ELEC-E4210 Introduction to Space (5 cr) **Exam 9.4.2020**

Answer all four questions. ***IMPORTANT: Always justify your answers.*** *Because you are allowed to use course materials in the exam, you need to show that you have understood the problems, and can explain how you have solved them and reached the final conclusions. Simply stating the answer will not be enough, so always explain what you have done.*

1. 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 **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 the “flux conserving" concept and also that:

-The magnetic field near the surface of Kepler S is like in an ideal magnetic dipole whose axis is along the z-axis (see the illustrative figure below).

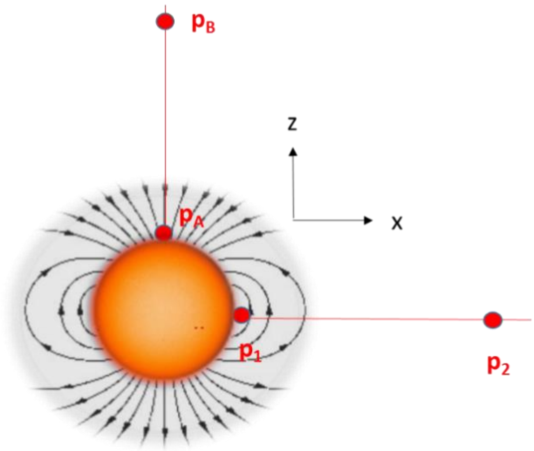
-The magnetic field at the point p_A= (x, y, z) = (0, 0, R_{SUN}) is (0, 0, -200 nT) and at the point p_1= (x, y, z) = (R_{SUN}, 0, 0) it is (0, 0, 100 nT).

-The solar wind flows radially outward starting from the distance of R_{SUN}.

-<u>Kepler S is not rotating.</u>

-The electrical resistivity in the solar wind is zero and the so called ideal Ohm’s law is a valid approximation. (6p)

Justify the used equations.



2. 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 below. 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 do that? (6p)

Write down all the assumptions that you make and other details of how you derive your answer. Especially in this home exam you cannot earn full points unless you carefully elaborate all the steps needed to get to your conclusion.

Table 1:

Nro	Source	RA	DEC
1.	PKS0735+17	07h 38m 07.400s	+17° 42' 19.000"
2.	PKS1514-24	15h 17m 41.814s	–24° 22' 19.482"

3. You land on exoplanet *Alpha* orbiting a red dwarf star (temperature 4000 K, diameter 10^8 m) in a circular orbit at 0.76 AU distance. Another planet, *Beta* (radius 5000 km*)*, orbits in the same plane, 1.52 AU from the star. When the planets are as close to each other as they can get, *Beta's* apparent magnitude is 0.61. You want to compare *Beta's* properties in two extreme cases: when the planets' orbits make *Beta* appear as bright as possible and as faint as possible, when seen from *Alpha* (cases BRIGHT and FAINT).

a) Sketch the positions of the planets relative to the star and each other in the extreme cases BRIGHT and FAINT. Mark the distances of the planets to the star (r_α and r_β), and the distances between the planets (d_{Bright} and d_{Faint}). (1p)
b) How much radiative power *Beta* receives from the star in each case? Answer in watts. (2p)
c) Seen from *Alpha*, how many times brighter *Beta* is when it is BRIGHT compared to FAINT? (2p)
d) What is the apparent magnitude of *Beta* when it's FAINT? (1p)

4. A small satellite mission is parked to Mars circular orbit at 300 km altitude above the surface. The mission requires an orbit which intercepts with both Phobos orbit (6000 km above surface) and Deimos orbit (23460 km above surface). The orbit should be achieved with minimal amount of fuel for the propulsion.

a) How many speed kicks and with what direction are required? (1p)
b) What is the most effective orbital transfer sequence to desired orbit? (2p)
c) Calculate needed delta V budget for proposed transfer. (3p)

Assume circular orbits for Phobos and Deimos.

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Constants:
Gravitational constant: 6.674×10^{-11} N m^2 kg^{-2}
Mass of the Sun: 1.9891×10^{30} kg
Radius of the Sun : 6.957×10^{8} m
Mass of Mars: 6.4185×10^{23} kg
Diameter of Mars: 6752.4 km

Astronomical unit: 149597870700 m
Light year: 9.461×10^{15} m
Wien's displacement constant: 2.898×10^{-3} m K
Stefan-Boltzmann constant: 5.671×10^{-8} W m^{-2} K^{-4}
Planck constant: 6.626×10^{-34} J s
Boltzmann constant: : 1.381×10^{-23} J K^{-1}
Speed of light in vacuum: : 2.998×10^{8} m s^{-1}