Optical Spectroscopy of GLIMPSE Stars with 8 Micron Infrared Excesses

Georgi Chunev (Manchester College), Sarah Bird (Missouri University), Chip Kobulnicky , and Brian Uzpen (University of Wyoming)

Abstract

Optical spectra (3910 - 6660 Å) for 23 stars having 8 micron excess in the Spitzer GLIMPSE Point Source Catalog were obtained with the Wyoming Infrared Observatory's (WIRO) 2.3 m telescope and longslit spectrograph. The targets were selected to have [4.5]-[8.0] and *J-K* colors consistent with A or B stars having mid-IR excesses. The collected spectra were used to measure Hα equivalent widths and classify the stars by comparison with stellar atlases. Three of the stars show Hα in emission, one has a mixed profile, and 19 have Hα in absorption. Six of the stars are evolved (luminosity class III or IV) while 17 appear to be main-sequence stars. The main-sequence stars with emission are probable Be stars or Herbig AeBe stars. The evolved stars may be B[e] stars with dusty photospheres. The 13 main-sequence stars lacking Hα emission may have hot circumstellar dust and are candidates for young systems with warm massive dust disks.

Introduction

The *Spitzer* GLIMPSE Legacy survey (Benjamin et al. 2003), which provides mid-IR data for tens of millions of Galactic sources, is opening a new view on Galactic structure and star formation in the Milky Way. GLIMPSE photometry at 3.6, 4.5, 5.8 and 8.0 μm can be combined with MIPSGAL Legacy program photometry at 24 μm to identify interesting stellar objects with characteristic infrared colors such as nebulae, protostars, evolved stars, and potentially even stars encircled by dusty disks known as debris disks, a signature of planet formation. Given the new suite of wavebands accessible with Spitzer and the orders-of-magnitude increase in sensitivity and angular resolution over previous missions, namely IRAS, these wide-area surveys enable searches for distinctive stellar populations. In this program, we seek to characterize stars with infrared excesses at 8 μm using optical spectroscopic classifications. These stars are candidates for having hot, terrestrial-temperature circumstellar "debris disk" dust.

Selection Criteria

We selected a spectroscopic targets sample from among the >10^7 objects in the northern half of the GLIMPSE I Point Source Catalog on the basis of IR photometry. The colors were chosen to select A and late-B stars showing an extraphotospheric excess at mid-IR wavelengths, similar to the prototype debris disk object, Beta Pictoris. Figure 1 shows the J-K versus [4.5]-[8.0] colors for solar-mass Class II protostars (T-tauri stars--triangles), 2-4 solar mass Class II protostars (Herbig AeBe stars--squares), and Class III solar mass protostars (weak-line T-Tauri stars--diamonds). Beta Pictoris, a warm A5V star with a debris disk, is denoted by a filled star. Asterisks and pluses show IR excess stars investigated by Uzpen et al. (2005, 2007). The dashed line shows the main sequence.

We selected stars with -0.03 < J-K < 0.25 and 0.2 < [4.5]-[8.0] < 0.8, yielding a subsample of 449 objects, shown as dots in Figure 2, a plot of [4.5]-[8.0] vs. J-K color. Stars in this color box have similar color to Beta Pictoris and may be pre-main sequence stars undergoing disk clearing and approaching the main sequence or warm debris disks like Beta Pictoris. These stars partially bridge the gap between Herbig AeBe stars and the main sequence, making this an interesting color regime to investigate from the standpoint of identifying evolutionary descendants of Herbig AeBe stars. However, classical Be stars and evolved intermediate-mass stars may also occupy this color space, necessitating additional data to determine the origin of the IR excess.

Figure 1

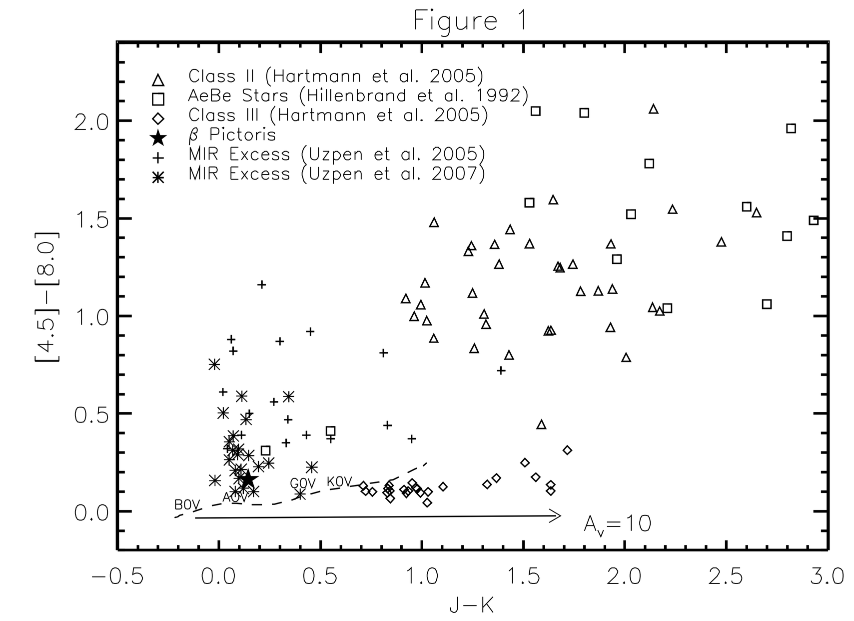


Figure 2

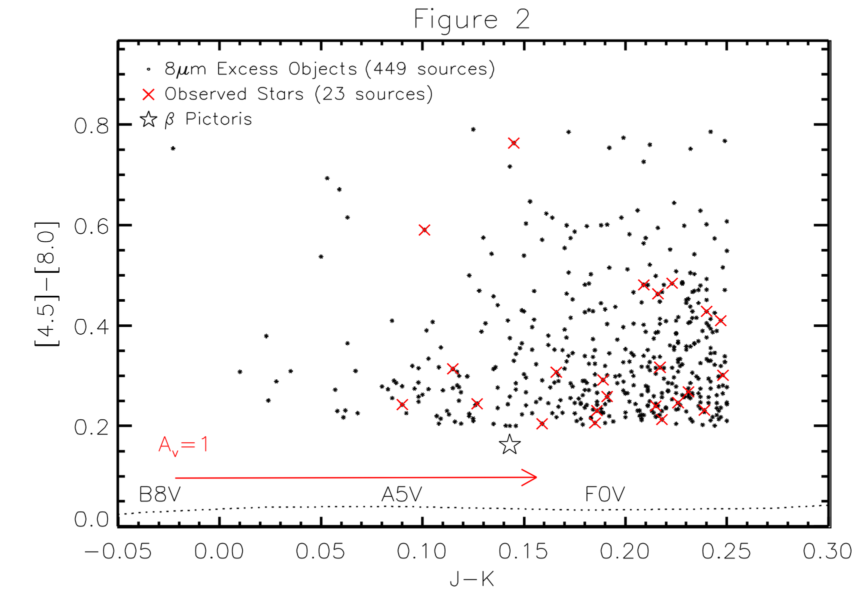
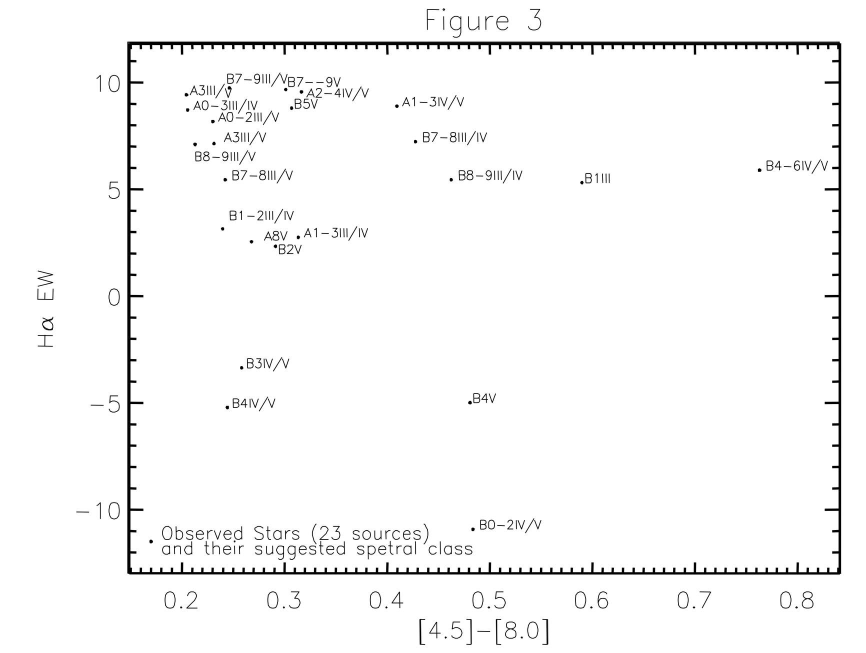


Figure 3

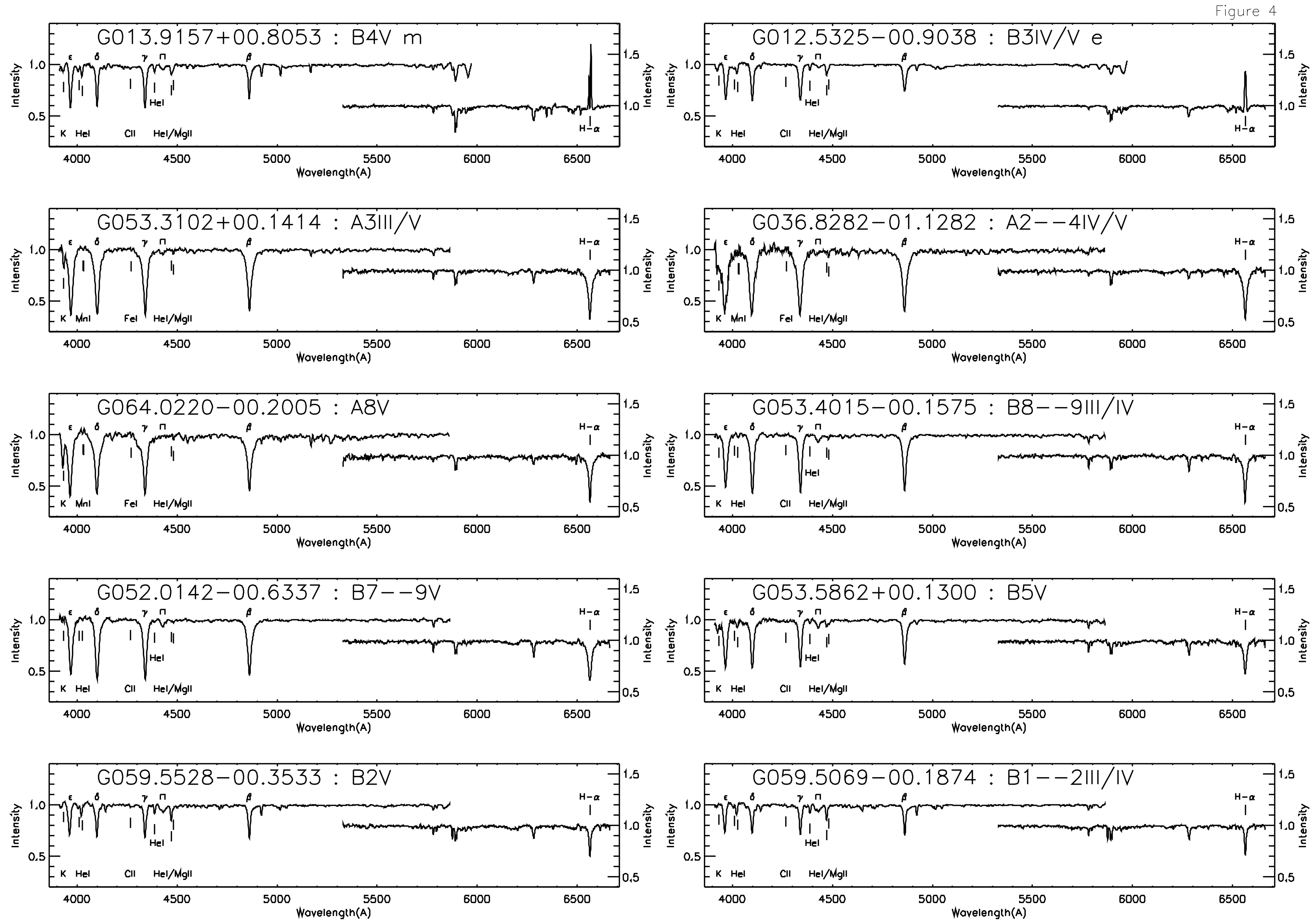


Observations

Optical spectra (3910 - 6660 Å) for 23 sources (J ~10), shown as crosses in Figure 2, were collected during three runs at the Wyoming Infrared Observatory (WIRO) in the summer of 2007. The WIRO Long-Slit instrument, which is a low-resolution spectrograph, designed for efficient spectroscopy of faint sources, was used. The bluer sections of the observed spectra, which include most of the detected metal features, were collected with a 600 l/mm grating in second order yielding a spectral resolution of R~2000, while Hα observations were done with a 1800 l/mm grating, yielding R~4000. All spectral data was reduced and continuum normalized using the IRAF data reduction package. Further modifications of the data, as well as most of its analysis, were done using custom-built IDL tools. We assigned a spectral and luminosity class for each star by comparison with standard stellar atlases (e.g., Silva & Cornell 1992). We measured the EW of the Hα line and noted the presence of emission which may indicate that the object is a classical Be star or possibly Herbig AeBe star. Table 1 contains a summary of the observed objects and their resulting derived properties. Figure 4 shows the optical spectra for a representative sample of 10 observed objects.

Sample Spectra

Figure 4



Results

NAME	J mag.	J-K	[4.5]-[8.0]	Spectral Type	Hα profile	Hα EW (Ang)
G011.7710+00.7428	10.36	0.15	0.76	B4-6IV/V	absorption	5.89±0.08
G012.2321-00.1289	9.76	0.09	0.24	B7-8III/V	absorption	5.44±0.06
G012.4488-01.0225	9.91	0.16	0.20	A3III/V	absorption	9.42±0.12
G012.5325-00.9038	9.92	0.19	0.26	B3IV/V	emission	-3.37±0.03
G013.1871-00.6730	9.22	0.13	0.24	B4IV/V	emission	-5.23±0.03
G013.9157+00.8053	9.97	0.21	0.48	B4V	mixed	-5.00±0.50
G036.8282-01.1282	9.98	0.25	0.41	A2-4IV/V	absorption	8.88±0.14
G044.1564-00.1019	10.99	0.22	0.32	A0-3III/IV	absorption	9.56±0.05
G046.6761+00.7553	10.46	0.19	0.21	B8-9III/V	absorption	8.71±0.08
G049.0294-01.0909	10.21	0.22	0.21	B7-9III/V	absorption	7.10±0.09
G051.2198+00.2156	10.85	0.23	0.25	A0-2III/V	absorption	9.74±0.06
G052.0142-00.6337	10.81	0.19	0.23	B7--9V	absorption	8.17±0.11
G053.3102+00.1414	10.80	0.25	0.30	A3III/V	absorption	9.66±0.04
G053.4015-00.1575	10.40	0.24	0.23	B8-9III/IV	absorption	7.13±0.05
G053.5862+00.1300	10.75	0.22	0.46	B5V	absorption	5.44±0.07
G054.8416+00.1924	10.29	0.17	0.31	A1-3III/IV	absorption	8.79±0.20
G059.5069-00.1874	9.85	0.11	0.31	B1-2III/IV	absorption	2.75±0.03
G059.5528-00.3533	10.33	0.21	0.24	B2V	absorption	3.14±0.01
G063.3831+00.3244	10.61	0.19	0.29	B1III	absorption	2.32±0.05
G063.7242-01.0033	10.54	0.10	0.59	B7-8III/IV	absorption	5.31±0.06
G064.0220-00.2005	10.81	0.24	0.43	A8V	absorption	7.22±0.04
G064.2692-00.0280	10.22	0.23	0.27	B0-2IV/V	absorption	2.53±0.05
G064.7559+00.5491	10.46	0.22	0.48	B5-6V	emission	-10.93±0.02

Table 1

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Conclusions

- The majority of our objects show Hα in absorption, effectively ruling out gaseous ionized disks, such as in classical Be stars, as the source of the IR excesses.
- Figure 3 shows that the objects with the largest IR excesses (i.e., reddest [4.5]-[8.0] colors) have the strongest emission lines, suggesting that, in stars with emission lines, free-free emission in an ionized disk is the likely cause of the IR excess.
- The majority of our present sample show Hα in absorption. Circumstellar dust is the probable cause of the IR excess. These objects may be dusty evolved stars in some cases, while others are good candidates for young, near-main-sequence star systems harboring dust disks, possibly debris-disk systems.