VERA のデータ解析結果の報告

2016 年 10 月 3 日

永山匠、VERA プロジェクトチーム

1 解析結果

VERA で観測済みの水メーザー源約 180 天体のうち、未解析のデータと再解析が必要なデータの解析を進めた。35 天体解析し、27 天体で固有運動・年周視差が測定できた。表 1 に解析した天体リストを示す。

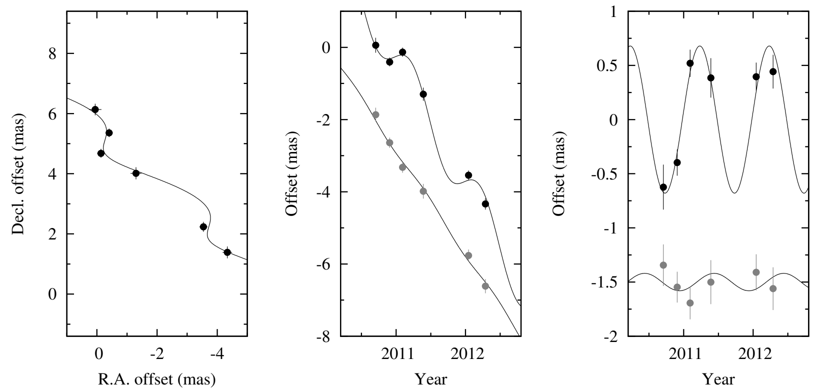
表 1: 天体リスト

No	Name	l	b	α(J2000)	δ(J2000)	π	$\mu_\alpha \cos\delta$	μ_δ	$v_{\rm LSR}$
		(deg)	(deg)			(mas)	(mas yr^{-1})	(mas yr^{-1})	(km s^{-1})
1	IRAS1814	13.657	−0.599	18h17m24.2446s	−17d22'12.782"	...	...	...	50.6
2	IRAS1815	14.228	−0.509	18h18m12.3118s	−16d49'27.994"	0.693 ± 0.137	-3.36 ± 0.16	-2.88 ± 0.13	9.0
3	02301-00	23.010	−0.411	18h34m40.3191s	−09d00'38.132"	0.304 ± 0.045	-0.39 ± 0.09	-4.61 ± 0.18	79.5
4	G35.03	35.025	0.350	18h54m00.6456s	+02d01'19.393"	0.457 ± 0.025	-1.44 ± 0.03	-4.36 ± 0.07	44.3
5	W48	35.200	−1.736	19h01m45.5423s	+01d13'32.573"	0.394 ± 0.029	-0.50 ± 0.71	-4.11 ± 0.42	41.1 ± 1.2
6	I18517	37.430	1.518	18h54m14.2947s	+04d41'40.559"	0.505 ± 0.059	3.48 ± 0.09	-2.26 ± 0.15	37.6
7	18553+04	37.498	0.530	18h57m53.3876s	+04d18'17.394"	0.077 ± 0.018	-2.75 ± 0.12	-5.52 ± 0.07	10.8 ± 2.2
8	18563+04	37.820	0.413	18h58m53.8800s	+04d32'15.004"	0.082 ± 0.029	-2.82 ± 0.11	-5.44 ± 0.11	17.9 ± 0.7
9	S76E	40.496	2.539	18h56m11.4413s	+07d53'17.608"	0.521 ± 0.024	-0.89 ± 0.34	-2.27 ± 0.56	31.9 ± 1.7
10	I19087+0	43.261	−0.210	19h11m11.7000s	+09d05'06.000"	...	...	...	...
11	I19088+0	43.307	−0.211	19h11m17.2311s	+09d07'32.135"	0.136 ± 0.023	-2.16 ± 0.04	-5.26 ± 0.05	59.2
12	G45.07	45.072	0.133	19h13m22.0696s	+10d50'55.399"	0.235 ± 0.042	-3.14 ± 0.08	-5.44 ± 0.15	63.4
13	IRAS1918	48.606	0.023	19h20m31.1861s	+13d55'25.176"	0.084 ± 0.015	-2.89 ± 0.03	-5.43 ± 0.04	20.7
14	I19446	61.476	0.094	19h46m47.9175s	+25d12'52.698"	0.279 ± 0.055	-0.24 ± 0.23	-6.35 ± 0.16	59.0
15	I2014+35	73.653	0.194	20h16m21.9324s	+35d36'06.102"	0.119 ± 0.010	-2.49 ± 0.06	-4.07 ± 0.08	-75.6 ± 1.0
16	IRAS2023	74.044	−1.710	20h25m07.8013s	+34d50'34.733"	0.611 ± 0.022	-2.83 ± 0.33	-3.28 ± 0.19	6.8 ± 0.4
17	I2014+37	75.296	1.324	20h16m16.0214s	+37d35'44.888"	0.110 ± 0.014	-2.88 ± 0.02	-4.46 ± 0.02	-57.1 ± 1.8
18	WB93	94.262	−0.411	21h32m31.5000s	+51d02'22.000"	...	...	...	...
19	I22566+5	108.754	−0.988	22h58m46.4000s	+58d44'50.000"	...	...	...	...
20	IC1805W	134.279	0.856	02h29m01.9375s	+61d33'30.999"	0.814 ± 0.013	-1.72 ± 0.11	-1.01 ± 0.18	−42.5
21	G135.28	135.277	2.798	02h43m28.5825s	+62d57'08.390"	0.110 ± 0.009	-0.60 ± 0.16	0.16 ± 0.16	-70.0 ± 1.9
22	IRAS0246	136.384	2.267	02h50m08.9000s	+61d59'53.500"	...	...	...	...
23	G137.07	137.068	3.003	02h58m13.1793s	+62d20'32.915"	0.183 ± 0.012	-0.73 ± 0.14	0.01 ± 0.17	-50.1 ± 0.4
24	NGC1579	165.475	−9.054	04h30m27.4008s	+35d09'17.649"	1.695 ± 0.190	2.84 ± 0.20	-8.32 ± 0.22	7.8
25	WB668	172.874	2.269	05h36m52.4670s	+36d10'58.260"	0.582 ± 0.070	-0.05 ± 0.34	-1.69 ± 0.10	−23.7
26	WB673	173.165	2.355	05h38m00.2573s	+35d59'01.103"	...	...	...	−18.5
27	WB763	188.978	0.933	06h09m08.0300s	+21d38'10.700"	...	...	...	...
28	IRAS0646	209.602	1.195	06h49m37.2030s	+03d30'30.474"	0.452 ± 0.051	-0.69 ± 0.07	0.83 ± 0.13	13.8
29	IRAS0650	211.593	1.056	06h52m45.3205s	+01d40'23.048"	0.283 ± 0.108	-0.72 ± 0.15	0.66 ± 0.19	47.3
30	WB886	212.064	−0.740	06h47m13.3344s	+00d26'05.920"	0.110 ± 0.130	-0.58 ± 0.35	0.77 ± 0.53	55.2
31	IRAS0702	224.337	−2.137	07h04m44.3900s	−11d07'12.450"	0.850 ± 0.070	-0.18 ± 0.91	2.33 ± 0.97	14.6 ± 0.8
32	G226.27	226.273	−0.463	07h14m26.9333s	−12d03'58.884"	0.609 ± 0.070	2.22 ± 0.15	2.72 ± 0.59	16.1
33	IRAS0720	229.561	0.152	07h23m01.8407s	−14d41'32.807"	0.080 ± 0.034	-1.38 ± 0.03	0.60 ± 0.08	57.3
34	IRAS0727	235.685	−1.246	07h30m05.2000s	−20d44'04.500"	...	...	...	...
35	IRAS0742	240.316	0.071	07h44m51.9368s	−24d07'42.811"	0.286 ± 0.035	-1.79 ± 0.04	2.01 ± 0.10	66.4

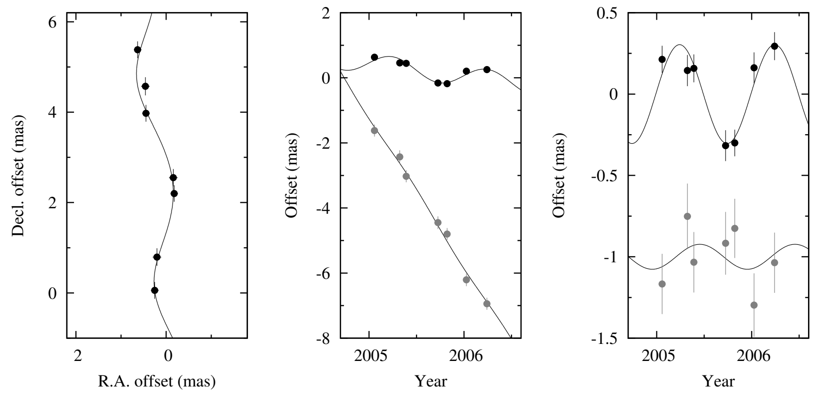
2　年周視差

27 天体の固有運動と視差を示す。18553+04, 18563+04, I19088+0, I2014+35, I2014+37, G135.28, G137.07 など 10 kpc 前後の遠方の天体の視差も得られた。

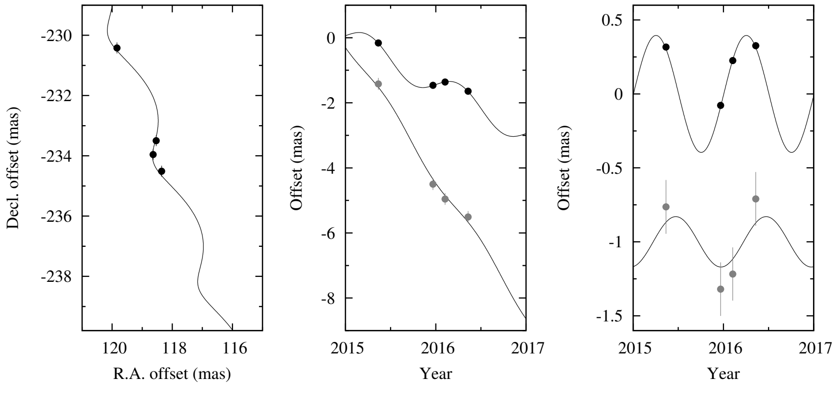
IRAS1815
18h18m12.3118s -16d49'27.994"
π = 0.680±0.133 mas (D = $1.47^{+0.36}_{-0.24}$ kpc)
(μ_x, μ_y) = (-3.46±0.14, -2.87±0.12) mas/yr
(σ_x, σ_y) = (0.137, 0.151) mas



02301-00
18h34m40.3191s -09d00'38.132"
π = 0.304±0.045 mas (D = $3.29^{+0.57}_{-0.42}$ kpc)
(μ_x, μ_y) = (-0.39±0.09, -4.61±0.18) mas/yr
(σ_x, σ_y) = (0.083, 0.187) mas



G35.03
18h54m00.6456s +02d01'19.393"
π = 0.397±0.023 mas (D = $2.52^{+0.15}_{-0.14}$ kpc)
(μ_x, μ_y) = (-1.50±0.03, -4.17±0.27) mas/yr
(σ_x, σ_y) = (0.014, 0.180) mas



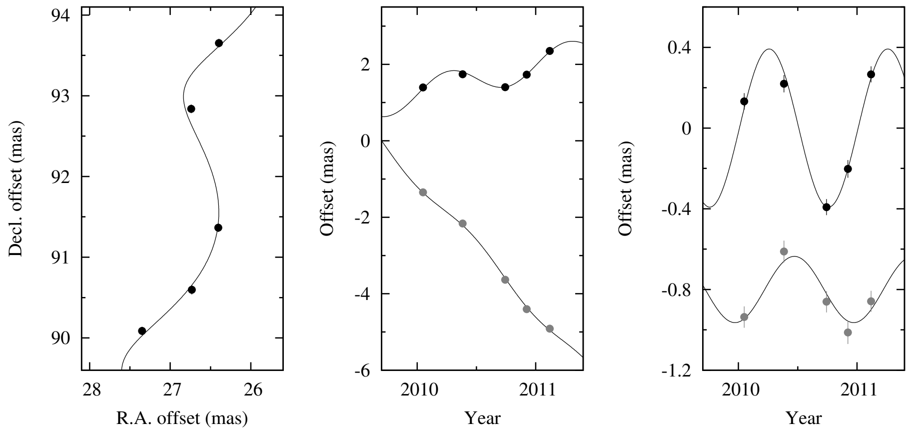
W48

19h01m45.5423s +01d13'32.573"

π = 0.394±0.029 mas (D = $2.54^{+0.20}_{-0.17}$ kpc)

(μ_x, μ_y) = (0.77±0.05, -3.41±0.07) mas/yr

(σ_x, σ_y) = (0.040, 0.054) mas



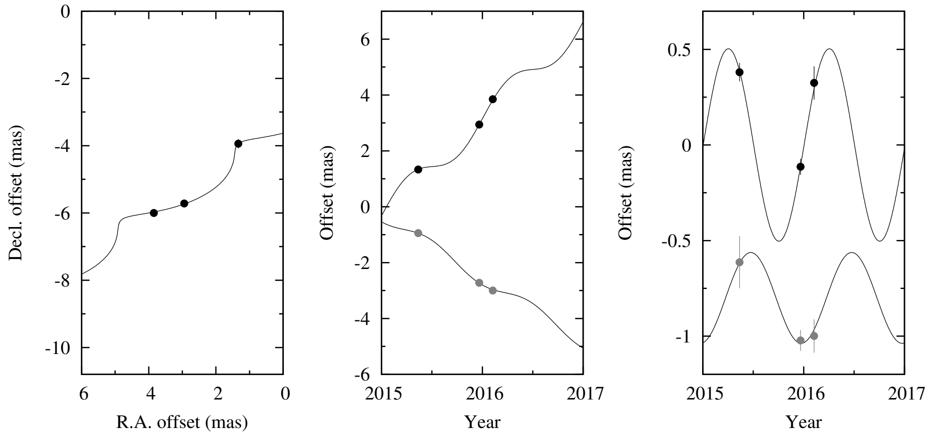
I18517

18h54m14.2947s +04d41'40.559"

π = 0.505±0.059 mas (D = $1.98^{+0.26}_{-0.21}$ kpc)

(μ_x, μ_y) = (3.48±0.09, -2.26±0.15) mas/yr

(σ_x, σ_y) = (0.030, 0.040) mas



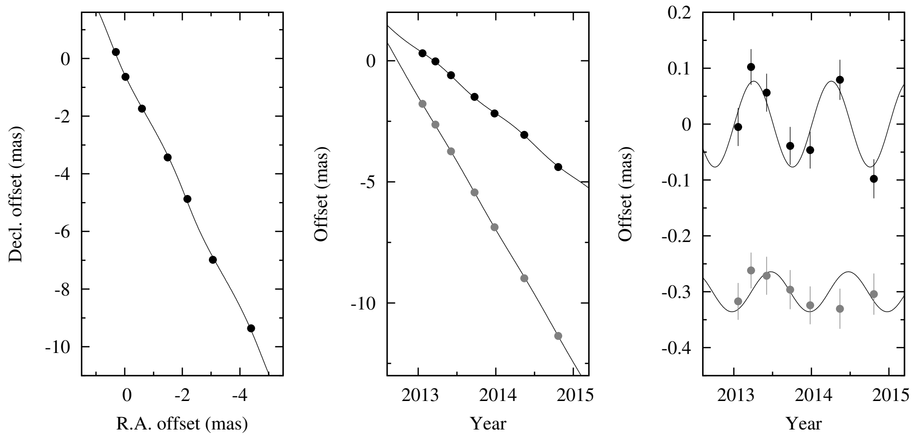
18553+04

18h57m53.3876s +04d18'17.394"

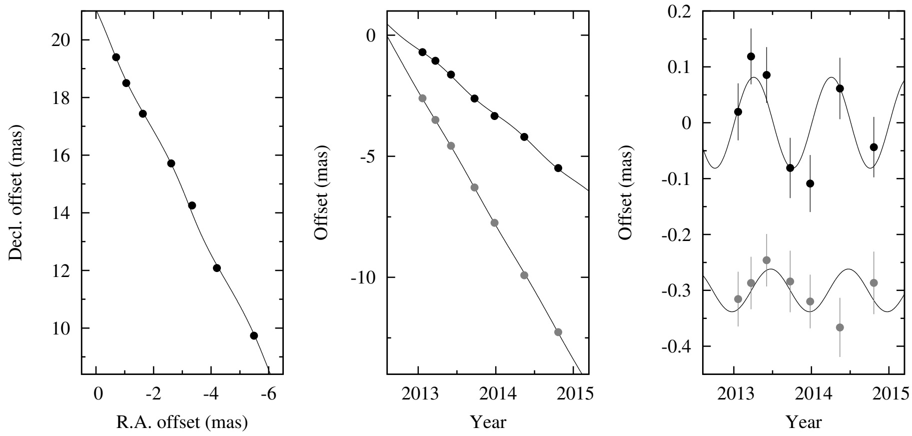
π = 0.077±0.018 mas (D = $13.0^{+4.0}_{-2.5}$ kpc)

(μ_x, μ_y) = (-2.63±0.03, -5.49±0.02) mas/yr

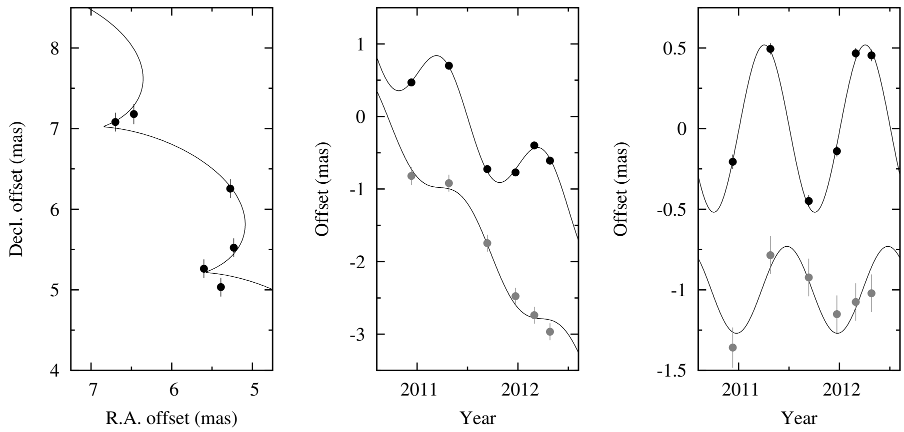
(σ_x, σ_y) = (0.033, 0.033) mas



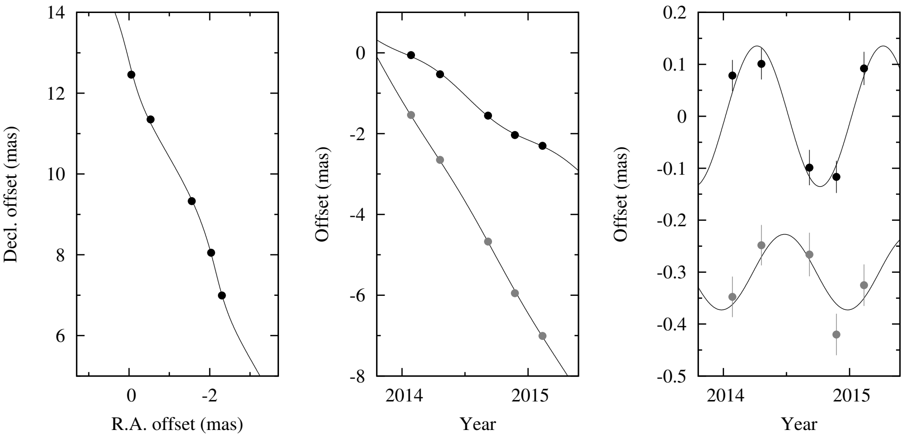
18563+04
18h58m53.8800s +04d32'15.004"
π = 0.082±0.029 mas (D = $12.2^{+6.7}_{-3.2}$ kpc)
(μ_x, μ_y) = (-2.70±0.04, -5.54±0.03) mas/yr
(σ_x, σ_y) = (0.053, 0.048) mas



S76E
18h56m11.4413s +07d53'17.608"
π = 0.521±0.024 mas (D = $1.92^{+0.09}_{-0.08}$ kpc)
(μ_x, μ_y) = (-1.27±0.04, -1.81±0.11) mas/yr
(σ_x, σ_y) = (0.035, 0.120) mas



IRAS19088+0902
19h11m17.2311s +09d07'32.135"
π = 0.136±0.023 mas (D = $7.35^{+1.50}_{-1.06}$ kpc)
(μ_x, μ_y) = (-2.16±0.04, -5.26±0.05) mas/yr
(σ_x, σ_y) = (0.032, 0.040) mas



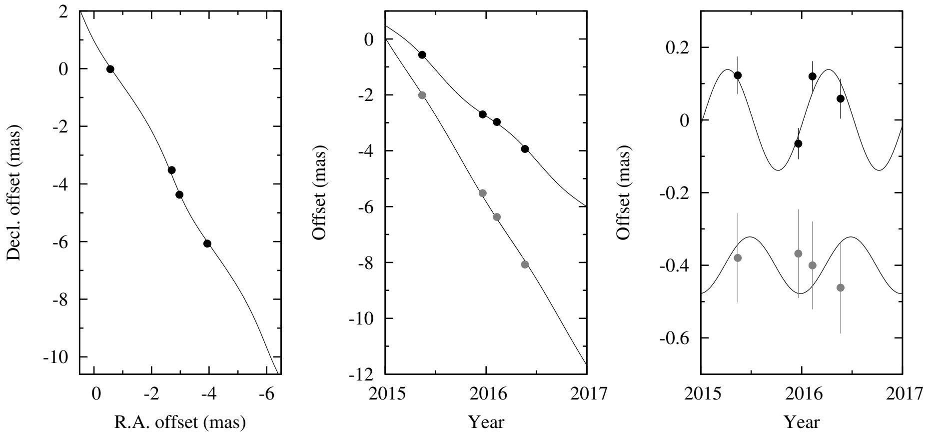
G45.07

19h13m22.0696s +10d50'55.399"

$\pi = 0.140 \pm 0.059$ mas ($D = 7.1^{+5.2}_{-2.1}$ kpc)

$(\mu_x, \mu_y) = (-3.25 \pm 0.08, -5.86 \pm 0.20)$ mas/yr

$(\sigma_x, \sigma_y) = (0.048, 0.127)$ mas



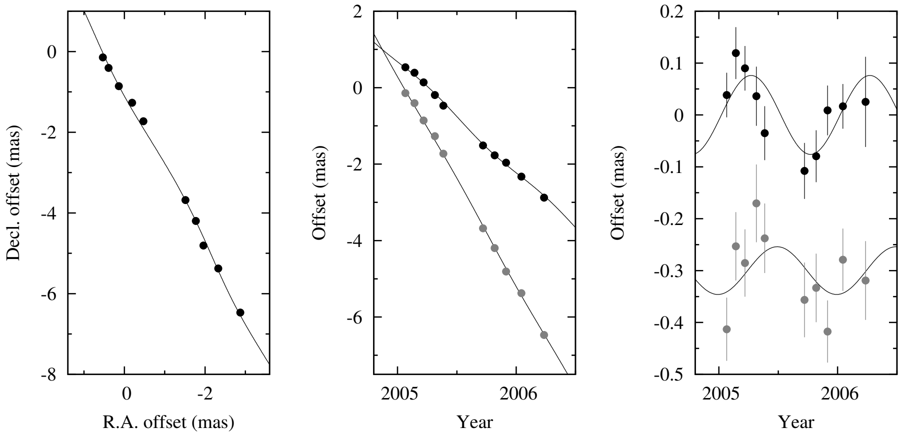
IRAS1918 (TXS1920)

19h20m31.1861s +13d55'25.176"

$\pi = 0.077 \pm 0.026$ mas ($D = 13.0^{+6.6}_{-3.3}$ kpc)

$(\mu_x, \mu_y) = (-2.90 \pm 0.05, -5.49 \pm 0.06)$ mas/yr

$(\sigma_x, \sigma_y) = (0.052, 0.069)$ mas



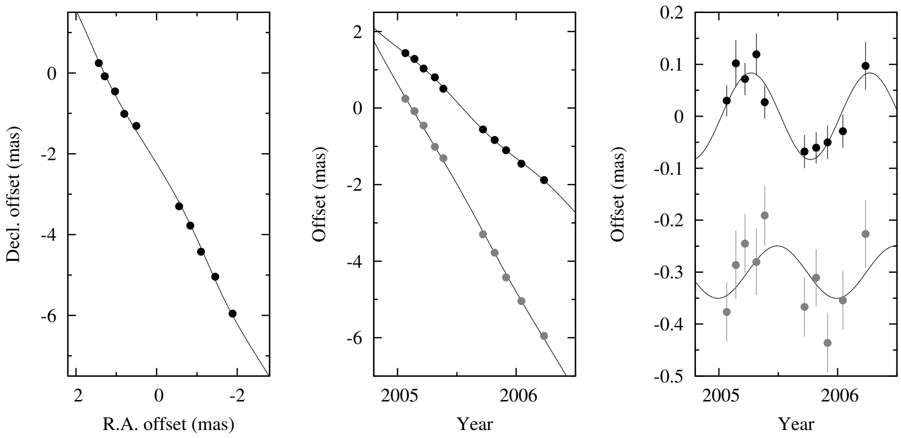
IRAS1918 (TXS1922)

19h20m31.1861s +13d55'25.176"

$\pi = 0.084 \pm 0.015$ mas ($D = 11.9^{+2.6}_{-1.8}$ kpc)

$(\mu_x, \mu_y) = (-2.89 \pm 0.03, -5.43 \pm 0.04)$ mas/yr

$(\sigma_x, \sigma_y) = (0.030, 0.062)$ mas



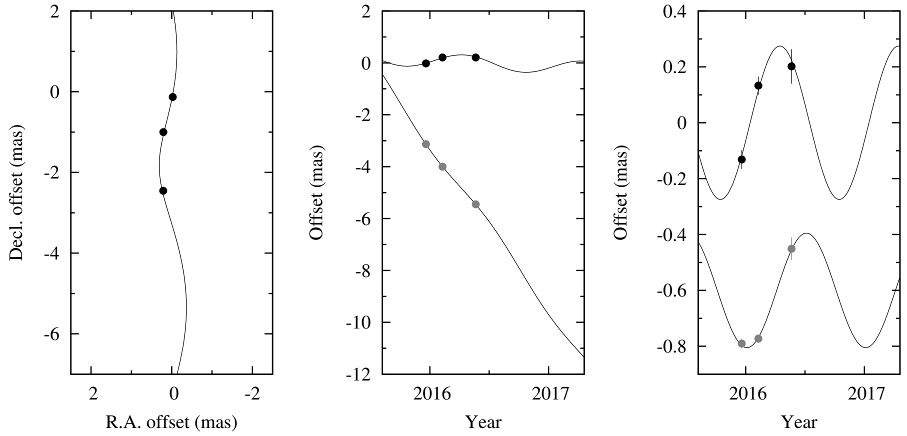
I19446

19h46m47.9175s +25d12'52.698"

$\pi = 0.279 \pm 0.055$ mas (D = $3.6^{+0.9}_{-0.6}$ kpc)

$(\mu_x, \mu_y) = (-0.24 \pm 0.23, -6.35 \pm 0.16)$ mas/yr

$(\sigma_x, \sigma_y) = (0.031, 0.009)$ mas



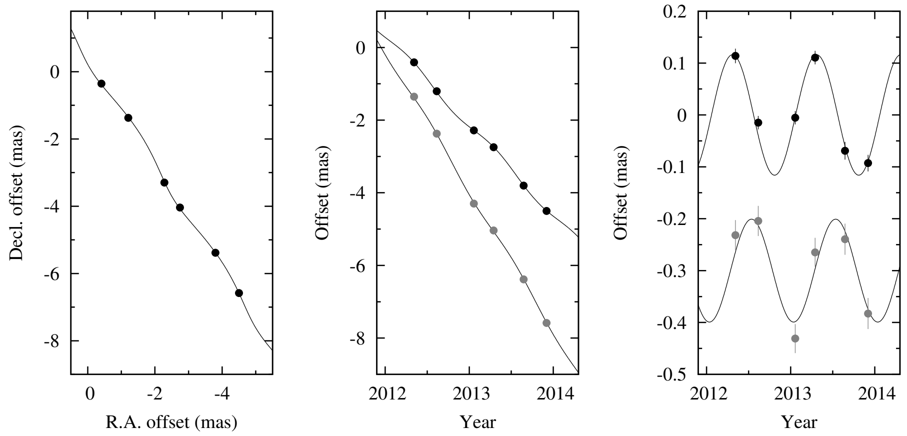
I2014+35

20h16m21.9324s +35d36'06.102"

$\pi = 0.119 \pm 0.010$ mas (D = $8.40^{+0.77}_{-0.65}$ kpc)

$(\mu_x, \mu_y) = (-2.46 \pm 0.01, -3.85 \pm 0.02)$ mas/yr

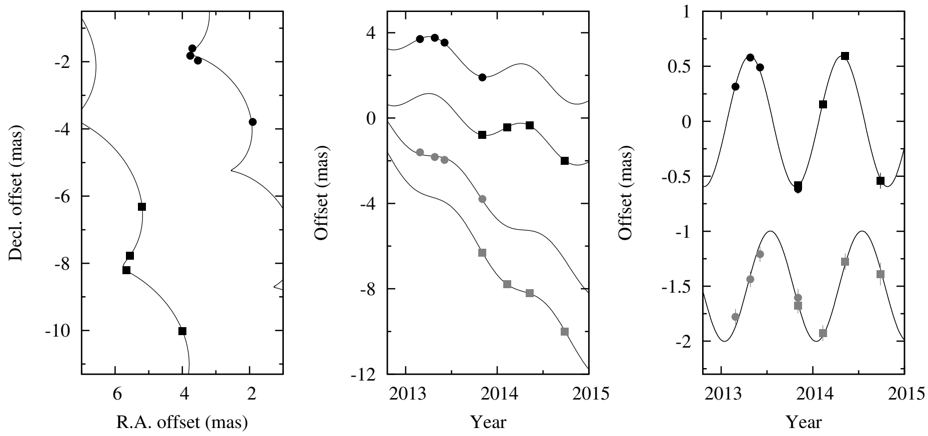
$(\sigma_x, \sigma_y) = (0.013, 0.029)$ mas



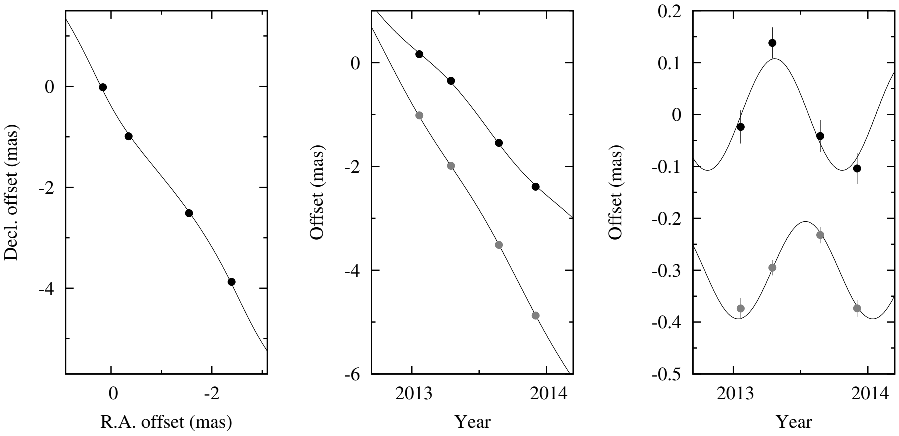
IRAS2023

20h25m07.8013s +34d50'34.733"

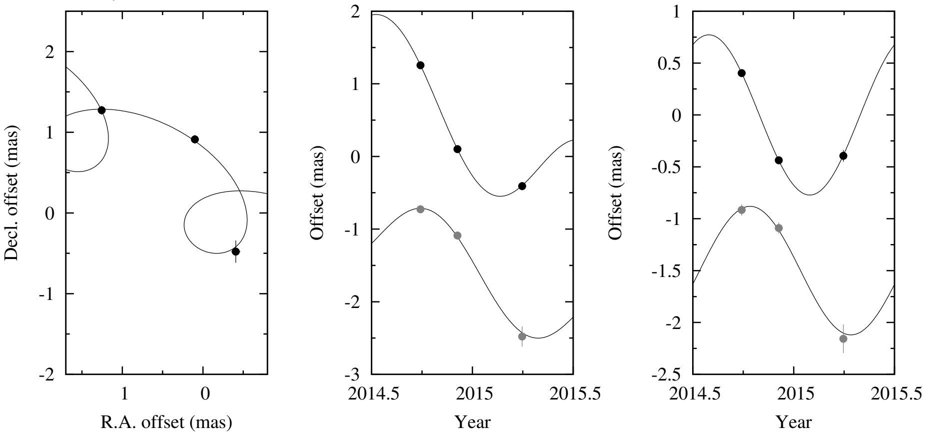
$\pi = 0.611 \pm 0.022$ mas (D = 1.64 ± 0.06 kpc)



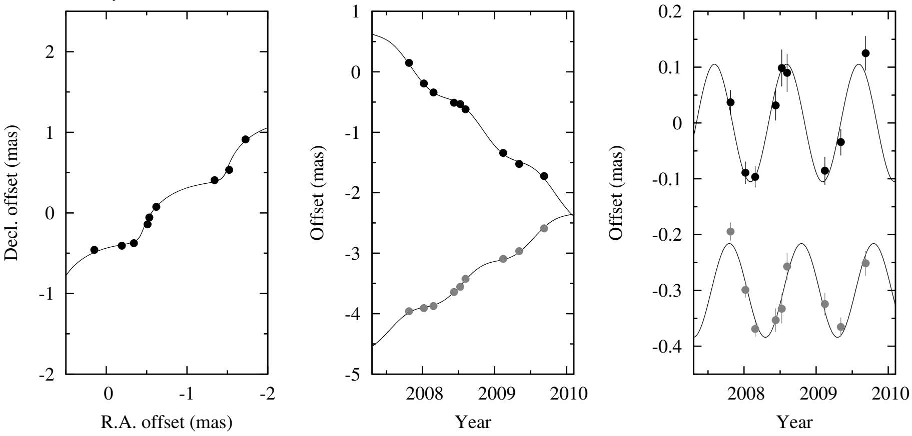
I2014+37
20h16m16.0214s +37d35'44.888"
$\pi = 0.110 \pm 0.014$ mas (D = $9.09^{+1.33}_{-1.03}$ kpc)
$(\mu_x, \mu_y) = (-2.86 \pm 0.05, -4.46 \pm 0.03)$ mas/yr
$(\sigma_x, \sigma_y) = (0.032, 0.015)$ mas



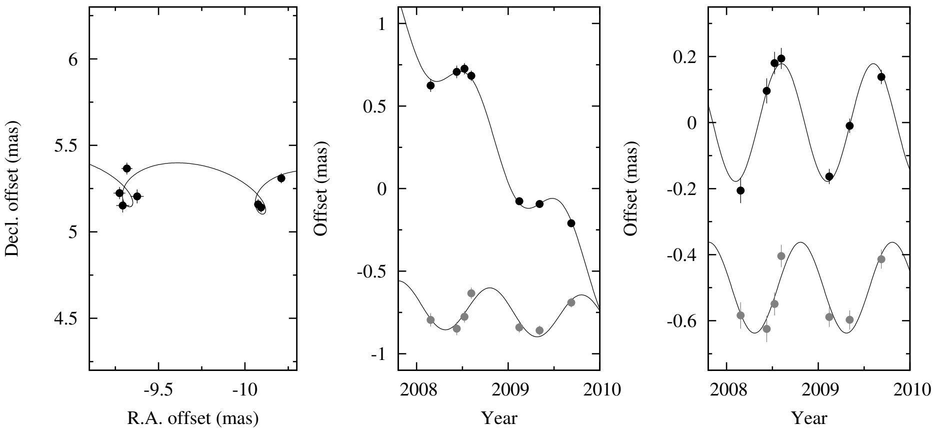
IC1805W
02h29m01.9375s +61d33'30.999"
$\pi = 0.814 \pm 0.013$ mas (D = $1.23^{+0.02}_{-0.02}$ kpc)
$(\mu_x, \mu_y) = (-1.72 \pm 0.11, -1.01 \pm 0.18)$ mas/yr
$(\sigma_x, \sigma_y) = (0.007, 0.060)$ mas



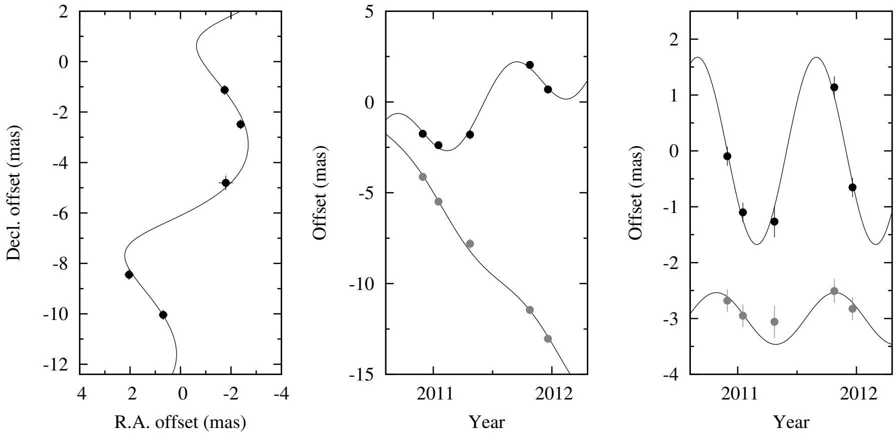
G135.28
02h43m28.5825s +62d57'08.390"
$\pi = 0.110 \pm 0.009$ mas (D = $9.09^{+0.81}_{-0.69}$ kpc)
$(\mu_x, \mu_y) = (-1.05 \pm 0.01, 0.76 \pm 0.01)$ mas/yr
$(\sigma_x, \sigma_y) = (0.026, 0.018)$ mas



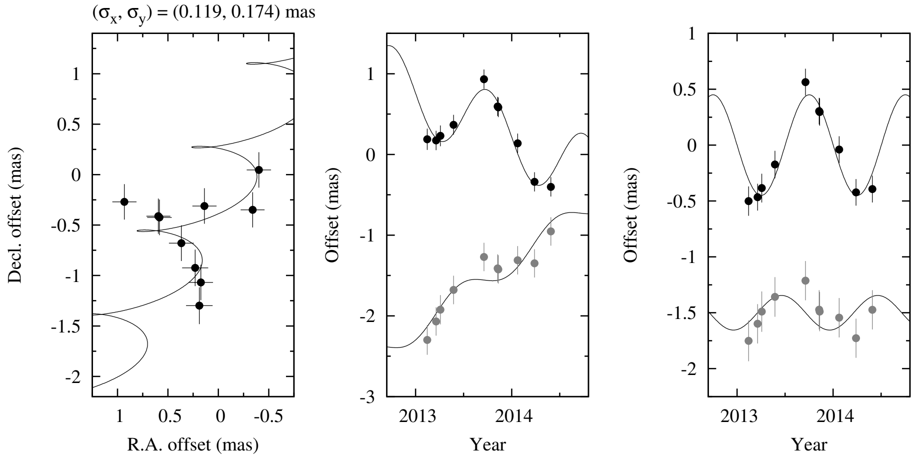
G137.07
02h58m13.1793s +62d20'32.915"
π = 0.183±0.012 mas (D = $5.45^{+0.38}_{-0.34}$ kpc)
(μ_x, μ_y) = (-0.77±0.02, -0.04±0.02) mas/yr
(σ_x, σ_y) = (0.022, 0.039) mas



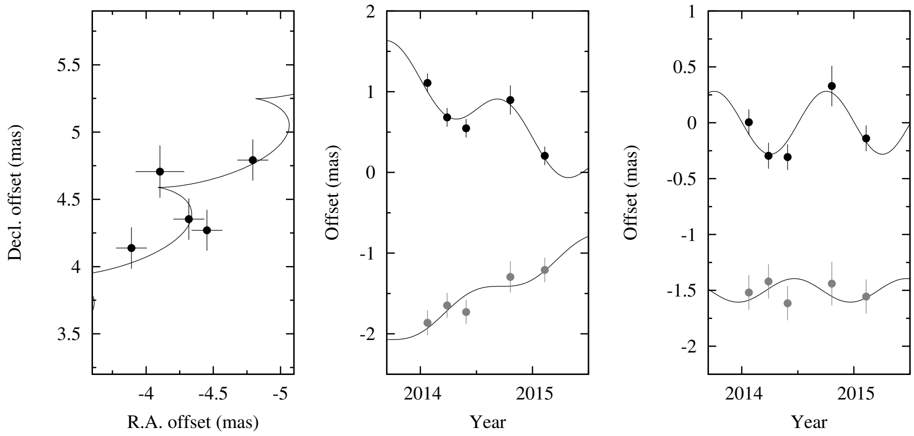
NGC1579
04h30m27.4008s +35d09'17.649"
π = 1.695±0.190 mas (D = 590^{+74}_{-59} pc)
(μ_x, μ_y) = (2.84±0.20, -8.32±0.22) mas/yr
(σ_x, σ_y) = (0.208, 0.245) mas



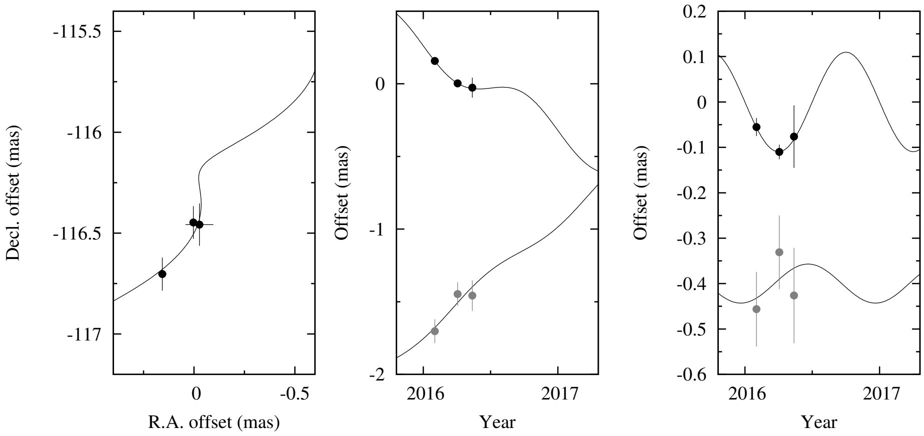
IRAS06469+0333
06h49m37.2030s +03d30'30.474"
π = 0.452±0.051 mas (D = $2.21^{+0.28}_{-0.22}$ kpc)
(μ_x, μ_y) = (-0.69±0.07, 0.83±0.13) mas/yr
(σ_x, σ_y) = (0.119, 0.174) mas



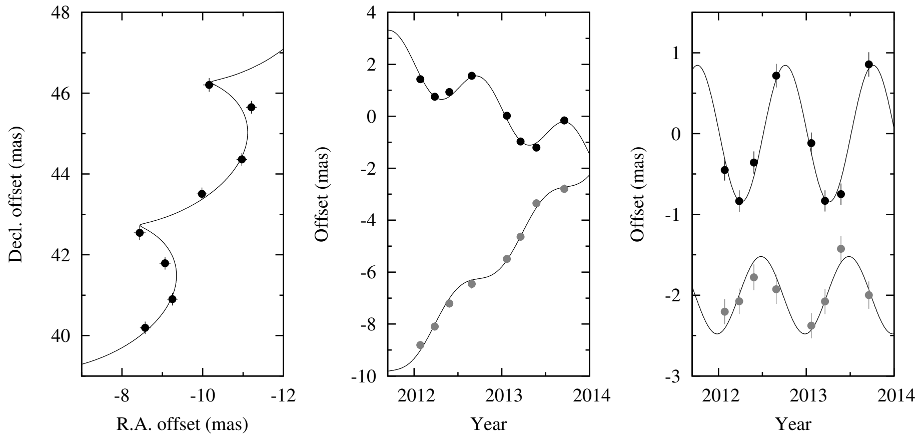
IRAS06501+0143
06h52m45.3205s +01d40'23.048"
π = 0.283±0.108 mas (D = $3.53^{+2.18}_{-0.98}$ kpc)
(μ_x, μ_y) = (-0.72±0.15, 0.66±0.19) mas/yr
(σ_x, σ_y) = (0.113, 0.150) mas



WB886
06h47m13.3344s +00d26'05.920"
π = 0.110±0.130 mas (D = $9.1^{+X.X}_{-X.X}$ kpc)
(μ_x, μ_y) = (-0.58±0.35, 0.77±0.53) mas/yr
(σ_x, σ_y) = (0.010, 0.080) mas



IRAS07024-1102
07h04m44.3900s -11d07'12.450"
π = 0.850±0.070 mas (D = $1.18^{+0.11}_{-0.09}$ kpc)
(μ_x, μ_y) = (-1.76±0.09, 3.54±0.10) mas/yr
(σ_x, σ_y) = (0.131, 0.155) mas



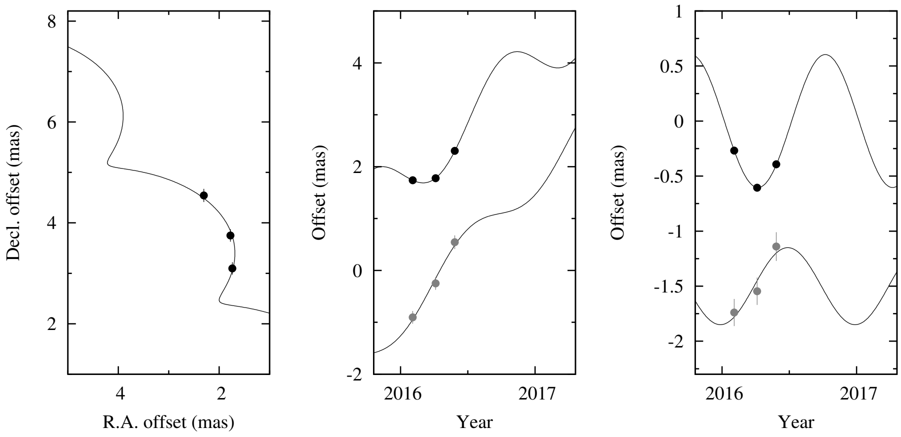
G226.27

07h14m26.9333s -12d03'58.884"

$\pi = 0.609 \pm 0.070$ mas ($D = 1.64^{+0.21}_{-0.17}$ kpc)

$(\mu_x, \mu_y) = (2.22 \pm 0.15, 2.72 \pm 0.59)$ mas/yr

$(\sigma_x, \sigma_y) = (0.005, 0.119)$ mas



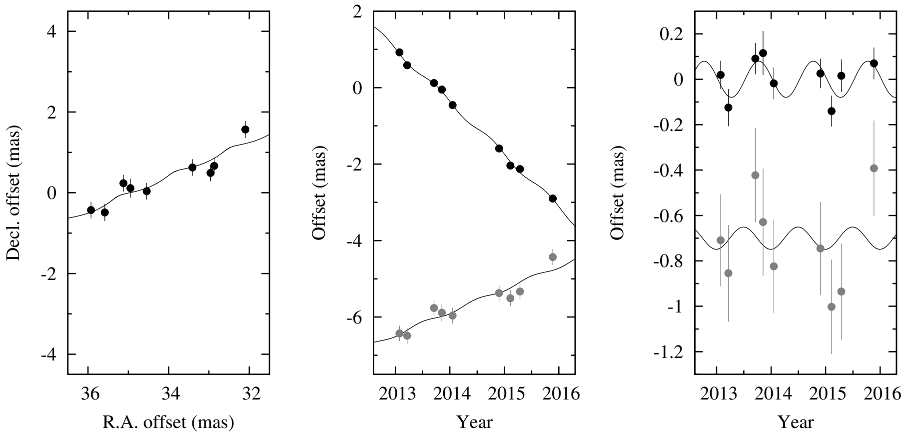
IRAS07207-1435

07h23m01.8407s -14d41'32.807"

$\pi = 0.080 \pm 0.034$ mas ($D = 12.5^{+9.2}_{-3.7}$ kpc)

$(\mu_x, \mu_y) = (-1.38 \pm 0.03, 0.60 \pm 0.08)$ mas/yr

$(\sigma_x, \sigma_y) = (0.062, 0.228)$ mas



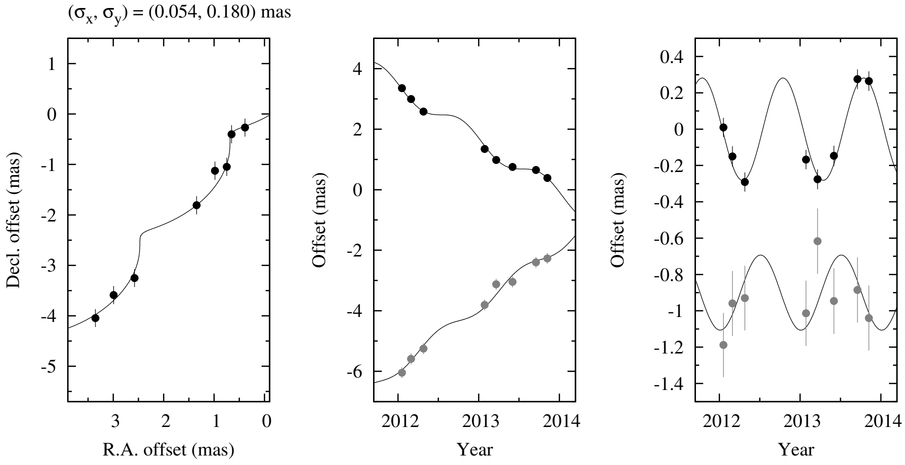
IRAS07427-2400

07h44m51.9368s -24d07'42.811"

$\pi = 0.286 \pm 0.035$ mas ($D = 3.50^{+0.49}_{-0.38}$ kpc)

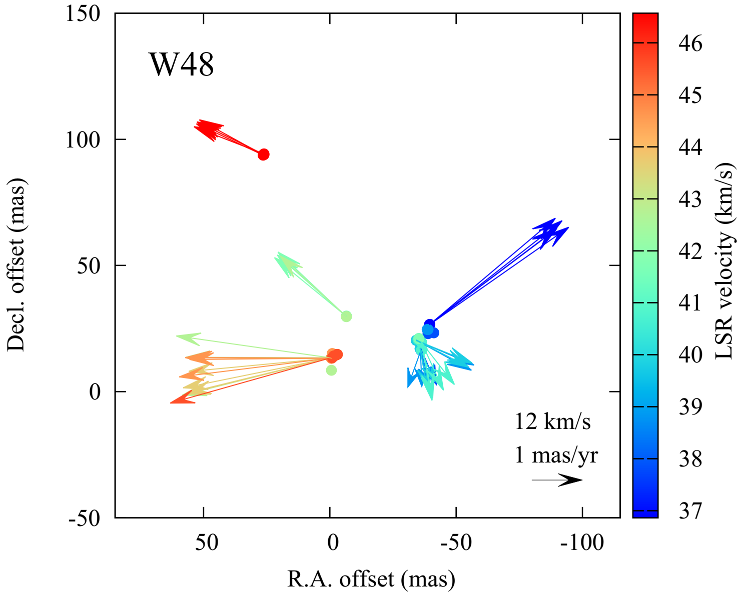
$(\mu_x, \mu_y) = (-1.79 \pm 0.04, 2.01 \pm 0.10)$ mas/yr

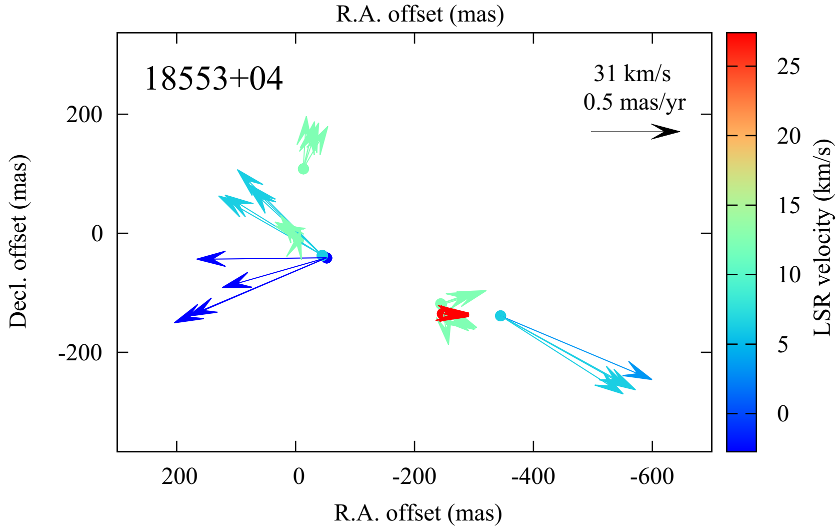
$(\sigma_x, \sigma_y) = (0.054, 0.180)$ mas

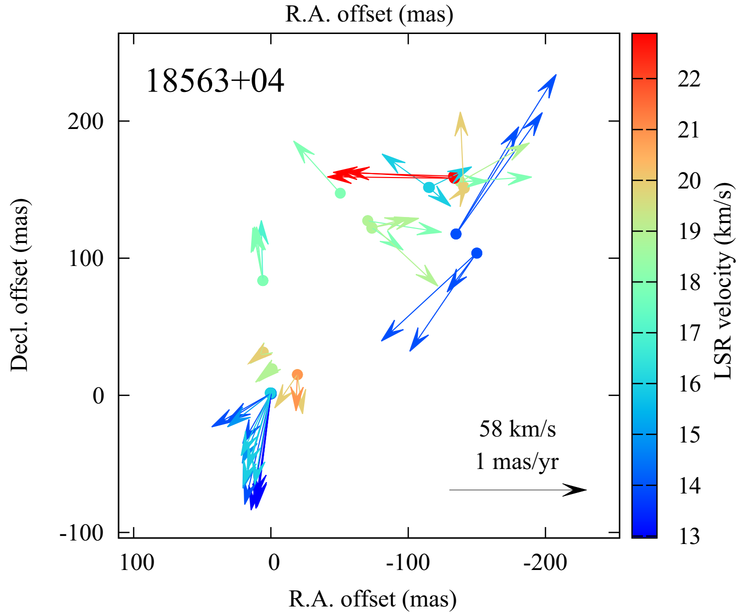


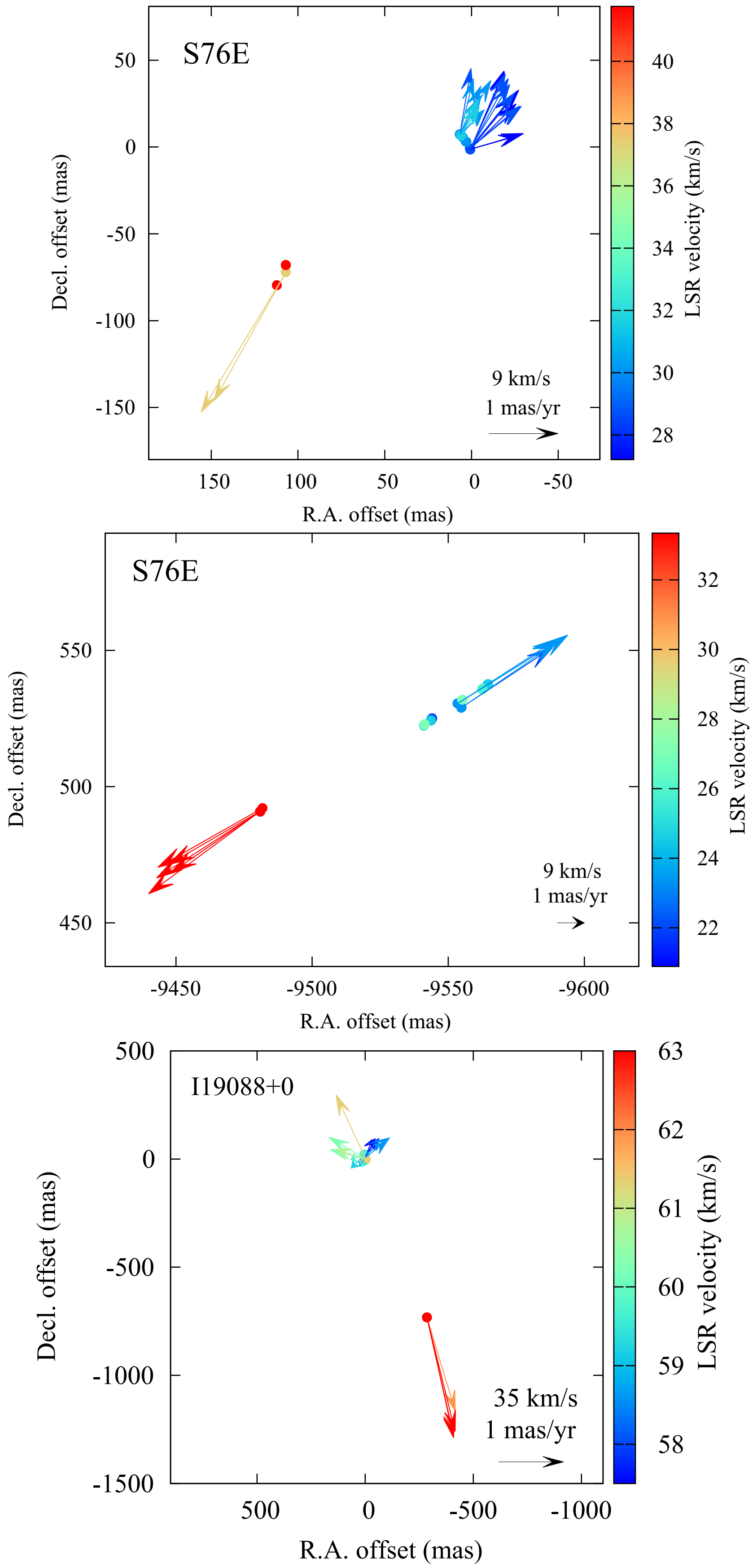
3　内部運動

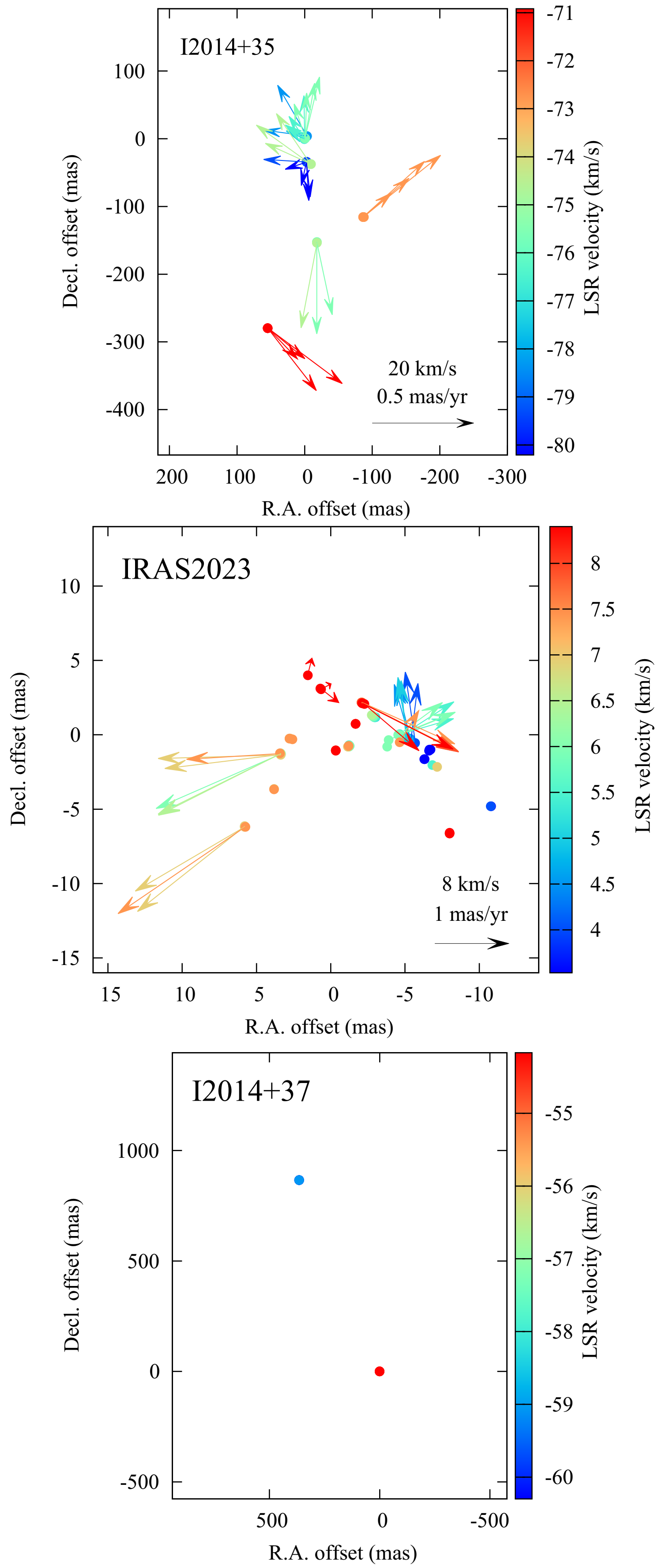
12 天体のメーザーの内部運動を示す。

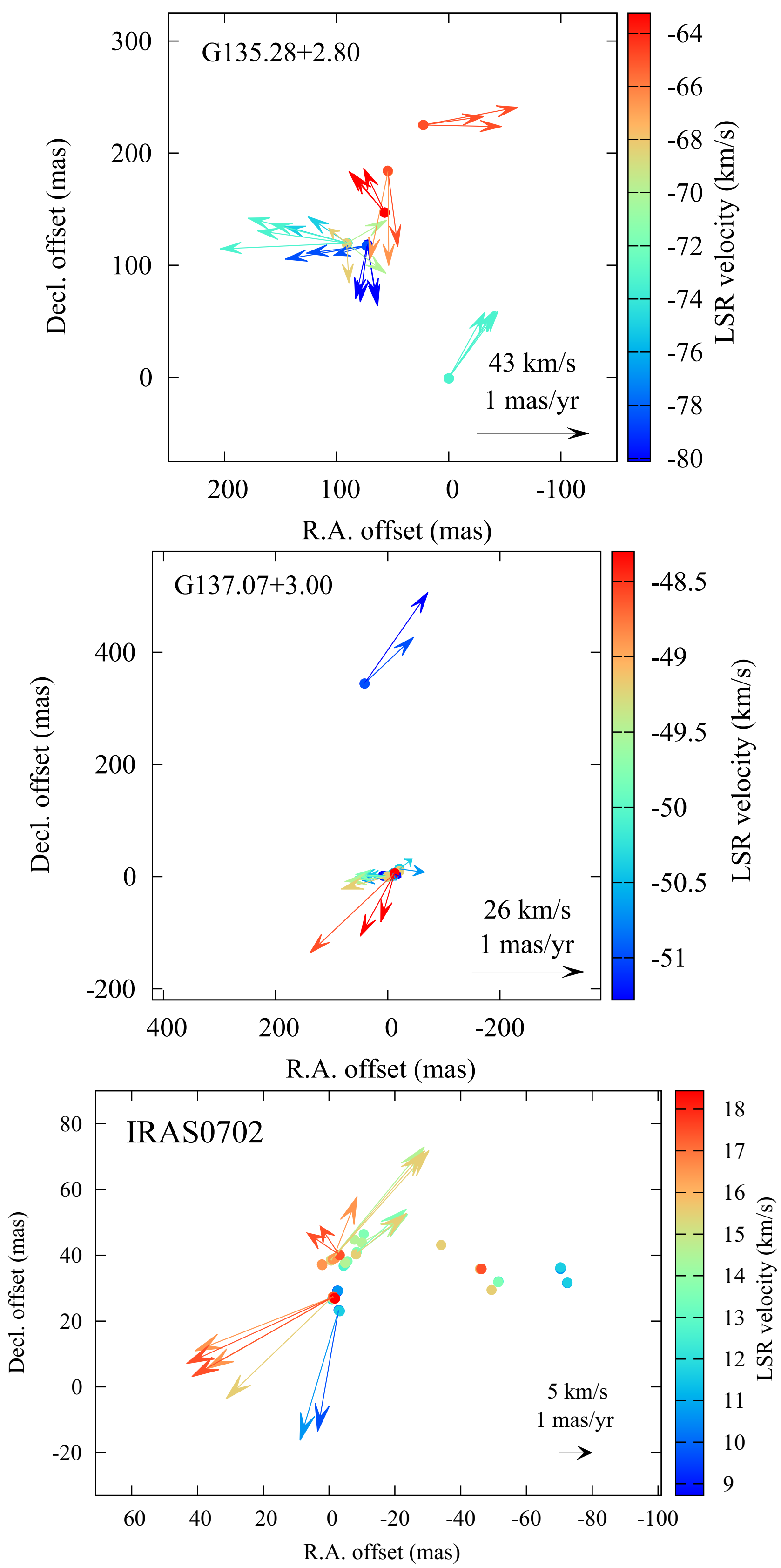







S76E
Decl. offset (mas)
R.A. offset (mas)
9 km/s
1 mas/yr
LSR velocity (km/s)
50
0
-50
-100
-150
150
100
50
0
-50
40
38
36
34
32
30
28
S76E
Decl. offset (mas)
R.A. offset (mas)
9 km/s
1 mas/yr
LSR velocity (km/s)
550
500
450
-9450
-9500
-9550
-9600
32
30
28
26
24
22
I19088+0
Decl. offset (mas)
R.A. offset (mas)
35 km/s
1 mas/yr
LSR velocity (km/s)
500
0
-500
-1000
-1500
500
0
-500
-1000
63
62
61
60
59
58


I2014+35
20 km/s
0.5 mas/yr
Decl. offset (mas)
R.A. offset (mas)
LSR velocity (km/s)
IRAS2023
8 km/s
1 mas/yr
Decl. offset (mas)
R.A. offset (mas)
LSR velocity (km/s)
I2014+37
Decl. offset (mas)
R.A. offset (mas)
LSR velocity (km/s)


G135.28+2.80
Decl. offset (mas)
300
200
100
0
200
100
0
-100
R.A. offset (mas)
43 km/s
1 mas/yr
LSR velocity (km/s)
-64
-66
-68
-70
-72
-74
-76
-78
-80
G137.07+3.00
400
200
0
-200
400
200
0
-200
26 km/s
1 mas/yr
-48.5
-49
-49.5
-50
-50.5
-51
IRAS0702
80
60
40
20
0
-20
60
40
20
0
-20
-40
-60
-80
-100
5 km/s
1 mas/yr
18
17
16
15
14
13
12
11
10
9

4 銀河系内での分布と銀河回転曲線

視差測定済みの天体数は、昨年の約 50 天体から 86 天体 (SFR が 70 天体、AGB が 16 天体) となった。Bessel(VLBA/EVN) を含めると 159 天体となった。視差測定済みの SFR143 天体の銀河系内での分布と銀河回転曲線を示す。

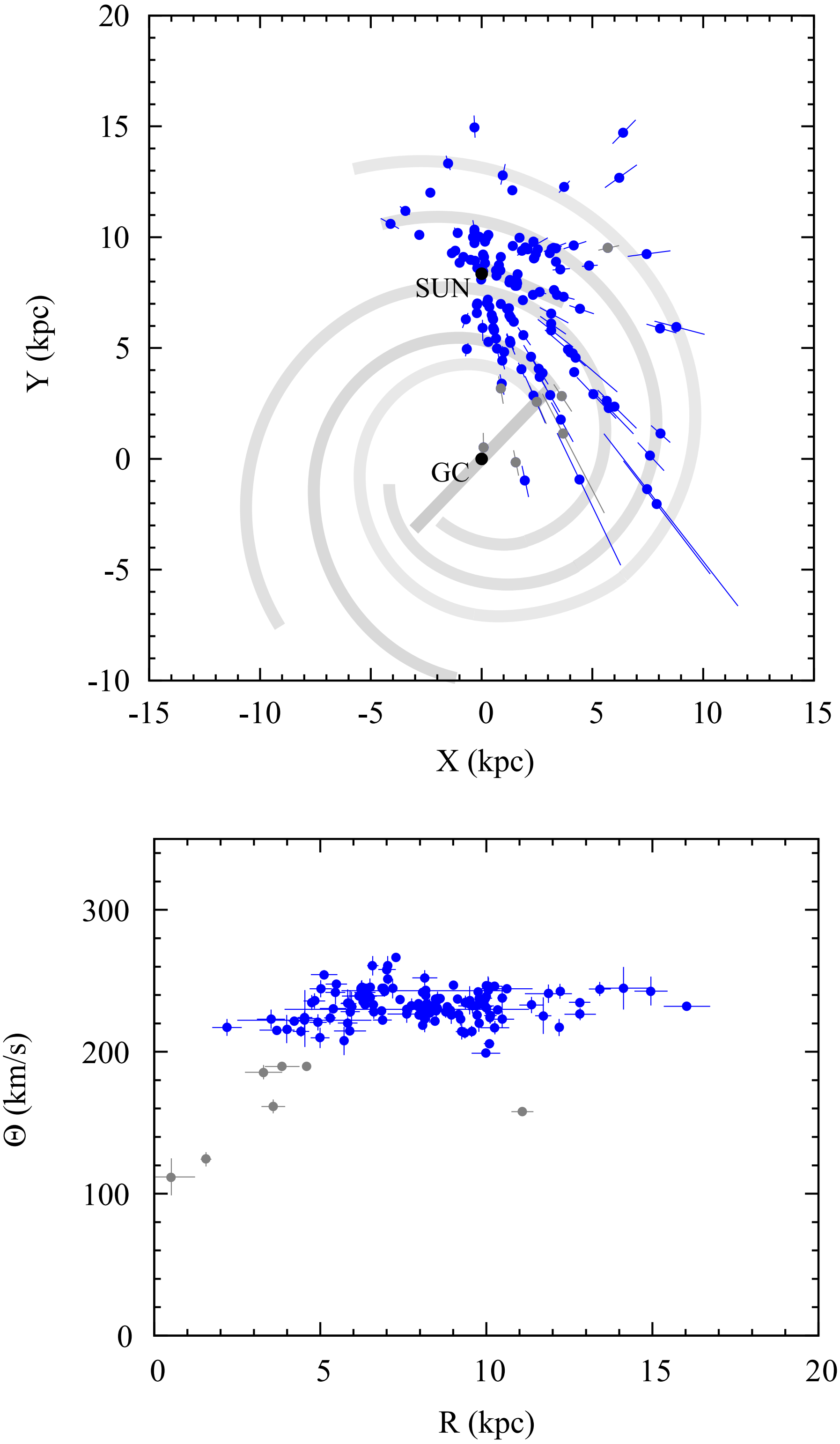


図 1: 銀河系の分布 (上) と銀河回転曲線 (下)。

5　銀河系パラメータの推定

視差測定済みの SFR143 天体のうち、bar 付近の非円運動の大きい 7 天体を除いた 136 天体を用いて、銀河定数 (R_0, Ω_0)、rotatin curve index (α)、天体の非円運動 (U_s, V_s, W_s) を求めた。結果を表 2 に示す。銀河定数の精度は Honma et al. (2012) の 52 天体時の約 5%から約 3%へ向上した。

表 2: 銀河系パラメータ

R_0	8.26 ± 0.24 kpc
Ω_0	28.84 ± 0.37 km s^{-1} kpc^{-1} ($\Theta_0 = 238 \pm 8$ km s^{-1})
α	0.011 ± 0.015
U_s	4.00 ± 1.09 km s^{-1}
V_s	-5.33 ± 1.01 km s^{-1}
W_s	-0.61 ± 0.85 km s^{-1}

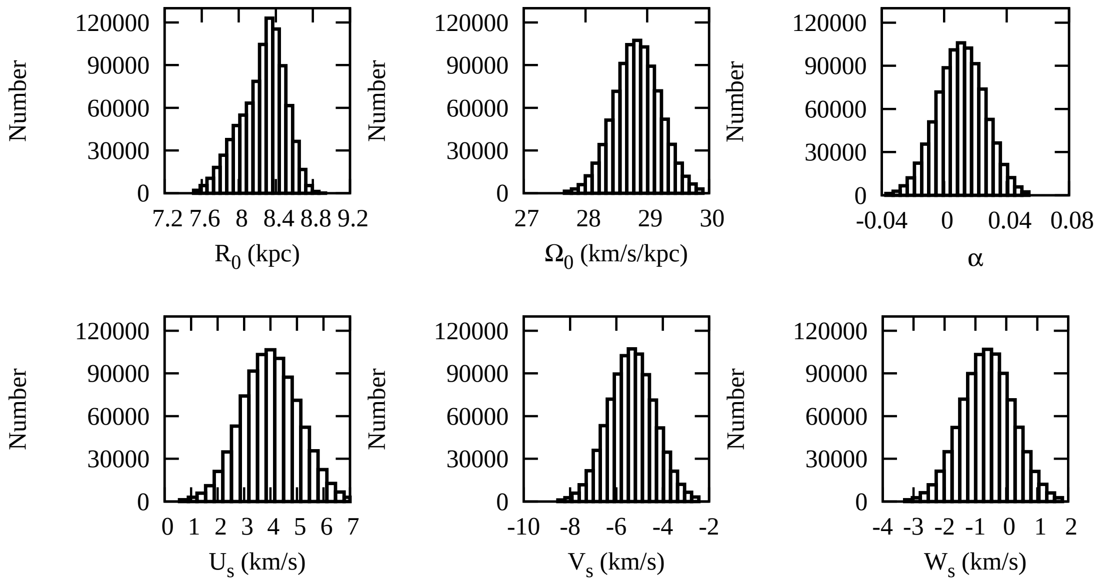


図 2: ヒストグラム