Homi Bhabha Center for Science Education

Tata Institute for Fundamental Research

8TH INDIAN NATIONAL ASTRONOMY OLYMPIAD

May 1 to 20, 2006

Exam **Theory Test 2-Sr**	*Date* May 15, 2006	*Time* 09:00	*Marks* 50	*Duration* 2^h

Q1) A star HIP41727 in Cancer lies very close to the ecliptic. Its equatorial coordinates for the present day are (8^h 30.881^m, 18^0 55.403'). It is presently moving along the RA & Dec axes at speeds -0.0136 "/yr & -0.0108 "/yr, respectively. What would be its equatorial coordinates on 14th Dec 2016 at 12:00 noon? *You may use any of the given transformation equations.* 10

$$\left[\begin{array}{l}\sin(\delta)=\sin(\beta)\cos(\varepsilon)+\cos(\beta)\sin(\varepsilon)\sin(\lambda)\\ \tan(\alpha)=\dfrac{\sin(\lambda)\cos(\varepsilon)-\tan(\beta)\sin(\varepsilon)}{\cos(\lambda)}\end{array}\right]\quad\left[\begin{array}{l}\sin(\beta)=\sin(\delta)\cos(\varepsilon)-\cos(\delta)\sin(\varepsilon)\sin(\alpha)\\ \tan(\lambda)=\dfrac{\sin(\alpha)\cos(\varepsilon)+\tan(\delta)\sin(\varepsilon)}{\cos(\alpha)}\end{array}\right]$$

$$\sin\delta=\sin\phi\sin a+\cos\phi\cos a\cos A\qquad\tan H=\frac{\sin A}{\sin\phi\cos A-\cos\phi\tan a}$$

Q2) General Theory of Relativity adds up a correction to Newtonian gravitation formula. As per the theory Force of gravitation can be taken as $F_{GR}=\dfrac{GMm}{r^2}\left(1+6\left(\dfrac{v}{c}\right)^2\right)$ where *M* & *m* are the masses of Sun & Mercury, *r* is the radius of orbit & *v* is its velocity. Find the new expression for the time period in terms of the Newtonian time period. Approximate using the binomial theorem, by which $(1+a)^n=1+na,\ \text{if } a\ll 1$. Find the additional angle through which the planet has to travel to reach the new perihelion point (give a valid reason for the same). Using the data, find the precession of Mercury's perihelion point. 15

Q3) 'Stacking' is a method used by many amateur astronomers to get a better signal to noise ratio by capturing many short exposure frames and averaging them pixel by pixel to cancel out the random noise and improve the signal. Professional astronomers, however, prefer giving very long exposures by which the signal to noise ratio increases too. What is the difference between the two methods? Which would give better results (in terms of signal to noise ratio / contrast)? What would be the difficulties associated with each of these? 5

Q4) On 16th May, 2006, at 10:02 am, as seen from Mumbai (72.5^0E, 18.6^0N), the moon shares its RA with the winter solstice and is 5^0 16^m to its north. At what time will its next meridian crossing occur? In what constellation will the moon be at this time? Assuming a circular orbit what is the RA of the sun at this time? 10

Q5) A planet is in circular orbit of radius R about a central star of mass M. At some instant, the star bursts and sheds *x* percent of its mass. Find the eccentricity of the resulting orbit of planet after outburst. Discuss the cases for elliptical, parabolic & hyperbolic orbits. Assume that the mass going out of star does not affect or tear apart the planet. If the star were now to become a black hole then how will your answer change? 10