

DARK MATTER

ASTR 333/433

HOMEWORK DUE NEXT TIME

**TODAY:
JEANS EQUATIONS
TIME SCALES
GALACTIC CONSTANTS**



Galactic Kinematics

Galactic constants

$$R_0 \quad \Theta_0 \quad A \quad B$$

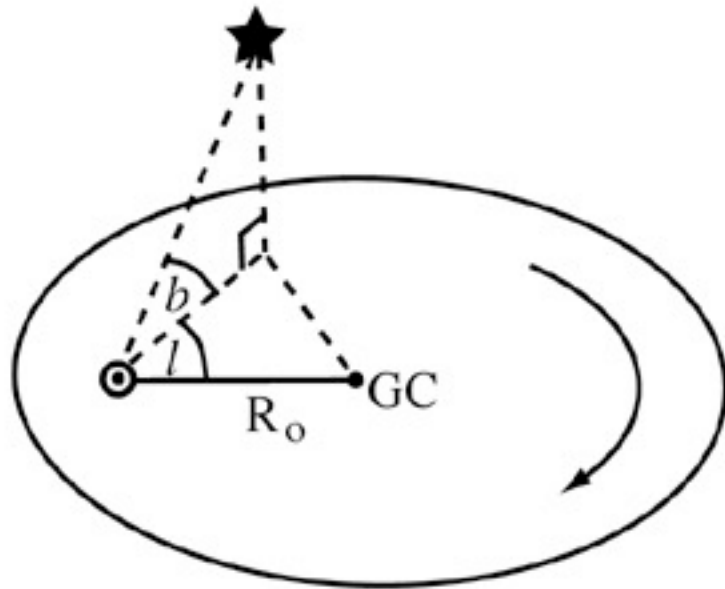
$$\Omega < \kappa < \nu_z$$

Epicyle approximation



Galactic Coordinates

from solar system



from Galactic Center

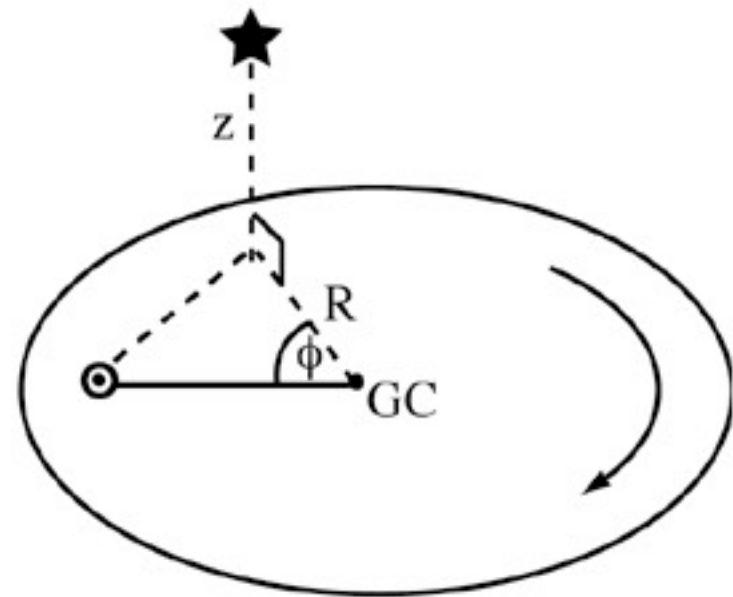


Fig 1.10 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

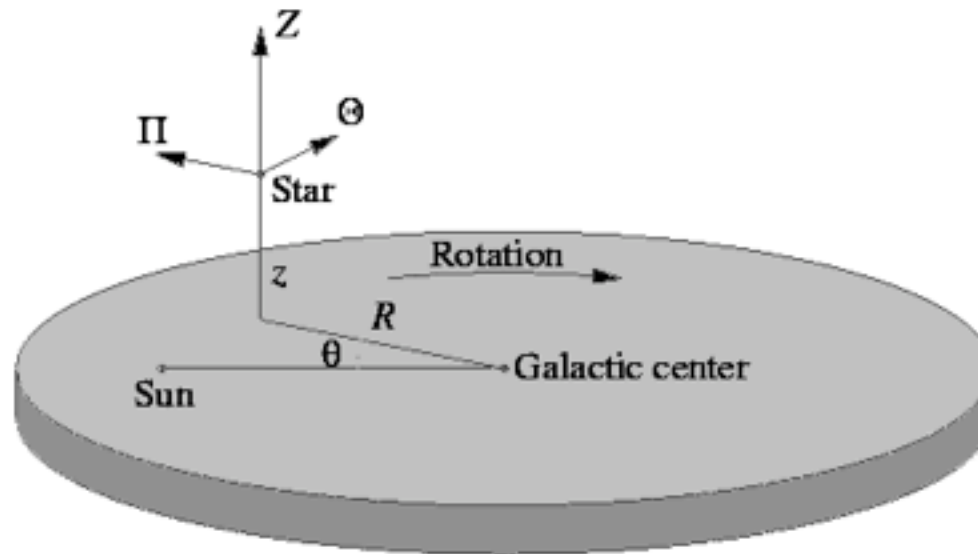
longitude & latitude

l, b

R, ϕ, z

The Local Standard of Rest

Let's define a coordinate system:



Position : (R, θ, z)

- R = galactocentric distance
- theta = azimuthal coordinate
- z = height above/below the plane

Velocity : (Π, Θ, Z)

- Pi = velocity in/out from center
- Theta = tangential velocity
- Z = velocity up and down

LSR - local standard of rest

Define a point in space that is moving on a perfectly circular orbit around the center of the galaxy at the Sun's galactocentric distance. We measure all velocities of stars relative to this point, which is known as the **Local Standard of Rest**.

The velocity of the Local Standard of Rest (LSR) is then given by

$$\Pi_{LSR} = 0$$

$$\Theta_{LSR} = \Theta_0$$

$$Z_{LSR} = 0$$

More generally, if the Galactic potential is not axis-symmetric (e.g., because of the Galactic bar), then the LSR orbit is oval.

R_0 distance to Galactic Center

Θ_0 orbital velocity of LSR

$\Omega_0 = \frac{\Theta_0}{R_0}$ angular velocity of LSR

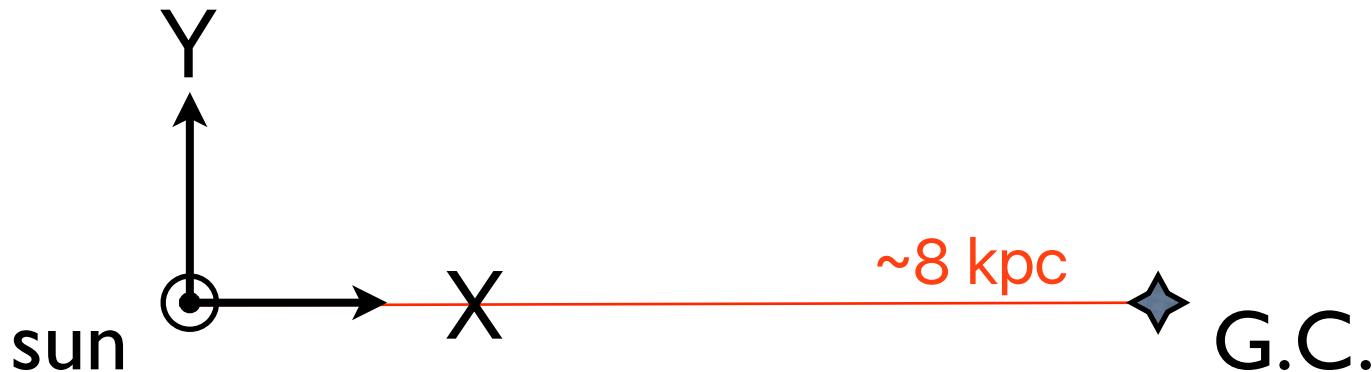
A Oort constant A

B Oort constant B

Local Galactic Coordinates

Cartesian coordinates centered on solar system

As opposed to Galactic Center. Beware sign conventions



X, Y, Z :

X points towards the Galactic Center

Y points in direction of the sun's orbital motion

Z is perpendicular to the Galactic Plane

U, V, W are velocities in these directions

Solar Motion

The residual solar motion wrt the average of local stars is

radial $U_{\odot} = 10 \text{ km s}^{-1}$

azimuthal $V_{\odot} = 12 \text{ km s}^{-1}$ Some say $V = 5 \text{ km/s}$,
some say 15 km/s!

vertical $W_{\odot} = 7 \text{ km s}^{-1}$

The Sun is moving

- a bit towards the galactic center
- faster than the LSR
- northward out of the galactic plane

Currently we are near the mid-plane

(Remember this doesn't account for the rotation of the disk!)

The Velocity Distribution of Stars

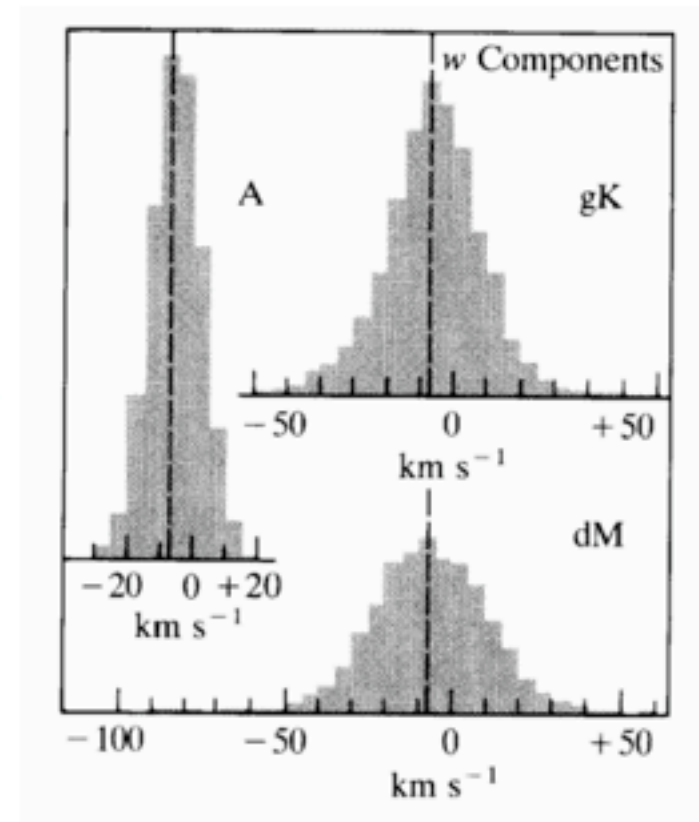
Make a histogram of the Z (up/down) velocities of stars of different spectral type:

- A stars ("A")
- K giants ("gK")
- M dwarfs ("dM")

(what is different about these groups of stars?)

The spread in velocities -- called the **velocity dispersion** and calculated as the standard deviation of the distribution -- is different for each group:

Stars	Dispersion (km/s)
A	9
gK	17
dM	18
white dwarfs	25



$$\sigma_z = \sqrt{\sum W_i^2}$$