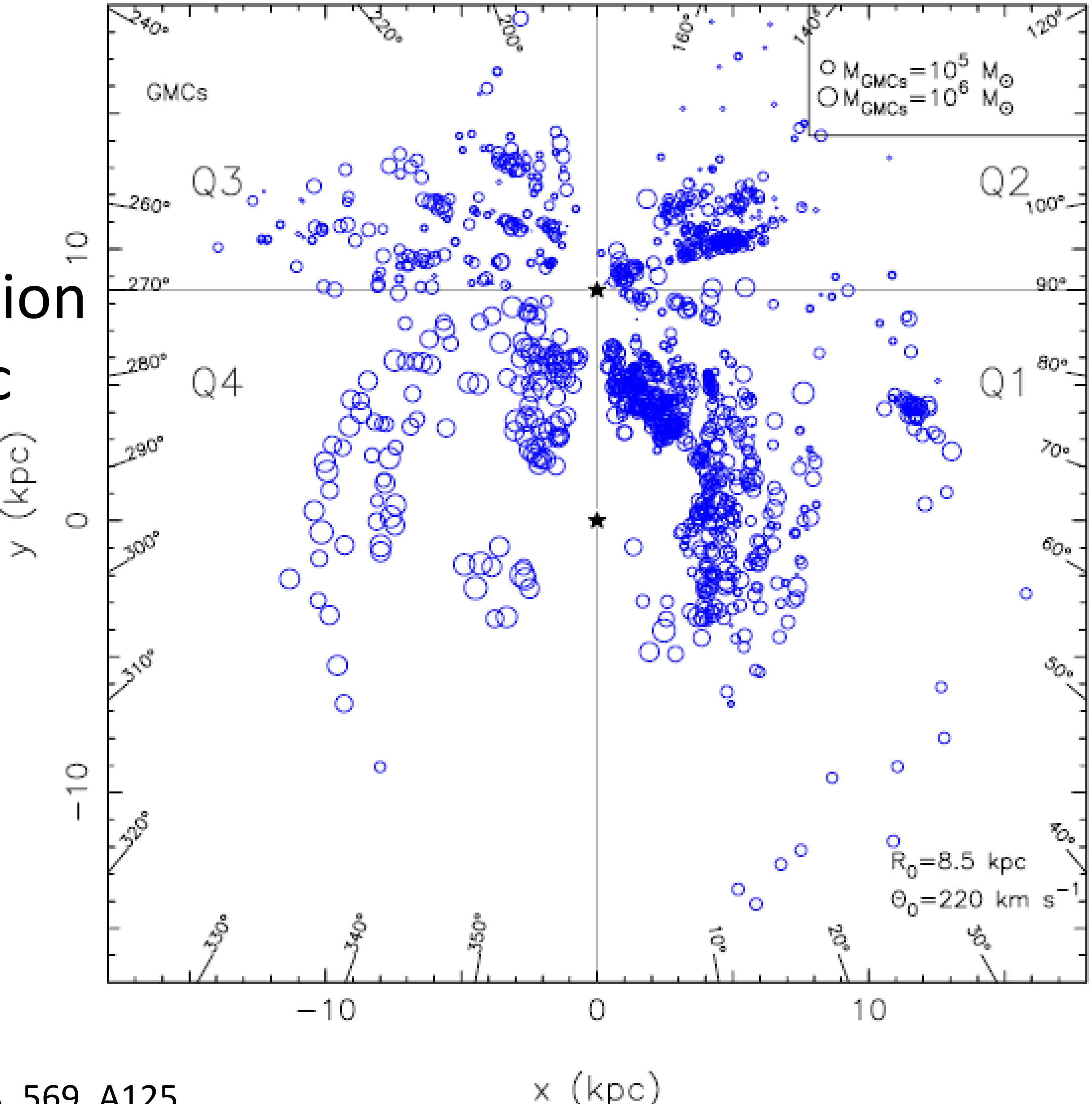
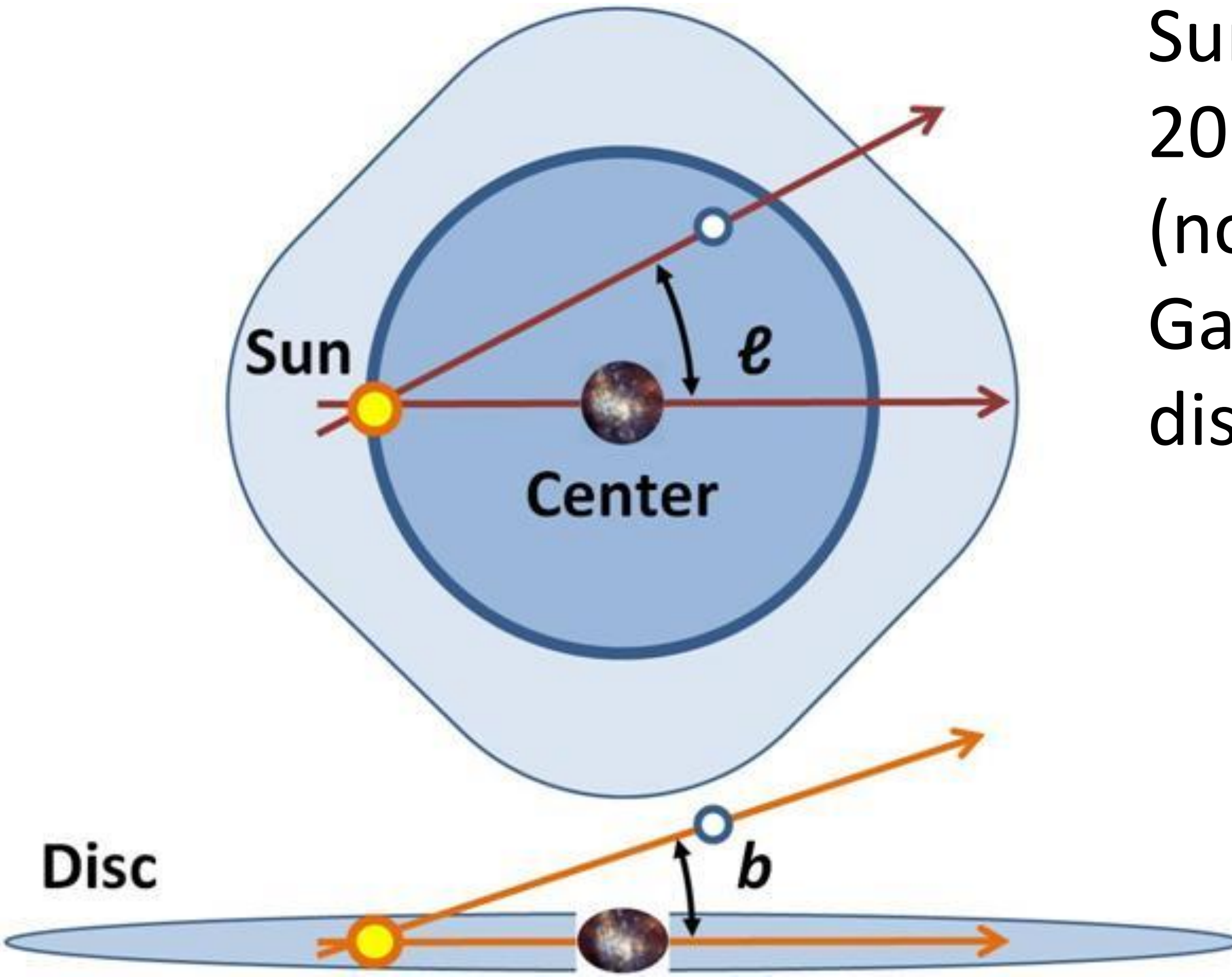
Galactic coordinates

Transformation from ecliptic coordinates



Hou & Han, 2014, A&A, 569, A125

Galactic coordinates



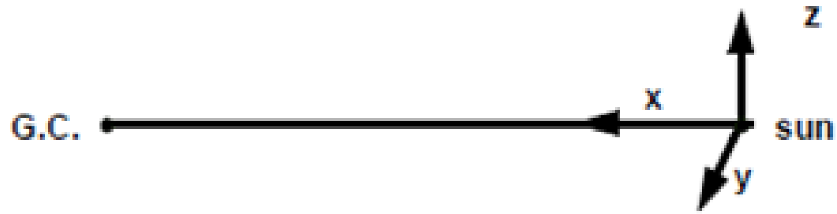
Sun about 20pc "above" (north) of Galactic disk

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

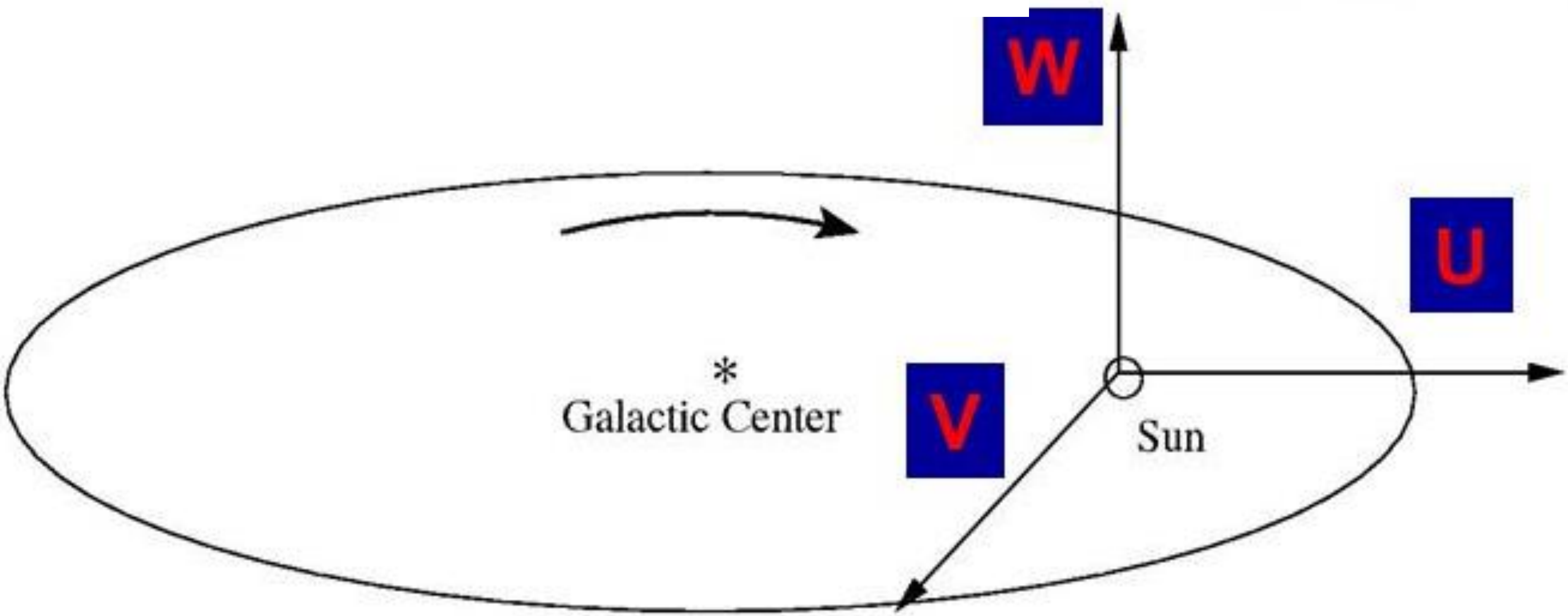
$0 < \alpha < 24h$; $-90 < \delta < +90d$, $0 < l < 360d$, $-90 < b < +90d$

Galactic Components

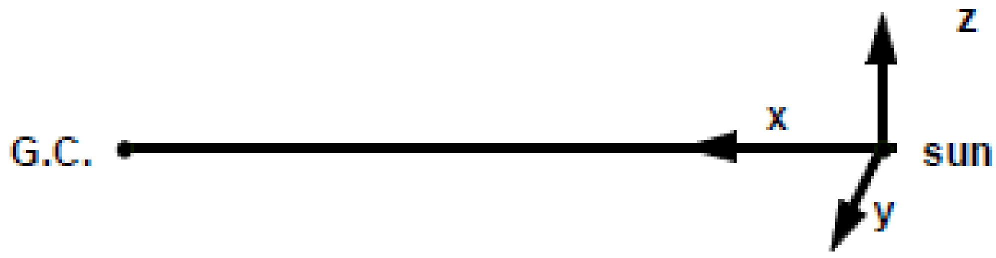


- **coordinates:**
  - x: l = 0 b = 0 (Galactic Centre)
  - y: l = 90 b = 0 (Cygnus) direction of disc rotation
  - z: b = 90 (North Galactic Pole)

Be careful about the sign/direction of X and U



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

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

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

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

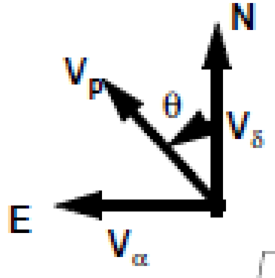
- **Note:**
  - radial velocity $\dot{r} = v_r$; velocity components along l and b, $[\cos b]r\dot{l} = v_l$; $r\dot{b} = v_b$

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

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

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

motions on plane of sky



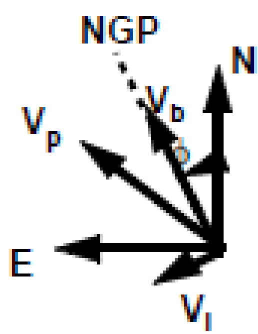
$$v_\delta = r\mu_\delta$$

$$v_\alpha = r\mu_\alpha$$

$$v_p = \sqrt{v_\alpha^{\ 2} + v_\delta^{\ 2}}; \qquad \tan\theta = {v_\alpha}/{v_\delta}$$

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

- in Gal coords:



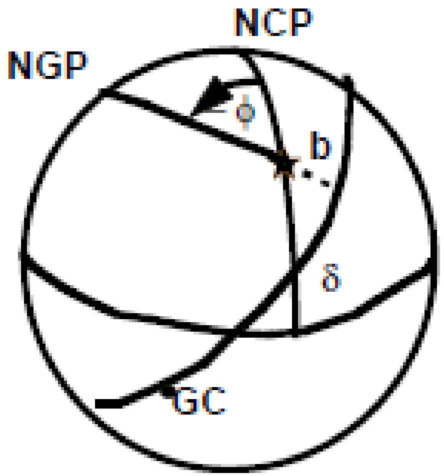
ϕ : position angle of NGP

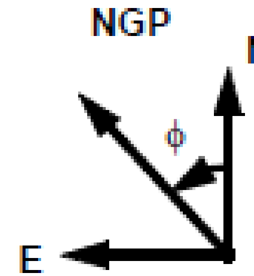
$$v_l = v_\alpha \cos\phi - v_\delta \sin\phi$$

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

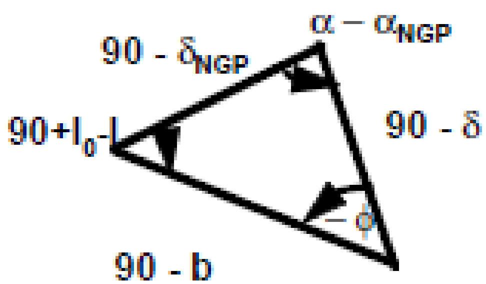
$$v_p = \sqrt{v_l^{\ 2} + v_b^{\ 2}}; \qquad \tan(\theta - \phi) = {v_\alpha}/{v_\delta}$$

Galactic Parallactic 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:**

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

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

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

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

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

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