are the properties of materials used for producing telescope mirrors? What is the purpose of mirror coating? What is a Ritchey-Chrétien system and why is it used so widely? Why small telescopes tend to use refractive optics while larger telescopes use mirrors?

1.3. Which mirror of a telescope is corrected by an active optics system? Why do we need active optics? What is the time-scale for correction?

1.4. What is corrected by adaptive optics (AO)? What are the time scales? What is the purpose of a wave-front sensor in an AO system? What is the purpose of a deformable mirror? Which of the two (wave-front sensor or deformable mirror) comes first in the optical path? When do we need a laser guide star?

1.5. Space telescopes: list 3 main reasons to put a telescope in space?

2. Detectors

2.1. CCD as an integrating detector: list the steps of photon registration. Keep it short.

2.2. Quantum efficiency of a CCD: what are the reasons for a drop in the red and in the blue.

2.3. What is the origin of fringing? How it is related to the quantum efficiency?

2.4. What is the origin and the purpose of bias?

2.5. What is CCD "cosmetics"?

2.6. What are the sources of noise of a CCD?

2.7. Photon-counting detector: list the steps of a photon registration by a photomultiplier.

2.8. What are the sources of noise in a photon-counting device?

2.9. What is different in reaction of a photon-counting detector to a cosmic ray hit compared to a CCD?

3. Infrared detectors

3.1. What is the main difference of a hybrid IR detector compared to a CCD?

4. Imaging and Photometry

4.1. What is a point spread function (PSF) of a telescope? How many pixels should one have across the PSF to keep the information content according to the optimal sampling theorem?

4.2. What device is used to achieve optimal sampling of the PSF in imaging mode on a given telescope with a given detector pixel size?

4.3. Why the use of identical filters on different telescopes and photometers does not guarantee identical results? How to remedy this problem?

4.4. Describe the procedure of a single-channel photometry (science and standard stars)?

4.5. Vega (zero-magnitude star) sends 1000 photons per second per cm^2 per 1Å at maximum flux. Can you detect variability in a 15^{th} magnitude star that changes its brightness periodically with the amplitude of 1% and the period of 3 minutes? You are using a 40 cm (diameter) telescope, 600 Å wide filter and the total throughput of the telescope+photometer+detector is 40%. Consider the shot noise only.

5. Spectroscopy

5.1. Using the grating equation, how do you find the spectral order number for a given wavelength?

5.2. What are the main advantages of an echelle grating over conventional grating?

5.3. *What is the resolving power of an echelle spectrometer ($\lambda/\Delta\lambda$) working in 80^{th} order? The grating blaze angle is 66.5° and it has 36 grooves per mm. The central wavelength is 6368 Å. The focal lengths of the camera and collimator are 100cm each and the entrance slit width is 80 microns. Careful with unit conversion!*

6. Data reduction

6.1. What is the purpose of flat field correction of CCD observations?

6.2. How does one measure and apply dark-current corrections to a CCD observation?