ASTR 5500

Assignment 4.

1. For gas in the 1st Galactic quadrant following circular orbits about the Galactic centre, we have:

$v_R(\max) = \theta(R_{min}) - \theta_0 \sin l$, where

$R_{min} = R_0 \sin l$

$\therefore v_R(\max) = \theta(R_0 \sin l) - \theta_0 \sin l$

$\theta(R_{min}) = v_R(\max) + \theta_0 \sin l$

For the data cited; with $R_0 = 8.5$ kpc, $\theta_0 = 251$ km/s:

l	$\sin l$	v_{max}	R_{min}	$\theta(R_{min})$
15°	0.2588	123 km/s	2.20 kpc	188.0 km/s
30°	0.5000	95 km/s	4.25 kpc	220.5 km/s
45°	0.7071	64 km/s	6.01 kpc	241.5 km/s
60°	0.8660	29 km/s	7.36 kpc	246.4 km/s
75	0.9659	7.5 km/s	8.21 kpc	249.9 km/s

The plot differs according to the data set employed (see results with Santo & Uddin data (2013, IJA, 2, 37)).

2. Kinetic Energy, $KE = \frac{1}{2} m v^2$

$\therefore KE(3\,\text{kpc arm}) = \frac{1}{2} \times 10^8 M_\odot \times 1.989 \times 10^{30}\,\text{kg} \times (5.0 \times 10^4\,\text{m/s})^2$

$= 2.4863 \times 10^{47}\,\text{J} = 2.5 \times 10^{47}\,\text{J}$

$KE(200\,\text{pc arm}) = \frac{1}{2} \times 10^7 M_\odot \times 1.989 \times 10^{30}\,\text{kg} \times (1.5 \times 10^5\,\text{m/s})^2$

$= 2.2376 \times 10^{47}\,\text{J} = 2.2 \times 10^{47}\,\text{J}$

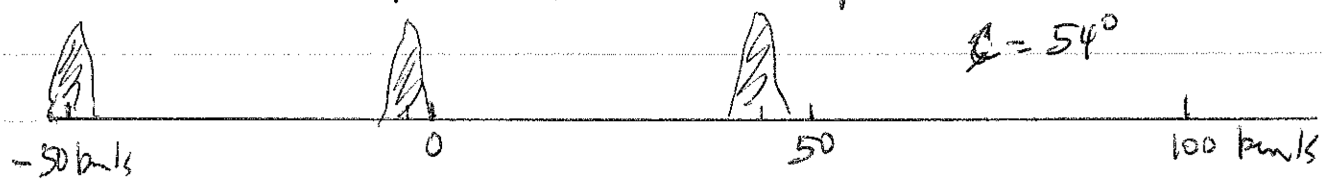
The gravitational potential energy of a 1 solar mass neutron star is $\sim 2 \times 10^{46}$ J, whereas typical energies of Type I and Type Supernovae are $\sim 10^{44}$ J and 10^{43} J, respectively. The energetics required to propel the 3 kpc and 200pc arms of the Galaxy might result from explosions of supermassive stars, say $> 10 M_\odot$

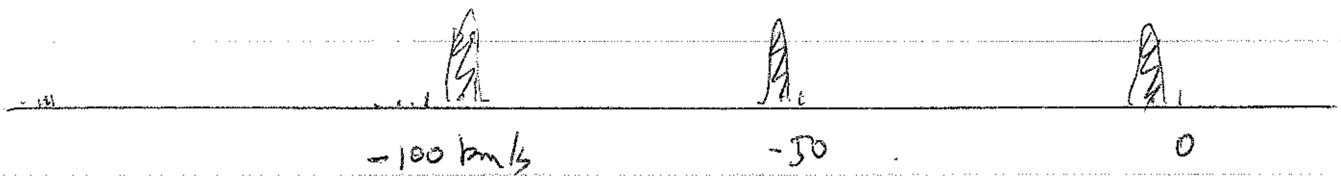
3. For Galactic rotation: $v_R = R_0 \left(\frac{\theta}{R} - \frac{\theta_0}{R_0} \right) \sin l$

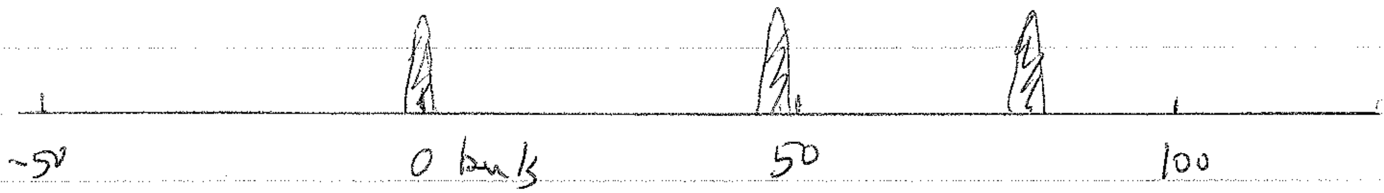
Assume a flat rotation curve, i.e. $\theta = \theta_0 = 251$ km/s and $R_0 = 8.5$ kpc.
The longitudes are $l = 50°$ (54°), 110° (107°), and 230° (243°).
The arm segments can be measured geometrically, yielding:

Segment	R_1	v_R	R_2	v_R	R_3	v_R
1	7.0 kpc	43.6 km/s	8.6 kpc	−3.9 km/s	8.5 kpc	0.0 km/s
2	8.6 kpc	−3.3 km/s	10.9 kpc	−53.0 km/s	10.8 kpc	47.1 km/s
3	11.2 kpc	−48.8 km/s	14.1 kpc	−95.4 km/s	13.3 kpc	80.9 km/s

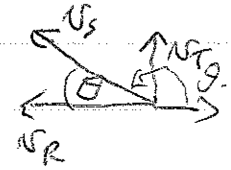
$l = 54°$







4. $d = 1/\pi \text{(arcsec)} = \frac{1}{0.549 \text{ arcsec}} = 1.821 \text{ pc}.$



$\Delta d = d \frac{\Delta \pi}{\pi} = 1.8214936 \text{ pc} \times \frac{1.6}{549} = 0.0053 \text{ pc}.$

$\therefore d = 1.821 \pm 0.005$ pc.

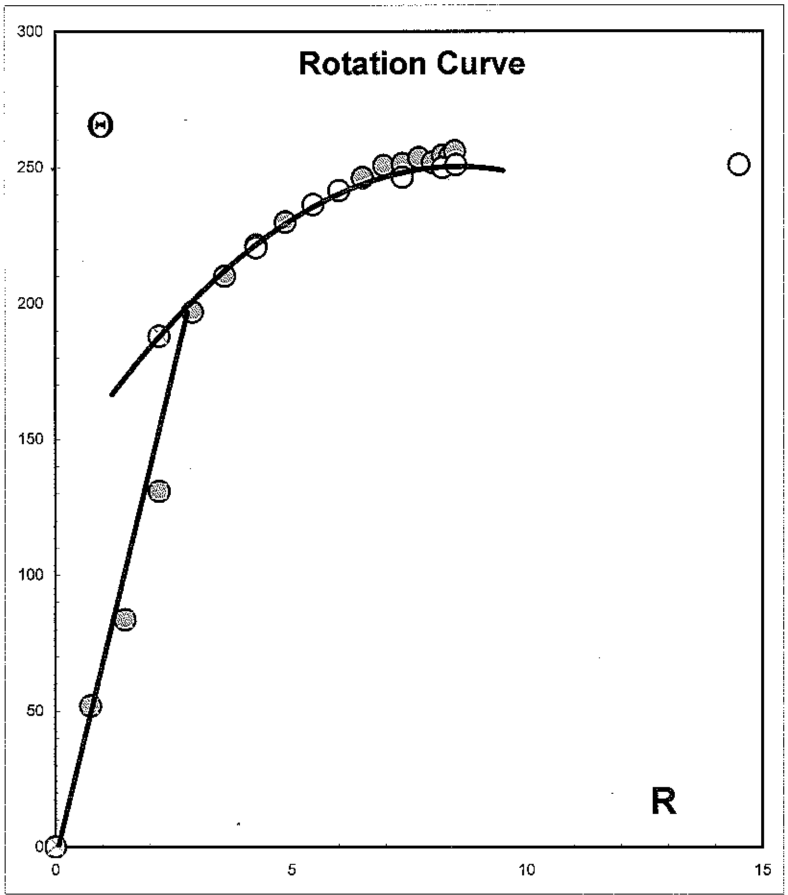
$v_T = 4.74 \mu d = 4.74 \times 10.34 \times 1.821$ km/s $= 89.27$ km/s

$v_{space} = (v_R^2 + v_T^2)^{1/2} = [(-108)^2 + (89.27)^2]^{1/2} = 140.1$ km/s

$v_R = v_{space} \cos\theta$. $\therefore \theta = \cos^{-1}(-108/140.1) = \cos^{-1}(-0.7707622)$

$= 140.4°$ or $39.6°$ relative to line of sight.

l	sin l	Rmin	vmax	theta
15	0.258819	2.199962	123	187.9636
		0	0	0
5	0.087156	0.740824	30	51.87609
10	0.173648	1.47601	40	83.58569
15	0.258819	2.199962	66	130.9636
20	0.34202	2.907171	111	196.8471
25	0.422618	3.592255	104	210.0772
30	0.5	4.25	96	221.5
35	0.573576	4.8754	86	229.9677
40	0.642788	5.463695	75	236.3397
45	0.707107	6.010408	64	241.4838
50	0.766044	6.511378	54	246.2772
55	0.819152	6.962792	45	250.6072
60	0.866025	7.361216	34	251.3724
65	0.906308	7.703616	26	253.4833
70	0.939693	7.987387	16	251.8628
75	0.965926	8.21037	12	254.4474
80	0.984808	8.370866	7	254.1867
85	0.996195	8.467655	6	256.0449



		14.5		251
		0	0	0
15	0.258819	2.199962	123	187.9636
30	0.5	4.25	95	220.5
40	0.642788	5.463695	75	236.3397
45	0.707107	6.010408	64	241.4838
60	0.866025	7.361216	29	246.3724
75	0.965926	8.21037	7.5	249.9474
		8.5		251
		14.5		251

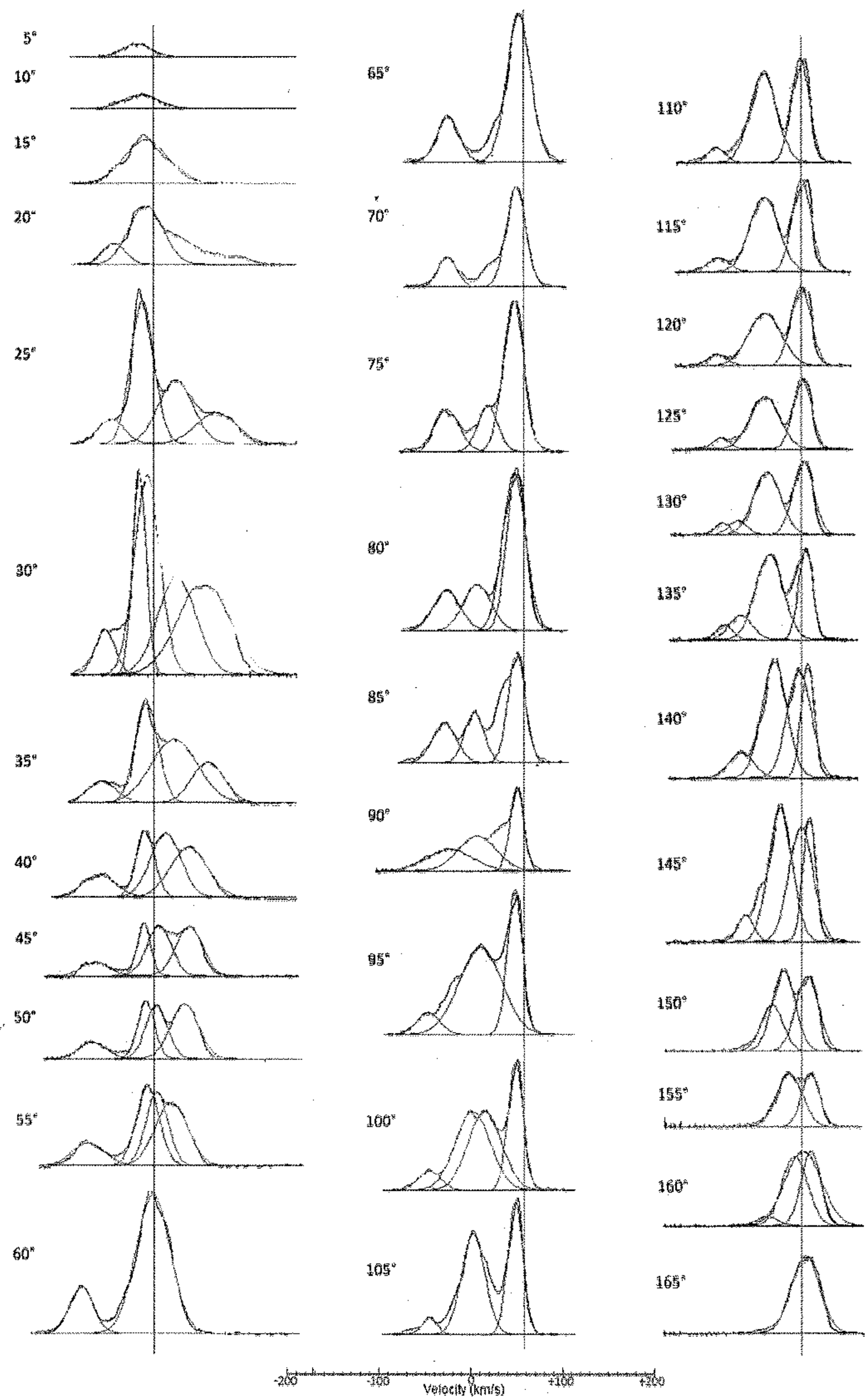


Figure 3. Base line corrected (blue line) and Gaussian fitted line profiles (red) from 5° to 165° galactic longitude

l	sin l	Rmin	ucosl	vsinl	vmax	theta
15	0.258819	2.199962	-11	-1.1	123	174.8242
		0	-11	-0.1	0	0
5	0.087156	0.740824	-11	-0.4	21.5	29.81734
10	0.173648	1.47601	-11	-0.8	37	67.28111
15	0.258819	2.199962	-11	-1.1	75	126.8242
20	0.34202	2.907171	-10	-1.5	137	209.7825
25	0.422618	3.592255	-10	-1.9	145	237.9967
30	0.5	4.25	-9.6	-2.2	142	254.3129
35	0.573576	4.8754	-9.1	-2.5	109	239.584
40	0.642788	5.463695	-8.5	-2.8	95	242.671
45	0.707107	6.010408	-7.8	-3.1	92	255.444
50	0.766044	6.511378	-7.1	-3.4	71	248.7827
55	0.819152	6.962792	-6.4	-3.6	59	249.5781
60	0.866025	7.361216	-5.6	-3.8	52	253.7329
65	0.906308	7.703616	-4.7	-4	38	249.1621
70	0.939693	7.987387	-3.8	-4.1	32	250.7939
75	0.965926	8.21037	-2.9	-4.3	24	248.5703
80	0.984808	8.370866	-1.9	-4.3	21.5	249.9474
85	0.996195	8.467655	-1	-4.4	21	251.3956
90	1	8.5	-0	-4.4	22	252.4
		14.5				251

		14.5				251
		0			0	0
15	0.258819	2.199962			123	187.9636
30	0.5	4.25			95	220.5
40	0.642788	5.463695			75	236.3397
45	0.707107	6.010408			64	241.4838
60	0.866025	7.361216			29	246.3724
75	0.965926	8.21037			7.5	249.9474
		8.5				251
		14.5				251