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Звезды
Stars

The spectrum of θ Virginis

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The A1V star θ Vir has very sharp spectral lines with no established noticeable anomalies in their intensities. Much more lines can be resolved in its spectrum than in the spectra of such stars as α Lyr, γ Gem and α CMa and the intensity of these lines can be estimated directly. That is why this star was used to determine effective wavelengths necessary in the search of differential line shifts in the spectra of early supergiants (Dobrichev et al., 1985). Furthermore, θ Vir has been adopted as a spectrophotometirc standard (Taylor, 1984). The colour indices of the star in the Strömgren system are as follows: $b-y=0{,}007$, $m_1=0{,}142$, $c_1=1{,}148$ and $\beta=2{,}838$ (Stokes, 1972). So far as θ Vir appears to be one of the few sharp line main sequence stars in the spectral range where the great majority of peculiar A stars is placed, it could be used as a chemical composition standard also. Owing to these characteristics, θ Vir has been included in our observation program for search and investigation of sharp line stars.

Photographic range spectra of θ Vir (3700-4800 Å) were obtained with the coudé spectrograph of the 2 m telescope at the Rojen National Astronomical Observatory of the Bulgarian Academy of Sciences. IIaO plates were used. The data about the spectrograms are given in Table 1.

In this paper we shall seek to carry out a complete identification and intensity measurement of the θ Vir spectral lines. For this purpose the spectra were traced on the Schnell microphotometer of Rojen Observatory, with 80×

Table 1

Spectrum No	Date (UT)	Dispersion (Å/mm)	Spectrum width (mm)	Exposure time	Quality
3c-436	17. 01. 1982	4,2	0,8	53^m	good
2c-990	12. 02. 1982	9	0,8	1^h30^m	slightly overexposed
3c-477	30. 01. 1983	4,2	0,8	2^h17^m	good
3c-487	30. 04. 1983	4,2	1,0	1^h50^m	slightly underexposed
3c-488	3. 05. 1983	4,2	1,0	5^h00^m	good

scale magnification and the optimum experimentally found slit width at which the spectral resolution does not change. The calibration spectrum disposed on the two sides of the stellar one was traced in the same conditions. In the observed spectral region the calibration curve changes by a negligible margin only.

For the line identification we used mainly the tables of Kurucz and Peytremann (1975) and Moore (1959) which supplement one another. Other published identification lists for individual stars, e. g. that of Kohl (1964), Wright et al. (1964) were also used. Since the oscillator strengths are very often inaccurate (Dobrichev, Raikova, 1981), we used the spectral line identifications for different sharp line peculiar stars (our working atlases) of similar temperature based on analogous observations and reduction procedure. The good resolution of the lines in the θ Vir spectrum and the study of their maximums made it possible to reduce the number of the lines usually considered as blends.

The measurement of the equivalent widths W_λ was performed according to the method described by Dobrichev (1970). This procedure is rather cumbersome, but control-accessible at each phase, in particular at drawing the continuum level. Regardless of the large scale of the tracings, 0,084 Å/mm, all metallic lines are too narrow: a line of equivalent width about 50 mÅ has a full width at half maximum (FWHM)$\sim$0,16 Å near λ 4300 Å. That is why a magnifying glass with measuring grid was used. In this way the profiles and equivalent widths of strong, intermediate and weak lines were measured. As it would be expected, the measurement of the central depth R_c and FWHM $\Delta\lambda$ was sufficient to determine W_λ for not very strong lines. Because of the Doppler effect $\Delta\lambda$ varies with λ in close limits. For partly blended lines the central depths of which are not affected from one another, the empiric relation between W_λ and R_c was used. For badly resolved lines the total equivalent width was determined.

Table 2 presents the results of more than 500 lines. In the blends the lines of approximately equal contribution are written in column 2 by the order of the wavelengths. If one of the lines predominates in the blend, the other is written in brackets. When blending with a line of very low contribution is suspected, this line is written in the last column. As usual, the colon designates uncertain value of W_λ. For the faintest lines at the detection threshold no equivalent widths were estimated. The lines measured from the Balmer line wings are also indicated in the remarks column.

The lower limit of the evaluated equivalent widths is $\sim$10 mÅ. Camera 3 of the coudé spectrograph at dispersion 4.2 Å/mm gives a spectral resolution of $\sim$0.08 Å in the observed photographic range. In using fresh plates and still larger widening of the spectrum, it would be possible to estimate intensities down to $\sim$5 mÅ in a star of such a small projected rotation as θ Vir is. Nevertheless, this is hardly achievable because of the photographic noise and the uncertainty of the continuum level drawing.

Special mention deserves the presence of high excitation lines (mainly of FeII and CrII) in the spectrum of θ Vir. Most of them have low values of log (gf) which are not consistent with their intensities. If the oscillator strengths are exact, it turns out that the corresponding energy levels are overpopulated. The lack of experimental oscillator strengths for high excitation lines and the inaccuracy of the theoretical ones make it impossible to judge about the presence of non-LTE effects. A special study of these lines in other stars and their intensity changes depending on T_{eff} and logg is necessary. That will

Table 2

λ (Å)	Identification		W_λ (mÅ)	Remarks
1	2		3	4
3805,35	FeI	608	33	23 % H_{10}
3806,70	FeI	607	32	17 % H_{10}
3807,14	NiI	33	28	15 % H_{10}
3807,53	FeI	73	16	14 % H_{10}
3808,73	FeI	222	9	9 % H_{10}
3810,74	CrII		8:	4 % H_{10}
3810,76	FeI	665		
3811,89	FeI	287		
3812,96	FeI	22	48	FeI 222 ?
3813,39	TiII	12	51	
3813,89	FeI	854		
3814,12	FeII	153	46	CrII ?
3814,58	TiII	12	71	
3815,38	VII	166	29	
3815,84	FeI	45	84	
3816,34	FeI	73	9:	
3817,59	ZrII	18	17	FeI 701 ?
3818,34	YII	7	13	
3819,61	HeI	22		
3820,43	FeI	20	104	2 % H_9
3821,18	FeI	608	34	3 % H_9
3821,83	FeI	222	9:	5 % H_9
3821,92	FeII	14	25	5 % H_9
3823,51	MnI	6		10 % H_9
3824,31	FeI	607	18:	11 % H_9
3824,44	FeI	4	52	11 % H_9
3824,91	FeII	29	45	13 % H_9
3825,88	FeI	20	92	16 % H_9
3827,08	FeII	153	30	22 % H_9
3827,82	FeI	45	70	26 % H_9
3829,35	MgI	3	84	35 % H_9
3832,30	MgI	3	82	54 % H_9
3832,89	YII	7	16:	57 % H_9
3834,22	FeI	20	35:	67 % H_9
3835,39	H_9		9500	
3838,29	MgI	3	92	54 % H_9
3840,44	FeI	20	48	41 % H_9
3841,05	FeI	45	50	37 % H_9
3843,03	ZrII	7	19	26 % H_9
3843,26	FeI	528	20	25 % H_9
3844,21	MnII			22 % H_9
3845,18	FeII	127	36	18 % H_9
3845,47	CoI	34		17 % H_9
3846,41	FeI	804		15 % H_9
3846,80	FeI	664	26	14 % H_9
3847,32	VII	156	14	12 % H_9
3848,24	MgII	5	33	10 % H_9
3849,58	NiII	11	58	8 % H_9
3849,97	FeI	20	52	7 % H_9
3850,40	MgII	5	22	7 % H_9
3850,82	FeI	22	18	6 % H_9
3852,57	FeI	73	14	3 % H_9
3853,66	SiII	1	80	2 % H_9
3856,02	SiII	1	130	
3856,37	FeI	4	58	
3858,30	NiI	32	42	
3859,21	FeI	175	21	MgI 21 ?
3859,91	FeI	4	80	
3862,59	SiII	1	125	
3863,41	FeII	152	10:	
3863,74	FeI	280	14:	
3863,81	VII	33		
3863,94	FeII	152	16:	
3865,53	FeI	20	85	
3865,59	CrII	167		
3866,01	CrII	130	10	
3866,54	CrII	130	12	
3866,74	VII	11	16	
3867,22	FeI	488	20	
3871,75	FeI	429	14	
3872,50	FeI	20	55	2 % H_8
3872,76	FeII	29	32	2 % H_8
3873,76	FeI	175	16	3 % H_8
3878,02	FeI	20	49	11 % H_8
3878,58	FeI	4	50:	12 % H_8
3878,72	VII	33	50:	12 % H_8
3878,73	FeI	664		
3882,26	TiII	34	27	32 % H_8
3886,28	FeI	4	40:	55 % H_8
3887,05	FeI	20	20:	61 % H_8
3889,05	H_8		10800	
3893,39	FeI	430	12	46 % H_8
3894,07	CoI	34		40 % H_8
3895,66	FeI	4	35	33 % H_8
3896,16	VII	10	19	FeII 23 ?
3897,90	FeI	280	20	22 % H_8
3898,01	FeI	20		
3899,14	VII	33	37	18 % H_8
3899,71	FeI	4	47	15 % H_8
3900,55	TiII	34	121	13 % H_8
3902,95	FeI	45	50	8 % H_8
3903,27	VII	11	37	7 % H_8
3903,76	FeII		11:	ZrII 7 ?
3903,82	FeII			
3903,90	FeI	429	12:	6 % H_8
3905,53	SiI	3	95	5 % H_8
3905,64	CrII	167		
3906,04	FeII	173	42	4 % H_8
3906,48	FeI	4	19	4 % H_8
3907,94	FeI	280	8:	2 % H_8
3913,46	TiII	34	123	
3914,33	VII	33	35	
3914,48	FeII	3	31	
3915,94	ZrII	17	16	
3916,42	VII	10	33	
3916,73	FeI	606	12	
3917,18	FeI	20	10	
3918,32	FeI	124	8:	
3918,42	FeI	364		
3918,51	FeII	191	10:	
3918,64	FeI	430	12:	
3919,07	FeI	430		
3920,26	FeI	4	37	
3920,64	FeII		22	no FeI

Table 2 (continued)

1	2		3	4
3920,68	CII	4		
3922,91	FeI	4	45	
3925,65	FeI	364	9:	
3925,95	FeI	364	15	
3926,00	FeI	562		
3926,50	VII	11		
3927,92	FeI	4	55	
3928,08	FeI	565	10	
3929,73	VII	10	16	
3930,30	FeI	4	61	2 % K
3930,31	FeII	3		
3930,66	YII	16		3 % K
3932,01	TiII	34	50	5 % K
3933,66	CaII	1	990	
3934,80	ZrII	43	12	10 % K
3935,94	FeII	173	48	4 % K
3938,29	FeII	3	50	
3938,97	FeII	190	31	
3941,28	FeI	562	7:	
3942,44	FeI	364	8:	
3944,01	AlI	1	75	2 % H_ε
3945,21	FeII	3	30	2 % H_ε
3947,00	FeI	561		3 % H_ε
3947,30	OI	3	12:	3 % H_ε
3947,49	OI	3	13:	FeI 361 ?
3947,59	OI	3		
3948,10	FeI	562	12	4 % H_ε
3948,78	FeI	604	17	4 % H_ε
3949,95	FeI	72	11	5 % H_ε
3950,35	YII	6	22	5 % H_ε
3951,16	FeI	661	16	6 % H_ε
3951,97	VII	10	49	6 % H_ε
3952,61	FeI	278	9:	7 % H_ε
3955,35	FeI	562	8:	12 % H_ε
3956,46	FeI	604	14	13 % H_ε
3956,68	FeI	728	22	13 % H_ε
3957,03	FeI	562	9	13 % H_ε
3958,24	ZrII	16	36	16 % H_ε
3960,90	FeII	212	8	23 % H_ε
3961,52	AlI	1	72	26 % H_ε
3968,47	CaII	1	290	67 % H_ε
3969,26	FeI	43		73 % H_ε
3970,07	H_ε		12200	
3973,64	VII	9	20	FeI 769 ?
3974,16	FeII	29	18	50 % H_ε
3976,62	FeI	729	8:	37 % H_ε
3977,73	VII	10	16	FeI 72 ?
3979,51	CrII	183	25	24 % H_ε
3981,61	FeII	3		17 % H_ε
3981,78	FeI	278	9	17 % H_ε
3982,00	TiII	11	18	16 % H_ε
3982,59	YII	6	20	15 % H_ε
3983,96	FeI	277	13	13 % H_ε
3986 18	FeI	655		10 % H_ε
3986,76	MgI	17	10	9 % H_ε
3987,63	TiII	11	15	8 % H_ε
3989,86	FeI	768		7 % H_ε
3991,14	ZrII	30	30	6 % H_ε
3997,13	VII	9	27	3 % H_ε
3997,39	FeI	827	27	3 % H_ε
3998,05	FeI	276	14	3 % H_ε
3998,98	ZrII	16	28	2 % H_ε
4002,07	FeII	29	29	
4002,55	FeII	190	27	CrII 166 ?
4002,94	VII	9	20	
4003,33	CrII	194	14	
4004,83	FeI	601		
4005,25	FeI	43	50	
4005,71	VII	32	60	
4006,63	FeI	488	8	
4007,28	FeI	277		
4009,71	FeI	72	11	
4012,37	TiII	11	91	
4012,50	(CrII	183)		
4013,82	FeI	486		
4014,49	ScII	8	17	
4014,53	FeI	808		
4015,50	NiII	12	40	
4017,16	FeI	527		
4021,87	FeI	278	17	
4023,39	VII	32	50	
4024,55	FeII	127	46	
4024,74	FeI	560	8:	
4025,14	TiII	11	43	
4026,19	HeI	18		
4028,33	TiII	87	64	
4029,68	ZrII	41	21	
4030,28	CrII	19	9:	
4030,50	FeI	560	12	
4030,76	MnI	2	19	
4031,46	FeII	151	8	
4032,95	FeII	126	29	
4033,07	MnI	2	13:	
4034,49	MnI	2	10	
4035,63	VII	32	46	
4036,78	VII	9	15	
4038,03	CrII	194	20	
4039,57	VII	32	7:	
4041,36	MnI	5	8	
4044,01	FeII	172	15	
4044,61	FeI	359		
4045,63	ZrII	30	20	
4045,82	FeI	43	92	
4046,07	FeI	557		
4048,68	ZrII	43	25	
4048,83	FeII	172	20	
4049,14	CrII	193	12	
4050,32	ZrII	43	11	
4051,97	CrII	19	30	
4053,81	TiII	87	58	
4054,11	CrII	19	18	
4054,83	FeI	698		
4054,88	FeI	698		
4056,21	TiII	11		
4057,50	MgI	16	30	FeII 212 ?
4062,45	FeI	359	13	
4063,60	FeI	43	82	
4067,05	NiII	11	70	2 % H_δ
4067,98	FeI	559	16	2 % H_δ
4069,88	FeII	188		2 % H_δ

Table 2 (continued)

1	2		3	4
4070,77	FeI	558	8:	2 % H_δ
4070,90	CrII	193	20	2 % H_δ
4071,74	FeI	43	79	2 % H_δ
4072,52	(FeI	698)	13	2 % H_δ
4072,56	CrII	26		
4073,76	FeI	558	8:	3 % H_δ
4074,79	FeI	524	9	3 % H_δ
4075,45	SiII		14	4 % H_δ
4075,95	FeII	21	8:	4 % H_δ
4076,64	FeI	558	13:	4 % H_δ
4076.78	(SiII	)	25	4 % H_δ
4076,87	CrII	19		
4077,71	SrII	1	106	5 % H_δ
4078,36	FeI	217		6 % H_δ
4082,30	CrII	165	12	7 % H_δ
4084,50	FeI	698	10	9 % H_δ
4085,31	FeI	559	10	10 % H_δ
4086,14	CrII	26	13	11 % H_δ
4090,52	ZrII	29		18 % H_δ
4101,74	H_δ		13 000	
4107,49	FeI	354		41 % H_δ
4109,81	FeI	357	12	30 % H_δ
4111,00	CrII	26	24	27 % H_δ
4111,02	CrII	18		
4111,90	FeII	188	8:	23 % H_δ
4118,55	FeI	801	33	9 % H_δ
4119,53	FeII	21	10	9 % H_δ
4122,64	FeII	28	51	5 % H_δ
4124,79	FeII	22	21	5 % H_δ
4127,61	FeI	357	9	4 % H_δ
4128,05	SiII	3	106	4 % H_δ
4128,74	FeII	27	36	4 % H_δ
4129,14	TiII		9	4 % H_δ
4130,65	BaII	4	17	3 % H_δ
4130,88	SiII	3	108	3 % H_δ
4132,06	FeI	43	48	3 % H_δ
4132,41	CrII	26	9	3 % H_δ
4132,90	FeI	357	9	3 % $И_\delta$
4134,68	FeI	357	18	2 % H_δ
4136,96	MnII		12:	2 % H_δ
4137,00	(FeI	726)		
4138,21	FeII	150	7:	2 % H_δ
4138,40	FeII	39	9	2 % H_δ
4143,42	FeI	523	25	
4143,87	FeI	43	58	
4145,77	CrII	162	29	
4147,67	FeI	42		
4149,22	ZrII	41	45	
4149,37	FeI	694	8:	
4150,97	ZrII	42	11	CrII 163 ?
4153,91	FeI	695	18	
4154,50	FeI	355	15	
4154,81	FeI	694	15	
4156,24	ZrII	29	16	
4156,80	FeI	354	11	
4157,79	FeI	695	12	
4160,62	FeII	39	8:	
4161,20	ZrII	42	20	
4161,52	TiII	21	29	
4161,80	SrII	3	13	
4163,64	TiII	105	86	
4167,27	MgI	15	30	
4170,86	CrII	181	12	
4170,91	FeI	482		
4171,90	TiII	105	81	
4172,60	CrII	18	13	
4172,64	FeI	689		
4173,45	FeII	27	120	
4173,54	TiII	21		
4174,09	TiII	105	22	
4174,31	MnII	2	9:	
4175,64	FeI	354	14	
4176,57	FeI	695	11	FeII 149 ?
4177,54	YII	14	33:	
4177,70	FeII	21	50:	
4178,86	FeII	28	93	
4179,43	CrII	26	33	
4181,76	FeI	354	33	
4183,44	VII	37	20	
4184,33	TiII	21	18	
4184,90	FeI	355	14	
4187,04	FeI	152	30	
4187,80	FeI	152	50	
4187,85	NiII			
4188,73	?		10	FeI 1116 ?
4191.44	FeI	152	22	
4192,07	NiII	10	19	
4195,34	FeI	693	17:	
4195,41	CrII	161	16:	
4196,22	FeI	693	9	
4198,31	FeI	152	34	
4199,10	FeI	522	49	
4200,93	FeI	689	9	
4202,03	FeI	42	55	
4202,35	VII	25	16	
4203,95	FeI	850	12	
4203,99	FeI	355		
4205,05	VII	25	24	EuII 1 ?
4205,08	VII	37		
4205,37	MnII	2	9:	
4206,38	MnII	7	13	
4207,35	CrII	26	9	
4208,99	ZrII	41	28	
4210,35	FeI	152	18	
4211,88	ZrII	15	10	
4215,52	SrII	1	101	
4217,55	FeI	693	10	
4219,36	FeI	800	25	
4220,05	VII	25		
4222,22	FeI	152	18	
4224,18	FeI	689	11	
4224,51	FeI	689	7	
4224,85	CrII	162	24	
4225,23	VII	37	15	
4225,46	FeI	693	13	
4226,73	CaI	2	75	
4227,34	TiII	33	56	
4227,42	FeI	689		
4233,17	FeII	27	136	
4233,61	FeI	152	30	

Table 2 (continued)

1	2		3	4
4235,94	FeI	152	42	
4238,82	FeI	693	27	
4242,38	CrII	31	65	
4244,80	NiII	9	14	
4245,26	FeI	352	7:	
4246,83	ScII	7	87	
4247,43	FeI	693	20	
4250,12	FeI	152	37	
4250,79	FeI	42	50	
4251,7	?		9	
4252,62	CrII	31	29	
4253,02	MnII	7	8:	
4254,35	CrI	1	35	
4254.55	CrII		12	
4258,16	FeII	28	45	ZrII 15 ?
4258,35	FeII	21	10	
4259,20	MnII	7	7:	
4260.48	FeI	152	62	
4261,92	CrII	31	58	
4263,90	FeII		9	
4267,02	CII	6	8:	
4267,27	CII	6	8:	
4267,83	FeI	482	8	
4269,28	CrII	31	26	
4271,16	FeI	152	40	
4271,76	FeI	42	82	
4273,32	FeII	27	52	
4274,80	CrI	1	28	
4275,57	CrII	31	43	
4278,13	FeII	32	26	
4282,41	FeI	71	30	
4283,01	CaI	5	10:	
4284,21	CrII	31	34	
4285,44	FeI	597		
4286,31	FeII		8	?
4287,89	TiII	20	46	
4289,36	CaI	5	9	
4289,72	CrI	1	22	
4290,22	TiII	41	100	
4292,25	MnII	6	9	
4294,10	TiII	20	105	
4294,77	ScII	15	9	
4296,57	FeII	28	73	
4298,99	CaI	5	9	2 % H_γ
4299,24	FeI	152	39	2 % H_γ
4300,05	TiII	41	128	2 % H_γ
4301,93	TiII	41	81	2 % H_γ
4302,53	CaI	5	23	2 % H_γ
4303,17	FeII	27	88	2 % H_γ
4305,45	SrII	3	24	2 % H_γ
4305,72	ScII	15	9:	2 % H_γ
4306,93	CrII		10	3 % H_γ
4307,90	TiII	41	116	3 % H_γ
4307,90	(FeI	42)		
4309,38	FeI	414		3 % H_γ
4309,62	YII	5	16	3 % H_γ
4312,86	TiII	41	87	4 % H_γ
4314,08	ScII	15	54	5 % H_γ
4314,29	FeII	32	40	5 % H_γ
4314,98	TiII	41	99	5 % H_γ
4315,09	(FeI	71)		
4316,81	TiII	94	27	5 % H_γ
4318,65	CaI	5	11	5 % H_γ
4319,72	FeII	220	9:	6 % H_γ
4320,74	ScII	15	44	7 % H_γ
4320,96	TiII	41	39	7 % H_γ
4325,01	ScII	15	36	13 % H_γ
4325,40	CrII		14	14 % H_γ
4325,42	FeII			
4325,54	FeII			
4325,76	FeI	42	82	14 % H_γ
4326,76	MnII	6	12	FeI 413 ?
4330,26	TiII	94	22	24 % H_γ
4330,71	TiII	41	28	25 % H_γ
4337,92	TiII	20	50	60 % H_γ
4340,47	H_γ		15 000	
4343,99	MnII	6	9	55 % H_γ
4344,29	TiII	20	20	53 % H_γ
4350,83	TiII	94	17	25 % H_γ
4351,76	FeII	27	105	22 % H_γ
4351,90	MgI	14	30:	22 % H_γ
4352,74	FeI	71	10	19 % H_γ
4354,36	FeII	213	10	15 % H_γ
4357,57	FeII		19	10 % H_γ
4359,74	ZrII	79	18	7 % H_γ
4361,25	FeII		11	6 % H_γ
4362,10	NiII	9	32	6 % H_γ
4367,66	TiII	104	50	3 % H_γ
4368,24	OI	5	20	FeII ?
4368,30	OI	5		
4369,40	FeII	28	34	2 % H_γ
4369,77	FeI	518	12	2 % H_γ
4370,96	ZrII	79	10	2 % H_γ
4374,46	ScII	14	40	
4374,82	TiII	93	30:	
4375,94	YII	13	40:	
4379,78	ZrII	88	20	
4383,55	FeI	41	100	
4384,08	FeII		8:	
4384,33	FeII	32	41	
4384,64	MgII	10	50	
4385,38	FeII	27	88	
4386,86	TiII	104	42	
4388,41	FeI	830	8	
4390,51	MgII	10	60	
4390,58	MgII	10		
4391,05	TiII	61	22	FeI 414 ?
4394,06	TiII	51	48	
4395,03	TiII	19	128	
4395,85	TiII	61	40	
4398,02	YII	5	11	
4398,31	TiII	61		
4399,77	TiII	51	78	
4400,36	ScII	14	33	
4401,55	NiI	86	16	FeI 350 ?
4402,88	FeII		13	
4404,75	FeI	41	82	
4407,68	TiII	51	15	
4407,71	(FeI	68)		

Table 2 (continued)

1	2		3	4
4408,42	FeI	68	9:	
4409,52	TiII	61	16	
4411,08	TiII	115	45	
4411,94	TiII	61	9	
4413,60	FeII	32	17	
4415,12	FeI	41	56	
4415,56	ScII	14	31	
4416,82	FeII	27	86	
4417,72	TiII	40	81	
4418,34	TiII	51	30	
4421,95	TiII	93	27	
4422,57	FeI	350	11	
4422,59	YII	5		
4425,44	CaI	4	8:	
4427,31	FeI	2	8:	
4428,00	MgII	9	23	
4433,99	MgII	9	35	
4434,96	CaI	4	10	
4435,69	CaI	4		
4440,45	ZrII	79	8	
4441,73	TiII	40	20	
4442,34	FeI	68	15	
4442,99	ZrII	88	14	
4443,19	FeI	350		
4443,80	TiII	19	115	
4444,56	TiII	31	33	
4446,25	FeII	187		
4447,72	FeI	68	14	
4449,66	FeII	222	8:	
4450,49	TiII	19	69	
4451,54	FeII		31	
4454,38	FeI	350		
4454,78	CaI	4	25	
4454,80	ZrII	40		
4455,26	FeII		20	
4456,65	TiII	115		
4459,12	FeI	68	17	NiI 86 ?
4461,43	FeII	26	14	
4461,65	FeI	2	14	
4461,70	FeII			
4464,46	TiII	40	45	
4466,55	FeI	350	20	
4468,49	TiII	31	117	
4469,16	TiII	18	15	
4469,38	FeI	830	14	
4470,86	TiII	40	27	
4471,48	HeI	14		
4472,92	FeII	37	37	
4476,02	FeI	350	32	FeI 830 ?
4480,69	FeII			
4481,13	MgII	4	180:	
4481,33	MgII	4	170:	
4482,17	FeI	2	17	
4482,26	FeI	68		
4484,23	FeI	828	9	
4488,32	TiII	115	51	
4489,18	FeII	37	71	
4491,40	FeII	37	77	
4493,53	TiII	18	17	
4493,58	FeII	222		
4494,57	FeI	68	15	
4496,96	ZrII	40	14	+ other ?
4501,27	TiII	31	106	
4508,28	FeII	38	95	
4515,34	FeII	37	88	
4518,30	TiII	18	13	
4520,22	FeII	37	88	
4522,63	FeII	38	110	
4525,14	FeI	826	12	
4528,51	VII	56	25:	
4528,62	FeI	68	20:	
4529,47	TiII	82	37	
4531,15	FeI	39	9	
4533,97	TiII	50	112	
4534,17	FeII	37	50	
4539,62	CrII	39	15	
4541,52	FeII	38	67	
4544,01	TiII	60	12	
4545,14	TiII	30	20	
4547,85	FeI	755		
4549,21	FeII	186	35:	
4549,47	FeII	38	235	
4549,62	TiII	82		
4552,25	TiII	30		
4554,03	BaII	1	80	
4555,02	CrII	44	51	
4555,89	FeII	37	95	
4558,66	CrII	44	100	
4563,76	TiII	50	100	
4564,59	VII	56	14	
4565,78	CrII	39	28	
4571,97	TiII	82	123	
4576,33	FeII	38	69	
4579,52	FeII		17	
4580,06	FeII	26	30	
4582,84	FeII	37	57	
4583,83	FeII	38	123	
4585,87	CaI	23		
4588,22	CrII	44	88	
4589,89	(CrII	44)	57	
4589,96	TiII	50		
4592,09	CrII	44	56	
4596,02	FeII		27	
4598,53	FeII	219		
4616,64	CrII	44	47	
4618,83	CrII	44	78	
4620,51	FeII	38	49	
4625,91	FeII	186	10:	
4629,34	FeII	37	94	
4634,11	CrII	44	66	
4635,33	FeII	186	47	
4638,02	FeI	822	18	?
4656,97	FeII	43	30	
4657,21	TiII	59	20	
4663,1	?		25	
4663,70	FeII	44	22	
4666,75	FeII	37	48	
4670,17	FeII	25	24	
4670,40	ScII	24	14	
,678,85	FeI	821		

Table 2 (continued)

1	2	3	4
4691,41	FeI 409		
4702,99	MgI 11	45	
4707,28	FeI 554		
4708,66	TiII 49	20	
4714,42	NiI 98	19	
4722,16	ZnI 2		
4731,44	FeII 43	57	
4736,78	FeI 554	12	
4755,73	MnII 5	16	
4763,84	TiII 48	20	
4771,72	CI 6		
4779,99	TiII 92	46	
4798,54	TiII 17	18	
4805,10	TiII 92	60	
4812,35	CrII 30	23	
4824,13	CrII 30	75	
4836,22	CrII 30	40	
4848,24	CrII 30		

be the object of another work, as well as the analysis of the chemical composition of θ Vir.

Finally we should like to point out that a detailed study of θ Vir on the whole available spectral range would be very useful. The star is relatively bright and accessible for the maximum dispersion of the spectrographs of many observatories. The line sharpness makes it possible to obtain many useful data, e. g. the transition probabilities between high excitation levels.

References

Kohl K. 1964. Das Spektrum des Sirius λλ 3100—8863 A, Kiel.

Kurucz R. L., Peytremann E. 1975. Smithsonian Astrophys. Obs. Special Rep. No 362.

Moore Ch. E. 1959. Revised Multiplet Tables of Astrophysical Interest, NBS, USA.

Stokes N. R. 1972. Monthly Not. Roy. Astron. Soc., **160**, 155.

Taylor B. J. 1984. Astrophys. J., Suppl., **54**, 259.

Wright K. O., Lee E. K., Jacobson T. V., Greenstein J. L. 1964. Publ. Domin. Astrophys. Obs. Victoria, **12**, 173.

Добричев В. 1970. Изв. секции астрон. болг. АН, **4**, 47.

Добричев, В., Райкова, Д. 1981. Астрофиз. исслед. болг. АН, **3**, 18.

Добричев В. М., Ченцов Е. Л., Шхагошева З. У. Астрофиз. исслед., Изв. САО (in press).

Спектр θ Virginis

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(Резюме)

Звезда θ Vir спектрального класса A1V имеет очень резкие спектральные линии ($\Delta\lambda \sim 0{,}16$ Å). По спектрам с дисперсией 4,2 Å/mm проведено полное отождествление линий ее спектра в диапазоне 3800—4800 Å. Для всех линий приводятся также измеренные эквивалентные ширины с нижним пределом ~10 mÅ.

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