

# DARK MATTER

ASTR 333/433

FALL 2013

M T 4:00-5:15PM

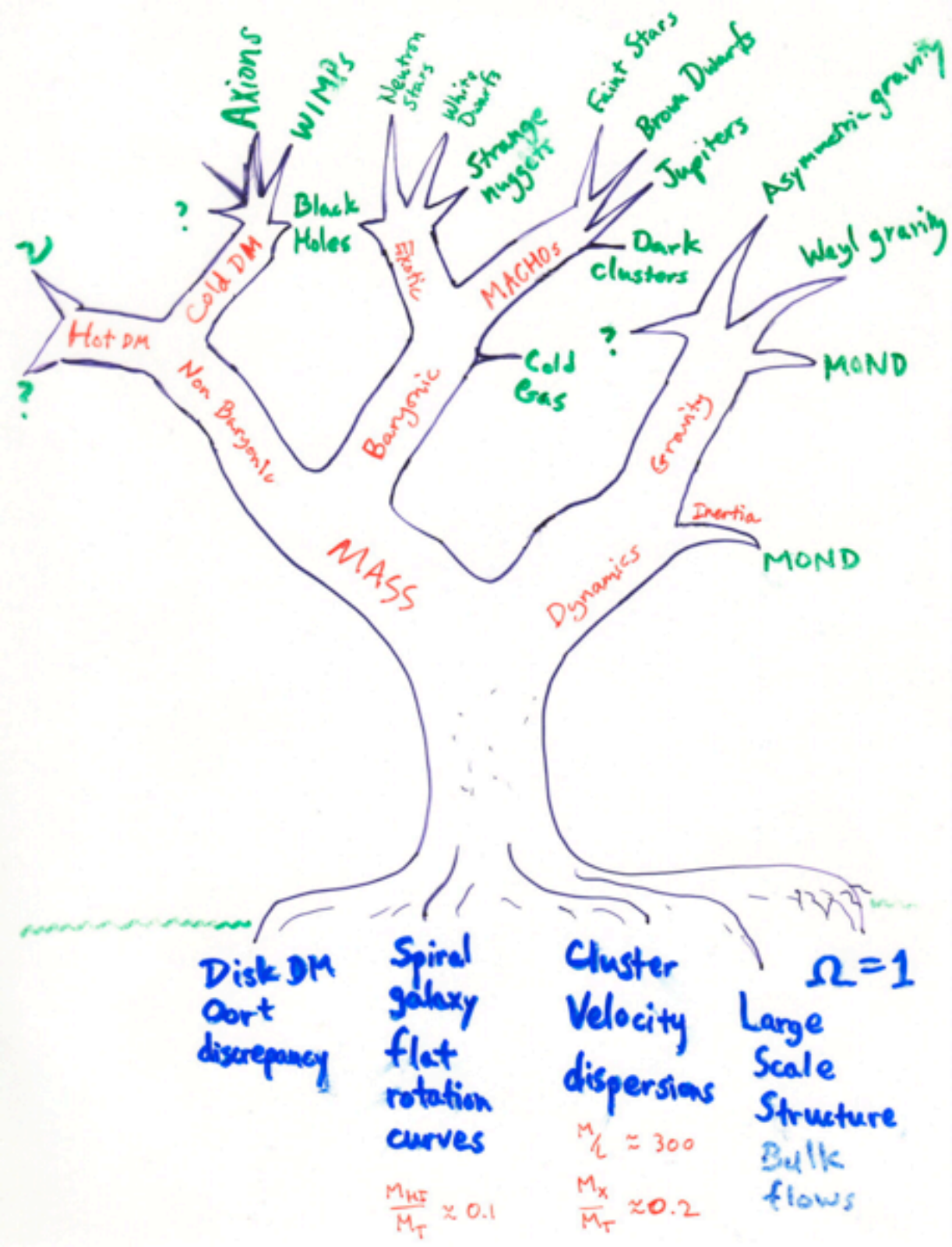
SEARS 552

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368-1808

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# Galactic Kinematics

Galactic constants

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

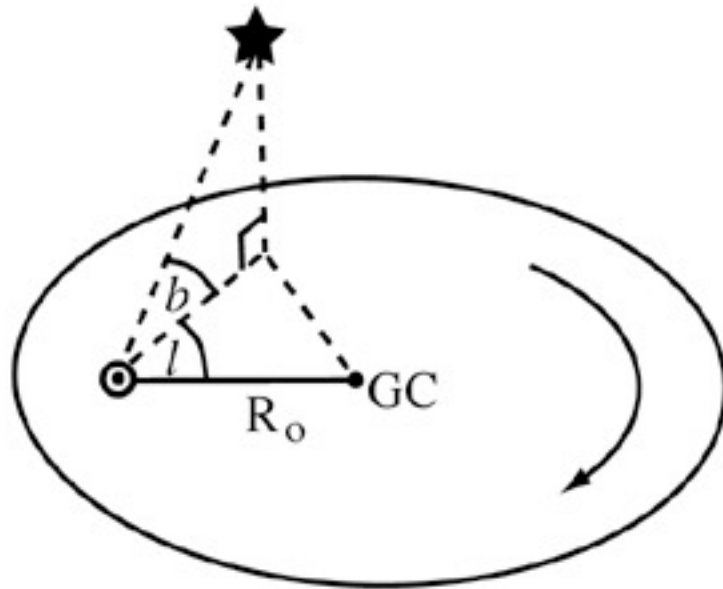
$$\Omega < \kappa < \nu_z$$

Epicycle approximation



# Galactic Coordinates

from solar system



from Galactic Center

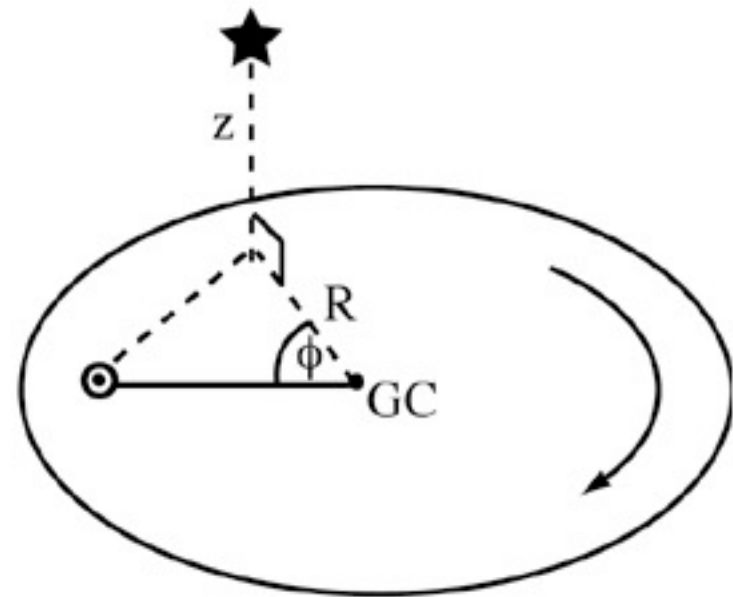


Fig 1.10 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

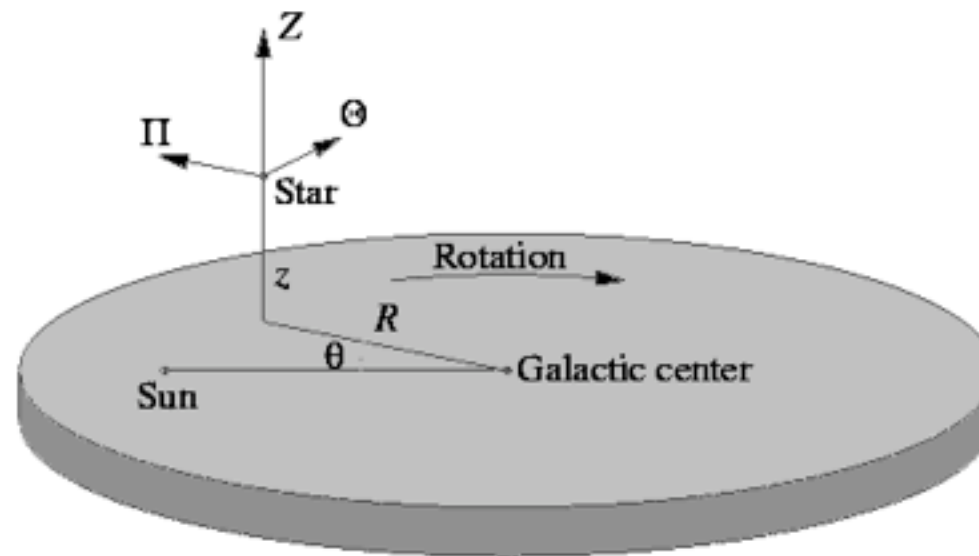
longitude & latitude

$l, b$

$R, \phi, z$

## The Local Standard of Rest

Let's define a coordinate system:



Position :  $(R, \theta, z)$

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

Velocity :  $(\Pi, \Theta, Z)$

- $\Pi$  = 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**.

$$\Pi_{LSR} = 0$$

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

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

$$Z_{LSR} = 0$$

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

$\Theta_0$  orbital velocity of LSR

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

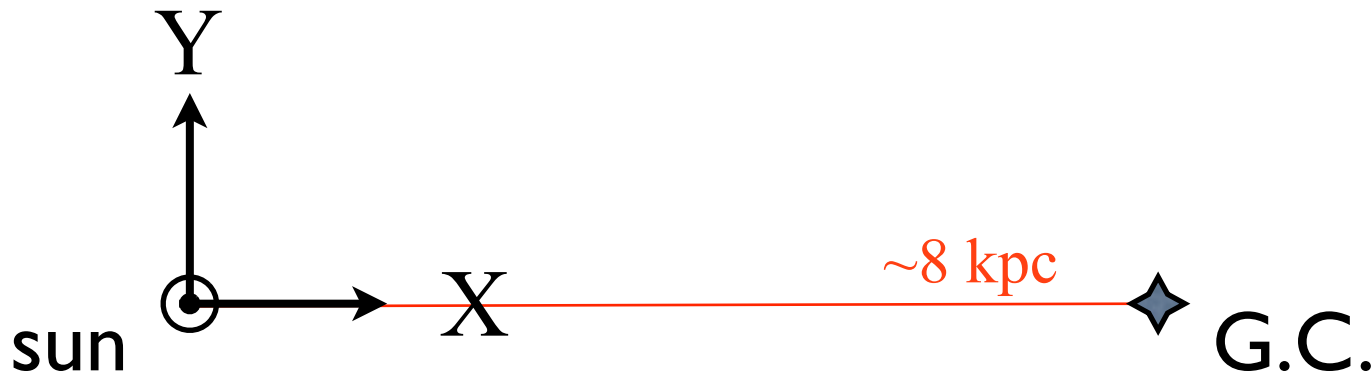
$A$  Oort constant A

$B$  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  $15 \text{ km/s}$ !

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!)