ELEC-E4210 Introduction to Space (5 cr) **Exam 7.4.2017**

Answer all five questions. Always justify your answers. However, there is no need to write a book, the facts count! Additional information, such as constants, can be found at the end of the paper.

1. On September 21st, you are making radio observations in Metsähovi (latitude: N 60° 13' 4.1", longitude: E 24° 23' 35.2") at 37 GHz as part of the AGN team's monitoring programme. You are observing through the night, from 21 to 9 o'clock, local time. Each observation (continuum flux density measurement) takes about half an hour.

In the beginning of your shift you see the latest Astronomer's Telegram announcing bright multiwavelength flares in two quasars listed in Table 1. Because your observing schedule is fairly flexible and you are always encouraged to quickly react to flare alerts, you would like to observe them during your shift. Can you? (6p)
(Write down all the assumptions that you make and other details of how you derive your answer.)

Table 1:

Nr	Source	RA	DEC
1.	PKS0735+17	07h 38m 07.400s	+17° 42' 19.000"
2.	PKS2155-304	21h 58m 52.065s	–30° 13' 32.120"

2. The McNaught comet C/2012 Y3 has a known perihelion distance $r_p = 1.76482$ AU and semi-major axis $a_{Y3} = 29.38$ AU (measured in 2012 as it passed the perihelion). A yet-to-be-built research base on Saturn's moon Titan plans to collect samples from the comet, and to do that they decide to bring the comet's aphelion to the distance of Saturn's semi-major axis ($a_{\text{saturn}} = 9.5549$ AU). Using the gravitational constant $G = 6.67408 \times 10^{-11} \frac{\text{m}^3}{\text{kgs}^2}$ and the mass of the Sun $m_{\text{sun}} = 1.9891 \times 10^{30}$ kg, determine:

a) Determine where in the original orbit the speed kick should be given (assume instantaneous speed kick) to change the original comet orbit into the desired orbit. (1p)

b) Based on the answer from part (a), calculate the delta V at that point in orbit. Is it an acceleration or deceleration? (3p)

c) Calculate the next opportunity to carry out the mission (the time of the speed kick). Ignore whether the comet have to intersect directly with Saturn's position when it reaches the desired aphelion – just forecast the earliest opportunity for speed kick. (2p)

3. At Earth's orbit the Sun's angular diameter is 32 arcseconds, and the flux density is 1390 W/m^2.
a) Calculate the temperature of the Sun based on the given information; do you think it is a reasonable answer? (4 p)
b) Calculate the maximum wavelength of the emission; do you think it is a reasonable answer? (1 p)
c) What happens to the frequency of the "H I" emission line of hydrogen (wavelength 21 cm) if the temperature increases by 15 %? (1 p)

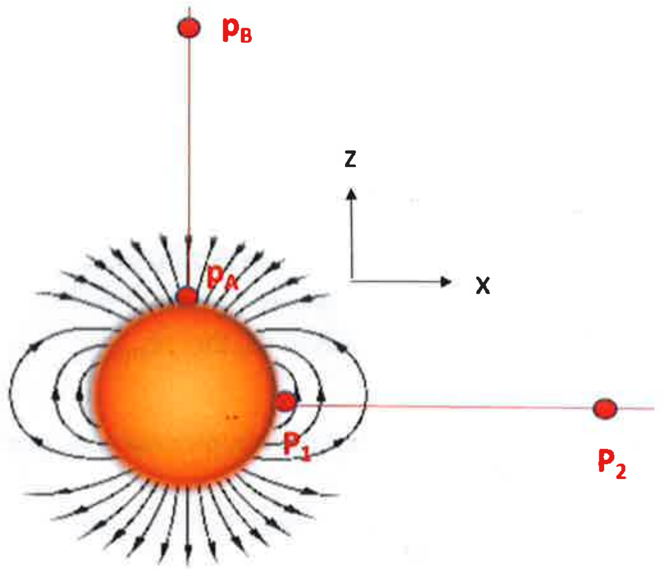
MORE QUESTIONS ON THE SECOND PAGE!

4. Explain briefly the following concepts (one or two sentences is enough).
a) Absolute magnitude (2p)
b) Main sequence (of stars) (2p)
c) Redshift (2p)

5. An exoplanet has been found at the distance of 10 R_{SUN} from the centre of its local sun Kepler S, where R_{SUN} is the radius of the Kepler S.
Calculate the interplanetary magnetic field vector $\mathbf{B} = (B_x, B_y, B_z)$ at points
$p_B = (x, y, z) = (0, 0, 10\ R_{SUN})$ and
$P_2 = (x, y, z) = (10\ R_{SUN}, 0, 0)$
by assuming that:

- the magnetic field near the surface of Kepler S is like in an ideal magnetic dipole whose axis is along the z-axis (c.f. Figure below).
- the magnetic field at the point $p_A = (x, y, z) = (0, 0, R_{SUN})$ is (0, 0, 200 nT) and at the point $P_1 = (x, y, z) = (R_{SUN}, 0, 0)$ it is (0, 0, 100 nT).
- the solar wind flows radially outward starting from the distance of R_{SUN}.
- Kepler S is not rotating.
- the resistivity in the solar wind is zero.

A hint: "flux conserving" might be a useful concept. (6p)



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Constants:
$G=6.67408*10^{-11}\ m^3kg^{-1}s^{-2}$
$m(Sun)=1.9891*10^{30}$ kg
1 AU = 149597870700 m
μ= G M(Sun)