Velocity Curve Activity

The Tangent Method For Determining The Galactic Rotational Velocity

Study the figures below to try to understand the "tangent method", applied to radio astronomy spectra. This method is used for determining the speed of the galaxy as a function of distance from the galactic center (GC).

Note the following:

- A radio telescope will detect radio waves from objects at all points along the same line from the galaxy, regardless of the distance of those points from the earth (i.e. the sun in the diagrams).
- Assume the hydrogen is moving in circular orbits around the galactic center.
- The motion of the hydrogen whose tangent motion is along the direction toward the sun has the greatest speed along the line of sight from the sun compared to points where the motion is not tangent, as illustrated in Figure 1.

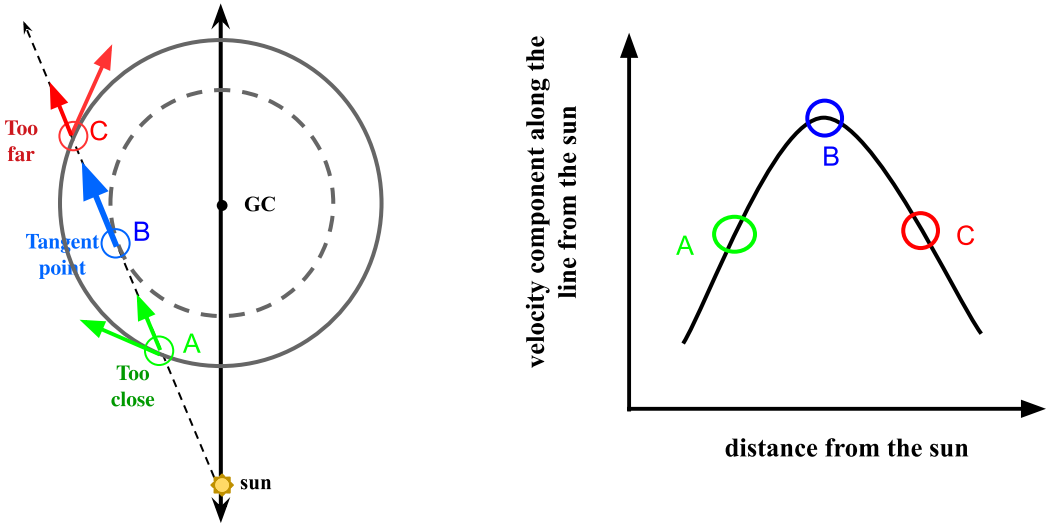


Figure 1

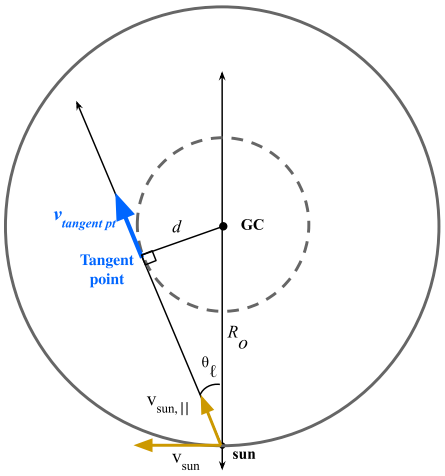
- The velocity of the hydrogen ***relative*** to the earth can be determined using the Doppler shift.

- The motion of the sun must be taken into account when determining the actual velocity of the detected hydrogen. The sun's (our) velocity along the direction of the tangent line to the point of interest must be added to the measured relative velocity:

$$v_{tangent\ pt} = v_{radio\ telescope\ spectrum} + v_{sun\ tangent\ line}$$

$$v_{tangent\ pt} = v_{radio\ telescope\ spectrum} + v_{sun}\ sin\ \theta_{\ell}$$

See Figure 2 below.



R_o = distance of sun from GC = 8.0 kpc

d = distance of tangent point from GC = $R_o \sin\theta_\ell$

$v_{sun,||} = v_{sun} \cdot \sin\theta_\ell$ = motion of sun along tangent line

$v_{tangent\ pt} = v_{radio\ telescope} + v_{sun,||}$

Figure 2

- The sun's orbital speed, v_{sun}, around the galactic center is approximately 200 km/s.
- The distance of the tangent point from the galactic center can be calculated using the trigonometric identity indicated in Figure 2.