SPECTRAL CLASSIFICATION OF FAINT STARS AND ITS APPLICATION TO THE STUDY OF OPEN CLUSTERS, STAR FORMING REGIONS AND THE GALAXY. I. SPECTRAL TYPES AND LUMINOSITIES OF STARS TO 22.0^m (V) IN THE STELLAR CLUSTERS NGC 2244, NGC 2264, AND NGC 6913

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СПЕКТРАЛЬНАЯ КЛАССИФИКАЦИЯ СЛАБЫХ ЗВЕЗД И ЕЕ ПРИМЕНЕНИЕ К ИССЛЕДОВАНИЮ РАССЕЯННЫХ СКОПЛЕНИЙ, ОБЛАСТЕЙ ЗВЕЗДООБРАЗОВАНИЯ И ГАЛАКТИКИ. I. СПЕКТРАЛЬНЫЕ ТИПЫ И СВЕТИМОСТИ ЗВЕЗД ДО 22.0^m (V) В ЗВЕЗДНЫХ СКОПЛЕНИЯХ NGC 2244, NGC 2264 И NGC 6913, Кузнецов В. И., Бускомб В., Бутенко Г. З., Лазоренко Г. А., Лазоренко П. Ф. – Описывается двумерная спектральная классификация 203 членов молодого звездного скопления NGC 2264, соответствующая опубликованным фотометрическим UBV-данным. Для NGC 6913 мы приводим спектральные типы и UBV-величины 36 звезд, полученные с 2-м телескопом обсерватории Терскол.

The two-dimensional spectral classifications of 203 members of the young star cluster NGC 2264 corresponding to published UBV photometry are described. For NGC 6913 we present spectral types and UBV photometry of 36 stars derived with the 2-m RCC telescope of the Terskol Observatory.

INTRODUCTION

A one-dimensional technique of spectral classification for faint O–M stars from their temperature parameters on the basis of UBV photometry was described previously by Kuznetsov *et al.* [9]. Characteristics of the interstellar light absorption dependence on distance in the given direction of the sky are used as a main criterion for excluding possible multiple spectral classifications on the basis of a particular set of values for Q_{UBV}. Spectra for stars to $V = 22^m$ were thus obtained by Kuznetsov *et al.* [9].

In this study we derive the new and improve the existing two-dimensional spectral classifications for members of the open cluster NGC 2264 using the published UBV photometric data. The list for 203 member stars in the open cluster NGC 2264 which were used for the study is given in Table 1. The list has been compiled by Prof. W. Buscombe in the catalogue series of stellar data retrieval under the general title "MK Spectral Classifications" [1]. For this particular region, the data were taken from studies at the Lick Observatory [14, 15], the Uttar Pradesh Observatory [11], the Vatican Observatory [3] and the Siding Spring Observatory [10]. Unfortunately, it contains rather approximate spectra (enclosed in brackets in the column 10 of Table 1) for about a half of faint 13–16^m (V) stars. It was a reason to carry out a new study to obtain better spectral estimates for this cluster.

Table 1. Photometric and spectral characteristics of NGC 2264 stars

N	Name of the star	α	δ	V	B–V	U–B	Ref.	$Sp(UBV)$	Sp'	Com.	Ref.	Note
1	2	3	4	5	6	7	8	9	10	11	12	13
1	W2 V 588 Mon 261331	06 39.0	+09 41	9.68	0.27	0.12	W	A7 III	A7 III-IV		W	
2	AB 47469	06 39.2	+09 39	7.74	–0.11	–0.65	W	B3 V	B: V		B	
3	V 589 Mon 261446	06 39.4	+09 42	10.27	0.43	0.10	W	F2 III	F2 III		W	
4	Walker 26	06 39.6	+09 23	11.78	0.48	–0.02	W	G0 IV	(F5 V)		B	
5	Vas. 1	06 39.7	+09 44	12.58	0.62	0.23	S	G2 IV	GO(IV)	S	B	
6	Vas. 2	06 39.7	+09 35	13.33	0.74	0.14	S	G4 IV	(G8 IV)	S	B	
7	Vas. 5	06 39	+09	13.89	0.87	0.37	S	G2 V	(KO IV)	S	B	
8	BD+ 09 1326 261585	06 39.8	+09 28	10.75	0.05	–0.02	W	A0 V	A0 V		Y	
9	BD+ 09 1325 261586	06 39.8	+09 22	10.25	0.34	–0.04	W	F5 III	A7 IV(p?)		W	U:
10	Vas. 12	06 39.9	+09 31	13.73	0.62	–0.23	S	G2 III	(G0 V)	S	B	
11	BD+ 09 1327 261658	06 40.0	+09 23	10.32	0.05	0.07	B	A1 V	A0 V		B	
12	Walker 36	06 40.1	+09 26	10.88	0.03	0.04	W	B9 V	B9 V		Y	
13	Vas. 20 261657	06 40.0	+09 34	11.29	0.57	0.04	S	G2 III	F9(IV)		B	
14	Vas. 22	06 40.2	+09 42	13.22	0.78	0.29	S	G0 IV	F5 V	S X2	Y	
15	Vas. 25	06 40	+09	13.01	0.92	0.37	S	G1 III	K3(IV)		B	~
16	Vas. 26	06 40.3	+09 29	13.32	0.47	0.14	S	F3 V	G2(V)	S	B	
17	Herbig 5 QX MON	06 40.2	+09 38	16.8	–	–	B	–	M1 IV	E	B	
18	BD+ 09 1329 261737	06 40.3	+09 42	10.50	0.29	0.13	W	A6 III	A7 III	N	W	
19	Walker 42 VAS.29	06 40.3	+09 37	13.24	0.84	0.49	W	G7 IV	(G8 IV)		B	
20	Walker 41 VAS.28	06 40.3	+09 36	14.06	0.80	0.36	W	G5 IV	(K0 IV)		B	
21	Herbig 11 LL MON	06 40.4	+09 51	–	–	–	–	–	K2 (IV)	(E)	B	
22	BD+ 09 1330 261736	06 40.4	+09 46	9.19	0.21	0.13	W	A6 III	A5 III	NE	W	
23	Walker 45 VAS.33	06 40.4	+09 36	15.25	0.94	0.74	W	K0 V	(K2 V)		B	
24	Walker 44 KY MON	06 40	+09	15.85	0.58	0.06	W	G2 IV	F9 V	E	B	~
25	Vas. 35	06 40.4	+09 59	13.62	0.97	0.61	S	K0 IV	K3 (IV)	S	B	
26	Walker 49	06 40.4	+09 33	15.34	1.00	0.88	W	K5 V	(K5 IV		B	
27	Vas. 36	06 40.4	+09 25	13.33	0.70	0.37	F	G0 IV	(G5 V)	S	B	
28	Herbig 14 PT MON	06 40.5	+09 50	–	–	–	–	–	K5 IV	(E)	B	
29	Walker 54 VAS.40	06 40.5	+09 50	14.25	1.25	1.03	W	K4 IV	(K7 IV)		B	
30	A V 641 Mon 47732	06 40.5	+09 49	8.16	–0.17	–0.75	S	B3 V	B3 V	N+B 2	Y	
31	V 413 Mon WAL.58	06 40.5	+09 49	15.50	0.97	0.63	W	K2 V	(K3 IV)	E	B	
32	Walker 51	06 40.5	+09 36	15.95	1.52	1.2	W	M4 IV	(M0 IV)		B	
33	Walker 55 NT MON	06 40.5	+09 35	14.60	1.32	0.96	W	K5 IV	(M0 IV)	E	B	~
34	Vas. 38	06 40.5	+09 31	14.40	1.10	–	V	–	(K5 IV)		B	
35	Walker 56 VAS.41	06 40.5	+09 31	14.96	1.48	1.32	W	K5 V	(M0 IV)		B	
36	Herbig 17 LM MON	06 40.6	+09 51	15.28	1.56	–	B	–	(M3 IV)	E	B	
37	Walker 66 VAS.47	06 40.6	+09 47	12.34	0.71	0.12	S	G4 IV	(G5 V)		B	
38	A V 684 Mon 47755	06 40.6	+09 47	8.44	–0.13	–0.60	W	B4 V	B3 V	N X2	B	
39	Walker 67 VAS.47	06 40.6	+09 47	10.83	0.62	–0.43	S	B0 V	B2 V	N	Y	
40	BD+ 09 1333 261783	06 40.6	+09 36	8.28	1.39	1.56	B	–	K3 II-III		W	U:
41	Walker 75	06 40.6	+09 36	15.64	1.38	0.16	W	–	(M0 IV)		B	U:
42	Walker 72 NV MON	06 40.6	+09 35	16.49	1.61	–	B	–	(M2 IV)	E	B	
43	BD+ 10 1217 261809	06 40.7	+10 08	10.74	0.23	0.07	B	A4 IV	(B9 V)		B	
44	Walker 68 VAS.48	06 40.7	+09 55	11.71	0.62	0.15	S	G1 IV	G0 IV-V	N	W	
45	Walker 79	06 40.7	+09 55	15.92	0.50	1.02	W	–	K0 IV	E	B	~
46	Vas. 55	06 40.7	+09 54	13.68	0.84	0.24	S	G4 V	(K0 V)	E	B	
47	Walker 78 LP MON	06 40.7	+09 52	15.40	1.23	–0.42	W	–	M0 IV	E	B	~
48	Walker 80	06 40.7	+09 52	15.25	1.54	0.72	W	M6 IV	(M0 IV)		B	~
49	Walker 81	06 40.7	+09 50	16.27	1.26	0.08	W	–	(K7 IV)		B	U:
50	BD+ 09 1335 261810	06 40.7	+09 46	9.02	–0.10	–0.66	W	B3 V	B5 V	N	W	
51	BD+ 09 1334 47777	06 40.7	+09 39	7.93	–0.14	–0.84	W	B1 V	B2 V	HE-STG	Y	
52	Walker 77 NW MON	06 40.7	+09 35	14.12	1.18	0.88	W	K3 IV	K4 IV	E	B	~
53	Walker 86	06 40.7	+09 34	16.33	1.51	–	W	–	(M0 IV)		B	~
54	Walker 84 VAS.59	06 40.7	+09 33	12.01	0.66	0.09	W	G2 IV	G0 V	E	Y	
55	Walker 85	06 40.7	+09 32	14.98	1.09	0.78	W	K5 V	(K5 IV)		B	
56	Cohen 75	06 40.7	+09 05	–	–	–	–	–	K3(IV)	E	B	
57	Walker 96 LR MON	06 40.8	+09 50	14.00	0.96	0.45	S	K5 IV	K6 (IV)	E	B	
58	Walker 92 VAS.67	06 40.8	+09 49	11.69	0.86	0.48	W	G9 IV	K0 IV p	X2	W	
59	V 590 Mon WAL.90	06 40.8	+09 48	12.76	0.14	0.08	S	A0 V	B8 (V)	PEQ	B	
60	Walker 89 LQ MON	06 40.8	+09 47	16.34	1.05	–	W	–	(K5 IV)	E	B	~
61	Walker 93 VAS.68	06 40.8	+09 46	13.22	0.92	0.65	W	K0 IV	G5 (IV)		B	

1	2	3	4	5	6	7	8	9	10	11	12	13
62	Walker 112 261879	06 40.8	+09 39	10.81	−0.02	−0.12	B	B8 V	A0 V		W	
63	Walker 105 LT MON	06 40.8	+09 37	14.94	0.89	−0.28	W	–	K1 (IV)	E	B	~
64	Walker 97	06 40.8	+09 37	16.77	1.17	0.5	W	M5 IV	(M3 IV)		B	
65	Walker 101	06 40.8	+09 33	16.33	1.72	–	W	–	(M3 IV)		B	
66	Walker 102	06 40.8	+09 33	15.67	1.39	1.26	W	K9 IV	(M0 IV)		B	
67	Walker 95 NY MON	06 40.8	+09 33	15.74	1.11	−0.14	W	–	(K6 IV)	E	B	
68	Vas. 65	06 40.8	+09 29	14.35	1.04	0.46	S	K1 V	(K0 IV)		B	
69	Vas. 66	06 40.8	+09 24	14.47	0.98	0.69	S	K0 V	(K0 IV)		B	
70	BD+ 09 1337 261842	06 40.8	+09 22	10.03	0.02	−0.16	B	B9 V	(B7 V)		B	
71	BD+ 10 1219 W.107	06 40.9	+10 02	8.81	−0.06	−0.44	W	B6 V	B6 V	N	Y	
72	Walker 104 VAS.74	06 40.9	+09 53	11.36	0.26	0.14	W	A7 IV	A5 IV		W	
73	F BD+ 09 1338 261878	06 40.9	+09 52	9.08	−0.10	−0.56	W	B5 V	B6 V	N	W	
74	BD+ 09 1336 261841	06 40.9	+09 51	9.98	0.14	0.07	W	A3 IV	A2 IV	E	W	
75	V 347 Mon HER.37	06 40.9	+09 49	16.55	–	–	B	–	M1 IV	(E)	B	
76	Walker 108 VAS.78	06 40.9	+09 45	11.87	0.55	0.06	W	G1 IV	G0 III-IVp	E	W	
77	V 345 Mon HER.33	06 40.9	+09 43	14.50	1.02	0.30	W	–	(K5 IV)	E	B	~
78	Walker 119	06 40.9	+09 37	15.70	1.38	0.67	P	M5 IV	(K7 IV)		B	
79	BD+ 09 1339 261902	06 41.0	+09 34	10.23	−0.03	−0.32	W	B8 V	B8 V		Y	
80	V 419 Mon W.115	06 40.9	+09 33	14.38	1.03	0.59	W	G8 IV-V	K4 (IV)	E	B	
81	Walker 116 VAS.83	06 40.9	+09 31	11.64	0.53	0.05	S	F9 IV	F7 V		Y	
82	Walker 127	06 40.9	+09 30	15.66	1.54	0.96	W	M6 V	(K7 IV)		B	~
83	Vas. 89	06 41.0	+09 56	13.86	0.93	0.37	S	G2 IV	K2 (IV)	N	B	
84	Vas. 90	06 41.0	+09 54	10.50	0.01	−0.31	S	B7 V	(B6 V)		B	
85	Walker 134 VAS.92	06 41.0	+09 55	12.38	0.84	0.05	W	G3 IV	G5 V		Y	
86	AB S Mon 47839	06 41.0	+09 54	4.62	−0.24	−1.08	W	O8 V	O7 V	(F)	Y	
87	C BD+ 10 1220	06 41.0	+09 54	9.88	−0.06	−0.40	W	B7 V	B5 V		Y	
88	E1 47839 E	06 41.0	+09 53	7.6	–	–	B	–	B5 V		B	
89	E2 47839	06 41.0	+09 53	–	–	–	–	–	A0 V		B	
90	V 353 Mon	06 41.0	+09 51	–	–	–	–	–	K0 (IV)		B	
91	Walker 125 VAS.87	06 41.0	+09 48	12.40	0.57	0.06	S	G1 IV	F6-G0 III-Vp		W	
92	Walker 144 VAS.99	06 41.0	+09 48	13.83	1.38	0.33	W	M2 IV	K7(IV)	S	B	
93	Walker 153 LW MON	06 41.0	+09 40	15.86	1.15	−0.13	W	–	K7 IV	E	B	~
94	Vas. 103 W.146	06 41.0	+09 39	14.63	1.11	0.62	W	G7 IV-V	(K6 IV)		B	
95	Walker 126 LU MON	06 41.0	+09 38	15.03	1.15	0.32	B	M6 IV	K6 IV	SE	B	~
96	Walker 122 GQ MON	06 41.0	+09 36	15.98	1.53	0.55	W	M5 IV	(M2 IV)	E	B	~
97	V 350 Mon W.123	06 41.0	+09 36	16.54	1.40	−0.35	W	–	(M0 IV)	E	B	~
98	Vas. 105 W.149	06 41.0	+09 35	14.20	0.99	0.68	W	K6 V	(K5 IV)		B	~
99	V 421 Mon W.136	06 41.0	+09 35	15.16	1.58	1.07	B	M5 IV	(M2 IV)	E	B	
100	Walker 150	06 41.0	+09 35	15.44	1.28	1.22	B	K7 IV	(K7IV)		B	~
101	V 356 Mon W.140	06 41.0	+09 35	16.16	1.59	0.50	W	M5 IV	(M2 IV)		B	
102	Vas. 100 W.141	06 41.0	+09 34	14.70	1.15	0.87	W	K2 IV	(K6 IV)		B	
103	Walker 135 VAS.93	06 41.0	+09 33	14.93	1.03	0.07	W	–	(K5 IV)		B	:
104	BD+ 09 1342 261940	06 41.0	+09 33	10.09	−0.15	−0.36	B	B7 V	B8 V		Y	
105	Walker 139 IP MON	06 41.0	+09 33	13.25	1.29	0.82	W	–	K6(IV)	S	B	~
106	Vas. 109 W.154	06 41.0	+09 31	12.74	0.71	0.12	W	G2 IV	G3 III-IV		W	
107	Walker 133 IO MON	06 41.0	+09 31	13.77	1.08	0.78	W	K6 IV	K6(IV)	E	B	~
108	Vas. 102 W.145	06 41.0	+09 28	10.66	0.05	0.01	B	A1 V	A0 V		W	
109	BC 261903 W.152	06 41.0	+09 27	9.10	−0.07	−0.38	W	B7 V	B8 V	N	B	
110	Walker 138 261904	06 41.0	+09 24	10.21	−0.07	−0.02	F	B9 V	(B8 V)		B	
111	Herbig 52 SS MON	06 41.1	+10 26	13.40	1.30	0.94	B	G6 IV	K3 IV	E	B	
112	BD+ 10 1224 261937	06 41.1	+09 55	10.36	0.36	0.12	B	F0 III	F2 (IV)	N	B	
113	AB 261938 W.142	06 41.1	+09 53	8.97	−0.07	−0.58	W	B4 V	B6 V	N	B	
114	BD+ 10 1222 W.137	06 41.1	+09 52	9.96	−0.37	−0.37	S	B8 V	B5 V	N	Y	
115	Walker 156	06 41.1	+09 48	14.66	1.25	0.69	W	K1 IV	(K7 IV)		B	
116	Walker 161 LX MON	06 41.1	+09 48	14.96	0.67	−0.61	W	–	K5 IV	E	B	~
117	Vas. 107 W.151	06 41.1	+09 47	12.53	0.52	−0.07	W	G2 IV	F8(V)		B	
118	Walker 169 NG2264	06 41.1	+09 44	13.48	0.68	0.26	W	G2 V	K0(IV)		B	
119	Walker 173	06 41.1	+09 43	16.41	1.29	0.77	W	M0 V	(K7 IV)		B	
120	Vas. 129 W.174	06 41.1	+09 41	15.17	1.02	–	S	–	(K5 IV)		B	
121	Herbig 50 PW MON	06 41.1	+09 38	16.3	–	–	B	–	M2 IV	E	B	
122	Walker 159 261939	06 41.1	+09 36	10.96	0.06	0.00	P	–	A0 V		W	
123	V 360 Mon W.164	06 41.1	+09 36	13.43	0.85	0.36	P	G2 IV	G8 V	SE	Y	~
124	Vas. 120 W.163	06 41.1	+09 36	14.05	0.89	0.52	S	G9 V	(K2 IV)		B	
125	Vas. 123 W.167	06 41.1	+09 36	14.09	0.89	0.14	S	G9 V	(K2 IV)		B	

1	2	3	4	5	6	7	8	9	10	11	12	13
126	Herbig 49 LY MON	06 41.1	+09 35	15.46	1.02	–	B	–	K5 IV	(E)	B	
127	V 608 Mon W.166	06 41.1	+09 35	16.26	1.53	0.40	W	–	(M2 IV)		B	~
128	Vas. 115 W.157	06 41.1	+09 33	10.06	−0.06	−0.35	W	B6 V	B8 V		Y	
129	Walker 160	06 41.1	+09 33	14.85	0.96	0.67	W	K3 V	(K5 IV)		B	
130	Vas. 111	06 41.1	+09 31	12.74	0.71	0.36	F	G2 IV	G8 V		Y	
131	Walker 162	06 41.1	+09 31	15.28	1.34	0.84	W	–	(M0 IV)		B	
132	Walker 175	06 41.1	+09 31	15.65	1.20	1.09	P	–	(K5 IV)		B	~
133	Vas. 124	06 41.1	+09 28	12.95	1.11	0.12	S	–	K6(IV)	S	B	
134	V 426 Mon HER.54	06 41.1	+09 28	13.16	1.14	–	B	–	K6(IV)	E	B	
135	Vas. 116	06 41.1	+09 24	14.46	0.71	0.04	S	G2 IV-V	(G5 V)		B	
136	BD+ 09 1343 261941	06 41.1	+09 23	10.99	0.15	0.15	S	A2 V	A2 V	E	Y	
137	BD+ 10 1225 261936	06 41.2	+10 08	10.04	−0.05	−0.45	B	B6 V	B8:IV		B	
138	A BD+ 10 1227 221969	06 41.2	+09 53	9.93	−0.03	−0.20	B	B9 V	B8 V	N	B	
139	B Vas. 136 W.181	06 41.2	+09 53	10.03	−0.04	−0.32	W	B8 V	B9 V	N	Y	
140	Walker 184 MM MON	06 41.2	+09 53	14.14	1.00	−0.01	W	K4 V	K3(IV)	E	B	~
141	BD+ 09 1346 262013	06 41.2	+09 36	9.21	−0.06	−0.40	W	B7 V	B8 V	N	Y	
142	Vas. 141 W.190	06 41.2	+09 35	12.38	0.63	0.15	S	G2 IV	G4(V)		B	
143	Walker 176	06 41.2	+09 35	15.79	1.59	0.85	W	M5 IV	(M2 IV)		B	
144	Walker 191	06 41.2	+09 33	15.37	1.34	0.98	W	K6 IV	(K7 IV)		B	~
145	AFGL 899 431 MON	06 41.2	+09 30	16.12	1.41	–	B	–	(M0 IV)	E	B	
146	A 47887 A/W.178	06 41.2	+09 28	7.14	−0.20	-0.97	W	B1 V	B1.5		B	
147	Vas. 140 W.189	06 41.2	+09 27	11.20	0.47	0.21	W	F0 III	F2 V		Y	
148	Vas. 132	06 41.2	+09 27	14.50	1.24	–	B	–	(K5 IV)		B	
149	V 365 Mon VAS.139	06 41.2	+09 26	13.81	0.92	–	P	–	K4 IV	(E)	B	
150	V 591 Mon HER.61	06 41.2	+09 26	13.55	0.84	0.23	S	G3 IV	G – ?	E	Y	
151	V 363 Mon W.183	06 41.2	+09 26	15.22	0.97	0.66	W	K0 V	(K3 IV)	E	B	~
152	Vas. 149 W.196	06 41.3	+09 57	11.46	0.53	−0.05	W	G0 IV	F6-F8 IV		W	
153	V 368 Mon W.200	06 41.3	+09 40	16.95	1.40	−0.67	W	–	(M0 IV)	E	B	~
154	V 432 Mon W.199	06 41.3	+09 34	15.00	1.09	0.29	W	–	K5(IV)	SE	B	~
155	Walker 201	06 41.3	+09 40	15.76	1.04	0.44	W	G2 IV	(K5 IV)		B	
156	Vas. 152 W.198	06 41.3	+09 34	15.32	1.25	0.89	W	K6 IV	K7(IV)		B	
157	Vas. 165 W.209	06 41.3	+09 34	11.31	0.35	−0.02	S	F5 III-IV	F2 V		Y	
158	Vas. 155	06 41.3	+09 32	14.39	1.06	1.12	S	K5 IV	(K5 IV)		B	
159	Vas. 150	06 41.3	+09 30	14.80	1.39	1.13	P	–	(M0 IV)		U	
160	Vas. 154	06 41.3	+09 30	14.02	1.05	0.91	S	K2 V	(K0 IV)		B	
161	Vas. 151	06 41.3	+09 28	15.08	0.92	−0.24	S	–	(K0 IV)		B	~
162	Vas. 156 W.203	06 41.3	+09 27	12.90	0.76	0.18	W	G2 IV	(G8 IV)		B	
163	Walker 205 262041	06 41.3	+09 22	10.60	0.34	−0.04	W	F1 III	(F2 V)		B	
164	AB 47934 W.206	06 41.4	+09 44	8.70	−0.08	−0.43	W	B7 V	B7 V	N	B	
165	Walker 207	06 41.4	+09 43	13.62	1.03	–	B	–	K2 (IV)	S	B	
166	Vas. 170	06 41.4	+09 35	14.39	0.84	–	V	–	(K3 IV)		B	
167	Walker 204 OV MON	06 41.4	+09 34	15.30	1.15	0.47	W	G5 IV	(K5 IV)	E	B	~
168	Vas. 166	06 41.4	+09 34	13.34	0.57	0.11	S	G2 V	(F8 V)		B	
169	Vas. 164 W.208	06 41.4	+09 27	12.63	0.76	0.23	S	G0 IV	(G8 V)		B	
170	Vas. 167 W.210	06 41.4	+09 26	13.43	0.79	0.22	S	G2 IV	(G8 V)		B	
171	Vas. 169	06 41.4	+09 24	12.70	0.44	0.19	S	F0 V	F5: V:		B	
172	BD+ 09 1348 262042	06 41.4	+09 13	8.98	0.09	−0.63	B	B2 V	B2 V		B	
173	C BD+ 09 1350 47961	06 41.5	+09 51	7.48	−0.14	−0.80	S	B2 V	B2.5 V		W	
174	A Vas. 175 262066	06 41.5	+09 50	9.32	0.04	−0.14	B	B9 III-IV	A0 IV-V		W	
175	Vas. 174 W.214	06 41.5	+09 40	13.12	0.80	0.22	S	G1 IV	K0 (IV)	S	B	
176	Vas. 178 W.215	06 41.5	+09 27	13.76	0.93	0.34	S	–	(K0 IV)		B	
177	Walker 217 MO MON	06 41.5	+09 27	13.54	1.22	–	B	–	K5 IV:	SE	B	
178	BD+ 09 1352 262110	06 41.5	+09 19	9.69	0.48	−0.04	W	G0 III	A7: IV:		B	
179	Herbig 73 OW MON	06 41.6	+10 09	14.51	–	–	B	–	K2 IV	(E)	B	
180	BD+ 09 1353 262108	06 41.6	+09 51	9.92	0.14	0.15	B	A3 III	A3 IV	N	B	
181	Herbig 74	06 41.6	+09 45	15.4	–	–	B	–	K6 IV	E	B	
182	Vas. 193	06 41.6	+09 33	12.84	0.54	−0.10	B	G2 IV	F9 (IV)	S	B	
183	Vas. 189	06 41.6	+09 32	14.95	1.30	–	V	–	(K5 V)		B	
184	Vas. 188 W.224	06 41.6	+09 21	11.53	0.66	0.17	S	G2 IV	G2 (IV)	S	B	
185	Herbig 75 OX MON	06 41.7	+10 10	14.5	–	–	B	–	K2 IV	E	B	
186	BD+ 10 1228 48012	06 41.7	+10 02	8.52	1.20	1.18	W	K2 III	K2 II-III		W	
187	BD+ 09 1355 262138	06 41.7	+09 47	9.59	0.15	0.12	W	A4 III	A3-A4 III		W	
188	Vas. 196 W.228	06 41.7	+09 43	11.07	0.36	0.09	W	F1 III	F0 V		Y	
189	Vas. 200 OZ MON	06 41.7	+09 41	14.05	0.96	0.52	S	G9 IV	K5(V)	E	B	
190	Vas. 191 OY MON	06 41.7	+09 40	14.06	1.00	0.22	S	K1 IV	K5 (IV)	SE	B	

1	2	3	4	5	6	7	8	9	10	11	12	13
191	Vas. 204	06 41.7	+09 34	14.70	0.94	0.86	S	K4 IV	(K5 IV)		B	
192	Vas. 192	06 41.7	+09 34	14.43	1.95	1.58	S	M4 IV	(M3 IV)		B	
193	V 370 Mon HER.76	06 41.7	+09 32	15.3	–	–	B	–	K4 IV	E	B	
194	Vas. 199 W.230	06 41.7	+09 27	12.45	0.89	0.68	S	K1 IV	K1 IV	S	B	
195	Vas. 205	06 41.8	+09 43	13.18	0.75	0.35	S	G6 IV	K1(IV)		B	
196	Vas. 207	06 41	+09	13.85	0.97	0.44	S	G6 IV	K2 (IV)	S	B	
197	BD+ 09 1356 48055	06 41.8	+09 30	8.96	−0.13	−0.66	W	B3 V	B3 V	N	B	
198	Vas. 217	06 41	+09	14.12	0.89	0.49	S	K1 IV	G7 (IV)	S	B	
199	BD+ 10 1230 262177	06 41.9	+10 01	9.78	−0.12	−0.08	W	B9 V	B9 V		B	
200	Vas. 228	06 42	+09	13.53	1.67	1.25	S	M0 IV	(K9 IV)	S	B	
201	Vas. 238	06 42.2	+09 44	11.21	1.01	1.11	S	K1 IV	K1 (IV)	SE	B	
202	Herbig 83 MQ MON	06 42.2	+09 41	14.56	1.32	0.42	B	K4 IV	K3 IV	(E)	B	
203	BD+ 09 1358 262320	06 42.2	+09 32	9.44	1.44	1.27	B	K1 III	K2 II-III		B	

Notes to Table 1:
B – Buscombe [1];
F – Flaccomio *et al.* [3];
P – Park *et al.* [10];
S – Sagar & Joshi [11];
V – Vasilevskis *et al.* [14];
W – Walker [15];
Y – Young [16];
∼ – variable star;
U:B:V: – unreliable estimates.

Table 2. Possible photometric and spectral characteristics of the star number 29

N	Sp	$(B–V)_0$	$E(B–V)$	A_V	V_0	M_V (MS)	V_0-M_V (MS)	r (MS)	M_V (ZAMS)	V_0-M_V (ZAMS)	r (ZAMS)	Sp
1	A0 V	−0.02	1.27	4.06	10.19	0.65	9.54	814	1.3	8.89	597	
2	A5 V	0.15	1.10	3.52	10.75	1.95	8.78	570	2.1	8.65	535	
3	K3 V	1.12	0.13	0.42	13.83	6.65	7.18	270	6.56	7.17	257	K3 V
4	A0IV	−0.02	1.27	4.06	10.19	0.30	8.89	950	–	–	–	
5	A7IV	0.21	1.04	3.33	10.92	1.70	9.22	700	–	–	–	
6	K1IV	0.97	0.28	0.90	13.35	3.10	10.25	1120	–	–	–	K1 IV
7	A0III	−0.02	1.27	4.06	10.19	0.00	10.19	1100	–	–	–	
8	A7III	0.21	1.04	3.33	10.92	1.10	9.82	920	–	–	–	
9	K1III	0.97	0.28	0.90	13.35	0.60	12.75	3550	–	–	–	
10	M5III	1.63	−0.38	0.00	14.25	−0.30	14.55	8130	–	–		
11	A7I	0.21	1.04	3.33	10.92	−6.60	17.52	32000	–	–		
12	F8I	0.53	0.72	2.30	11.95	−6.50	18.45	50000	–	–		
13	K1 I	0.97	0.28	0.90	13.35	−6.00	12.35	75000	–	–		
14	M0 I	1.48	−0.23	0.00	14.25	−5.60	19.85	93000	–	–		

TECHNIQUE OF THE SPECTRAL CLASSIFICATION

We describe here a technique of the two-dimensional spectral classification of O–M stars on temperature parameters and luminosity classes in application to members of the cluster NGC 2264.

As an example we use the photometric data for star 29 in Table 1, for which [15] gives $V = 14.25$, $B-V = 1.25$ and $U-B = 1.03$. From these data we calculate the value $Q_{UBV} = (U-B)-X(B-V) = -0.03$, where $X = E(U-B)/E(B-V) = 0.85$ [13]. Using the value $Q = -0.03$, we find a set of 14 possible spectra and other individual characteristics of the star which are listed in Table 2.

Distances r to the stars and intrinsic distance module $V_0 - M_V$ for the dwarf luminosity class were calculated and given in Table 2 for the two absolute magnitude scales: the cluster zero-age-main-sequence (ZAMS) scale and a background main sequence (MS) scale [12].

To eliminate the multiplicity of spectral classifications, we used information on the distribution

Table 3. Photometric and spectral characteristics of the star number 29 for spectra K4 V and K4 IV

Sp	$(B-V)_0$	$E(B-V)$	A_V	V_0	$M_V(MS)$	$V_0-M_V(MS)$	$M_V(ZAMS)$	$V_0-M_V(ZAMS)$	Sp
K4 V	1.06	0.19	0.61	13.64	7.0	6.64	6.9	6.74	K4 V
K4 IV	1.22	0.03	0.10	14.15	3.5	10.65	–	–	K4 IV

of absorbing dust in the interstellar medium along the given direction. According to [6] and [15], up to distances smaller than r = 760 pc from the Sun where the cluster NGC 2264 is located, there is practically no dust matter. Circumstellar light absorption is here $A_V = 0.26^m$. Beyond the cluster, at distances 1.0 to 1.5 kpc from the Sun, which corresponds to the distance modulus 10 to 11 mag, there are located dust clouds with immersed T Tau stars, and with an absorption up to $A_V = 2.60$ [8]. At yet greater distances, there is a much denser practically opaque dust cloud that totally shields the light of background stars.

The pairs of real values $E(B-V)$ and (V_0-M_V) from Table 2 should conform with the described picture of the absorption of light for cluster members and satisfy the following conditions:

$$E(B-V) = \overline{E(B-V)} \pm 3\sigma_{E(B-V)}, \quad (V_0-M_V) = \overline{(V_0-M_V)} \pm 3\sigma_{(V_0-M_V)}, \tag{1}$$

where $\overline{E(B-V)}$ and $\overline{(V_0-M_V)}$ are average values for the cluster, and $\sigma_{E(B-V)}$, $\sigma_{(V_0-M_V)}$ are standard errors of their determination.

It should be noted that some field stars can contaminate a list of cluster members and condition (1) could not be satisfied for any spectrum from Table 2. In these rare cases it is necessary to use spectra which satisfy inequalities (2), (3) with distance moduli calculated on a scale of absolute magnitudes $M_V(MS)$:

$$E(B-V) < \overline{E(B-V)} \pm 3\sigma_{E(B-V)}, \quad (V_0-M_V) < \overline{(V_0-M_V)} \pm 3\sigma_{(V_0-M_V)} \tag{2}$$

for foreground stars and

$$E(B-V) > \overline{E(B-V)} \pm 3\sigma_{E(B-V)}, \quad (V_0-M_V) > \overline{(V_0-M_V)} \pm 3\sigma_{(V_0-M_V)} \tag{3}$$

for stars of the remote background, *i. e.*, stars located far behind the cluster. Conditions (1) – (3) are criteria useful to bypass possible errors in membership studies.

An average colour excess $\overline{E(B-V)} = 0.08^m$ and average distance modulus $\overline{(V_0-M_V)} = 9.40$ for the cluster NGC 2264 have been derived in [8], [6] and [15]. According to [7], errors in determination of colour excesses and intrinsic distance moduli are $\sigma_{E(B-V)} = 0.10^m$ and $\sigma_{(V_0-M_V)} = 0.80^m$, though in some rare cases the errors $\sigma_{(V_0-M_V)}$ can reach $\pm 1.00^m$. Therefore, a system of inequalities (1) – (3) in our case can be rewritten as: $-0.22^m < E(B-V) < 0.38^m$, $7.00^m < (V_0-M_V) < 11.80^m$ for cluster members; $-0.30^m < E(B-V) < 0.38^m$, $0.00^m < (V_0-M_V) < 11.80^m$ for stars of the foreground; and $-0.38^m < E(B-V)$, $11.80^m < (V_0-M_V)$ for background stars.

The two possible spectra K3 V and K1 IV in Table 2 satisfy the system of inequalities (1). The average of these two estimates is K2 IV–V. Having calculated a value Q_{UBV} with a coefficient $X = 0.95$ valid for the spectral type K2 IV–V [13], we obtain $Q_{UBV} = -0.16$. So, the final estimate of the spectrum is Sp = K4 IV–V.

Now the luminosity class of the star with the serial number 29 can be determined more accurately. For this purpose we calculate individual characteristics of this star with the spectra K4 V and K4 IV (Table 3). The mean value of V_0 for spectra K4 V and K4 IV is 13.90^m. With this value, using condition (1) we find $V_0 - M_V = 9.40^m \pm 2.40^m$ which yields $2.10^m < M_V < 6.70^m$. The last limitation allows to reject a value $M_V = 7.0^m$, thus $Sp(UBV)$ = K4 IV is finally obtained with $M_V = 3.5^m$. This is an improved estimate which agrees relatively well with a preliminary spectrum K7 IV given in [1].

Table 4. Photometric and spectral characteristics of NGC 6913 stars

N	α	δ	V	$U-B$	$B-V$	Sp	N	α	δ	V	$U-B$	$B-V$	Sp
1	20 23 25	38 33 55	15.507	0.185	1.023	G2V	19	20 23 47	38 31 34	15.052	0.594	0.931	G0
2	20 23 29	38 33 50	14.214	0.325	0.912	G0V	20	20 23 27	38 31 37	15.158	0.066	0.986	B5
3	20 23 38	38 34 50	15.280	0.485	0.942	G1V	21	20 23 29	38 31 36	14.871	0.508	1.232	B7V
4	20 23 46	38 34 39	13.678	0.053	0.645	G2V	22	20 23 49	38 31 11	15.424	0.780	0.918	K5V
5	20 23 54	38 34 37	14.521	0.448	0.833	G1V	23	20 23 36	38 31 11	16.876	0.282	0.969	G2
6	20 23 36	38 34 28	14.597	0.055	0.745	G2V	24	20 23 28	38 31 26	13.822	0.582	0.946	G7
7	20 23 51	38 34 15	14.685	0.540	1.021	G3V	25	20 23 24	38 31 20	12.945	1.226	1.771	M5
8	20 23 23	38 33 29	14.709	0.522	0.957	G2V	26	20 23 46	38 31 16	12.321	0.039	0.658	B5
9	20 23 22	38 33 26	15.095	0.596	0.982	G0V	27	20 23 55	38 30 49	15.326	0.329	0.930	G0
10	20 23 57	38 33 12	15.432	0.782	0.946	K2V	28	20 23 33	38 30 45	15.225	0.714	0.892	K6
11	20 23 54	38 33 11	13.565	0.864	0.851	K3IV	29	20 23 46	38 30 39	16.292	0.691	0.867	G3V
12	20 23 24	38 32 36	14.276	0.663	1.224	K0	30	20 23 34	38 30 36	15.411	0.392	1.048	G4V
13	20 23 50	38 32 33	15.195	0.293	0.840	G0V	31	20 23 36	38 30 29	14.087	0.157	0.768	G3V
14	20 23 50	38 32 17	13.905	0.647	0.935	G2V	32	20 23 51	38 30 21	14.622	0.377	0.982	G3
15	20 23 23	38 32 09	15.023	0.406	1.061	K5V	33	20 23 35	38 30 20	14.619	0.501	0.910	G2
16	20 23 57	38 32 02	14.693	0.943	0.940	K5V	34	20 23 48	38 30 18	14.266	0.643	1.046	G3
17	20 23 47	38 31 46	15.452	0.823	0.907	K5V	35	20 23 49	38 30 15	14.449	0.437	1.020	G2
18	20 23 56	38 31 50	14.564	0.497	0.902	F7	36	20 23 29	38 30 05	14.182	0.218	0.843	G2

SPECTRAL CLASSIFICATIONS FOR OPEN CLUSTERS NGC 2244, NGC 2264, AND NGC 6913

Spectra of stars, obtained in the way described are given in Table 1. In the first seven columns of the table, serial numbers, star names, coordinates α and δ at the epoch J2000.0, magnitudes V, and colour indices are given. The eighth column contains references to the photometric data sources; in the ninth column the spectral characteristics of stars $Sp(UBV)$ obtained in this study on the basis of UBV photometry are given. In the tenth, eleventh and twelfth columns are given spectral characteristics found by other authors, remarks to these spectra, and references on data sources. The thirteenth column contains supplementary notes.

Spectral types of 17–22^m (V) stars in the direction of NGC 2264, and of 14^m (V) stars in the direction of NGC 2244 derived from UBV data are given in [9]. The UBV magnitudes for stars of NGC 6913 were measured with the two-channel focal reducer [4] at the 2-m RCC telescope of the Terskol Observatory. During the observations we used the U filter DUG11 ($\lambda_0^\alpha = 338$ nm, $\Delta\lambda = 93$ nm); the B filter BB+BG39/2 ($\lambda_0^\alpha = 431$ nm, $\Delta\lambda$=128 nm) and the V filter ($\lambda_0^\alpha = 531$ nm, $\Delta\lambda = 93.3$ nm). The exposures ranged from 10 to 600 s in the U band, from 10 to 300 s in the B band, and from 10 to 600 s in the V band. The reduction of the measured ubv magnitudes was performed using 11–14^m photoelectric standards [5] in the same frame. A linear transformation $U = a_1 + b_1 u$, $B = a_2 + b_2 b$, $V = a_3 + b_3 v$ with $a_1 = 23.64$, $a_2 = 25.78$, $a_3 = 26.09$, $b_1 = 0.96$, $b_2 = 0.97$, $b_3 = 0.96$ was applied. Standard deviations for photometric magnitudes of stars used as standards [5] were estimated to be $\pm 0.02^m$, $\pm 0.03^m$ and $\pm 0.01^m$ in the UBV bands, respectively. An internal accuracy for the target stars was found to be $\pm 0.09^m$ for U, B magnitudes and $\pm 0.005^m$ for V. For 36 stars of NGC 6913 in Table 4 we give their positions α and δ at the epoch J2000.0, V magnitudes, colours $U-B$, $B-V$ and spectra Sp derived from the photometric data.

In this study we present first results of the spectral classification for faint stars that can be applied for solving many problems of modern astrophysics and stellar astronomy.

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