Physics of Galaxies HW: Set 5

Issue Date: 02/11/17 Hand-In Date: 16/11/17

Students should hand in their exercises by **4.00pm** on the date given above; exercises will not be accepted for marking later than this. The **Course Title**, the exercise **Set Number** and the **Student's Name** should be stated clearly.

1. A star in the disc of a spiral galaxy, with a flat rotation curve, is in circular motion about the centre of the galaxy. It is given a purely radial impulse outward. Explain (a) why the star finds itself going slower than the stars amongst which it now finds itself **[2 marks]** and (b) why it cannot remain at this increased radial distance from the centre **[2 marks]**. Sketch and state the name of the motion of the star in a frame that is rotating at the angular velocity of the star in its original, unperturbed orbit. **[3 marks]**

2. a) Beginning with the Kepler's third law $P^2 = \frac{4\pi^2}{G(m_1 + m_2)} a^3$, where P is orbital period, m_1 and m_2 are masses orbiting about the centre of mass, and a is orbit semi-major axis, derive an expression for the circular velocity $\Theta(r)$, assuming that the Sun travels in a Keplerian orbit about the centre of the Galaxy. **[3 marks]**

b) From your result in part a), derive analytic expressions for the Oort parameters

$$A(r) = +\frac{1}{2}\left[\frac{\Theta(r)}{r} - \frac{d\Theta(r)}{dr}\right],$$
$$B(r) = -\frac{1}{2}\left[\frac{\Theta(r)}{r} + \frac{d\Theta(r)}{dr}\right].$$

[3 marks]

c) Using the Keplerian expression from part b), determine numerical values for A and B in the solar neighbourhood, assuming $R_{sun} = 8$ kpc and $\Theta_{sun} = 220$ km s^{-1}. Express your answer in km s^{-1} kpc^{-1}. **[2 marks]**

d) Explain why your answers in part c) differ from the observed values $A = 14.8 \pm 0.8$ km s^{-1} kpc^{-1} and $B = -12.4 \pm 0.6$ km s^{-1} kpc^{-1}. **[3 marks]**

18 marks in total