SHORT QUESTIONS

1. There are several exoplanets observed in the Gliese 876 system ($M_G = 0.334 \pm 0.03 M_\Theta$) as given in the following table,

Gliese System	Mass	Semi Major Axis (au)
Gliese 876 b	2.2756 ± 0.0045M_J	0.2083 ± 0.000020
Gliese 876 c	0.7142 ± 0.0039 M_J	0.1296 ± 0.000024
Gliese 876 d	6.83 ± 0.40 $M_\oplus$	0.0208 ± 0.00000015
Gliese 876 e	14.6 ± 1.7 $M_\oplus$	0.3343 ± 0.0013

where $M_\odot$ is mass of Sun, M_J is mass of Jupiter ($M_J = 1.89813 \times 10^{27}\ kg$), and $M_\oplus$ is mass of Earth.~~where mass of Sun,~~ $M_\Theta = 1.9891 \times 10^{30}\ kg$ ~~, mass of Jupiter,~~ $M_J = 1.89813 \times 10^{27}\ kg$ ~~, mass of Earth,~~ $M_\oplus = 5.97219 \times 10^{24}\ kg$ ~~.~~

Find, if any of the exoplanets of Gliese 876 system have ~~a~~ resonant orbits (their synodic period is a multiple integer of one of the periods).

2. Volcanic activity on Io which has a synchronous orbital period, was proposed to be the result of a tidal heating. Resultant tidal force is the difference in gravitational force experienced by the near and far sides of a satellite orbiting a parent body. Measurements of the surface distortion of Io via satellite radar altimeter mapping indicate that the surface rises and falls by up to 100 m during one-half orbit. Only the surface layers will move by this amount. Interior layers within Io will move by a smaller amount, thus we assume that on average, the entire mass of Io is moved through 50 m. Mass of Jupiter and Io are $M_J = 1.89813 \times 10^{27}\ kg$ and $m_{Io} = 8.931938 \times 10^{22}\ kg$, respectively. Given that the perijove and apojove distances are r_{peri} = 420000 km and r_{apo} = 423400 km respectively, the orbital period 152853 s, and the radius of Io is R_{Io} = 1821.6 km, calculate the *average power* of this tidal heating of Jupiter's gravitational force on Io. **Hint :** you can use the following approximation $(1+x)^n \approx 1 + nx$ for small x.

3. On 27 May 2015 at 02:18:49, the occultation of ~~-~~ the star HIP 89931 ($\delta - ¿$ Sgr) by the asteroid 1285 Julietta ~~on the star HIP 89931 ($\delta - ¿$ Sgr)~~ was observed from Borobudur temple, it lasted for only 6.2 s. Assuming that Earth's orbit is circular and the orbit of Julietta is~~n~~ on the ecliptic plane, find the approximate ~~the~~ size of asteroid Julietta, if the semi major axis of Julietta $a = 2.9914$ au, and at occultation, the distance of Julietta to the Sun and the Earth is 3076 au and –2.156 au, respectively.

4.

4. Recently, ~~a~~n observer is using a hypothetical far-infrared Earth-sized telescope with wavelength in the range of 20 to 640 μm. He finds a static and neutral supermassive black hole with a mass of 21 billions (2.1 x 10^{10}) $M_\odot$. Determine the maximum distance from the observer to this black hole that can be measured with his telescope.~~Nowadays, a supermassive black holes up to 21 billion (2.1 x 10^{10}) $M_\odot$ has been discovered. In the Herschel Space Observatory, aAn observer usinged a (hypothetical) far-infrared Earth-sized telescope with wavelength in the range of 20 to 640 μm. He finds a supermassive black hole with a mass 21 billion $M_\odot$. Determine the maximum observer distance to this black hole that can be measured with his telescope.~~

5. An observer is trying to determine an~~the~~ approximate value of the orbital eccentricity of a man-made satellite. When it is at ~~farthest~~ apogee~~point~~, in a short time the satellite moved by $\Delta\theta_1 = 2'44.$ Meanwhile, when the position of the satellite is perpendicular to its major axis~~,~~ – (true anomaly is equal to 90°), within the same duration of time, it is observed that the satellite moved by $\Delta\theta_2 = 21'17.$ Find an approximate value of the eccentricity of the satellite's orbit.

6. Before running an observ~~ation~~ation~~ing run~~, a radio telescope is pointed to a point-source calibrator that has a flux density of 21.86 Jy. However, the measured flux density is 14.27 Jy. If the observation was being made at an elevation of 35 degrees above the horizon, estimate the zenith atmospheric opacity, τ_z . ~~τ_z.~~

7.

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8. A ~~Assumed that the Sun is in a globular~~ cluster of galaxies ~~with~~ has a~~the~~ total mass ~~is~~ M. A galaxy with mass m is expected~~stimated~~ ~~will~~ to escape from this cluster. ~~If~~ $G=6.67\times10^{-11} m^3 kg^{-1} s^{-2}$ ~~and Hubble constant is~~ $H=15\,km\,s^{-1}10^{-6}ly$,. ~~What i~~Determine ~~s~~ the density of the~~is~~ ~~globular~~ cluster.~~?~~

~~It is determined that a galaxy of mass *m* can escape from a cluster of galaxies of total mass *M*. If~~ $G=6.67\times10^{-11} m^3 kg^{-1} s^{-2}$ ~~and Hubble constant is~~ $H=15\,km\,s^{-1}10^{-6}ly$ ~~, what is the density of this cluster?~~

9. A strong radio signal from a celestial body has been observed as a burst with very short duration of 700 μs. ~~Flux density~~The observed flux density at a frequency of 1660 MHz is measured to be 0.35 kJy. If the distance of the source is known to be 2.3 kpc, estimate the brightness temperature of this source.

~~Note that~~ $1\,pc=3.086\times10^{18}$ ~~cm,~~ 1 ~~Jy =~~ 10^{-26} ~~W m^{-2} Hz^{-1} = 10^{-23} ergs s^{-1} cm^{-2} Hz^{-1}~~

10. Assume that the Sun is a perfect blackbody. Venus is also assumed to be a blackbody, with temperature T_V, radiating about as much energy as it receives from the Sun at its orbital distance of 0.72 au. Suppose that at closest approach to Earth, Venus has an angular diameter of about 66 arcsec. What is the flux density of Venus at closest approach to Earth as observed by a radio telescope at an observing frequency of 5 GHz.~~Assume that the Sun is a perfect blackbody with temperature of $T_{\odot}$~~ = 57~~78 K. Venus is also assumed as to be a blackbody, with temperature T_V~~, radiating about as much ~~gy as it receives from Sun at its orbital distance of 0.72 au. Suppose that at closest approach to Earth, Venus has an angular diamete~~r of about 66 arcsec. What is the flux density of Venus at closest approach to Earth as observed by a radio telescope ~~at an observing frequency of 5 GHz.~~

11. A molecular cloud is known to have a temperature ***T*** = 115 K. If interstellar molecules (assumed spherical) have masses of about 5 × 10^{-23} ~~g~~ g and radii of 3.5 Å and are in thermal equilibrium with the surrounding gas, can you estimate the frequency they will radiate? Describe your answer mathematically.

12. Consider a star ~~with~~ whose~~its~~ mass density is inversely proportional to the radial distance from the center of the star, with the factor of proportionality ~~is~~ ¿$5.0 \times$ ❑❑ kg/m^2 . If the escape velocity of any objects to leave the star is $v_0 = 1.5 \times 10^4 \, m/s$, calculate the mass of the star.

~~(hint?)~~

13. An $1 GeV$ energetic proton propagates out from the surface of the Sun toward the Earth. What is the ~~elapse~~ travel time of the proton as seen from the Earth?

14.

15. Two protons collide to ~~give rise~~produce deuteron, positron, and neutrino in the center of a star. Write down the reaction equation and calculate the minimum temperature needed for this reaction. Assume that the neutrino mass is negligible.

16. Suppose we live in an infinitely large and infinitely old universe where the average density of stars is $n = 10^9 \, Mpc^{-3}$ and the average stellar radius is equal to the ~~Sun's~~ Solar radius ❑❑ ~~m~~. How far, on average, could you see in any direction before your line of sight struck a star? (Assume standard Euclidean geometry holds true in this universe)

17. An airplane was flying from Lima, capital of Peru ($12^0 2' S$ and $77° 1' W$) to Yogyakarta ($7° 47' S$ and $110^0 26' E$). The airplane choose the shortest flight path from Lima to Yogyakarta. Neglecting Earth's revolution, find the latitude of the southernmost point of the flight path.