EXAMPLE: THE HAWAIʻI THESIS CLASS WITH AASTEX

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAIʻI IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

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By
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To the sundial in the center of the courtyard

Acknowledgements

I wish to thank Trevor Jim for the arduous task of converting and correcting the UH Thesis macros so that they would work properly with modern forms of Latex. And thanks to Kevin Jim for putting all the documentation together for thesis work. Huge thanks to Jason Surace, Joe Jensen, Chris Dudley, Jeff Goldader, and the many others who created the initial versions of the macros.

Abstract

This is the abstract, which the university deems should be less than 350 words.

The density and nature of Ph.D. dissertations is of little or no importance. However, finishing yours is of great importance.

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Chapter 1

Introduction

Abstract *this shows use of natbib–ADS citations*

The idea that galaxies could act as gravitational lenses was proposed by F. Zwicky (Zwicky (1937) and Schneider et al. (1992).) *Note the use of the cite command and the period before the right parenthesis*

1.1 A New Section *this shows a section*

Fifty years later, Zwicky's predictions were confirmed with the discovery of giant blue arcs in the cores of the rich clusters CL2244-02 and Abell 370 (Soucail et al. (1988); Lynds & Petrosian (1989); Fort (1989); Fort et al. (1988)), which were interpreted as the distorted images of distant field galaxies.

1.1.1 A Subsection

Over the next few years more than ten sets of arcs were discovered, all of them in rich clusters of galaxies. Tyson also found sets of smaller and fainter "arclets" which he interpreted as distorted images of the population of faint blue field galaxies in the redshift range of $0.8 < z < 3$ (Tyson (1990)).

1.2 Another Section

Since the population of faint blue galaxies is so great ($>$ 150 galaxies per arcmin^2 at a limiting surface brightness of 29 mag$\cdot$arcsec^{-2}) most gravitational lens images by clusters should be of background galaxies (Fort (1990)).

References

Fort, B. 1990, in Gravitational lensing; Proceedings of the Workshop, Toulouse, France, Sept. 13-15, 1989 (A91-39303 16-90). Berlin and New York, Springer-Verlag, 1990, p. 221-229., 221–229

Fort, B., Prieur, J. L., Mathez, G., Mellier, Y., & Soucail, G. 1988, A&A, 200, L17

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Soucail, G., Mellier, Y., Fort, B., Mathez, G., & Cailloux, M. 1988, A&A, 191, L19

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Zwicky, F. 1937, ApJ, 86, 217+

Chapter 2

The UH 2.2m Fast Tip-Tilt Secondary System

Note: This chapter originally appeared as Jim et al. (2000), with co-authors Kevin T.C. Jim, Andrew J. Pickles, Hubert T. Yamada, J. Elon Graves, Alan Stockton, Malcolm J. Northcott, Tony Young, Lennox L. Cowie, Gerard A. Luppino, Robert J. Thornton, Renate Kupke, and Edward Sousa.

Abstract

Using a new f/31 secondary on a tip-tilt platform, we have built an image-stabilization system which has been used regularly for astronomical imaging and spectroscopy on the University of Hawaii 2.2-m telescope. Diffraction-limited cores of stellar point-spread functions are achieved in near infrared imaging, with Strehl ratios as high as 0.47. K-band images with $0.3''$ FWHM resolution (without deconvolution) are routinely obtained. The construction, operation, and capability of the current system are described, a summary of recent scientific findings is presented, and future improvements are outlined.

2.1 How to Include Figures The EASY Way Using AASTEX

Stellar images show the triaxial nature of the wings of the PSF which are due to the residual mirror support problems mentioned previously (see Figure 2.1). Nevertheless, the overall image quality is excellent, with Strehl ratios as high as 0.47 possible for bright guide stars.

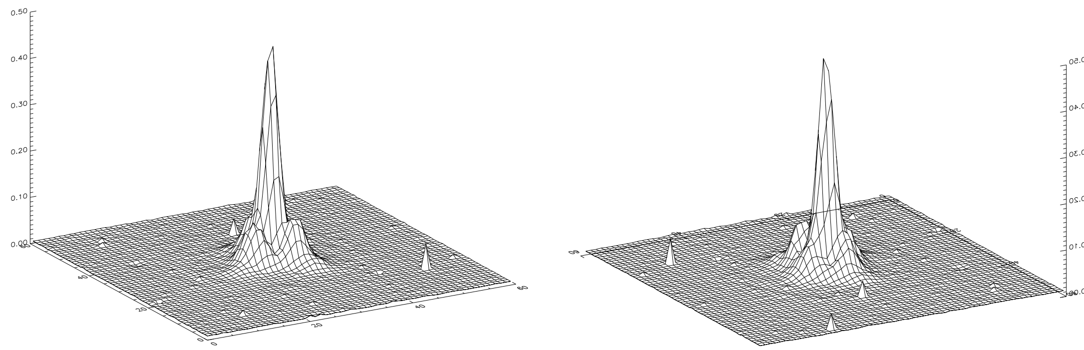

Figure 2.1 A 10 second K image of a star with a Strehl of 0.47, shown from two different perspectives (front and back). The triaxial nature of the PSF is caused by the problems with the primary mirror support, which have since been corrected. *Note this figure uses the plottwo command.*

Depending on the intrinsic seeing and the brightness of the guide star, loop update rates of 25–125 Hz are commonly used. At K', the tip-tilt system typically will improve the FWHM of stellar images by a factor of two, with the encircled energy in the Airy disk increasing by 25%. Unfortunately, the imperfect mirror support becomes evident with triaxial image formation caused by the airbags under the primary mirror. Adjustment of the airbag support under the primary mirror has reduced the effect of the airbags. This has reduced the amplitude of the triaxial wings from the airbags from 25% initially of the peak to less than 10% today.

References

Jim, K. T. C., Pickles, A. J., Yamada, H. T., Graves, J. E., Stockton, A., Northcott, M. J., Young, T., Cowie, L. L., Luppino, G. A., Thornton, R. J., Kupke, R., Sousa, E., Cavedoni, C. P., Keller, T. J., Nakamura, W., & Metzger, M. R. 2000, PASP, 112, 716

Chapter 3

Observations

3.1 Infrared Photometric Standards *Variations on Tables and Making Up BIBTEX Entries*

In the beginning of this project, the Elias infrared standards (Elias et al. (1982b); Elias et al. (1982a)) were the most commonly used infrared photometric standard stars. An improved version of the Elias standards, the bright UKIRT standards (Table 3.1) (Casali (1992)) were used for the initial observations. These were extensively observed using IRCAM on UKIRT, and it was assumed that the systematic errors would be lower than the Elias standards. Table 3.1 shows the list of the standards and the derived K' magnitudes.

In the second part of this thesis research, the UKIRT Faint standards (Casali & Hawardeen (1992)) became available (see Table 3.2). These are much fainter stars suitable for use on 4-m class telescopes. They are generally located close to the galactic plane, which leads to some problems, since the fields selected for this project are all deliberately chosen to be far from the galactic plane. In addition, the standards were never published in any journal, and were revised throughout the acquisition of the data. While the standard magnitudes were generally stable standards were removed and added to the list. The magnitudes derived in Table 3.3 were used for this work.

Table 3.1 UKIRT Bright Standards, March 3, 1992. Information is from the UKIRT Web site.

No.	Name	Sp	R.A. (J1950.0) h	m	s	Dec. (J1950.0) °	′	″	J	H	K	K' †
1	‡HD 225023	A0	00	00	11.8	35	32	14	7.082	6.993	6.962	6.970
2	‡G158-27	M5	00	04	12.0	-07	47	54	8.378	7.781	7.447	7.536
3	‡BS 33	F7V	00	08	43.2	-15	44	32	3.964	3.689	3.636	3.650
4	‡HD 1160	A0	00	13	23.1	03	58	24	7.060	7.051	7.040	7.043
5	HD 2811	A2	00	28	53.0	-43	52	58	7.178	7.093	7.067	7.074
6	HD 3029	A3	00	31	02.3	20	09	30	7.263	7.125	7.093	7.101
7	BS 337	M0III	01	06	55.5	35	21	22	-0.908	-1.70	-1.85	-1.813
8	BS 696	B2Iae	02	21	43.1	56	23	04	5.587	5.499	5.443	5.458
9	‡BS 718	B9III	02	25	29.8	08	14	13	4.374	4.390	4.390	4.390
10	BS 739	gG3	02	29	36.6	-01	15	17	3.748	3.218	3.121	3.147
11	BS 740	F4IV	02	29	43.0	-15	27	48	3.879	3.623	3.585	3.595
12	‡GL 105.5	M0	02	38	07.6	00	58	57	7.305	6.663	6.539	6.572
13	BS 816	gF0	02	42	43.4	04	30	08	5.502	5.384	5.353	5.361
14	HD 18881	A0	03	00	20.5	38	12	53	7.130	7.135	7.140	7.139
15	HD 19904	A2	03	08	49.1	-39	14	24	6.727	6.662	6.642	6.647
16	G77-31	M4?	03	10	40.5	04	35	12	8.816	8.187	7.857	7.944
17	‡HD 22686	A0	03	36	18.7	02	36	07	7.196	7.190	7.185	7.186
18	BS 1140	B7IV	03	41	49.5	24	08	01	5.520	5.500	5.510	5.507
19	BS 1457	K5III	04	33	02.9	16	24	37	-1.848	-2.61	-2.78	-2.738
20	BS 1543	F6V	04	47	07.4	06	52	32	2.353	2.117	2.095	2.101
21	BS 1552	B2III	04	48	32.4	05	31	16	4.029	4.087	4.138	4.124
22	BS 1641	B7V	05	03	00.2	41	10	08	3.518	3.646	3.677	3.669
23	BS 1637	F0V	05	06	40.6	51	35	52	4.312	4.204	4.153	4.167
24	BS 1713	B8Iae	05	12	08.0	-08	15	29	0.240	0.241	0.211	0.219

continued on the next page

† $K' = K + 0.265 * (H - K)$

‡ multiple star system

Table 3.1, continued.

No.	Name	Sp	R.A. (J1950.0) h	m	s	Dec. (J1950.0) °	′	″	J	H	K	K' †
25	BS 1708	G4III	05	12	59.5	45	56	58	-1.334	-1.71	-1.80	-1.779
26	SAO112626	F8	05	16	41.4	01	39	15	8.934	8.670	8.596	8.616
27	BS 1869	dF0	05	36	15.9	47	42	56	5.532	5.454	5.393	5.409
28	HD 38921	A0	05	45	41.0	-38	14	51	7.572	7.551	7.536	7.540
29	‡HD 40335	A0	05	55	37.6	01	51	09	6.555	6.473	6.452	6.458
30	BS 2228	F0V	06	17	34.6	46	25	57	6.012	5.943	5.892	5.906
31	‡HD 44612	A0	06	21	09.7	43	34	35	7.075	7.041	7.041	7.041
32	BS 2491	A1V	06	42	56.7	-16	38	46	-1.300	-1.31	-1.32	-1.320
33	‡BD+0 1694	?	06	52	07.3	00	00	52	5.750	4.857	4.606	4.673
34	BS 2721	G0V	07	12	07.6	47	19	51	4.475	4.180	4.126	4.140
35	BS 2943	F5IV	07	36	41.1	05	21	16	-0.437	-0.56	-0.64	-0.624
36	BS 2990	K0IIIb	07	42	15.6	28	08	55	-0.523	-0.97	-1.05	-1.030
37	BS 3314	A0V	08	23	09.7	-03	44	31	3.920	3.919	3.940	3.934
38	HD 75223	A0	08	45	29.8	-39	36	54	7.329	7.296	7.281	7.285
39	‡HD 77281	A2	08	59	05.4	-01	16	45	7.111	7.052	7.031	7.037
40	‡GL 347A	M3.5	09	26	25.0	-07	08	30	8.483	7.881	7.658	7.717
41	‡HD 84800	A2	09	45	35.9	43	53	56	7.592	7.549	7.538	7.541
42	BS 3888	F2IV	09	47	27.1	59	16	30	3.162	3.005	2.983	2.989
43	BS 3903	G7III	09	49	04.3	-14	36	40	2.617	2.136	2.050	2.073
44	V 569	M3	10	09	46.3	-03	29	41	5.992	5.310	5.106	5.160
45	BS 4069	M0III	10	19	21.5	41	45	06	0.132	-0.65	-0.80 -	0.764
46	GL 390	M1.5	10	22	44.0	-09	58	36	6.939	6.275	6.061	6.118
47	GL 406	M6	10	54	06.0	07	19	12	7.143	6.469	6.099	6.197
48	BS 4358	K3III	11	11	25.9	08	20	05	3.879	3.299	3.202	3.228

continued on the next page

† $K' = K + 0.265 * (H - K)$

‡ multiple star system

Table 3.1, continued.

No.	Name	Sp	R.A. (J1950.0) h	m	s	Dec. (J1950.0) °	′	″	J	H	K	K' †
49	HD101452	A2	11	37	45.1	-38	52	09	7.018	6.890	6.848	6.859
50	Y 2730	dM4.5	11	45	08.2	01	05	56	6.532	5.935	5.646	5.723
51	BS 4550	G8V	11	50	06.2	38	04	39	4.957	4.466	4.400	4.417
52	HD105601	A2	12	06	56.1	38	54	39	6.821	6.719	6.687	6.695
53	‡HD106965	A2	12	15	24.0	01	51	10	7.380	7.337	7.316	7.322
54	‡BS 4689	A2IV	12	17	20.8	00	23	21	3.810	3.781	3.781	3.781
55	BS 4935	F7V	13	01	05.1	-20	18	55	4.604	4.290	4.266	4.272
56	BS 4983	G0V	13	09	32.5	28	07	52	3.194	2.929	2.886	2.897
57	BS 5340	K1IIb	14	13	22.8	19	26	31	-2.200	-2.87	-2.97	-2.950
58	‡BS 5447	F2V	14	32	30.2	29	57	41	3.723	3.522	3.489	3.498
59	HD129653	A2	14	40	38.2	36	58	07	6.985	6.942	6.921	6.927
60	‡HD129655	A2	14	41	11.0	-02	17	38	6.826	6.724	6.692	6.700
61	HD130163	A0	14	44	36.2	-39	43	04	6.856	6.846	6.835	6.838
62	BD+3 2954	M0	14	52	23.2	03	11	33	5.926	5.026	4.825	4.878
63	BS 5685	B8V	15	14	18.7	-09	11	59	2.759	2.789	2.799	2.796
64	‡HD136754	A0	15	19	24.3	24	31	19	7.155	7.146	7.135	7.138
65	‡BD+2 2957	K2	15	22	29.0	01	41	06	5.280	4.454	4.263	4.314
66	BS 6084 B2	II+O9V	16	18	08.7	-25	28	29	2.491	2.442	2.421	2.427
67	‡BS 6092	A9III	16	18	14.1	46	25	54	4.192	4.257	4.298	4.287
68	S-R 3	?	16	23	07.7	-24	27	26	7.804	7.001	6.543	6.664
69	OPH S1	?	16	23	32.8	-24	16	44	9.007	7.344	6.378	6.634
70	BS 6136	K4III	16	26	00.9	00	46	32	2.898	2.184	2.036	2.075
71	BS 6147	G8IIIa	16	28	16.4	-16	30	19	2.767	2.334	2.269	2.286
72	BS 6406	M5Ib	17	12	22.0	14	26	45	-2.276	-3.11	-3.35	-3.287

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† $K' = K + 0.265 * (H - K)$
‡ multiple star system

Table 3.1, continued.

No.	Name	Sp	R.A. (J1950.0) h	m	s	Dec. (J1950.0) °	′	″	J	H	K	K' †
73	HD161743	A0	17	45	31.8	-38	06	11	7.620	7.620	7.615	7.616
74	‡HD161903	A2	17	45	43.3	-01	47	34	7.172	7.059	7.023	7.033
75	‡HD162208	A0	17	46	20.7	39	59	40	7.223	7.141	7.112	7.120
76	BS 6707	F2II	17	56	35.3	30	11	32	3.470	3.252	3.210	3.221
77	‡Y 4338	dM4.5e	18	46	44.1	-23	53	32	6.297	5.680	5.416	5.486
78	BS 7120	K3II	18	52	05.8	-22	44	08	2.739	2.120	2.033	2.056
79	‡GL 748	dM4	19	09	38.0	02	48	36	7.105	6.557	6.319	6.382
80	BS 7615	K0III	19	54	25.7	34	56	58	2.199	1.716	1.640	1.660
81	‡BS 7773	B9.5V	20	17	53.5	-12	55	04	4.825	4.859	4.859	4.859
82	‡GL 811.1	dM4	20	54	04.0	-10	37	36	7.832	7.185	6.946	7.009
83	‡HD201941	A2	21	10	13.6	02	26	12	6.696	6.657	6.626	6.634
84	BS 8143	B9Iab	21	15	27.0	39	11	04	3.886	3.838	3.797	3.808
85	‡HD203856	A0	21	21	37.1	39	48	12	6.926	6.887	6.861	6.868
86	HD205772	A3	21	35	33.6	-41	16	26	7.775	7.688	7.657	7.665
87	SAO34401	F0	22	21	47.7	54	57	12	7.933	7.766	7.734	7.742
88	‡BS 8541	B9Iab	22	22	29.0	49	13	21	4.305	4.267	4.235	4.243
89	BS 8551	K0III	22	25	19.6	04	26	39	2.956	2.378	2.312	2.329
90	‡Y 5546	dM5	22	50	36.2	-14	31	34	5.980	5.344	5.066	5.140
	*GL 299		08-	09	14.5	08	56	01	8.38	7.915	7.640	7.713

†$K' = K + 0.265 * (H - K)$

‡multiple star system

*GL299 has a high proper motion (1163, -5079 mas/yr) and was thus dropped off the list, but was previously available

Table 3.2 UKIRT Faint Standards - May 1998

	R.A. (J1950.0)			Dec. (J1950.0)								
Name	h	m	s	°	′	″	K	$K\ \sigma$	$J-K$	$J-K\ \sigma$	$H-K$	$H-K\ \sigma$
FS01	00	31	22.7	-12	24	29	12.967	0.021	0.462	0.011	0.081	0.012
FS02	00	52	36.0	+00	26	58	10.466	0.003	0.247	0.003	0.038	0.003
FS03	01	01	46.6	+03	57	34	12.822	0.007	-0.222	0.011	-0.097	0.007
FS04	01	52	03.7	+00	28	20	10.264	0.005	0.292	0.003	0.040	0.007
FS05	01	52	04.7	-07	00	47	12.342	0.006	-0.007	0.004	-0.002	0.004
FS06	02	27	39.2	+05	02	34	13.374	0.015	-0.135	0.014	-0.069	0.012
FS07	02	54	47.2	+00	06	39	10.940	0.005	0.165	0.012	0.037	0.010
FS08	02	55	12.9	+00	04	04	8.313	0.006	0.766	0.002	0.129	0.004
FS09	02	55	38.8	+00	58	54	8.266	0.006	0.884	0.003	0.158	0.005
FS10	03	46	17.4	-01	07	38	14.919	0.072	-0.170	0.077	-0.049	0.060
FS11	04	50	25.4	-00	19	34	11.278	0.018	0.076	0.025	0.016	0.019
FS12	05	49	34.8	+15	52	37	13.898	0.003	-0.217	0.014	-0.091	0.018
FS13	05	54	33.8	+00	00	53	10.135	0.003	0.382	0.002	0.047	0.005
FS14	07	21	41.2	-00	27	10	14.261	0.012	-0.153	0.005	-0.079	0.020
FS15	08	48	21.9	+11	55	02	12.360	0.021	0.418	0.008	0.060	0.007
FS16	08	48	31.0	+12	00	36	12.631	0.008	0.340	0.006	0.038	0.005

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The UKIRT Faint Standards as published on the UKIRT website in May of 1998. These were the values used in this dissertation. Some of the stars on this list were removed since that time, and some magnitudes may have changed. In addition, the errors in measurements are different-generally, better measurements are available. At the time of this dissertation, the standards had yet to be formally published. Coordinate epoch is J1950.0.

Table 3.2, continued.

	R.A. (J1950.0)			Dec. (J1950.0)								
Name	h	m	s	°	′	″	K	$K\ \sigma$	$J-K$	$J-K\ \sigma$	$H-K$	$H-K\ \sigma$
FS17	08	48	35.4	+12	03	26	12.270	0.007	0.411	0.007	0.073	0.003
FS18*	08	51	02.1	-00	25	14	10.522	0.008	0.292	0.003	0.031	0.003
FS19	10	31	14.5	-11	26	08	13.796	0.025	-0.231	0.021	-0.142	0.047
FS20	11	05	27.6	-04	53	04	13.473	0.017	-0.120	0.015	-0.069	0.012
FS21	11	34	27.6	+30	04	35	13.132	0.004	-0.184	0.033	-0.101	0.037
FS23	13	39	25.7	+28	44	59	12.374	0.000	0.623	0.004	0.072	0.018
FS24	14	37	33.3	+00	14	36	10.753	0.008	0.151	0.006	0.019	0.004
FS25	15	35	59.9	+00	24	03	9.756	0.017	0.475	0.003	0.070	0.005
FS26	16	34	26.3	-00	28	39	7.972	0.009	0.858	0.004	0.155	0.006
FS27	16	38	54.2	+36	26	56	13.123	0.018	0.371	0.013	0.058	0.014
FS28*	17	41	32.5	-00	23	44	10.597	0.016	0.148	0.010	0.047	0.005
FS29	21	49	53.0	+02	09	16	13.346	0.024	-0.171	0.011	-0.075	0.012
FS30	22	39	11.3	+00	56	55	12.015	0.020	-0.092	0.013	-0.036	0.005
FS31	23	09	50.4	+10	30	46	14.039	0.010	-0.241	0.020	-0.120	0.017
FS32	23	13	38.2	-02	06	58	13.664	0.012	-0.205	0.011	-0.088	0.015
FS33	12	54	35.1	+22	18	08	14.240	0.016	-0.223	0.010	-0.078	0.024
FS34	20	39	41.9	-20	15	21	12.989	0.011	-0.170	0.008	-0.070	0.009
FS35	18	24	44.5	+04	01	17	11.757	0.017	0.474	0.008	0.089	0.005

Coordinate epoch is J1950.0. Stars marked with (*) are double.

Table 3.3 Derived UKIRT Faint Standards Magnitudes - May 1998

Name	J	$J\ \sigma$	H	$H\ \sigma$	K	$K\ \sigma$	K'	$K'\ \sigma$
FS01	13.429	0.024	13.048	0.084	12.967	0.021	12.988	0.021
FS02	10.713	0.004	10.504	0.038	10.466	0.003	10.476	0.003
FS03	12.600	0.013	12.725	0.097	12.822	0.007	12.796	0.007
FS04	10.556	0.006	10.304	0.040	10.264	0.005	10.275	0.005
FS05	12.335	0.007	12.340	0.006	12.342	0.006	12.341	0.006
FS06	13.239	0.021	13.305	0.071	13.374	0.015	13.356	0.015
FS07	11.105	0.013	10.977	0.037	10.940	0.005	10.950	0.006
FS08	9.079	0.006	8.442	0.129	8.313	0.006	8.347	0.006
FS09	9.150	0.007	8.424	0.158	8.266	0.006	8.308	0.006
FS10	14.749	0.105	14.870	0.087	14.919	0.072	14.906	0.074
FS11	11.354	0.031	11.294	0.024	11.278	0.018	11.282	0.019
FS12	13.681	0.014	13.807	0.091	13.898	0.003	13.874	0.006
FS13	10.517	0.004	10.182	0.047	10.135	0.003	10.147	0.003
FS14	14.108	0.013	14.182	0.080	14.261	0.012	14.240	0.013
FS15	12.778	0.022	12.420	0.064	12.360	0.021	12.376	0.021
FS16	12.971	0.010	12.669	0.039	12.631	0.008	12.641	0.008
FS17	12.681	0.010	12.343	0.073	12.270	0.007	12.289	0.007
FS18*	10.814	0.009	10.553	0.032	10.522	0.008	10.530	0.008
FS19	13.565	0.033	13.654	0.144	13.796	0.025	13.758	0.028
FS20	13.353	0.023	13.404	0.071	13.473	0.017	13.455	0.017
FS21	12.948	0.033	13.031	0.101	13.132	0.004	13.105	0.011
FS23	12.997	0.004	12.446	0.072	12.374	0.000	12.393	0.005
FS24	10.904	0.010	10.772	0.021	10.753	0.008	10.758	0.008
FS25	10.231	0.017	9.826	0.072	9.756	0.017	9.775	0.017
FS26	8.830	0.010	8.127	0.155	7.972	0.009	8.013	0.009
FS27	13.494	0.022	13.181	0.061	13.123	0.018	13.138	0.018
FS28*	10.745	0.019	10.644	0.050	10.597	0.016	10.609	0.016
FS29	13.175	0.026	13.271	0.079	13.346	0.024	13.326	0.024
FS30	11.923	0.024	11.979	0.041	12.015	0.020	12.005	0.020
FS31	13.798	0.022	13.919	0.120	14.039	0.010	14.007	0.011
FS32	13.459	0.016	13.576	0.089	13.664	0.012	13.641	0.013
FS33	14.017	0.019	14.162	0.080	14.240	0.016	14.219	0.017
FS34	12.819	0.014	12.919	0.071	12.989	0.011	12.970	0.011
FS35	12.231	0.019	11.846	0.091	11.757	0.017	11.781	0.017

Coordinate epoch is J1950.0. $K' = K + 0.265(H - K)$ (from Wainscoat and Cowie (1992)). Errors are quadratic sum 1 σ values for J,H,K'. Stars marked with (*) are double.

3.2 *Referencing Equations*

As McCaughrean (1988) points out, the noise in the final, reduced pixel is much more complex than this. There are the additional noise components of the sky subtraction ($\sigma_{\text{sky}-}{}^2$), the residual flattening errors $\sigma_{\text{flatresidual}}{}^2()$, and noise in the flat field image ($\sigma_{\text{flatsky}-}{}^2$).

$$\sigma_{\text{pixel}}{}^2 = (tG)^2 \cdot [s_{\text{b}} + s_{\text{dc}} + T^2(s_{\text{sky}} + s_{\text{obj}} + \sigma_{\text{sky}-}{}^2 + \sigma_{\text{flatresidual}}{}^2 + \sigma_{\text{flatsky}-}{}^2)] + \sigma_{\text{rn}}{}^2 \quad (3.1)$$

In order to minimize the noise then, the $\sigma_{\text{sky}-}{}^2$, $\sigma_{\text{flatresidual}}{}^2$, and $\sigma_{\text{flatsky}-}$ terms of Equation 3.1 must be reduced as much as possible.

3.3 Using the graphicx includegraphics command

The optical and infrared–optical colors of elliptical galaxies are shown in Figure 3.1.

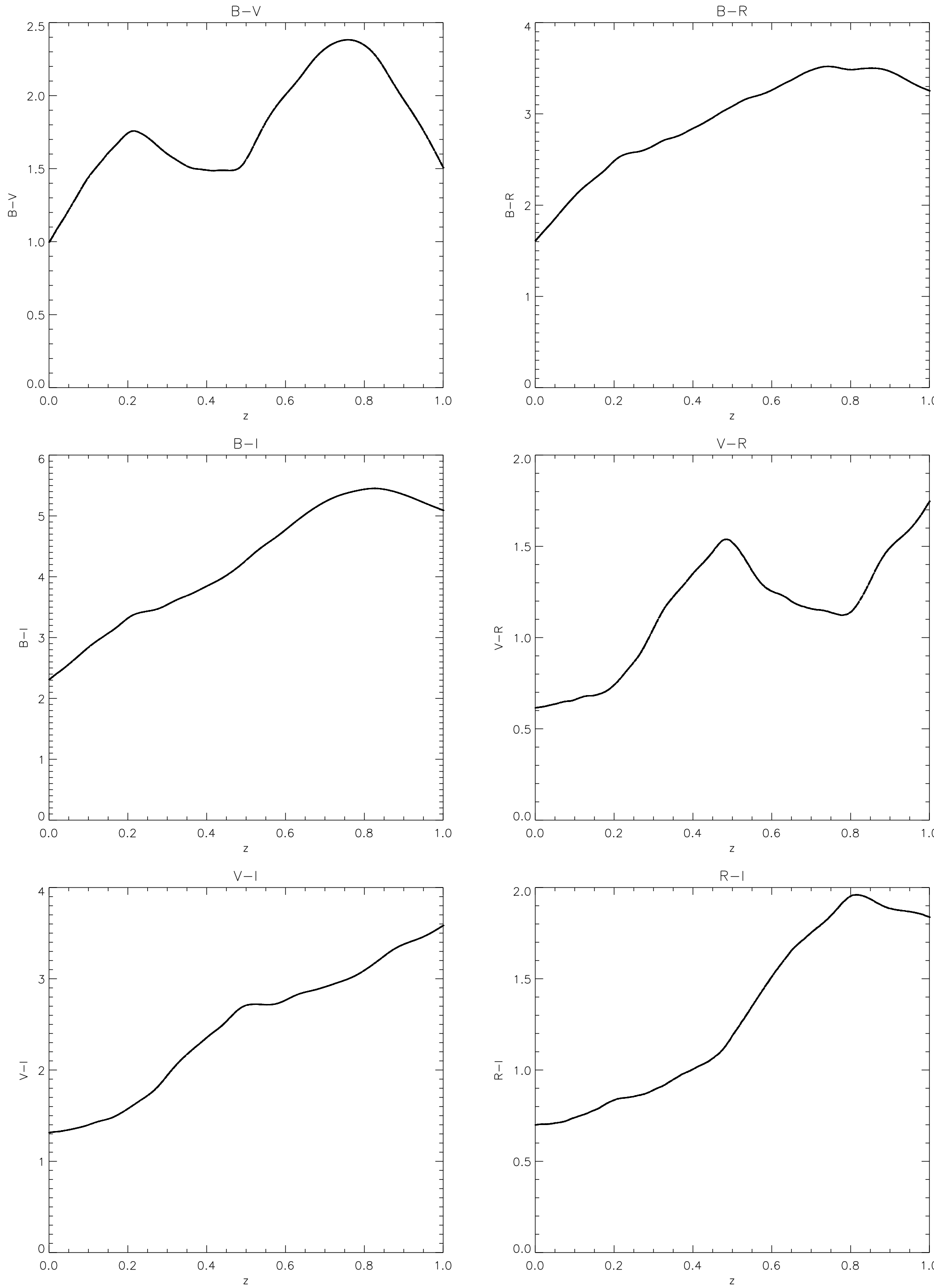

Figure 3.1 Optical colors of elliptical galaxies as a function of redshift assuming no evolution, with $H_0 = 75$, $\Omega_M = 0.3$, $\Omega_V = 0.7$.

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Appendix A

A Single Appendix

Note that when using BibTeX, you must have a citation in every chapter, or it will fail. Gratuitous citation: Jim et al. (2000).

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