ASTRONOMY & ASTROPHYSICS
SUPPLEMENT SERIES

Astron. Astrophys. Suppl. Ser. **131**, 43–47 (1998)

New CORAVEL spectroscopic-binary orbits of giant barium stars. II*

S. Udry[1], **M. Mayor**[1], **S. Van Eck**[1,2], **A. Jorissen**[2], **L. Prévot**[3], **S. Grenier**[4], **and H. Lindgren**[5]

[1] Observatoire de Genève, CH-1290 Sauverny, Switzerland
[2] Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, C.P. 226, Bd. du Triomphe, B-1050 Bruxelles, Belgium
[3] Observatoire de Marseille, 2 Place Le Verrier, F-13248 Marseille, France
[4] Observatoire de Paris-Meudon, D.A.S.G.A.L., URA 335, F-92195 Meudon Cedex, France
[5] Lund Observatory, Box 43, S-22100 Lund, Sweden

Received December 15, 1997; accepted January 29, 1998

Abstract. This paper complements the set of spectroscopic orbits for giant barium stars given in Udry et al. (1998) and provides data for 20 binaries (18 orbits + 2 minimum-period determinations).

Key words: stars: late-type — stars: chemically peculiar — binaries: spectroscopic

1. Introduction

In this paper, we present the second part of a set of spectroscopic orbits of giant barium stars, complementary to the orbits described in a companion paper (Udry et al. 1998, Paper I). The overall sample comes from a systematic survey undertaken in the framework of a collaboration between the Geneva and Bruxelles groups to gain insight into the formation process of barium and Tc-poor S stars. The binary nature of these stars accounts for the observed chemical peculiarities through mass transfer across the system. This sample also allows us to confirm the evolutionary link between barium and Tc-poor S stars. These points are addressed in a companion paper providing the complete analysis of the overall sample (Jorissen et al. 1998).

Other CORAVEL users, around LP in Marseille, also interested in some of the same stars, joined in to permit a better determination of the orbital parameters and thus take the best advantage of the available measurements. The join binary sample is presented here.

As the star sample and the observation characteristics are described in details in Paper I, we will just briefly summarize the main related information in Sect. 2. Section 3 provides the derived radial-velocity curves and orbital elements. Some individual stars are commented as well.

2. Samples and observations

2.1. Barium-star samples

The two samples of barium stars with *strong* and *mild* anomalies (Ba4 or Ba5 and Ba $<$ 1, Ba1 or Ba2, respectively, on the scale defined by Warner 1965) to which belong the binaries presented in this paper were taken from the list of Lü et al. (1983). The strong barium stars were followed to address the question of whether binarity is a necessary condition to form a strong barium star. The mild barium stars were selected to provide a comparison set. The samples are described in more details in Tables 1 and 2 of Paper I.

For the strong barium sample, 29 stars were followed yielding 29 spectroscopic orbits. Eight of them are described in Sect. 3, 18 in Paper I, 2 in Griffin et al. (1996) and 1 in Jorissen et al. (1995). For the mild barium set, 12 binaries are presented in Sect. 3 whereas 14 may be found in Paper I and 1 in Griffin (1991).

The individual measurements will be available at the *Centre de Données Stellaires* (CDS) in Strasbourg or on our dedicated web page:
obswww.unige.ch/∼udry/cine/barium/barium.html.

2.2. Observations

Starting back in 1984, the observations were performed with the two CORAVEL spectrometers (Baranne et al.

Send offprint requests to: S. Udry
* Based on observations obtained at the Haute-Provence Observatory (France) and at the European Southern Observatory (ESO, La Silla, Chile).

Table 1. Orbital elements for the strong barium stars. N is the number of measurements used to derive the orbital solution and O−C the residue around this solution. ΔT is the span of the observations

Id HD	P [days]	T [HJD −2400000]	e	γ [$\mathrm{km\,s^{-1}}$]	ω [deg]	K [$\mathrm{km\,s^{-1}}$]	$f(m)$	$a \sin i$ [Gm]	N	O−C [$\mathrm{km\,s^{-1}}$]	ΔT [days]
43389	1689.03	47222.46	0.082	53.14	189.50	6.26	4.267e-02	144.990	24	0.351	3350
	8.760	61.25	0.016	0.08	12.77	0.12	2.476e-03	2.892			
44896	628.889	48464.30	0.025	52.16	227.04	9.04	4.827e-02	78.187	19	0.209	3270
	0.886	28.41	0.010	0.06	16.27	0.07	1.091e-03	0.598			
46407	457.403	47677.45	0.013	−3.45	73.73	9.03	3.503e-02	56.825	68	0.396	5883
	0.140	40.73	0.008	0.05	32.08	0.07	8.655e-04	0.468			
50082	2896.034	45953.12	0.188	−17.37	205.61	4.54	2.676e-02	177.777	29	0.345	5543
	21.339	56.58	0.022	0.07	6.61	0.11	1.998e-03	4.593			
92626	918.188	49147.83	0.000	16.28	0.00	7.64	4.249e-02	96.436	35	0.315	3803
	1.193	2.06	0.011	0.06	36.85	0.09	1.531e-03	1.164			
107541	3569.924	44388.16	0.104	88.15	223.09	4.32	2.940e-02	210.901	16	0.284	3973
	46.120	124.56	0.031	0.08	12.23	0.12	2.555e-03	6.629			
201657	1710.414	46154.95	0.171	−27.66	272.52	2.86	3.966e-03	66.228	15	0.287	4481
	15.023	103.55	0.072	0.18	22.51	0.22	9.471e-04	5.300			
211594	1018.861	48538.19	0.058	−9.88	73.65	5.10	1.399e-02	71.381	49	0.333	5030
	2.709	38.80	0.015	0.05	13.89	0.06	5.376e-04	0.931			

1979), on the 1-m Swiss telescope at the Haute-Provence Observatory for the northern sky and on the 1.54-m Danish telescope at La Silla (Chile, ESO) for the southern sky. The distributions of individual errors ($\overline{\varepsilon_i} = 0.3\ \mathrm{km\,s^{-1}}$), number of measurements ($\overline{N} = 19$) and time span ($\overline{\Delta T} = 3398\,\mathrm{d}$) per star are displayed in Fig. 1 of Paper I. They attest the large observational effort dedicated to these programmes and the good quality and homogeneity of the measurements.

More detailed information on the scientific background of the different projects, on the sample selection strategies, or on the observational characteristics of the measurements can be found in Jorissen et al. (1998) and in Paper I as also in Gòmez et al. (1997) and Menessier et al. (1997).

3. Radial-velocity curves and orbital parameters

The same presentation strategy as in Paper I is adopted. The orbital elements and the phase-folded radial-velocity curves are provided for the binaries with stable orbital solutions. Badly constrained parameters are readily identifiable by their large uncertainties. In case the period has to be fixed to obtain a satisfactory orbit, it is fixed to a *minimized* value determined by the minimum residue around the obtained solution. In such a case, no uncertainty is given for the fixed period. When the star is clearly binary but the period is not sufficiently covered to derive a preliminary orbit, only a minimum period is given. The radial velocities in function of Julian dates are then displayed.

Figure 1 and Table 1 provide the results for the strong barium sample (8 orbits) whereas Fig. 2 and Table 2 give the information for the mild barium binaries (10 orbits + 2 minimum-period binaries).

For the uncompletely-covered star HD 53199, the period has been fixed to a *minimized* value. In a few cases (see Jorissen et al. 1998), even though the Lucy-Sweeney test was compatible with a circular orbital solution (Lucy & Sweeney 1971), the *free*-eccentricity solution has been given because their is no physical argument to prefer circular orbits in the case of barium stars. Two stars (HD 46407 and HD 223617) have an orbital solution derived from a combined set of CORAVEL measurements and radial velocities obtained at the Dominion Astrophysical Observatory (DAO) by McClure & Woodsworth (1990). The fair number of new CORAVEL measurements allows us to slightly improve the previously published orbits.

Finally, the star HD 101079 deserves a comment. Only 7 CORAVEL radial-velocity measurements are available to date. They permit to derive two equally-probable orbital solutions with periods of 1588 d and 3120 d. In the coming months, new measurements will allow us to decide between the two solutions but for the moment only a minimum period $P > 1550$ d is given in Table 2.

Acknowledgements. This research has been supported partly by the *Fonds National de la Recherche Scientifique* (Switzerland, Belgium) and the University of Geneva (Geneva Observatory).

References

Baranne A., Mayor M., Poncet J.L., 1979, Vistas Astron. 23, 279

Gòmez A.E., Luri X., Grenier S., et al., 1997, A&A 319, 881

Griffin R.F., 1991, The Observatory 111, 29

Griffin R.F., Jorissen A., Mayor M., 1996, The Observatory 116, 298

Jorissen A., Hennen O., Mayor M., Bruch A., Sterken C., 1995, A&A 301, 707

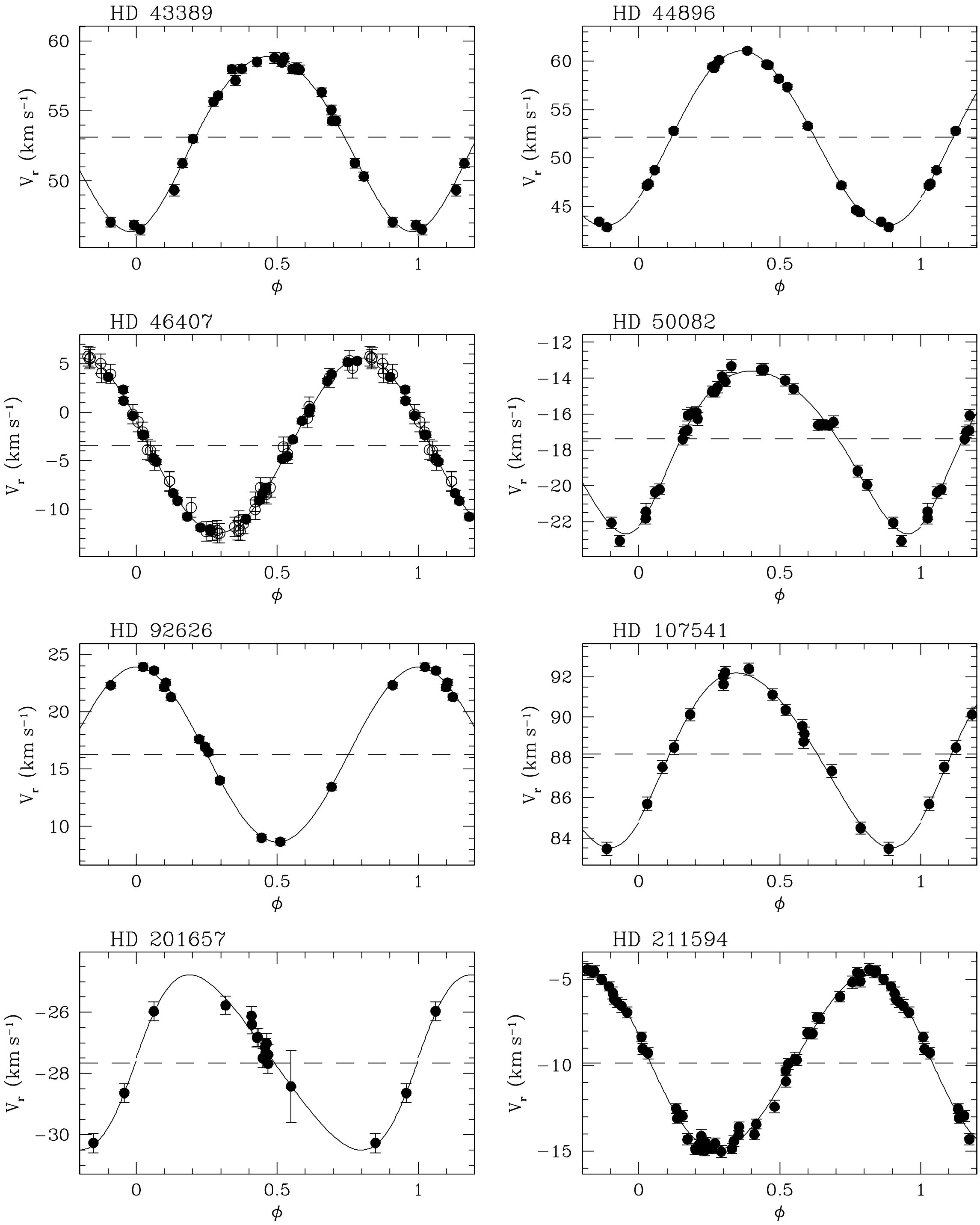

Fig. 1. Phase-folded radial-velocity curves for the strong barium stars. Open circles are for DAO measurements

Jorissen A., Van Eck S., Mayor M., Udry S., 1998, A&A (in press)

Lü P.K., Dawson D.W., Upgren A.R., Weis E.W., 1983, ApJS 52, 169

Lucy L.B., Sweeney M.A., 1971, AJ 76, 544

McClure R.D., Woodsworth A.W., 1990, ApJ 352, 709

Mennessier M.O., Luri X., Figueras S., 1997, A&A 326, 722

Udry S., Mayor M., Van Eck S., Jorissen A., 1998, A&AS 131, 25 (Paper I)

Warner B., 1965, MNRAS 129, 263

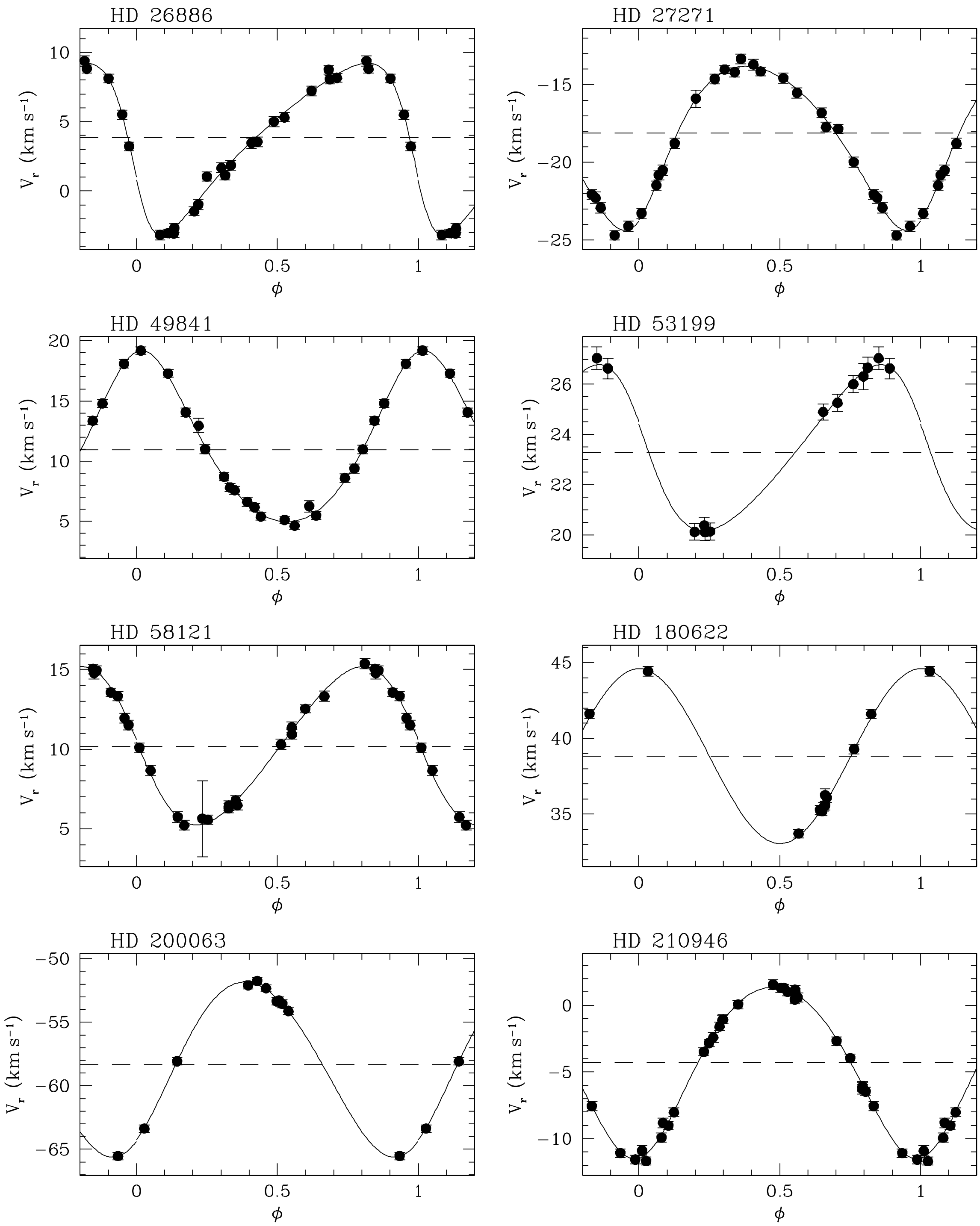

Fig. 2. Phase-folded radial-velocity curves for the mild barium stars. Open circles are for DAO measurements. Due to the non-complete coverage of the orbit a *minimized* period has been fixed for HD 53199. Long-period stars without orbital solution have their radial velocities displayed as a function of Julian dates

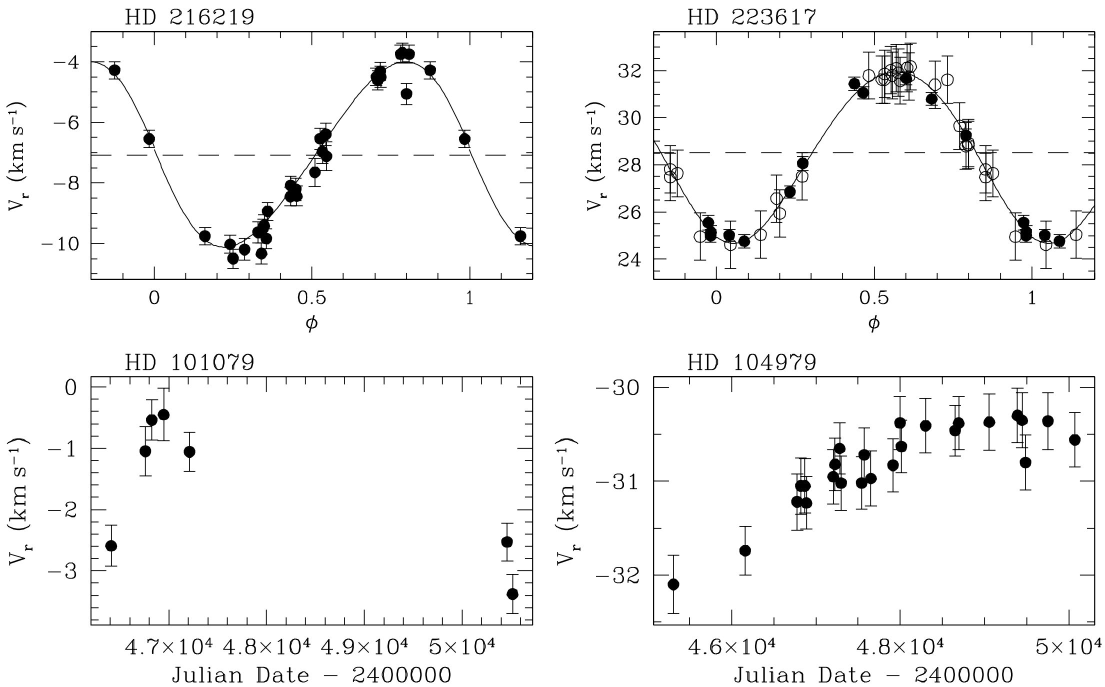

Fig. 2. continued

Table 2. Orbital elements for the mild barium stars. No uncertainties are given for fixed parameters

Id HD	P [days]	T [HJD −2400000]	e	γ [km s^{-1}]	ω [deg]	K [km s^{-1}]	$f(m)$	$a \sin i$ [Gm]	N	O−C [km s^{-1}]	ΔT [days]
26886	1263.230	48952.12	0.395	3.85	110.83	6.24	2.471e-02	99.580	23	0.400	4356
	3.729	9.23	0.025	0.09	3.35	0.17	2.161e-03	2.915			
27271	1693.838	47104.38	0.217	−18.10	208.83	5.28	2.406e-02	120.016	23	0.310	3350
	9.061	19.45	0.021	0.07	4.68	0.10	1.425e-03	2.445			
49841	897.098	48339.71	0.161	10.95	350.73	7.12	3.239e-02	86.739	21	0.331	3431
	1.823	13.51	0.015	0.08	5.47	0.12	1.693e-03	1.520			
53199	7500.0	41116.20	0.212	23.27	73.12	3.31	2.645e-02	333.996	11	0.174	4492
	–	62.94	0.225	0.06	1.59	0.07	1.570e-03	6.608			
58121	1214.257	46811.21	0.140	10.18	86.83	4.97	1.500e-02	82.125	23	0.236	3033
	5.712	23.25	0.015	0.05	7.62	0.07	6.856e-04	1.303			
101079	>1550								7		4107
104979	>4700								25		4764
180622	4049.166	50534.41	0.061	39.18	251.45	5.52	7.026e-02	306.681	10	0.255	4482
	37.709		0.097	1.17	184.26	0.54	2.053e-02	29.991			
200063	1735.451	47744.64	0.073	−58.32	216.25	6.89	5.849e-02	169.999	10	0.234	4483
	8.166	109.53	0.037	0.25	21.77	0.17	4.299e-03	4.083			
210946	1529.544	46578.18	0.126	−4.28	186.98	6.43	4.132e-02	134.265	30	0.264	3642
	4.058	24.23	0.011	0.05	5.86	0.07	1.448e-03	1.604			
216219	4098.036	44824.92	0.101	−7.17	82.32	3.11	1.261e-02	174.383	29	0.368	4486
	111.540	339.24	0.043	0.12	23.84	0.11	1.395e-03	7.835			
223617	1293.699	47276.68	0.061	28.51	157.61	3.63	6.381e-03	64.426	39	0.344	5843
	3.894	89.83	0.020	0.06	25.27	0.08	4.075e-04	1.383			