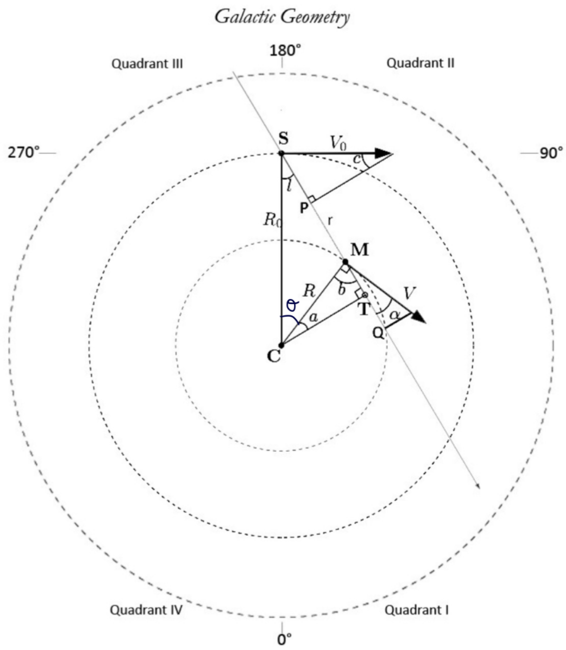
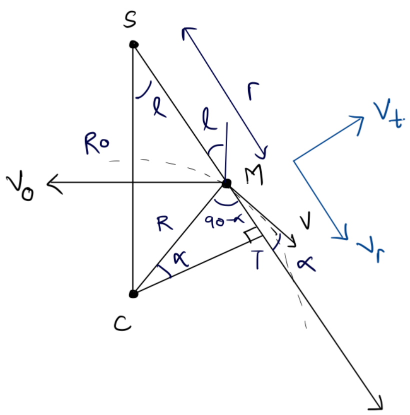
Tangent Point Method

Lumos

If the HI emission is measured inside the Solar-system radius, the tangent-point method can be used to derive the rotation curves. Suppose the motion of an object is relative to the Sun. In that case, the movement towards or away from the Sun is called radial velocity V_r, and the motion perpendicular to the direction of the Sun is called tangential velocity V_t. The combination of the two motions is called the spatial velocity of the object. The radial component of the velocity is responsible for a Doppler shift of the spectral lines that can be determined directly, even if the distance is unknown.



IN LSR FRAME OBSERVING HI CLOUD M ; [V_r & V_t]



$V_r = V\cos\alpha - V_0 \sin l$

$[CT] = R\cos\alpha$

In ΔCST;

$[CT] = R_0 \sin l$

$\therefore R_0 \sin l = R\cos\alpha$

$\therefore \cos\alpha = \dfrac{R_0 \sin l}{R}$

$$V(R_0) \equiv V_0 \tag{1}$$

$$V_r = V(R)\frac{R_0}{R}\sin l - V_0 \sin l \tag{2}$$

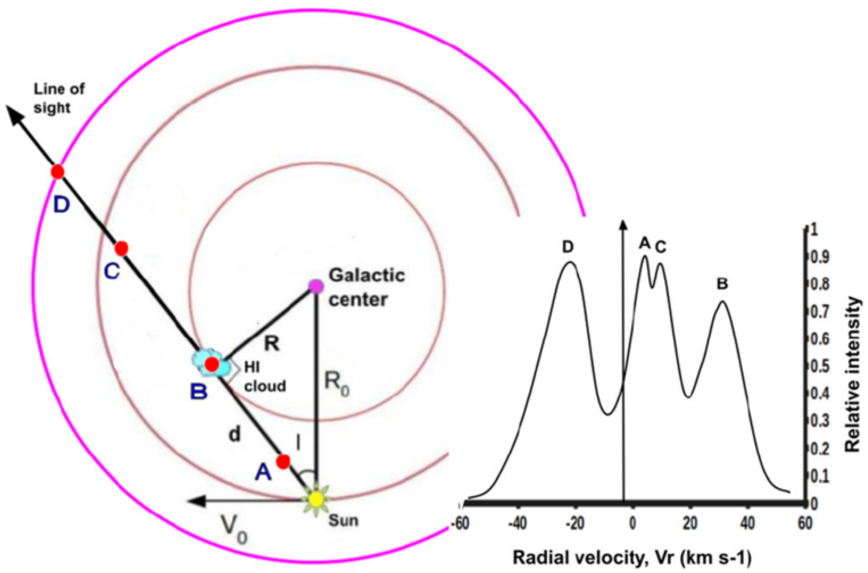
We preliminarily assume that $V(R) \approx V(R_0)$, and we obtain:

$$R \approx \frac{R_0 V(R_0)\sin l}{V_r + V(R_0)\sin l} \tag{3}$$

From equation (3), we learn that if the distance between the observation HI cluster and the galactic center takes the minimum value, i.e., $R_{\mathrm{min}} = R_0 \sin l$, under the fixed observation l, the radial velocity V_r will take the maximum value V_{rmax}. Here we take the V_{rmax} as the radial velocity corresponding to the right foot of the rightmost peak in the spectrum figure given below. We can calculate:

$$V(R) = V_{\mathrm{rmax}} + V(R_0)\sin l \tag{4}$$

Combining $V(R)$ with corresponding R_{min}, we draw the rotation curve. The above approximation process essentially proposes the method of tangent line fitting for drawing the rotation curve.



The Galactic structure can be derived using the observations. This requires knowledge of the Gaussian fitted spectra and the rotation curve, where for each peak we use the value of V_r and l to calculate the distance from the center. The position of each peak can be plotted on a polar plot in terms of R and θ.