PHY2003 Astrophysics I – Assignment 1

As explained in Level 2 induction, submission of this assignment will be via Canvas. If your document is illegible you will not receive any marks. Your completed assignment must be submitted as a scanned PDF file. A smartphone with a high pixel-count camera scanner app producing pdfs is an acceptable scanning method. Microsoft Office Lens will automatically upload the images as a pdf. You can find a Microsoft Office Lens Tutorial here. Alternatively, you can use the scanners in the McClay Library to scan your completed assignment.

Show all calculations/steps in your answers for the questions/tasks below. The deadline is 10pm, Wednesday October 6, 2021 but you can submit at any time before then.

1. Observational Astronomy (80 points)

(a) Canopus has an apparent visual magnitude of V = -0.74. If the pupil of the human eye has a diameter of 5mm, how many photons enter the eye per second? (15 points)

(b) The bright variable star Mira is 92 parsecs distant, and has a maximum diameter 402 times larger than our Sun. Can we resolve this star using adaptive optics at an infrared wavelength of $\lambda = 1.6 \times 10^{-6}$ m using the current 8.2m VLT? (15 points)

(c) In 2014, the 2.4-m Hubble Space Telescope was used to image the object 2014 MU69 (now known as Arrokoth) orbiting our Sun beyond Neptune, which has an apparent V-magnitude of V = 27.2. What was V-filter photon count rate per second using HST that allowed the detection of this distant body? (15 points)

(d) I want to use a spectrograph on the 10-m Keck Telescope to obtain a visual spectrum of 2014 MU69 (aka Arrokoth). If the resulting spectrum is measured in photons per nanometre (nm), calculate how many photons per nm are detected

per second in the V-band, and hence how long the Keck Telescope would have to collect the light to get roughly 100 photons per nm. (20 points)

(e) A problem with imaging from the Earth's surface is that even on a clear moonless night the atmosphere emits a faint glow, equivalent to a $V \simeq 21$ star everywhere you look. Clearly explain in a few sentences how the 8.2-m Very Large Telescope VLT can detect objects 6 magnitudes fainter than that background sky. (15 points)

2. Flux (10 points)

(a) Solar Proton Events (SPEs) are intense bursts of high-energy protons created as dense clouds of plasma are ejected from the sun. SPEs have been observed at Earth for decades and carefully measured. The following table shows the seven events that occurred during 2011 measured at Earth. The intensity is indicated by the number of particles per second that pass through a given square-centimetre of area at Earth orbit. The Parker Solar Probe spacecraft will be as close as 7 million kilometres to the Sun. How much more intense will the tabulated SPEs be for the Parker Solar Probe at closet approach to the Sun? (10 points)

Date	Intensity	Date	Intensity
March 8, 2011	50	August 9, 2011	26
March 21, 2011	14	September 23, 2011	35
June 7, 2011	72	November 26, 2011	80
August 4, 2011	96		

3. Telescopes (10 points)

(a) Two telescope proposals have been submitted to the Science and Technology Facilities Council: Proposal A wants to build an X-ray telescope located in the Atacama Desert to study the activity and evolution of black holes in the centres of galaxies. Proposal B wants to build a radio telescope in Antarctica to map dense molecular gas in star-forming regions of the Magellanic clouds. Clearly explain in a few sentences which proposal should be funded and why. (10 points)