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A near-infrared stellar spectral library: I. H-band spectra

Arvind Ranade[1], Ranjan Gupta,[1*], N. M. Ashok,[2] and Harinder P. Singh[3]
[1] *IUCAA, Post Bag 4,Ganeshkhind, Pune 411 007, India*
[2] *Physical Research Laboratory, Navrangpura, Ahmedabad 380009, India*
[3] *Department of Physics & Astrophysics, University of Delhi, Delhi 110 007, India*

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Abstract. This paper presents the H band near-infrared (NIR) spectral library of 135 solar type stars covering spectral types O5–M3 and luminosity classes I–V as per MK classification. The observations were carried out with 1.2 meter Gurushikhar Infrared Telescope (GIRT), at Mt. Abu, India using a NICMOS3 HgCdTe 256 × 256 NIR array based spectrometer. The spectra have a moderate resolution of 1000 (about 16 Å) at the H band and have been continuum shape corrected to their respective effective temperatures. This library and the remaining ones in J and K bands once released will serve as an important database for stellar population synthesis and other applications in conjunction with the newly formed large optical coudé feed stellar spectral library of Valdes et al. (2004). The complete H-Band library is available online at: http://vo.iucaa.ernet.in/~voi/NIR_Header.html

Keywords : infrared: stars — techniques: spectroscopic

1. Introduction

Near-infrared astronomy has seen a very rapid growth in the past few decades. This growth has also initiated efforts by various groups to observe stars in the NIR region, i.e., J, H and K bands and make photometric and spectroscopic measurements. A comprehensive set of reference spectra in these bands has special importance in stellar population synthesis studies of galaxies, clusters and AGN's and for the purpose of synthesizing the

*e-mail:rag@iucaa.ernet.in

integrated light spectrum of these objects. Large-area photometric sky surveys such as 2MASS (2 Micron All-Sky Survey, Skrutskie et al. 1997) and DENIS (Deep Near-Infrared Survey, Epchtein 1997) have produced large target lists that require spectroscopic follow-ups.

Modern spectral classification tools like Artificial Neural Networks (ANN) have recently made use of such spectral libraries in the optical region (Valdes et al. 2004). Near-infrared libraries would render a long wavelength baseline from optical to NIR region for the purpose of such classification. In particular, Blum et al. (1997) have used H band (1.5 μm to 1.8 μm) spectra to classify OB stars to an accuracy of ± 2 sub-spectral types.

The features of the most prominent near-infrared stellar spectral libraries available in the literature have been summarized recently by Ivanov et al. (2004). They have also presented H and K-Band spectra of 218 red stars spanning a range of [Fe/H] $\sim$ -2.2 to $\sim$ +0.3. We present here a spectral library of 135 stars in the H band at a moderate resolution of 16 Å covering a larger range in $T_{\rm eff}$ as compared to Ivanov et al. (2004) thus complementing the existing NIR libraries. For 119 of the stars, the wavelength coverage is from 1.52 μm to 1.78 μm and for 16 stars the coverage is from 1.55 μm to 1.73 μm.

Section 2 describes the observations and related issues. In section 3, we describe the basis of selection of the stars for this library and in section 4 we describe the data reduction and calibration procedure. Lastly, in section 5 we show examples of some H band spectra and their comparison with the existing database of Meyer et al. (1998).

2. Observations

The library of 135 stars has a substantial coverage of H-R diagram from O5-M3 spectral class and supergiants to dwarfs(I to V). This database has been compiled through six different observing runs (January -April 2003), details of which are shown in the observations log (Table 1). All the observations were made at the 1.2 meter Gurushikhar Infrared Telescope (GIRT) of Mt.Abu Infrared Observatory, India ($24^0 39' \ 10.9''$N, $72^0 46' \ 45.9''$E at an altitude of 1680 meters). The H band long slit spectra were obtained using the NIR Imager/Spectrometer equipped with a 256$\times$256 HgCdTe NICMOS3 array. The slit width corresponds to 2 arc-seconds for the f/13 Cassegrain focus with the slit covering most of 240 arc-seconds field of view and oriented along North-South direction in the sky. The reflection grating has 149 lines per mm and is blazed for H band center wavelength of 1.65 μm in the first order and combined with the slit width of 76 μm gives a moderate resolution of 1000.

The exposure time for individual spectrum ranged from 15 to 60 sec depending on the H magnitude of the programme star resulting in S/N ratio of 50 or better. Two sets of spectra were obtained at two dithered positions on the slit with typical separation of

Table 1. Observations Log at GIRT.

Date of Observations	Programme Stars	Standard Stars	Wavelength Region (Å)
20-24 Jan 03	16	1	15550 - 17300
07-12 Feb 03	36	3	15200 - 17800
02-04 Mar 03	12	2	15200 - 17800
17-20 Mar 03	27	1	15200 - 17800
04-07 Apr 03	25	9	15200 - 17800
27-30 Apr 03	19	18	15200 - 17800

20 arcsec. A total of 3 spectra were obtained at the two positions along the slit. The conventional JHK filters were placed in a filter wheel while the grating was mounted on a rotating platform. The selection of the filter and the positioning of the grating for the corresponding filter was achieved through a command line option of the stepper motor controller from the main console room. As the 256 elements of NICMOS3 array in the dispersion axis do not cover the entire H band, the spectra have been obtained at two different grating positions and subsequently single H band spectra have been computed. Section 4 gives the details on how these two spectral regions of H band have been combined together. In the first observing run in January 2003, spanning 16 stars, the spectra were obtained for only one position of the grating positioned at the central wavelength of H band.

For a majority of the programme stars, we have observed a nearby main-sequence A type star at nearly same air-mass to minimize the atmospheric extinction. To optimize the observing efficiency, a single standard star has been observed whenever some of the programme stars happened to be in the nearby region of the sky. For the early February and the late April 2003 observing runs, late B type standards have been observed. The list of standard stars that have been observed are given in Table 2. In this table the standard star identification is given in column (1) with right ascension and declination for J2000.0 in columns (2) and (3) respectively. Columns (4), (5) and (6) contain the spectro-luminosity class, observed V magnitude and T_{eff} respectively.

The wavelength calibration has been performed using OH airglow lines. In case of brighter stars when the individual integration time was less than 60 sec a separate sky frame was taken with 60 sec exposure time by drifting the star in RA axis by typically about 10 arc-seconds.This enabled the OH airglow lines to register with reasonably large counts.

3. Selection of stars

While building a spectral library, it is very important that one includes various spectral types so that we have a homogeneous and comprehensive coverage of all possible spectro-

Table 2. Standard star list with observational parameters*.

HD (1)	α(J2000.0) (2)	δ(J2000.0) (3)	Type (4)	V_{mag} (5)	T_{eff} (°K) (6)
HD71155	08 25 39.63	-03 54 23.13	A0V	3.90	9520
HD87901	10 08 22.31	+11 58 01.95	B7V	1.35	13000
HD28319	04 28 39.74	+15 52 15.17	A7III	3.41	8150
HD47105	06 37 42.70	+16 23 57.31	A0IV	1.90	9520
HD71155	08 25 39.63	-03 54 23.13	A0V	3.90	9520
HD47105	06 37 42.70	+16 23 57.31	A0IV	1.90	9520
HD139006	15 34 41.27	+26 42 52.90	A0V	2.21	9520
HD65456	07 57 40.11	-30 20 04.46	A2Vvar	4.79	8970
HD97633	11 14 14.41	+15 25 46.45	A2V	3.32	8970
HD155125	17 10 22.69	-15 43 29.68	A2.5Va	2.43	8845
HD94601	10 55 36.82	+24 44 59.3	A1V	4.50	9230
HD60179	07 34 35.9	+31 53 18	A1V	1.58	9230
HD106591	12 15 25.56	+57 01 57.42	A3V	3.30	8720
HD153808	17 00 17.37	+30 55 35.06	A0V	3.91	9520
HD103287	11 53 49.85	+53 41 41.14	A0Ve	2.43	9520
HD130109	14 46 14.92	+01 53 34.39	A0V	3.72	9520
HD85235	09 52 06.36	+54 03 51.56	A3IV	4.56	8720
HD141003	15 46 11.26	+15 25 18.57	A2IV	3.66	8970
HD79469	09 14 21.86	+02 18 51.41	B9.5V	3.88	10010
HD118098	13 34 41.60	-00 35 44.95	A3V	3.40	8720
HD82621	09 34 49.43	+52 03 05.32	A2V	4.48	8970
HD141003	15 46 11.26	+15 25 18.57	A2IV	3.66	8970
HD87737	10 07 19.95	+16 45 45.59	A0Ib	3.51	9730
HD141003	15 46 11.26	+15 25 18.57	A2IV	3.66	8970

*(2)-(5) From SIMBAD database,(6) From Lang (1992)

luminosity classes. Given the limitation of the instrument's saturation etc., we have limited the exposure times to about few minutes in each of the bands and this limitation allows us to go no fainter than visible magnitude 7 in brighness. The histogram in Fig. 1 represents the number of stars that could be covered with these limitations in terms of spectral types (top panel) and luminosity classes (bottom panel) in addition to the other limitations like availability at the observatory latitude, weather restrictions etc. The details of a number of stars covered in terms of spectral types per luminosity class is illustrated by the histogram in Fig. 2. It may be noted that we have covered the HR diagram in effective temperature and the luminosity parameters reasonably well, although we do not have enough stars for luminosity class II and main spectral type O.

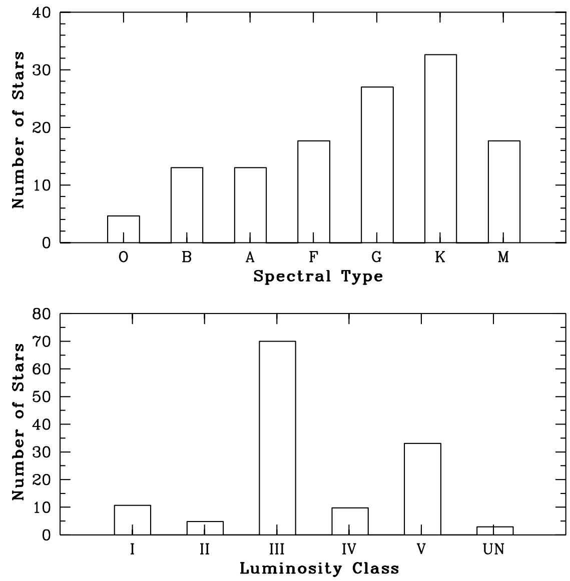

Figure 1. Distribution of stars in the database by spectral type and luminosity class. The UN class at the bottom panel denotes unknown luminosity class.

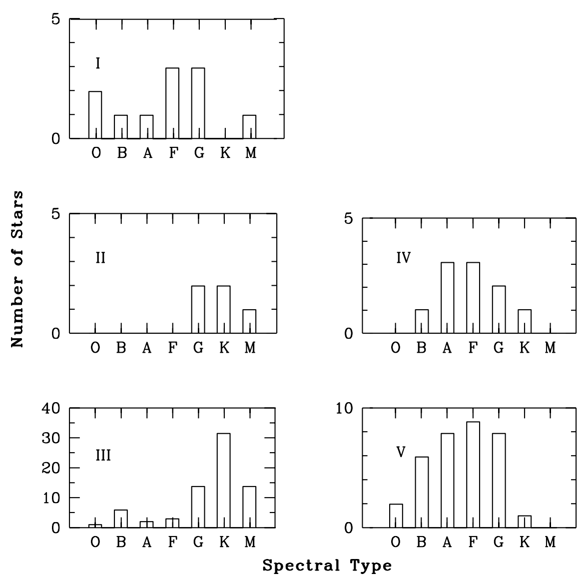

Figure 2. Distribution of stars in the database by spectral type per luminosity class.

The selection was further governed by three more criteria:

1. We have looked for catalogues in the literature that have stellar photometric observations in the J,H,K bands. The catalogues having this type of dataset are those by Koornneef (1983), Carter (1990) and Bouchet et al. (1991). These cover southern bright stars with a few having spectroscopic observations as well. Their photometric observations provided the J,H,K magnitudes for our programme stars. The details are given in Table 3. In this table, the first column contains the programme star ID, columns (2) to (6) list the J,H,K,L, & M magnitudes respectively. The references from which they have been taken are listed in column 7.

Table 3. NIR magnitudes of programme stars.

HD (1)	J_{mag} (2)	H_{mag} (3)	K_{mag} (4)	L_{mag} (5)	M_{mag} (6)	Reference (7)
HD007927						1997ApJ....111...445 (Wallace)
HD008538		2.30				1998ApJ....508...397 (Meyer)
HD010307		3.70				1998ApJ....508...397 (Meyer)
HD011353	1.92	1.36	1.22	1.16		1983A&AS....51...489 (Koornneef)
HD025204	3.66	3.67	3.66	3.65	3.71	1983A&AS....51...489 (Koornneef)
HD026846	2.97	2.39	2.27	2.19		1983A&AS....51...489 (Koornneef)
HD030652	2.37	2.15	2.08	2.09		1983A&AS....51...489 (Koornneef)
HD030836		4.10				1998ApJ....508...397 (Meyer)
HD035468	2.17	2.28	2.32	2.34	2.36	1983A&AS....51...489 (Koornneef)
HD035497	1.96	2.02	2.02	2.03	2.11	1983A&AS....51...489 (Koornneef)
HD036673	2.05	1.92	1.86	1.81		1983A&AS....51...489 (Koornneef)
HD036861						2004ApJS...152..251 (Valdes)
HD037128		2.40				1998ApJ....508...397 (Meyer)
HD037742	2.21	2.27	2.32	2.31		1983A&AS....51...489 (Koornneef)
HD038393	2.70	2.47	2.41	2.38		1983A&AS....51...489 (Koornneef)
HD038858	4.82	4.50	4.44			1991A&AS....91...409 (Bouchet)
HD040136	3.10	2.94	2.90	2.87		1983A&AS....51...489 (Koornneef)
HD043232	1.84	1.19	1.02	0.94		1983A&AS....51...489 (Koornneef)
HD047839		5.50				1998ApJ....508...397 (Meyer)
HD048329						1997ApJ....111...445 (Wallace)
HD049331						1997ApJ....111...445 (Wallace)
HD054605	0.77	0.51	0.41	0.32	0.28	1983A&AS....51...489 (Koornneef)
HD054810	3.18	2.64	2.53	2.47		1983A&AS....51...489 (Koornneef)
HD056537						1997ApJ....111...445 (Wallace)
HD058715	1.83	1.07	0.90	0.77		1983A&AS....51...489 (Koornneef)
HD060414	1.25	0.38	0.09	-0.09	0.17	1983A&AS....51...489 (Koornneef)
HD061935	2.28	1.77	1.62	1.57		1983A&AS....51...489 (Koornneef)
HD062345						1997ApJ....111...445 (Wallace)
HD062576	1.74	0.96	0.75	0.63		1983A&AS....51...489 (Koornneef)
HD062721						1997ApJ....111...445 (Wallace)
HD063700	1.52	1.03	0.89	0.81		1983A&AS....51...489 (Koornneef)
HD065810	4.40	4.33	4.32	4.31		1990MNRAS....242...1 (Carter)
HD066811						Girt2000
HD067228	4.13	3.91	3.83	3.79	3.92	1983A&AS....51...489 (Koornneef)
HD068312						1997ApJ....111...445 (Wallace)
HD070272						1997ApJ....111...445 (Wallace)
HD071369						1997ApJ....111...445 (Wallace)
HD072094	2.45	1.64	1.43	1.26	1.57	1994A&AS....105...311 (Fluks)
HD074918	2.80	2.33	2.23	2.17		1983A&AS....51...489 (Koornneef)
HD076943						2004ApJS...152..251 (Valdes)

Table 3. Continued.

HD (1)	J_{mag} (2)	H_{mag} (3)	K_{mag} (4)	L_{mag} (5)	M_{mag} (6)	Reference (7)
HD077912						2004ApJS...152..251 (Valdes)
HD080874	1.62	0.78	0.55	0.41		1983A&AS....51...489 (Koornneef)
HD081797	-0.36	-1.04	-1.21	-1.33	-1.16	1983A&AS....51...489 (Koornneef)
HD082328						2004ApJS...152..251 (Valdes)
HD085444	2.59	2.13	2.02	1.97		1983A&AS....51...489 (Koornneef)
HD085951	2.01	1.22	1.01	0.85	1.18	1994A&AS....105...311 (Fluks)
HD086663	1.54	0.72	0.50	0.34	0.66	1994A&AS....105...311 (Fluks)
HD087737		3.3				1998ApJ....508...397 (Meyer)
HD088230						2004ApJS...152..251 (Valdes)
HD088284	1.99	1.51	1.40	1.34		1983A&AS....51...489 (Koornneef)
HD089010	4.78	4.47	4.40	4.36	4.42	1983A&AS....51...489 (Koornneef)
HD089025		2.8				1998ApJ....508...397 (Meyer)
HD089021		3.3				1998ApJ....508...397 (Meyer)
HD089449						2004ApJS...152..251 (Valdes)
HD089490						2004ApJS...152..251 (Valdes)
HD090254	2.45	1.59	1.36	1.20	1.48	1994A&AS....105...311 (Fluks)
HD090277						2004ApJS...152..251 (Valdes)
HD090362	2.75	1.98	1.78	1.64	1.90	1994A&AS....105...311 (Fluks)
HD090432	1.31	0.56	0.38	0.26		1983A&AS....51...489 (Koornneef)
HD090610	1.81	1.07	0.91	0.77	1.00	1994A&AS....105...311 (Fluks)
HD092125						1997ApJ....111...445 (Wallace)
HD092588						2004ApJS...152..251 (Valdes)
HD093813	1.07	0.42	0.27	0.17		1983A&AS....51...489 (Koornneef)
HD094264						2004ApJS...152..251 (Valdes)
HD094481						1997ApJ....111...445 (Wallace)
HD095418						1997ApJ....111...445 (Wallace)
HD097603	2.32	2.27	2.27	2.29		1983A&AS....51...489 (Koornneef)
HD097778						1997ApJ....111...445 (Wallace)
HD098231		3.0				1998ApJ....508...397 (Meyer)
HD098430	1.68	1.07	0.94	0.86		1983A&AS....51...489 (Koornneef)
HD099028						2004ApJS...152..251 (Valdes)
HD099167						2004ApJS...152..251 (Valdes)
HD100407	2.01	1.58	1.44	1.40	1.50	1983A&AS....51...489 (Koornneef)
HD100920						2004ApJS...152..251 (Valdes)
HD101501		3.8				1998ApJ....508...397 (Meyer)
HD102212	1.12	0.29	0.08	-0.05		1983A&AS....51...489 (Koornneef)
HD102647		2.0				1998ApJ....508...397 (Meyer)
HD105707	0.94	0.31	0.14	0.03		1983A&AS....51...489 (Koornneef)
HD106625	2.79	2.83	2.82	2.76		1983A&AS....51...489 (Koornneef)
HD107259	3.81	3.78	3.77	3.76		1990MNRAS....242...1 (Carter)
HD107328	2.95	2.32	2.19	2.09		1983A&AS....51...489 (Koornneef)
HD108767	3.06	3.08	3.06	3.03		1983A&AS....51...489 (Koornneef)
HD109358						2004ApJS...152..251 (Valdes)
HD109379	1.24	0.81	0.70	0.64		1983A&AS....51...489 (Koornneef)
HD110379	2.07	1.90	1.86	1.84		1983A&AS....51...489 (Koornneef)
HD111812	3.73	3.46	3.36	3.29	3.34	1983A&AS....51...489 (Koornneef)
HD112142	1.28	0.38	0.13	-0.04	0.28	1994A&AS....105...311 (Fluks)
HD112300						2004ApJS...152..251 (Valdes)
HD113139		4.1				1998ApJ....508...397 (Meyer)
HD113226						1997ApJ....111...445 (Wallace)
HD113847						2004ApJS...152..251 (Valdes)
HD113996						2004ApJS...152..251 (Valdes)
HD114330						1997ApJ....111...445 (Wallace)
HD114961						2004ApJS...152..251 (Valdes)
HD115604		3.9				1998ApJ....508...397 (Meyer)
HD115892	2.73	2.74	2.73	2.70		1983A&AS....51...489 (Koornneef)
HD116656				–		1997ApJ....111...445 (Wallace)
HD116658	1.53	1.64	1.68	1.72	1.76	1983A&AS....51...489 (Koornneef)
HD116870	2.62	1.81	1.61	1.47	1.73	1994A&AS....105...311 (Fluks)
HD120052	2.14	1.24	1.01	0.84	1.08	1994A&AS....105...311 (Fluks)

Table 3. Continued.

HD (1)	J_{mag} (2)	H_{mag} (3)	K_{mag} (4)	L_{mag} (5)	M_{mag} (6)	Reference (7)
HD120315		2.4				1998ApJ....508...397 (Meyer)
HD120323	-0.51	-1.39	-1.66	-1.84	-1.40	1983A&AS....51...489 (Koornneef)
HD121299						2004ApJS...152..251 (Valdes)
HD123123	1.42	0.84	0.72	0.62		1983A&AS....51...489 (Koornneef)
HD123139	0.42	-0.09	-0.21	-0.31	-0.21	1983A&AS....51...489 (Koornneef)
HD123299		3.5				1998ApJ....508...397 (Meyer)
HD123657						2004ApJS...152..251 (Valdes)
HD123934						2004ApJS...152..251 (Valdes)
HD124294	1.89	1.18	1.03	0.94		1983A&AS....51...489 (Koornneef)
HD126053	5.12	4.76	4.70	4.64	4.62	1983A&AS....51...489 (Koornneef)
HD126661						2004ApJS...152..251 (Valdes)
HD127665						2004ApJS...152..251 (Valdes)
HD129116	4.38	4.46	4.52	4.56		1990MNRAS....242...1 (Carter)
HD129502	3.12	2.94	2.89	2.83		1983A&AS....51...489 (Koornneef)
HD130025						2004ApJS...152..251 (Valdes)
HD130819	4.40	4.21	4.16	4.13	4.13	1983A&AS....51...489 (Koornneef)
HD130841	2.52	2.45	2.42	2.40		1983A&AS....51...489 (Koornneef)
HD130952						2004ApJS...152..251 (Valdes)
HD131156						2004ApJS...152..251 (Valdes)
HD131918						2004ApJS...152..251 (Valdes)
HD134083						2004ApJS...152..251 (Valdes)
HD135722						2004ApJS...152..251 (Valdes)
HD135742	2.80	2.83	2.86	2.84		1983A&AS....51...489 (Koornneef)
HD136512						2004ApJS...152..251 (Valdes)
HD138716						2004ApJS...152..251 (Valdes)
HD138905	2.19	1.65	1.54	1.47		1983A&AS....51...489 (Koornneef)
HD141004	3.36	3.05	2.99			1991A&AS....91...409 (Bouchet)
HD141714						2004ApJS...152..251 (Valdes)
HD141850	2.05	1.23	0.69	-0.08	-0.10	1994A&AS....105...311 (Fluks)
HD145328						2004ApJS...152..251 (Valdes)
HD147165	2.49	2.44	2.42	2.42	2.43	1983A&AS....51...489 (Koornneef)
HD147394						2004ApJS...152..251 (Valdes)
HD148513						1990MNRAS....242...1 (Carter)
HD149757						2004ApJS...152..251 (Valdes)
HD161239						1997ApJ....111...445 (Wallace)

2. We have also looked into the catalogues by Wallace et al. (1997), Meyer et al. (1998) and Wallace et al. (2000). These catalogues have mostly studied the atomic and molecular features in different spectro-luminosity classes. However, these catalogues have a flat continuum and normalization at some particular wavelength and is not useful if one has to use them as reference spectra for comparison purposes. Another catalogue with 56 stars covering various spectro-luminosity classes is by Lançon & Rocca-Volmerange (1992). Till date there has not been much work carried out in NIR continuum, particularly devoted to cool stars, except by Lançon & Wood (2000). To check the consistency and continuum shape in the spectra we have selected a few stars from Meyer et al. (1998) and Wallace et al. (1997) for the sake of comparison. The details of this comparison procedure are discussed in section 5.2.

3. A large optical library has recently been released by Valdes et al. (2004) for which the atmospheric parameters are well known. It was decided to use some of their stars for which the NIR spectra do not exist. We also added a few metal rich stars from this

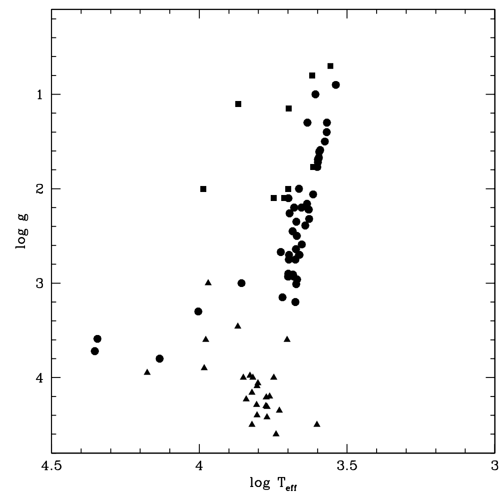

Figure 3. Distribution in the GIRT library: supergiants (I & II) with squares, giants (III) with filled circles and dwarfs (IV & V) with triangles on surface gravity log g vs. effective temperature T_{eff} plane.

library into our list and included some M type giants from Fluks et al. (1994). Further, from these two catalogues we selected a total of 3 stars (one F type and two K type) for which luminosity classes are not available.

Thus, we have covered a reasonable region of parameter space in temperature, gravity and metallicity for this library. Figs. 3–5 show the coverage in this parameter space. Fig 3 shows the plot of log g vs. T_{eff} for the GIRT stars. The general trend is quite similar to that of Ivanov et al. (2004) except for the larger coverage in effective temperature in our case. Figs. 4 & 5 show the plot of [Fe/H] vs. T_{eff} and log g respectively for GIRT sample.

4. Data reduction and calibration

The near infrared spectral data reduction is similar to that of optical data reduction with minor differences. The presence of strong telluric emission lines and varying atmospheric transmission due to changing water vapour content necessitates observation of standard star spectra at similar airmass soon after the programme star observation. Due to the uncertain slit losses, the flux calibration is done using the broad band photometric magnitudes. The whole process of near infrared long slit spectra reduction can be separated into a few major steps, viz., (i) pre-processing (ii) spectrum extraction (iii) wavelength calibration (iv) atmospheric transmission and instrument response determination using standard star data (v) continuum fitting and (vi) radial velocity correction. We have

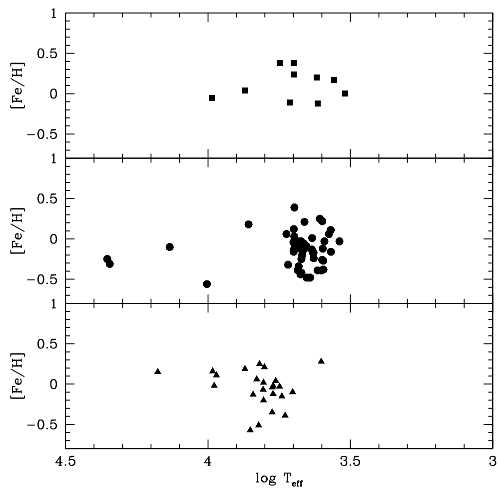

Figure 4. Distribution in the GIRT library: supergiants (I & II) with squares, giants (III) with filled circles and dwarfs (IV & V) with triangles (*from top to bottom*) on metallicity [Fe/H] vs. effective temperature $T_{\rm eff}$ plane.

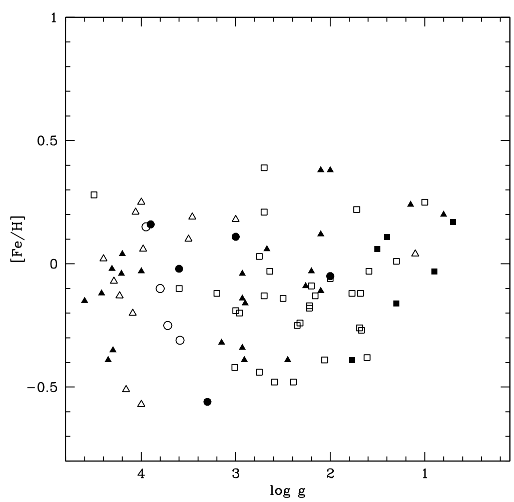

Figure 5. Distribution in the GIRT library: Stars of spectral types B (open circles), A (filled circles) F (open triangles), G (filled triangles), K (open squares) and M (filled squares) are shown in metallicity [Fe/H] vs. surface gravity log g plane.

Table 4. Line List of atmospheric OH airglow emissions used for wavelength calibrations in H-band.

Sr. Number	Wavelength in Å
1	15064.0
2	15187.0
3	15241.0
4	15287.8
5	15332.4
6	15395.3
7	15432.1
8	15540.4
9	15833.2
10	16128.6
11	16692.1
12	16840.5
13	16903.7
14	16955.1
15	17123.6

used standard tasks available in software package IRAF [1] in the data reduction. The NIR spectrometer stores the images in binary format. These files are converted into FITS image files. The pre-processing stage consists of correction for cosmic rays, subtraction of the dark and the sky counts. All the image frames are corrected for cosmic rays using the IRAF *cosmicrays* task. The availability of two sets of spectra taken at two different locations of the slit is utilized to remove the dark counts and the large sky background at near infrared wavelengths. This is accomplished by taking the difference of spectra obtained at two different locations on the detector. As there is no autoguider on the telescope, the frames with maximum counts in two positions are selected for data reduction. We thus have two difference frames for extraction of the spectrum.

The IRAF *apall* task is used to extract the spectrum in the form of background subtracted counts as a function of pixel number along the dispersion axis. A polynomial fit is done to the central peak along the dispersion axis and the extraction window is defined with full width at a 5% of the maximum. The Chebyshev averaged background function is subtracted from the central profile by defining two regions on either side of it in the extraction window. The extraction to 1D spectrum consists of summing the background subtracted pixel values along each column within the extraction window. After this, the atmospheric OH airglow lines (see Table 4 for the lines used) registered in the sky spectrum are used for wavelength calibration. The IRAF task *identify* is used for this purpose. The IRAF task *refspec* is used to specify the appropriate wavelength calibrated spectrum for the stellar spectra extracted earlier using the apall task. The IRAF task *dispcor* is used to set the wavelength calibration for the stellar spectra.

[1] IRAF is distributed by National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

The stellar spectra at this stage of data reduction are still affected by atmospheric transmission effects and the instrument effects like filter transmission and wavelength dependence of detector quantum efficiency. These effects can be removed by taking the ratio of the programme star spectrum with that of a standard star spectrum observed under similar conditions and subsequently multiplying with a model synthetic spectrum for the standard star. The selection of the standard star for this purpose is quite important and should be done carefully. Origlia et al.(1993) found that selecting G dwarf as a standard star at low resolution does not yield satisfactory results because intrinsic stellar features remain at ≥ 5 % of the continuum level. We have put special efforts in selecting standard stars for each observing run and observing slots for a particular night. We have selected bright A and late B type with $T_{eff} > 9000$ K because at this temperature only neutral hydrogen lines will be present and no metallic lines will survive in the NIR spectral region. Table 2 lists standard stars used for the purpose of taking ratios. The stellar absorption features due to hydrogen, namely the Brackett series lines from Br 10 to Br 20, are removed before taking the ratio. The programme star flux is divided by the corresponding standard star flux and in this process the modulation due to telluric features, atmospheric extinction and instrumental effects cancels out. The resultant function from this division is multiplied with a corresponding blackbody flux distribution at the temperature corresponding to the standard star. All the spectra are normalized to unity at the H band central wavelength of 1.65 μm. It must be pointed out that unlike many of the spectral libraries published earlier the spectra presented here have been continuum shape corrected to their respective effective temperatures.

As mentioned in Section 2, majority of the spectra were obtained at two positions (H1 and H2) of the grating to cover the entire H band with only 16 stars being observed in single grating position in January 2003. These spectra were individually reduced according to the procedure described above and subsequently combined to render a single H band spectrum by matching the overlap region of H1 and H2.

The next step in the data reduction is that of radial velocity correction using the values taken from SIMBAD data archive. It may be noted that though the corrections due to the radial velocities of programme stars are not significant at the resolution of this library they have been done for the sake of completeness. Finally we have the spectra as ASCII files rebinned at 5 Å steps.

The flux distribution for the programme stars in the present spectral library can be put on absolute scale by equating normalized value of unity at 1.65 μm to the monochromatic flux values calculated on the basis of broad band H magnitudes listed in Table 3 taken from the published literature.

5. Spectral library

The NIR H band spectral library of 135 stars is available in the format of reduced ASCII tables with wavelength versus flux at a spectral resolution of 1000 at 5 Å binning. The main goal of this paper is to make this library available for variety of investigators working in the NIR region. Thus, the complete library can be downloaded from the website:

http://vo.iucaa.ernet.in/∼voi/NIR_Header.html

The essential information of each star in the database is summarized in Tables 3 and 5 as observational parameters and in Table 6 as physical parameters. The contents of Table 3 have been mentioned in section 3. In Table 5, the first and second columns contain the star ID. Columns (3) and (4) contain the right ascension (J2000.0) and declination (J2000.0) respectively. Column (5) gives the apparent V magnitude. The last column gives the corresponding standard ID. Table 6 contains the star ID in the first column. Columns (2), (3) and (4) give the main spectral type, luminosity class and effective temperature respectively. Columns (5) and (6) give the log g and [Fe/H] values respectively. The last column gives the references from which the physical parameters have been obtained.

Table 5. Observational parameters (from SIMBAD) of programme stars.

HD (1)	HR (2)	α(J2000.0) (3)	δ(J2000.0) (4)	V_{mag} (5)	Standard Star (6)
HD007927	HR382	01 20 04.91	+58 13 53.79	5.01	HR3314
HD008538	HR403	01 25 48.95	+60 14 07.01	2.68	HR3314
HD010307	HR483	01 41 47.14	+42 36 48.12	4.90	HR3314
HD011353	HR539	01 51 27.63	-10 20 06.13	3.73	HR3314
HD025204	HR1239	04 00 40.81	+12 29 25.24	3.40	HR2421
HD026846	HR1318	04 14 23.68	-10 15 22.61	4.90	HR2421
HD030652	HR1543	04 49 50.41	+06 57 40.59	3.19	HR3314
HD030836	HR1552	04 51 12.36	+05 36 18.37	4.47	HR2421
HD035468	HR1790	05 25 07.86	+06 20 58.92	1.62	HR3314
HD03549-	HR1791	05 26 17.51	+28 36 26.82	1.68	HR3314
HD036673	HR1865	05 32 43.81	-17 49 20.23	2.59	HR2421
HD036861	HR1879	05 35 08.30	+09 56 30.00	3.00	HR3314
HD037128	HR1903	05 36 12.81	-01 12 06.91	1.70	HR3314
HD037742	HR1948	05 40 45.53	-01 56 33.50	1.70	HR3314
HD038393	HR1983	05 44 27.79	-22 26 54.17	3.60	HR2421
HD038858	HR2007	05 48 34.94	-04 05 40.73	5.97	HR2421
HD040136	HR2085	05 56 24.29	-14 10 03.72	3.71	HR1412
HD043232	HR2227	06 14 51.33	-06 14 29.19	3.98	HR3314
HD047839	HR2456	06 40 58.66	+09 53 44.71	4.66	HR3314
HD048329	HR2473	06 43 55.92	+25 07 52.04	3.01	HR2421
HD049331	HR2508	06 47 37.22	-08 59 54.60	5.10	HR3982
HD054605	HR2693	07 08 23.48	-26 23 35.51	1.84	HR5793
HD054810	HR2701	07 10 13.68	-04 14 13.58	4.92	HR3314
HD056537	HR2763	07 18 05.57	+16 32 25.37	3.58	HR2421
HD058715	HR2845	07 27 09.04	+08 17 21.53	2.88	HR2421
HD060414	HR2902	07 33 47.96	-14 31 26.01	4.97	HR1412
HD061935	HR2970	07 41 14.83	-09 33 04.07	3.93	HR2421
HD062345	HR2985	07 44 26.85	+24 23 52.77	3.57	HR2421
HD062576	HR2993	07 43 32.38	-28 24 39.18	4.62	HR2891
HD062721	HR3003	07 46 07.44	+18 30 36.15	4.88	HR2421
HD063700	HR3045	07 49 17.65	-24 51 35.22	3.33	HR3113
HD065810	HR3131	07 59 52.05	-18 23 57.22	4.61	HR5793
HD066811	HR3165	08 03 35.04	-40 00 11.33	2.25	HR2421
HD067228	HR3176	08 07 45.85	+21 34 54.53	5.30	HR2421

Table 5. Continued.

HD (1)	HR (2)	α(J2000.0) (3)	δ(J2000.0) (4)	V_{mag} (5)	Standard Star (6)
HD068312	HR3212	08 11 33.00	-07 46 21.14	5.35	HR5793
HD070272	HR3275	08 22 50.10	+43 11 17.27	4.25	HR3982
HD071369	HR3323	08 30 15.87	+60 43 05.40	3.37	HR2421
HD072094	HR3357	08 31 35.70	+18 05 40.00	5.33	HR5793
HD074918	HR3484	08 46 22.53	-13 32 51.79	4.32	HR3314
HD076943	HR3579	09 00 38.40	+41 46 58.00	3.90	HR2891
HD077912	HR3612	09 06 31.80	+38 27 08.00	4.50	HR3894
HD080874	HR3718	09 21 29.59	-25 57 55.58	4.72	HR2421
HD081797	HR3748	09 27 35.24	-08 39 30.96	2.00	HR2421
HD082328	HR3775	09 32 56.53	+51 41 04.80	3.20	HR3875
HD085444	HR3903	09 51 28.69	-14 50 47.77	4.11	HR2421
HD085951	HR3923	09 54 52.20	-19 00 34.00	4.93	HR5793
HD086663	HR3950	10 00 12.80	+08 02 39.00	4.64	HR3799
HD087737	HR3975	10 07 19.95	+16 45 45.59	3.51	HR3314
HD088230		10 11 22.14	+49 27 15.25	6.61	HR3665
HD088284	HR3994	10 10 35.27	-12 21 14.69	3.61	HR5793
HD089010	HR4030	10 16 32.28	+23 30 11.14	5.90	HR5793
HD089025	HR4031	10 16 41.41	+23 25 02.31	3.44	HR2421
HD089021	HR4033	10 17 05.79	+42 54 51.71	3.44	HR2421
HD089449	HR4054	10 19 44.10	+19 28 15.00	4.70	HR4259
HD089490	HR4059	10 19 32.20	-05 06 21.00	6.30	HR4359
HD090254	HR4088	10 25 15.20	+08 47 25.00	5.59	HR3799
HD090277	HR4090	10 25 59.90	+33 47 46.00	4.70	HR4554
HD090362	HR4092	10 25 44.30	-07 03 35.00	5.58	HR3975
HD090432	HR4094	10 26 05.42	-16 50 10.64	3.83	HR1412
HD090610	HR4104	10 27 09.10	-31 04 04.00	4.27	HR4660
HD092125	HR4166	10 38 43.21	+31 58 34.45	4.68	HR5793
HD092588	HR4182	10 41 24.62	-01 44 23.50	6.26	HR4359
HD093813	HR4232	10 49 37.48	-16 11 37.13	3.11	HR5793
HD094264	HR4247	10 53 18.33	+34 13 07.30	3.03	HR4554
HD094481	HR4255	10 54 17.77	-13 45 28.92	5.66	HR5793
HD095418	HR4295	11 01 50.47	+56 22 56.73	2.34	HR5793
HD097603	HR4357	11 14 06.50	+20 31 25.38	2.56	HR5793
HD097778	HR4362	11 15 12.22	+23 05 43.80	4.58	HR2421
HD098231	HR4375	11 18 10.92	+31 45 14.41	4.41	HR1412
HD098430	HR4382	11 19 20.44	-14 46 42.74	3.50	HR5793
HD099028	HR4399	11 23 55.50	+10 31 45.00	3.90	HR4259
HD099167	HR4402	11 24 36.62	-10 51 34.90	4.83	HR4357
HD100407	HR4450	11 33 00.11	-31 51 27.45	3.54	HR5793
HD100920	HR4471	11 36 57.02	-00 49 26.00	4.30	HR4554
HD101501	HR4496	11 41 03.01	+34 12 05.88	5.32	HR2421
HD102212	HR4517	11 45 51.55	+06 31 45.75	4.05	HR2421
HD102647	HR4534	11 49 03.57	+14 34 19.41	2.14	HR2421
HD105707	HR4630	12 10 07.48	-22 37 11.15	3.01	HR5793
HD106625	HR4662	12 15 48.37	-17 32 30.94	2.59	HR2421
HD107259	HR4689	12 19 54.35	-00 40 00.49	3.89	HR5793
HD107328	HR4695	12 20 20.98	+03 18 45.26	2.06	HR2421
HD108767	HR4757	12 29 51.85	-16 30 55.55	2.95	HR2421
HD109358	HR4785	12 33 47.64	+41 21 12.00	4.26	HR4660
HD109379	HR4786	12 34 23.23	-23 23 48.33	2.65	HR5793
HD110379	HR4825	12 41 39.60	-01 26 57.90	3.65	HR3314
HD111812	HR4883	12 51 41.92	+27 32 26.56	4.93	HR3982
HD112142	HR4902	12 54 21.16	-09 32 20.38	4.80	HR5793
HD112300	HR4910	12 55 37.74	+03 23 53.40	3.38	HR5867
HD113139	HR4931	13 00 43.59	+56 21 58.81	4.93	HR2421
HD113226	HR4932	13 02 10.59	+10 57 32.94	2.83	HR3982
HD113847	HR4945	13 05 52.30	+45 16 07.00	5.60	HR4660
HD113996	HR4954	13 07 10.70	+27 37 29.00	4.80	HR5867
HD114330	HR4963	13 09 56.99	-05 32 20.43	4.38	HR5793
HD114961		13 14 04.45	-02 48 24.70	7.02	HR5867

Table 5. Continued.

HD (1)	HR (2)	α(J2000.0) (3)	δ(J2000.0) (4)	V_{mag} (5)	Standard Star (6)
HD115604	HR5017	13 17 32.54	+40 34 21.38	4.72	HR3314
HD115892	HR5028	13 20 35.81	-36 42 44.26	2.70	HR2421
HD116656	HR5054	13 23 55.54	+54 55 31.30	2.70	HR2421
HD116658	HR5056	13 25 11.57	-11 09 40.75	1.04	HR2421
HD116870	HR5064	13 26 43.16	-12 42 27.59	5.27	HR5793
HD120052	HR5181	13 47 25.39	-17 51 35.42	5.44	HR5793
HD120315	HR5191	13 47 32.43	+49 18 47.75	1.86	HR2421
HD120323	HR5192	13 49 26.72	-34 27 02.79	4.19	HR5793
HD121299	HR5232	13 54 42.42	-01 30 10.40	5.15	HR5867
HD123123	HR5287	14 06 22.29	-26 40 56.50	3.26	HR3314
HD123139	HR5288	14 06 40.94	-36 22 11.83	2.06	HR5893
HD123299	HR5291	14 04 23.34	+64 22 33.06	3.65	HR2421
HD123657	HR5299	14 07 55.65	+43 51 17.30	5.27	HR5511
HD123934	HR5301	14 10 50.50	-16 18 07.00	4.90	HR4259
HD124294	HR5315	14 12 53.74	-10 16 25.32	4.19	HR2421
HD126053	HR5384	14 23 15.28	+01 14 29.64	6.30	HR2421
HD126661	HR5405	14 26 27.36	+19 13 36.83	5.39	HR3314
HD127665	HR5429	14 31 50.13	+30 22 11.00	3.58	HR6324
HD129116	HR5471	14 41 57.59	-37 47 36.59	3.98	HR5793
HD129502	HR5487	14 43 03.62	-05 39 29.54	3.90	HR5793
HD130025	HR5507	14 45 20.70	+18 53 05.00	6.59	HR5107
HD130819	HR5530	14 50 41.18	-15 59 50.05	5.15	HR5793
HD130841	HR5531	14 50 52.71	-16 02 30.40	2.75	HR5793
HD130952	HR5535	14 51 00.70	-02 17 50.60	4.94	HR5867
HD131156	HR5544	14 51 23.30	+19 06 04.00	4.50	HR6324
HD131918	HR5564	14 56 46.02	-11 24 35.40	5.46	HR5867
HD134083	HR5634	15 07 17.34	+24 52 17.00	4.93	HR5867
HD135722	HR5681	15 15 29.77	+33 18 58.70	3.47	HR6324
HD135742	HR5685	15 17 00.41	-09 22 58.50	2.60	HR3314
HD136512	HR5709	15 20 08.94	+29 37 00.00	5.51	HR5511
HD138716	HR5777	15 34 09.61	-10 03 40.80	4.61	HR5867
HD138905	HR5787	15 35 31.57	-14 47 22.33	3.95	HR2421
HD141004	HR5868	15 46 26.61	+07 21 11.06	4.43	HR6378
HD141714	HR5889	15 49 35.88	+26 04 09.00	4.63	HR5511
HD141850	HR5894	15 50 41.70	+15 08 01.00	7.10	HR6324
HD145328	HR6018	16 08 58.45	+36 29 10.30	4.76	HR5107
HD147165	HR6084	16 21 11.31	-25 35 34.06	2.91	HR6324
HD147394	HR6092	16 19 44.40	+46 18 48.00	3.80	HR5867
HD148513	HR6136	16 28 33.98	+00 39 54.00	5.90	HR6378
HD149757	HR6175	16 37 09.50	-10 34 02.00	2.50	HR5867
HD161239	HR6608	17 43 21.56	+24 19 40.15	5.74	HR5867

Table 6. Physical parameters of programme stars.

HD (1)	Spectral Type (2)	Luminosity Class (3)	T_{eff}(°K) (4)	$\log_{10}$(g) (5)	(Fe/H) (6)	Reference (7)
HD007927	F0	Ia				
HD008538	A5	III	8090			1995A&AS...110..553 (Sokolov)
HD010307	G1.5	V	5898	4.31	-0.02	2004ApJS...152..251 (Valdes)
HD011353	K0	III	4600	2.70	-0.13	1997A&AS...124..299C (Cayrel)
HD025204	B3	V				
HD026846	K3	III	4582	2.70	0.21	1997A&AS...124..299C (Cayrel)
HD030652	F6	V	6380	4.40	0.02	2004ApJS...152..251 (Valdes)
HD030836	B2	III	22120	3.59	-0.31	1997A&AS...124..299C (Cayrel)
HD035468	B2	III	22570	3.72	-0.25	2004ApJS...152..251 (Valdes)

Table 6. Continued.

HD (1)	Spectral Type (2)	Luminosity Class (3)	T_{eff}(°K) (4)	$\log_{10}(g)$ (5)	(Fe/H) (6)	Reference (7)
HD035497	B7	III	13622	3.80	-0.10	2004ApJS...152..251 (Valdes)
HD036673	F0	Ib	7400	1.10	0.04	2004ApJS...152..251 (Valdes)
HD036861	O8	III				
HD037128	B0	Iab				
HD037742	O9	Iab				
HD038393	F7	V	6398	4.29	-0.07	1997A&AS...124..299C (Cayrel)
HD038858	G4	V				
HD040136	F1	V	6939	4.23	-0.13	2004ApJS...152..251 (Valdes)
HD043232	K1.5	III	4270	2.22	-0.18	2004ApJS...152..251 (Valdes)
HD047839	O7	Ve				
HD048329	G8	Ib	4150	0.80	0.20	2004ApJS...152..251 (Valdes)
HD049331	M1	Iab	3600	0.70	0.17	1997A&AS...124..299C (Cayrel)
HD054605	F8	Iab				
HD054810	K0	III	4697	2.35	-0.25	2004ApJS...151..387 (Ivanov)
HD056537	A3	V				
HD058715	B8	Ve	11710			1995A&AS...110..553 (Sokolov)
HD060414	M2	III				
HD061935	G9	III	4776	2.20	-0.03	2004ApJS...151..387 (Ivanov)
HD062345	G8	IIIa	5000	2.90	-0.16	1997A&AS...124..299C (Cayrel)
HD062576	K3	III	4308	1.30	0.01	1997A&AS...124..299C (Cayrel)
HD062721	K4	III	3940	1.67	-0.27	1997A&AS...124..299C (Cayrel)
HD063700	G6	Ia	4990	1.15	0.24	1997A&AS...124..299C (Cayrel)
HD065810	A1	V				
HD066811	O5	Ia				
HD067228	G1	IV	5779	4.20	0.04	2004ApJS...152..251 (Valdes)
HD068312	G6	III				
HD070272	K4.5	III	3900	1.59	-0.03	1997A&AS...124..299C (Cayrel)
HD071369	G5	III	5300	2.67	0.06	2004ApJS...152..251 (Valdes)
HD072094	K5	III				
HD074918	G8	III	4950	2.26	-0.09	1997A&AS...124..299C (Cayrel)
HD076943	F3	V	6590	4.00	0.25	2004ApJS...152..251 (Valdes)
HD077912	G7	Ib-II	5000	2.00	0.38	2004ApJS...152..251 (Valdes)
HD080874	M0	III				
HD081797	K3	II	4120	1.77	-0.12	2004ApJS...152..251 (Valdes)
HD082328	F6	IV	6380	4.09	-0.20	2004ApJS...152..251 (Valdes)
HD085444	G6	III	5000	2.93	-0.14	2004ApJS...152..251 (Valdes)
HD085951	k5	III				
HD086663	M2	III				
HD087737	A0	Iab	9700	2.00	-0.05	2004ApJS...152..251 (Valdes)
HD088230	K8	V	4000	4.50	0.28	1997A&AS...124..299C (Cayrel)
HD088284	K0	III	4971	2.70	0.39	2004ApJS...151..387 (Ivanov)
HD089010	G1.5	IV	5600	4.00	-0.03	2004ApJS...152..251 (Valdes)
HD089025	F0	III				
HD089021	A1	IV				
HD089449	F6	IV	6333	4.06	0.21	2004ApJS...152..251 (Valdes)
HD089490	K0					
HD090254	M3	III	3706	1.40	0.11	1997A&AS...124..299C (Cayrel)
HD090277	F0	V	7412	3.46	0.19	2004ApJS...152..251 (Valdes)
HD090362	M0	III				
HD090432	K4	III	3950	1.68	-0.12	1997A&AS...124..299C (Cayrel)
HD090610	K4	III	3990	1.77	-0.39	1997A&AS...124..299C (Cayrel)
HD092125	G2.5	IIa	5600	2.10	0.38	2004ApJS...152..251 (Valdes)
HD092588	K1	IV	5044	3.60	-0.10	2004ApJS...152..251 (Valdes)
HD093813	K0	III	4250	2.32	-0.24	2004ApJS...152..251 (Valdes)
HD094264	K0	III	4670	2.96	-0.20	2004ApJS...152..251 (Valdes)
HD094481	K0	II+..				
HD095418	A1	V	9620	3.90	0.16	2004ApJS...152..251 (Valdes)
HD097603	A4	V	8080			1995A&AS...110..553 (Sokolov)
HD097778	M3	IIb	3300		0.00	2004ApJS...151..387 (Ivanov)

Table 6. Continued.

HD (1)	Spectral Type (2)	Luminosity Class (3)	T_{eff}(°K) (4)	$\log_{10}(g)$ (5)	(Fe/H) (6)	Reference (7)
HD098231	G0	V	5950	4.30	-0.35	2004ApJS...152..251 (Valdes)
HD098430	K0	III	4500	2.59	-0.48	2004ApJS...152..251 (Valdes)
HD099028	F1	IV	6739	3.98	0.06	2004ApJS...152..251 (Valdes)
HD099167	K5	III	3930	1.61	-0.38	2004ApJS...152..251 (Valdes)
HD100407	G7	III	5010	2.93	-0.04	1997A&AS...124..299C (Cayrel)
HD100920	G8.5	III	4800	2.93	-0.34	2004ApJS...152..251 (Valdes)
HD101501	G8	V	5360	4.35	-0.39	2004ApJS...151..387 (Ivanov)
HD102212	M1	III	3761	1.50	0.06	2004ApJS...152..251 (Valdes)
HD102647	A3	V	8720			1995A&AS...110..553 (Sokolov)
HD105707	K2	III	4320	2.16	-0.13	1997A&AS...124..299C (Cayrel)
HD106625	B8	III				
HD107259	A2	IV	9333	3.00	0.11	2004ApJS...152..251 (Valdes)
HD107328	K0	IIIb	4380	2.39	-0.48	2004ApJS...152..251 (Valdes)
HD108767	B9.5	V	10350			1995A&AS...110..553 (Sokolov)
HD109358	G0	V	5903	4.42	-0.12	2004ApJS...151..387 (Ivanov)
HD109379	G5	II	5170	2.10	-0.11	1997A&AS...124..299C (Cayrel)
HD110379	F0	V	7099	4.00	-0.57	1997A&AS...124..299C (Cayrel)
HD111812	G0	IIIp			0.01	2004ApJS...152..251 (Valdes)
HD112142	M3	III				
HD112300	M3	III	3700	1.30	-0.16	2004ApJS...152..251 (Valdes)
HD113139	F2	V				
HD113226	G8	III	4994	2.10	0.12	2004ApJS...151..387 (Ivanov)
HD113847	K1	III	4510	2.20	-0.09	2004ApJS...152..251 (Valdes)
HD113996	K5	III	3970	1.69	-0.26	2004ApJS...151..387 (Ivanov)
HD114330	A1	Vs+..	9509	3.60	-0.02	2004ApJS...152..251 (Valdes)
HD114961	M7	III	3014	0.00	-0.81	2004ApJS...152..251 (Valdes)
HD115604	F3	III	7200	3.00	0.18	2004ApJS...152..251 (Valdes)
HD115892	A2	V	9030			1995A&AS...110..553 (Sokolov)
HD116656	A2	V	5793			2004ApJS...152..251 (Valdes)
HD116658	B1	III				
HD116870	K5	III				
HD120052	M2	III				
HD120315	B3	V	17200			1995A&AS...110..553 (Sokolov)
HD120323	M4.5	III				
HD121299	K2	III	4710	2.64	-0.03	2004ApJS...152..251 (Valdes)
HD123123	K2	III	4600	2.00	-0.06	1997A&AS...124..299C (Cayrel)
HD123139	K0	IIIb	4980	2.75	0.03	1997A&AS...124..299C (Cayrel)
HD123299	A0	III	10080	3.30	-0.56	2004ApJS...152..251 (Valdes)
HD123657	M4.5	III	3452	0.90	-0.03	2004ApJS...152..251 (Valdes)
HD123934	M2	IIIa				
HD124294	K2.5	IIIb	4120	2.06	-0.39	1997A&AS...124..299C (Cayrel)
HD126053	G1	V				
HD126661	F0m		7754	3.50	0.10	2004ApJS...152..251 (Valdes)
HD127665	K3	III	4260	2.22	-0.17	2004ApJS...152..251 (Valdes)
HD129116	B3	V				
HD129502	F2	III	6820			1995A&AS...110..553 (Sokolov)
HD130025	K0		5140	3.00	-0.19	2004ApJS...152..251 (Valdes)
HD130819	F3	V	6632	4.16	-0.51	1997A&AS...124..299C (Cayrel)
HD130841	A3	IV				
HD130952	G8	III	4820	2.91	-0.39	2004ApJS...152..251 (Valdes)
HD131156	G7	Ve	5500	4.60	-0.15	2004ApJS...152..251 (Valdes)
HD131918	K4	III	3970	1.72	0.22	2004ApJS...152..251 (Valdes)
HD134083	F5	V	6632	4.50	1.10	2004ApJS...152..251 (Valdes)
HD135722	G8	III	4834	2.45	-0.39	2004ApJS...151..387 (Ivanov)
HD135742	B8	V	13250			1995A&AS...110..553 (Sokolov)
HD136512	K0	III	4730	2.75	-0.44	2004ApJS...152..251 (Valdes)
HD138716	K1	III	4730	3.20	-0.12	2004ApJS...152..251 (Valdes)
HD138905	K0	III	4700	3.01	-0.42	2004ApJS...152..251 (Valdes)

Table 6. Continued.

HD (1)	Spectral Type (2)	Luminosity Class (3)	T_{eff}(°K) (4)	$\log_{10}$(g) (5)	(Fe/H) (6)	Reference (7)
HD141004	G6	V	5937	4.21	-0.04	2004ApJS...152..251 (Valdes)
HD141714	G5	III	5230	3.15	-0.32	2004ApJS...152..251 (Valdes)
HD141850	M7	III				
HD145328	K1	III	4678	2.50	-0.14	2004ApJS...151..387 (Ivanov)
HD147165	B1	III				
HD147394	B5	IV	15000	3.95	0.15	2004ApJS...152..251 (Valdes)
HD148513	K4	III	4046	1.00	0.25	2004ApJS...151..387 (Ivanov)
HD149757	O9.5	Vn				
HD161239	G2	IIIb				

Fig. 6 shows a series of six dwarf stars with spectral types from O to K to illustrate the basic features of the spectra with changing temperature. Fig. 7 is a similar plot for super giants (please note that the B0I and A0I spectra do not span the full band since they are from the January 2003 observations as mentioned earlier). We also attempt to show the quality of spectra by comparing some selected spectra with the already published H band library by Meyer et al. (1998). Following paragraphs describe the procedure adopted to bring both (Meyer et al. 1998 and GIRT) libraries at a common platform. The block diagram in Fig. 8 depicts the steps carried out on both libraries. The Meyer et al. (1998) spectra are in wave numbers (K) versus relative flux format with flat continuum and covers O7 to M5 spectral types and I to V luminosity classes with a spectral resolution of 3000. Our (GIRT) spectra have a continuum fitting to each spectra and are in wavelength versus relative flux format with a resolution of 1000.

There are three steps to be performed on the Meyer et al. (1998) library to bring it at a comparable platform with GIRT library:

(i) conversion of wavenumber vs. relative flux to wavelength vs. relative flux

(ii) degrading the resolution from 3000 to 1000

(iii) fitting a continuum to respective T_{eff} of each star and spline fitting for binning at 5 Å steps

These steps were performed by writing a common algorithm which could run uniformly on the Meyer et al. (1998) library. The T_{eff} values were taken from 'Astronomical Hand Book' by K. R. Lang and the black body spectra was generated by IRAF *mk1dspec* task in H band region.

Fig. 9 shows a sample of some of the common stars in GIRT and Meyer et al. library with good matching of the spectral features as evident from the correlation coefficient r values. This plot covers most of the main spectral types.

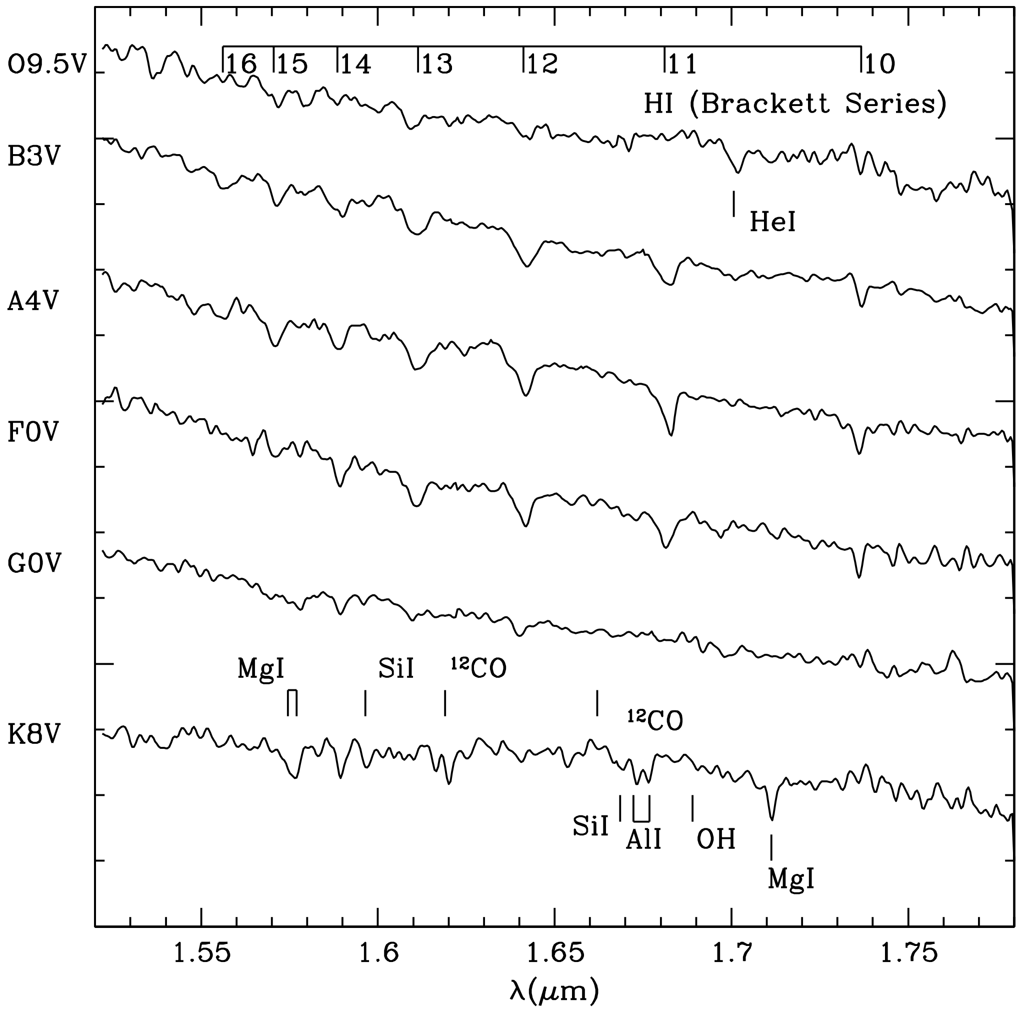

Figure 6. Spectra of six dwarf stars, covering a large range of MK spectral type, are plotted to illustrate the basic dependence of spectral features. The stars plotted, top to bottom, are HR6175, HR1239, HR4357, HR4090, HR4375 and HD88230. The spectral types are listed on the vertical axis. Also shown are some of the prominent absorption features like HI Brackett series and other species seen in the late type spectra.

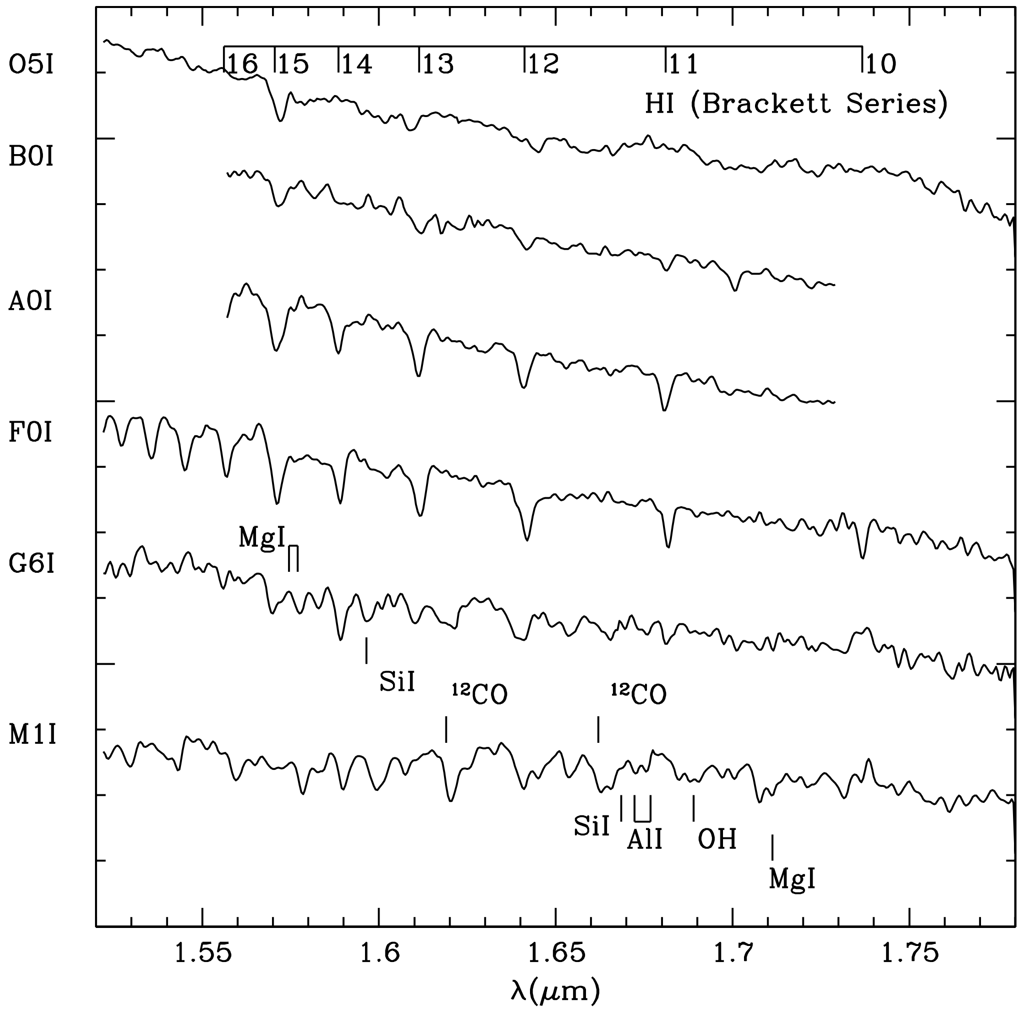

Figure 7. Spectra of six supergiant stars, covering a large range of MK spectral type, are plotted to illustrate the basic dependence of spectral features. The stars plotted, top to bottom, are HR3165, HR1903, HR3975, HR1865, HR3045 and HR2508. The spectral types are listed on the vertical axis. Also shown are some of the prominent absorption features like HI Brackett series and other species seen in the late type spectra.

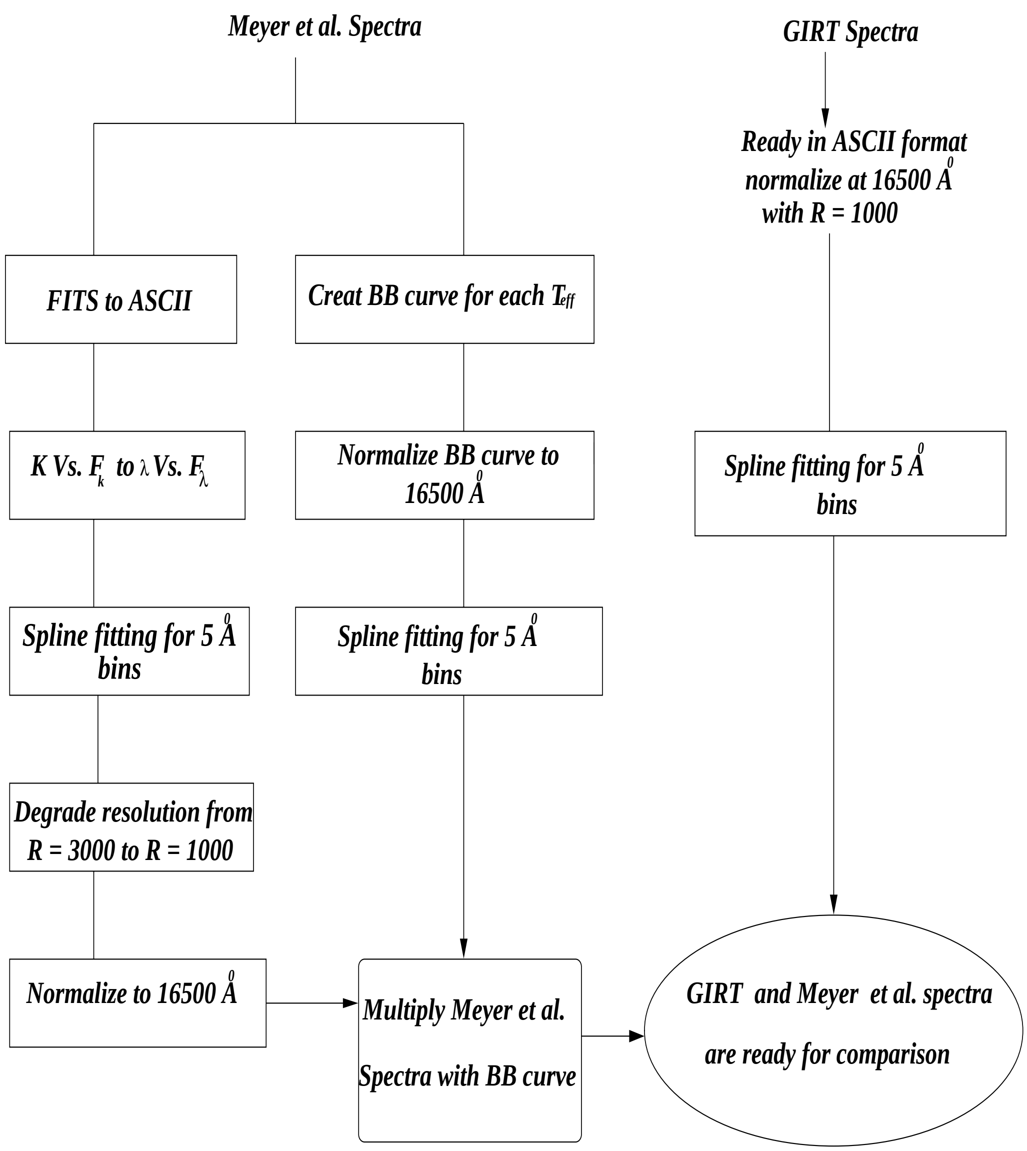

Figure 8. Block diagram illustrating the steps involved in comparison of GIRT and Meyer et al. (1998) libraries.

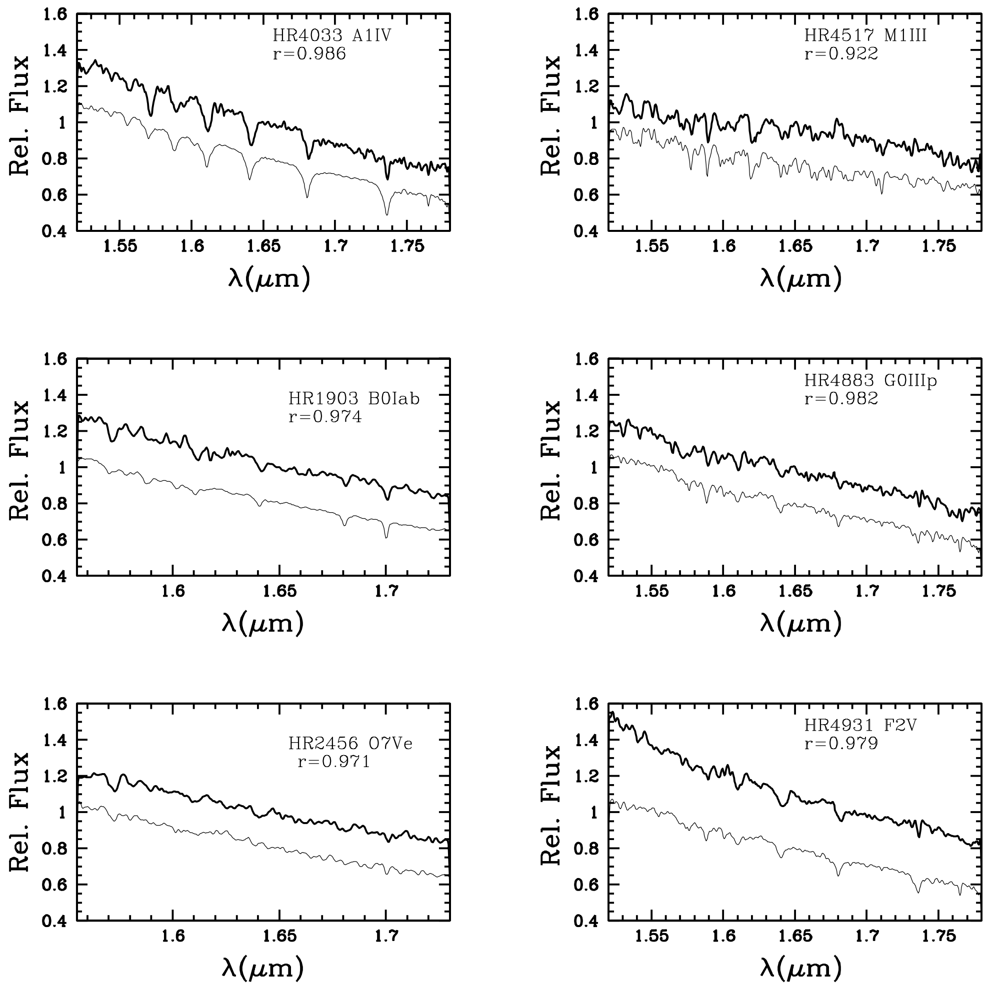

Figure 9. Spectra of a selection of common spectra from Meyer et al. 1998 (*thin* lines) and GIRT (*thick* lines) libraries. Please note that the two spectra in each panel have been offset purposely for sake of clarity and the flux values are relative.

In conclusion we may mention that this library of 135 stellar spectra in the NIR H band has been carefully checked for its consistency with earlier published libraries and provides a larger database with extended spectro-luminosity coverage for usage in stellar population synthesis work and other applications as well as complimenting large optical libraries.

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