Local standard of rest (LSR)

- Local standard of rest is the point that is located today at the present position of the sun and that moves along a perfectly circular orbit around the galactic center.So the locus of LSR is not the actual orbit of the Sun.But this is a good enough reference because although LSR changes with time,the timescale of such changes is very large so periodic corrections can be done when considerable change occurs.
- The need for LSR arises from the fact that galaxy does not rotate as a single rigid entity but has a differential rotation.This means as one goes further away from the apex,the velocity of objects keep decreasing as shown in the figure below
- The velocity of an object with respect to the LSR is called its peculiar velocity and has three components represented as (u,v,w) where u is the velocity towards(positive) or away (negative)from the the G.C ,v is the velocity of circular motion within the plane and w is the velocity towards(positive) or away (negative) from the NGP

$$U = \frac{dR}{dt} \tag{1}$$

$$V = \frac{Rd\phi}{dt} \tag{2}$$

$$W = \frac{dz}{dt} \tag{3}$$

- Since the motion of LSR is restricted to the plane , its u and w components are zero . Therefore $U_{LSR} = W_{LSR} = 0, V_{LSR} = V(R_0)$
- Peculiar velocity of any celestial object is (u,v,w) = $(u - U_{LSR}, v - V_{LSR}, w - W_{LSR})$=(u,v-$V(R_0)$,w)
- If $\overrightarrow{\triangle v}$ is the velocity of a star with respect to the sun,the peculiar velocity of the star is

$$\overrightarrow{V} = \overrightarrow{V_{sun}} + \overrightarrow{\triangle v} \tag{4}$$

$$\overrightarrow{\triangle v} = \overrightarrow{V} - \overrightarrow{V_{sun}} \tag{5}$$

$$\langle\overrightarrow{\triangle v}\rangle = \langle\frac{\overrightarrow{v}_1 + \overrightarrow{v}_2 + ... + \overrightarrow{v}_n}{n}\rangle - \overrightarrow{V_{sun}} \tag{6}$$

- Since the average of the random velocities of objects in the solar neighbourhood is zero,the mean of the velocity of stars is the peculiar velocity of the sun

$$\overrightarrow{V_{sun}} = -\langle\overrightarrow{\triangle v}\rangle \tag{7}$$

- Thus the average velocities of stars within the solar neighbourhood will give us the particular velocity of sun.
- Once both the direction and magnitude of this $\overrightarrow{\triangle v}$ is calculated,each component of the Sun's velocity can be obtained as

$$V_{sun} = (u_{sun}, v_{sun}, w_{sun}) \tag{8}$$

- Where,

$$u_{sun} = -10Km/sec \tag{9}$$

$$v_{sun} = 5Km/sec \tag{10}$$

$$w_{sun} = 7Km/sec \tag{11}$$