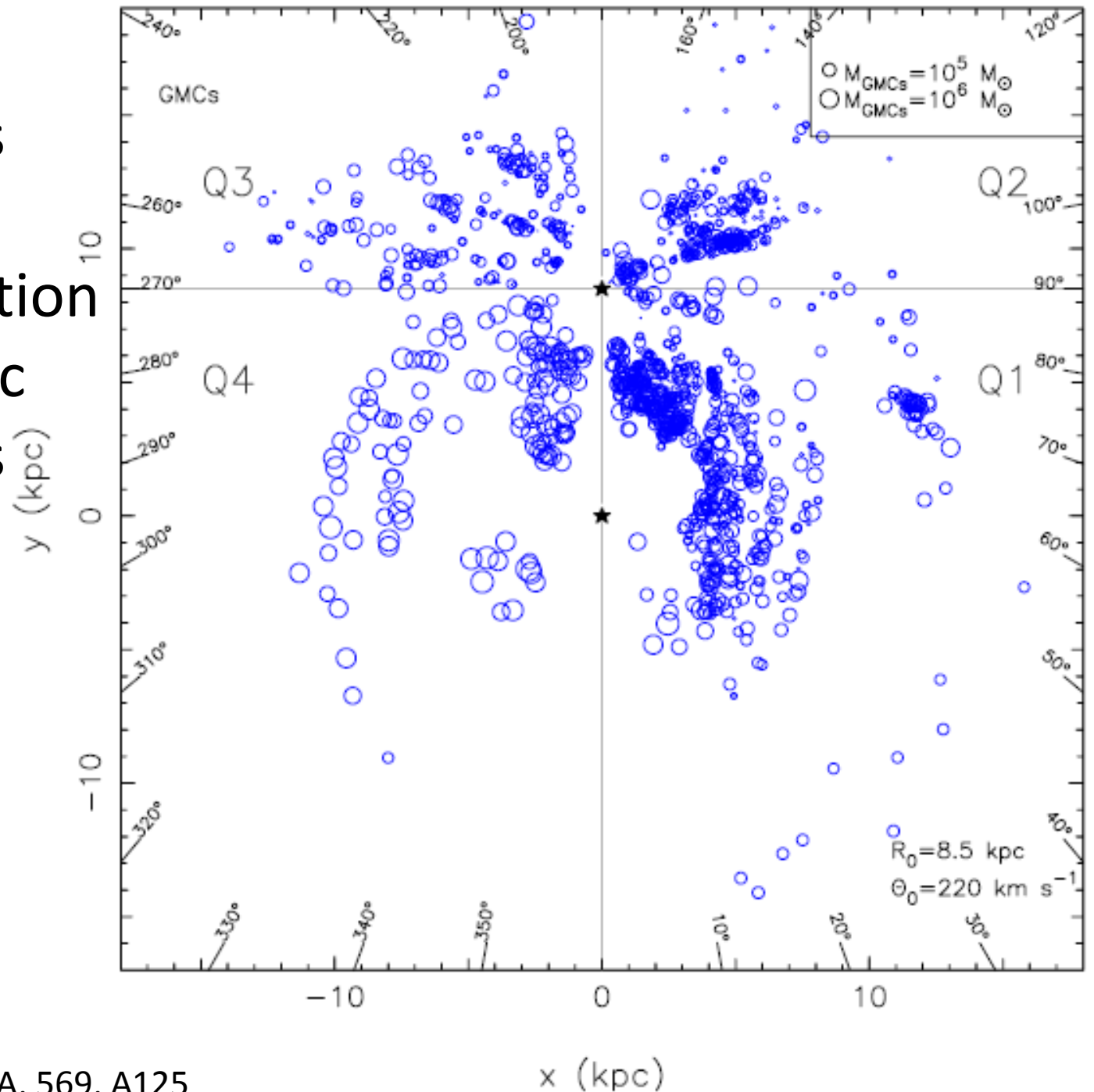
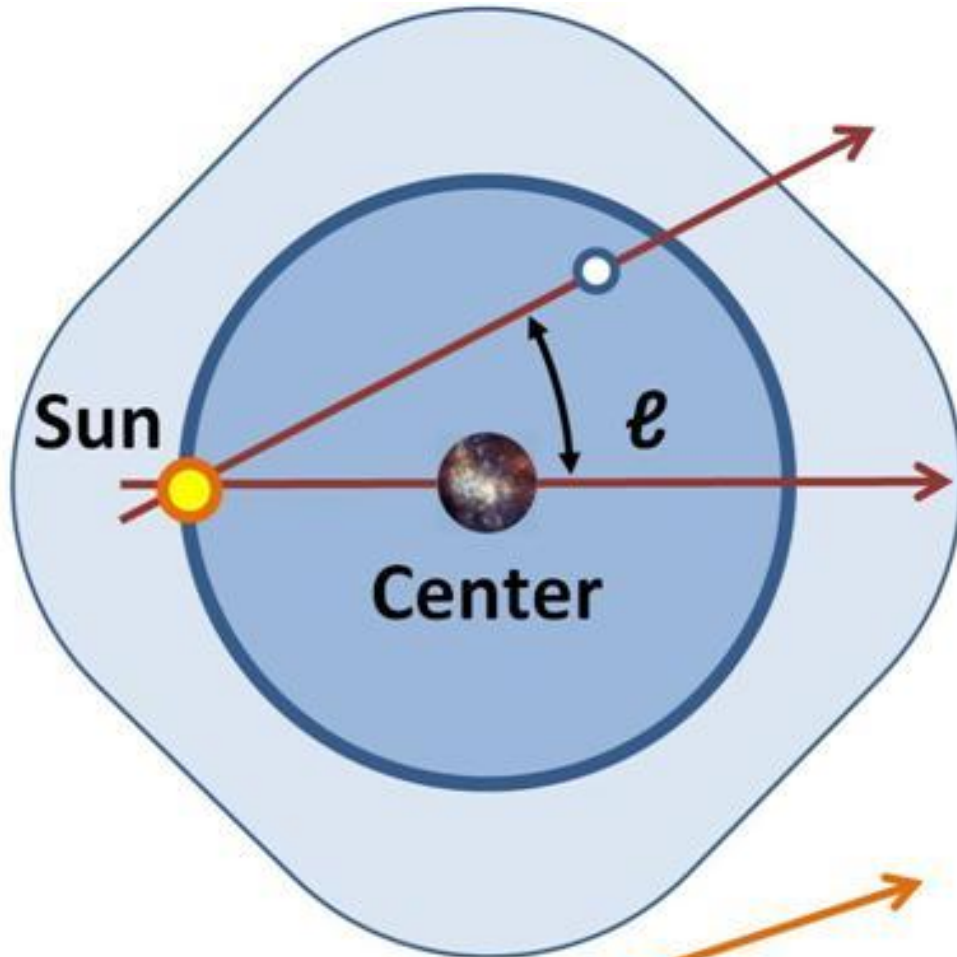


Galactic
coordinates

Transformation
from ecliptic
coordinates

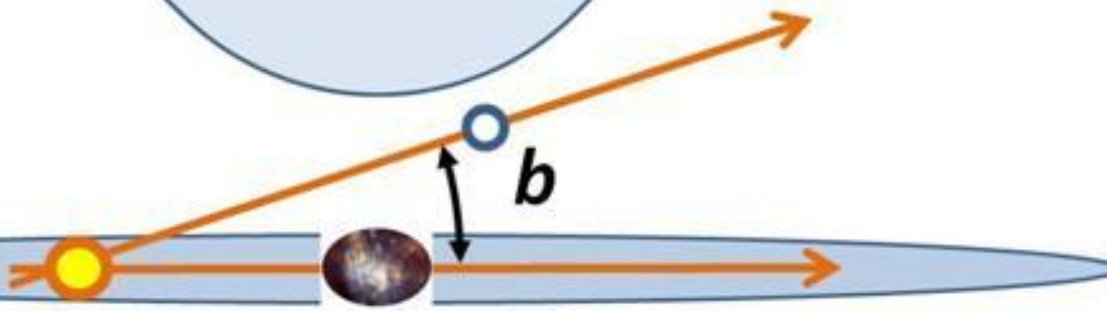


Galactic coordinates



Sun about
20pc “above”
(north) of
Galactic
disk

Disc

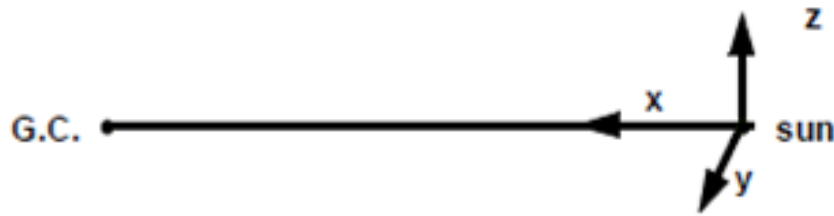


Galactic coordinates

Place	α (hour)	δ (degree)	l (degree)	b (degree)
Galactic Center	12h 45.6m	-28.94d	0d	0d
Galactic Anti-Center	5h 45.6m	+28.94d	180d	0d
Galactic North Pole	12h 51.4m	+27.13d	0d	+90d
Galactic South Pole	0h 51.4m	-27.13d	0d	-90d

$0 < \alpha < 24\text{h}$; $-90 < \delta < +90\text{d}$, $0 < l < 360\text{d}$, $-90 < b < +90\text{d}$

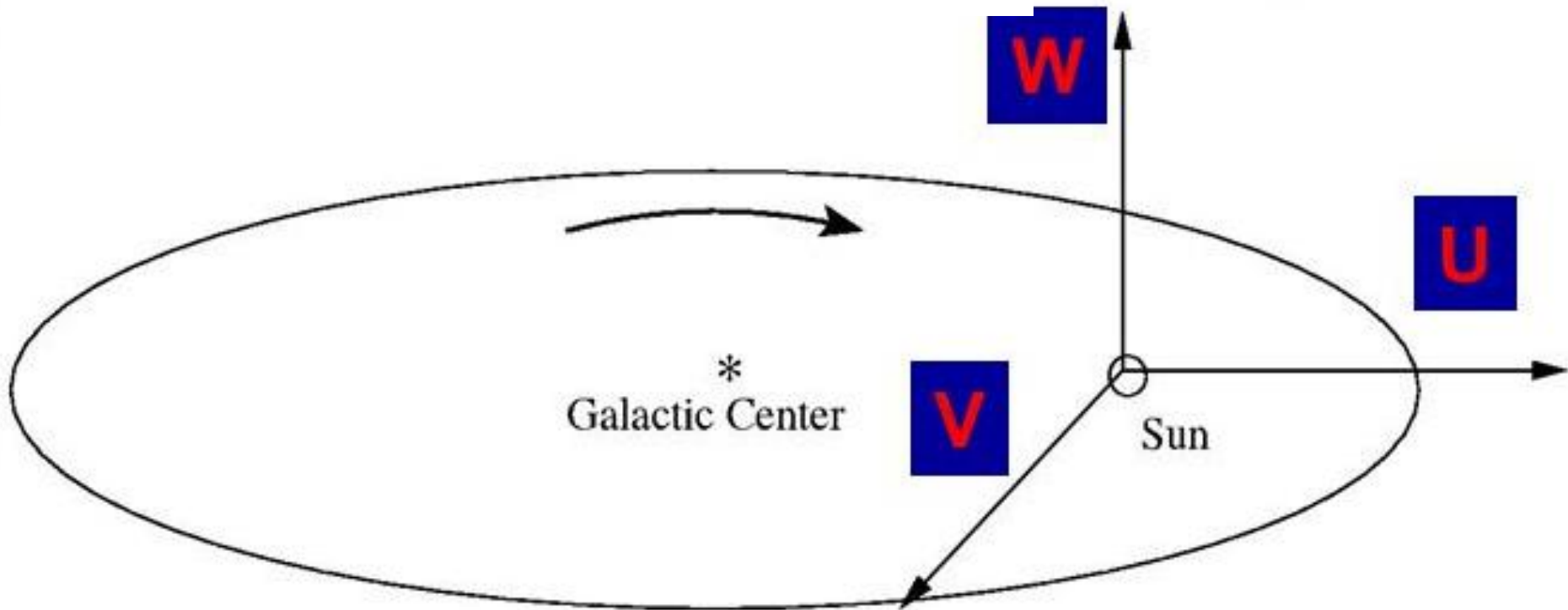
Galactic Components



Be careful about the sign/direction of X and U

- **coordinates:**

- x: $l = 0$ $b = 0$ (Galactic Centre)
- y: $l = 90$ $b = 0$ (Cygnus) direction of disc rotation
- z: $b = 90$ (North Galactic Pole)



Galactic Components



- **coordinates:**

- x: $l = 0$ $b = 0$ (Galactic Centre)
- y: $l = 90$ $b = 0$ (Cygnus) direction of disc rotation
- z: $b = 90$ (North Galactic Pole)

- **star positions:**

- $x = r \cos b \cos l$
- $y = r \cos b \sin l$
- $z = r \sin b$

$$r = \sqrt{x^2 + y^2 + z^2}$$

distance from sun
to star

- **star velocities:**

$$u, v, w \equiv \dot{x}, \dot{y}, \dot{z}$$

stellar velocities

- **star velocities:** $(u, v, w) \equiv \frac{d}{dt}(x, y, z) = (\dot{x}, \dot{y}, \dot{z})$

$$u = \dot{x} = \dot{r} \cos b \cos l + r(-\dot{b} \sin b) \cos l + r \cos b(-\dot{l} \sin l)$$

$$v = \dot{y} = \dot{r} \cos b \sin l + r(-\dot{b} \sin b) \sin l + r \cos b \dot{l} \cos l$$

$$w = \dot{z} = \dot{r} \sin b + r \dot{b} \cos b$$

- **Note:**

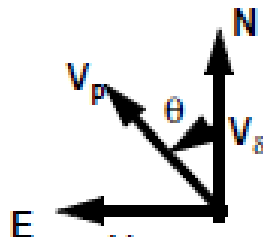
- radial velocity $\dot{r} = v_r$; velocity components along l and b ,
 $[\cos b] r \dot{l} = v_l$; $r \dot{b} = v_b$

$$u = v_r \cos b \cos l - v_b \sin b \cos l - v_l \sin l$$

$$v = v_r \cos b \sin l - v_b \sin b \sin l + v_l \cos l$$

$$w = v_r \sin b + v_b \cos b$$

motions on plane of sky



$$v_{\delta} = r\mu_{\delta}$$

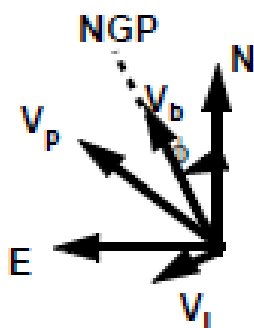
$$v_{\alpha} = r\mu_{\alpha}$$

$$v_p = \sqrt{v_{\alpha}^2 + v_{\delta}^2};$$

$$\tan \theta = \frac{v_{\alpha}}{v_{\delta}}$$

- θ : position angle of proper motion (from N to E)

- in Gal coords:



ϕ : position angle of NGP

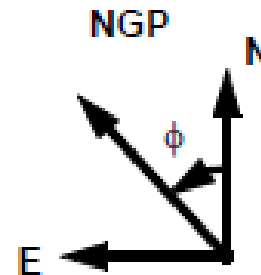
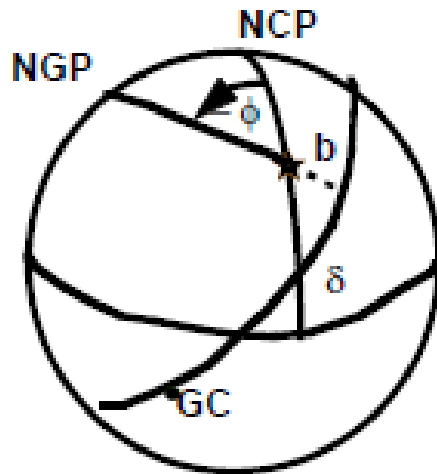
$$v_l = v_{\alpha} \cos \phi - v_{\delta} \sin \phi$$

$$v_b = v_{\alpha} \sin \phi + v_{\delta} \cos \phi$$

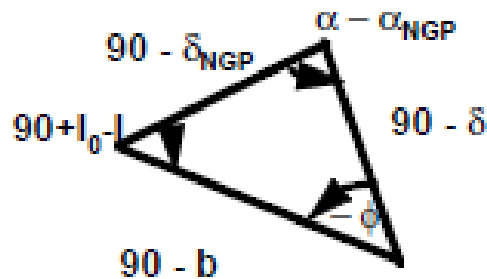
$$v_p = \sqrt{v_l^2 + v_b^2};$$

$$\tan(\theta - \phi) = \frac{v_{\alpha}}{v_{\delta}}$$

Galactic Parallaxic Angle



ϕ = position angle (from N to E)
of NGP at the star



$$\cos \phi = \frac{\sin \delta_{NGP} - \sin \delta \sin b}{\cos \delta \cos b}$$

$$\sin \phi = \frac{-\sin(\alpha - \alpha_{NGP}) \cos \delta_{NGP}}{\cos b}$$

Summary

- **Observe:**

$$\alpha, \delta, r, v_r, \mu_\alpha, \mu_\delta$$

- **Calculate:**

$$\alpha, \delta \Rightarrow l, b$$

$$\alpha, \delta, b \Rightarrow \phi$$

$$r, \mu_\alpha, \mu_\delta \Rightarrow v_\alpha, v_\delta$$

$$v_\alpha, v_\delta, \phi \Rightarrow v_l, v_b$$

$$v_r, v_l, v_b, b, l \Rightarrow u, v, w$$

$$r, l, b \Rightarrow x, y, z$$