Distribution of Globular Clusters in the Galaxy

- Stellar Pulsations as Distance Indicators

All types of variable stars have their own period-luminosity relationship as shown,

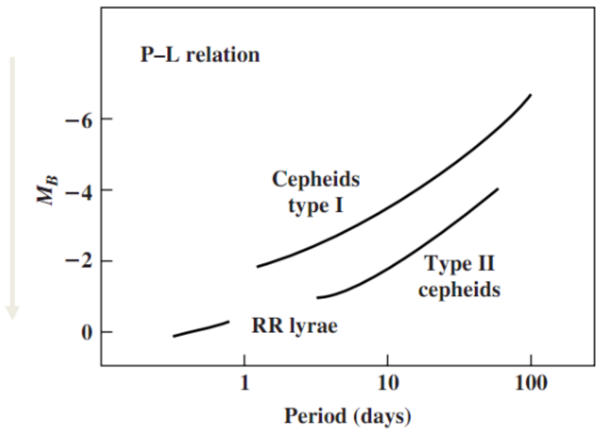

Figure 1. Period-luminosity relationships for variables

Once a variable star is identified in a globular cluster, its light curve can be used to determine the period of apparent magnitude variation.
Following is an example of such a star and its light curve,

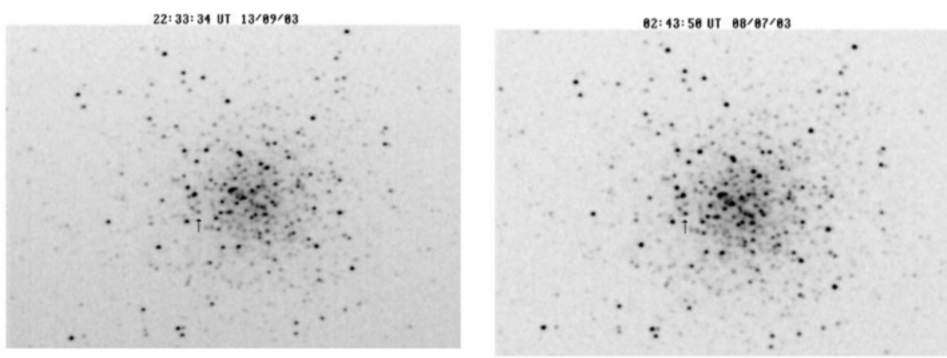

Figure 2. Cepheid V2 (arrowed) near its minimum (left) and maximum (right)

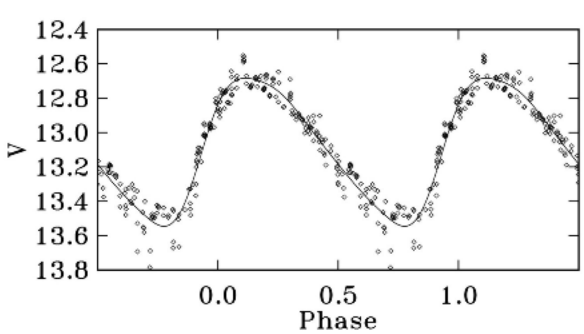

Figure 3. Ligth curve of V2

Once the period is derived, we can use the period-luminosity relationship for that type of variable star to determine its absolute magnitude. Since apparant magnitude can be taken from the light curve, the difference between apparant and absolute magnitude can be used to calculate distance to the star.

- Position of the Galactic Center

Harlow Shapley obtained a distribution of the globular clusters and represented it in a graph taking the Sun at (0,0). It is given as follows,

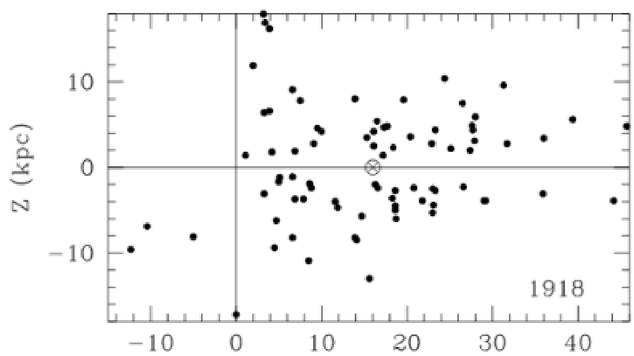

Figure 4. Distribution of globular clusters by Shapley (x-axis in kpc)

From this, he determined the galactic center to be at (16,0). But there was another distribution generated using a recent data which is shown here,

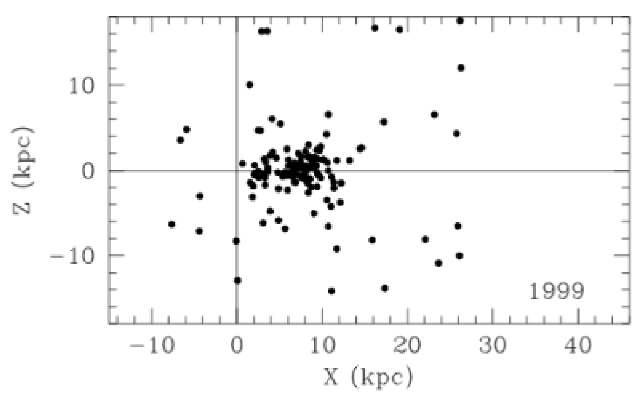

Figure 5. Distribution of globular clusters based on recent data(x-axis in kpc)

From this data, we can observe an aggregation of stars around (8,0) and an explicit spherical distribution of stars around it. Therefore, it is clear that there is indeed a morphological center of our galaxy and it is not at our Sun.
There have been various studies for estimating the distance to the galactic centre and the results are as given below,

Reference	R_o (kpc)	Calibration	Comments
Oort & Plaut 1975	8.7 ± 0.6	$M_{pg}(RR) = 0.7$	
Clube & Dawe 1980	7.0 ± 1.0	$M_v(RR) = 1.0$	
Blanco & Blanco 1985	8.0 ± 0.7	$M_v(RR) = 0.6$	all metallicities
	6.9 ± 0.6	$M_v(RR) \propto [Fe/H]$	mean $M_v = 0.82$
Walker & Mack 1986	8.1 ± 0.4	$M_v(RR) = 0.6$	
Fernley et al 1987	8.0 ± 0.6	$M_v(RR) \approx 0.6$	infrared
Walker & Terndrup 1991	8.2 ± 1.0	$M_v(RR) = 0.85$	$[Fe/H] \approx -1$
Ghez et al. (2008)	**$R_o = 8.4 \pm 0.4$ kpc**		
Gillessen et al. (2009)	**$R_o = 8.33 \pm 0.35$ kpc**		

Figure 6. Estimates of distance to the galactic center

Thus, the inferred distance comes as,

$$R_0 = 8.2 \pm 1.0 kpc$$

- Substructure of the Disk

In order to understand the structure within the galactic disk, we need to examine the distribution of its constituents. This can be done by mapping the distances to HI clouds, CO complexes, HII regions and OB associations. Such an attempt was made by Dame et al. who produced a distribution in the first galactic quadrant.

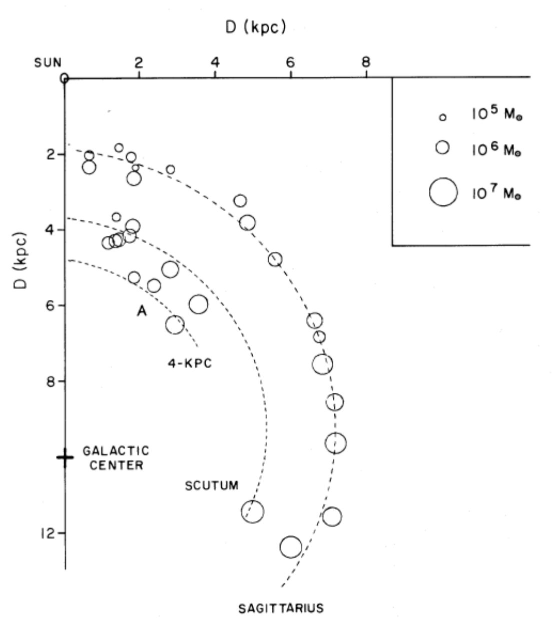

Figure 7. Location of large complexes in the galactic plane

Here the sizes of the circles indicate the masses of the complexes. The 4 kpc and Scrutum arms are drawn from the 21 cm maps. The Sagittarius arm is drawn as the best fit to the CO data.

On fitting the distribution of HII regions and Giant Molecular Clouds with arm models, we get the following result,

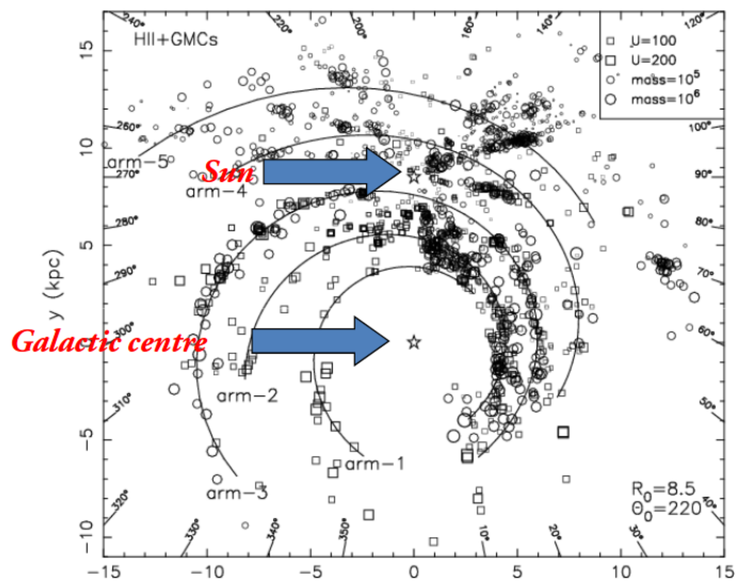

Figure 8

From the above figure, we can clearly see the spiral substructure of our galactic disk.