Color-color diagrams in near infrared: (J-H)/(H-K). II.

A. L. Gyulbudaghian[1], N. Baloian[2], I. A. Sanchez[3]

[1] Victor Ambartsumian Byurakan Astrophysical Observatory,
e-mail: *agylb@bao.sci.am*
[2]Department of Computer Science, Universidad de Chile, Chile,
e-mail: *nbaloian@gmail.com*
[3]Departamento de Astronomia, Universidad de Chile, Chile,
e-mail: *nachoandres_sanchezb@hotmail.com*

Abstract

In the paper the color-color diagrams (J-H)/(H-K) for all stars with visible magnitudes B<11^m (for which in the existing catalogs the magnitudes of J, H, K, and also their spectral types and luminosity classes are given) are presented. In the preceding paper the data for luminosity classes I, Ia, Ib, II and III were given. In this paper the data on luminosity classes IV (sub giants) and V (main sequence stars) are given. Among the diagrams of luminosity classes the most interesting are the diagrams for GII and GIV stars, each of these diagrams have two centers of concentrations. For stars of spectral class M the minimal amount of stars is at luminosity class IV, the maximal –at class III, which is not so for other spectral classes: for other classes the maximal amount is at class V. There is a tendency (seen in all diagrams)of increasing of the values of J-H and H-K along the sequence O-B-A-F-G-K-M.

Key words: *color-color diagrams: near infrared colors*

1. Introduction

The Two Micron All Sky Survey (2 MASS survey) is one of several surveys, proceeded during last decades in different parts of spectra. The 2MASS is a joint project of University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. 2MASS survey was done during (1997-2001)years, on 1.3m telescopes at Mt. Hopkins and CTIO (Cerro Tololo Inter American Observatory, Chile). 2MASS survey includes three spectral bands in near infrared. 1.J band (centered on 1,236μm). 2.H band (centered on 1.662μm). 3.K band (centered on 2.159μm). The K band traces sometimes also the emission in Br$_\gamma$ (2.166μm) and He I (2.058μm) (Comeron et al., 2005).In the preceding paper we presented the (J-H)/(H-K) diagrams for all spectral classes and for luminosity classes I, Ia, Ib, II and III. In this paper we give the (J-H)/(H-K) diagrams for luminosity classes IV (sub giants) and V (main sequence stars).

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The position in the (J-H)/(H-K) diagram is a clue to identify young low mass stars. It is a diagnostic for the existence of hot circumstellar discs, remnants from their formation, a very common signature of youth among intermediate mass, pre-main-sequence stars, and a frequently used approach to the identification of distributed star formation in molecular clouds (see e.g. review by Lada and Lada, 2003).

For constructing the color-color diagrams (J-H)/(H-K) for the stars, we used the known so far catalogs (Zacharias et al., 2005; Kharchenko et al., 2004). From the catalogs we have chosen the stars with $B<11^m$, which have data in the catalogs on their J, H, K colors, on their spectral types and luminosity classes.

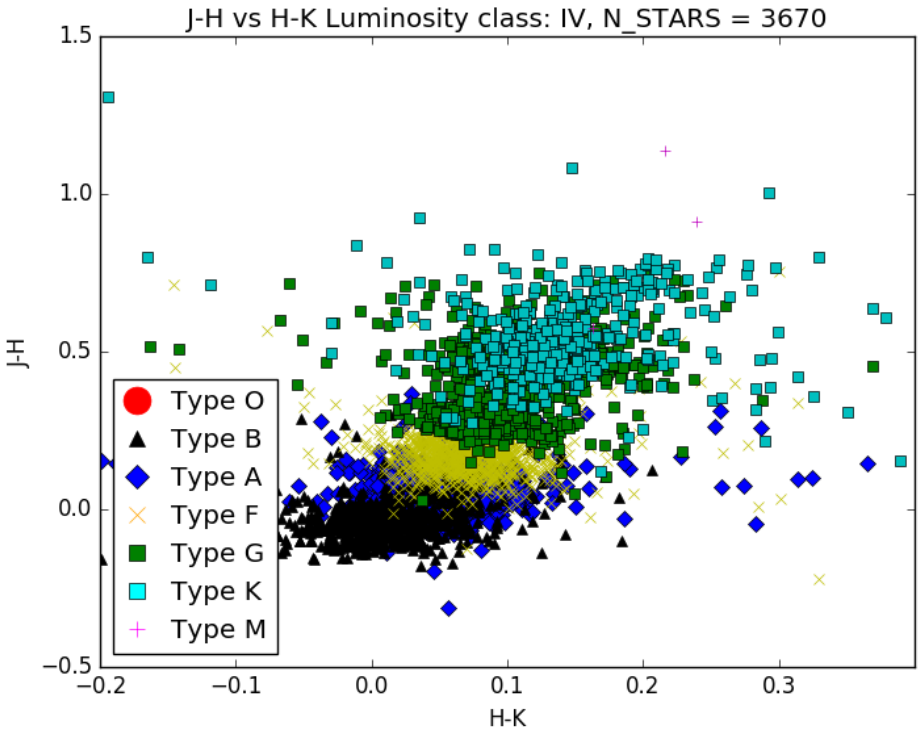

Figure 1. (J-H)/(H-K) color-color diagram for the stars of all spectral types, having luminosity class IV (sub giants).

2.The stars of luminosity class IV (sub giants)

In Fig. 1 there is a (J-H)/(H-K) diagram for stars of all spectral classes, which are of luminosity class IV. For this luminosity class we do not present here the figures of diagrams for each spectral type, aiming to use less space. Instead we give explanations for them. There are only four stars of spectral type O and luminosity class IV, these stars are situated on the diagram with the center on (J-H = 0.05, H-K = 0.1). The stars of spectral class B cover the following area on the diagram: -0.08<J-H<0.08, -0.3<H-K<0.1. The stars of spectral class A cover the area: -0.02<J-H<0.12, -

0.2<H-K<0.2. The stars of spectral type F cover the area: 0.0<J-H<0.15, 0.1<H-K<0.3. The stars of spectral class G cover the area: 0.0<J-H<0.2, 0.25<H-K<0.6. From the diagram for spectral class G we can conclude, that like the stars of class GIII, the stars of class GIV also have two centers of concentration on the diagram: one at (J-H = 0.1, H-K = 0.25), and the second at (J-H – 0.13, H-K = 0.4). The stars of spectral class K cover the area: 0.05<J-H<0.2, 03<H-K<0.7. There are only 3 stars of spectral class M, they are situated on the diagram around the point (J-H = 0.2, H-K = 0.8).

3.The stars of luminosity class V (main sequence stars)

The luminosity class V is the most numerous among other classes: there are 20381 stars of that luminosity class, which are included in our procedure. As the diagram for the stars of luminosity class V and all spectral types(on the same diagram) is overcrowded, we give separately the diagrams for each spectral class.

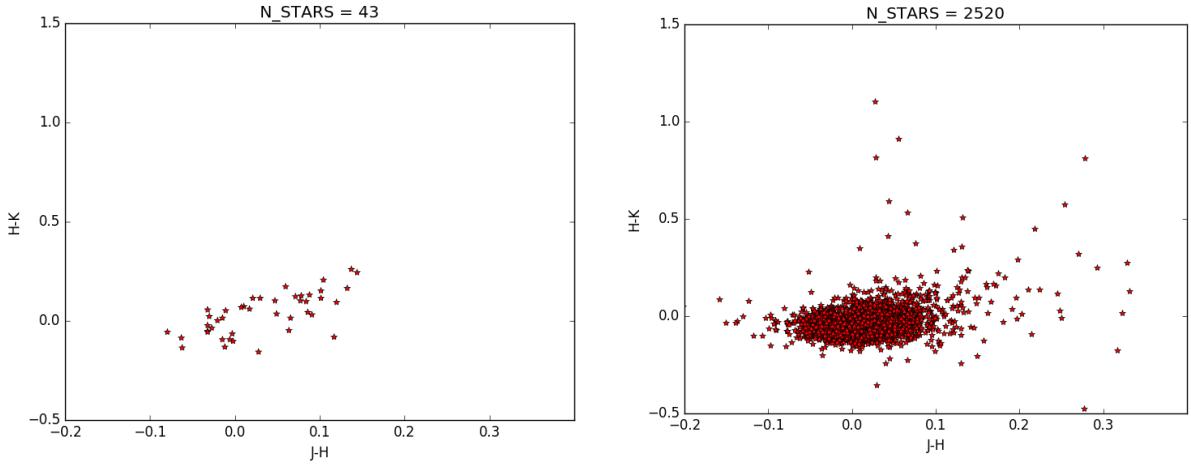

Figure 2. (J-H)/(H-K) color-color diagrams for the stars of luminosity class V (main sequence stars). left panel –(J-H)/(H-K) diagram for O type stars, right panel – (J-H/(H-K) diagram for B type stars.

In Fig. 2a the diagram for O type stars is presented. If we compare with O type stars of luminosity classes III and IV, the O stars of luminosity class V have larger values of J-H and H-K, than the stars of luminosity classes III and IV (see Table 1).

In Fig. 2b the diagram of B type stars is given. We can see that B type stars cover almost the same area as O type stars of the same luminosity class. If we compare B type stars of luminosity classes III, IV and V, the areas, covered by these stars in diagrams, are almost the same (see Table 1).

In Fig. 3a the diagram of A type stars is presented. If we compare these stars with B type stars (see Fig. 2b), then it is obvious, that A type stars have larger values

of J-H and H-K. If we compare A type stars of luminosity classes III, IV and V (see Table 1), the areas covered by them are almost the same (of course it is not true for amounts of stars included in these areas).

In Fig. 3b the diagram of F type stars is presented. The values of J-H and H-K are larger than for A type stars (see Fig.3a). The areas covered by F type stars of luminosity classes III, IV and V (see Table 1) are almost the same (but the amounts of stars, included in these areas, are rather different).

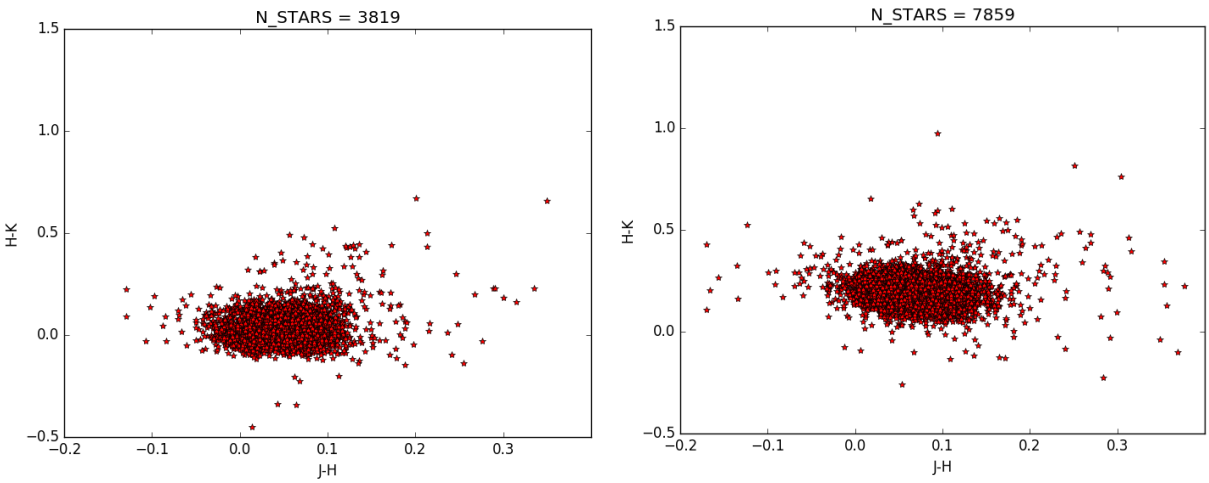

Figure 3. (J-H/(H-K) color-color diagrams for the stars of luminosity class V (main sequence). a – the diagram for A type stars, b – the diagram for F type stars.

In Fig. 4a the diagram of G type stars is presented. The values of J-H and H-K are larger than for F type stars (see Fig. 3b). The areas covered by G type stars of luminosity classes III, IV and V are almost the same (though the amount of stars, included in these areas, are rather different), but in the case of classes III and IV there are two definite concentrations of stars, and in class V there are only remnants of these concentrations.

In Fig. 4b the diagram of K type stars is presented. The values of J-H and H-K are larger than for G type stars (see Fig. 4a and Table 1). The areas covered by the stars of luminosity classes IV and V are almost the same, but the stars of luminosity class III cover larger area than two preceding. The amount of stars of class III is much more than of classes IV and V.

In Fig. 4c the diagram of M type stars is presented. The values of J-H and H-K are bigger than for K type stars (see Fig. 4b and Table 1). The area covered by M type stars of luminosity class III is much larger than of the class V (and there are much more stars in class III). In class IV there are only three stars, so that we cannot compare M type stars of class V with class IV.

On the (J-H)/(H-K) diagram for the stars of luminosity class VII (white dwarfs) there is only one star. It has the following magnitudes: J-H = 0.5, H-K = 0.12.

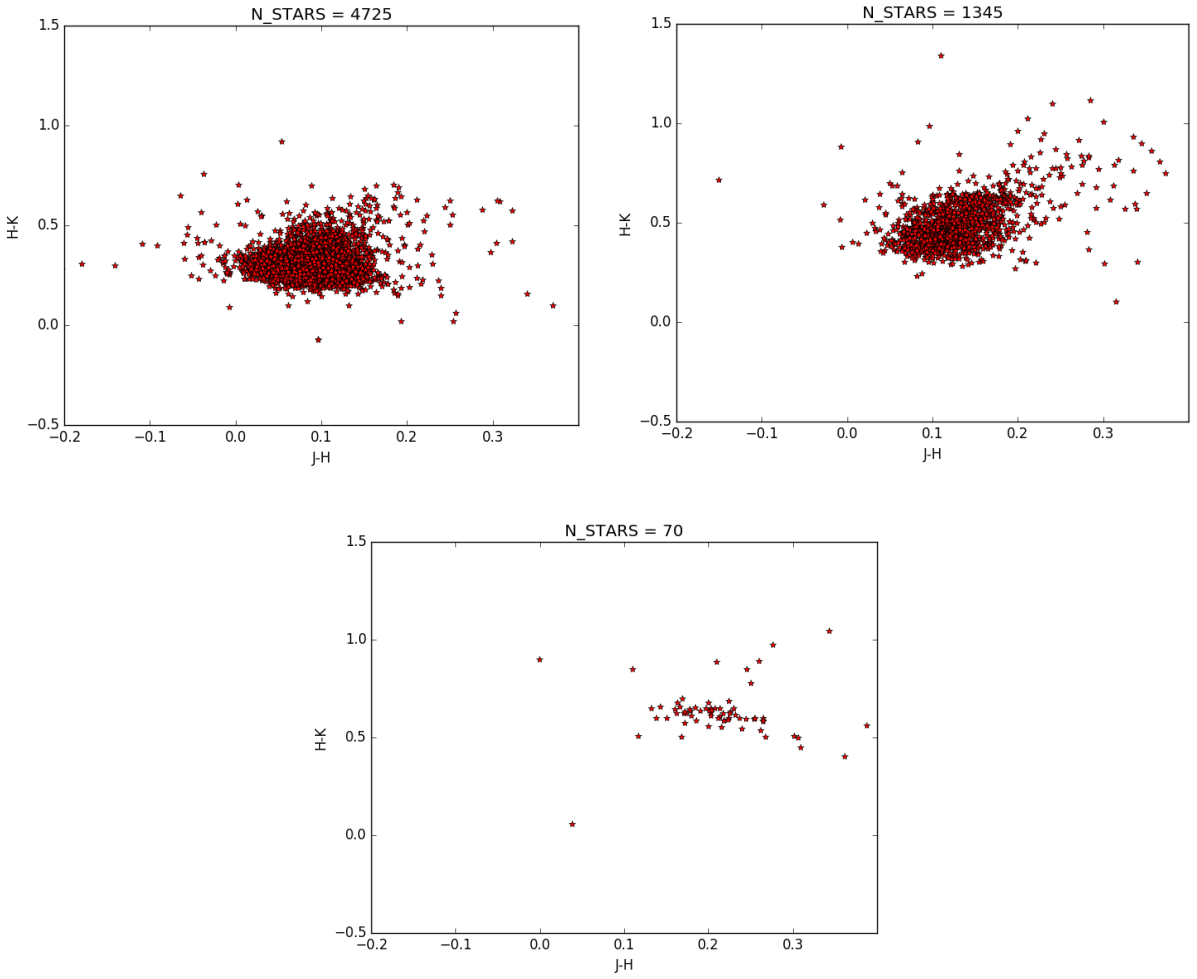

Figure 4. (J-H)/(H-K) diagrams for the stars of luminosity class V. a – the diagram for G type stars, b – the diagram for K type stars, c – the diagram for M type stars.

Table 1. *Mean values of (J-H) AND (H-K) for stars of different spectral types and classes of luminosity*

Spectra	I	Ia	Ib	II	III	IV	V
O			0.05; 0.0	0.05; 0.0	0.0; 0.0	0.05; 0.1	0.07; 0.1
B	0.08; 0.1	0.13; 0.2	0.08; 0.2	0.07; 0.1	0.02; -0.1	0.02; -0.1	0.02; 0.0
A		0.12; 0.25	0.1; 0.2	0.1; 0.2	0.07; 0.15	0.06; 0.15	0.05; 0.15
F	0.15; 0.3	0.2; 0.4	0.15; 0.3	0.1; 0.25	0.07; 0.2	0.08; 0.2	0.08; 0.2
G		0.25; 0.6	0.15; 0.6	0.12; 0.6	0.08; 0.25	0.08; 0.3	0.1; 0.3
					0.12; 0.6	0.13; 0.5	
K			0.22; 0.7	0.18; 0.6	0.18; 0.7	0.16; 0.6	0.15; 0.5
M			0.32; 0.9	0.26; 0.9	0.26; 0.9		0.2; 0.7

In Table 1 we have included the mean values of (J-H) and (H-K) for stars of different spectral types and classes of luminosity. In each cell the values of mean values of (J-H) and (H-K), respectively, are given.

We can conclude from Table 1, that the mean values of (J-H) and (H-K) are increasing for every class of luminosity along the sequence O-B-A-F-G-K-M. It is also obvious from Table 1, that there are two centers of concentration for stars of spectral types GIII and GIV. For the spectral classes OI, OIa, AI, GI, KI, Kia, MI and MIV there are very few data, so it was impossible to calculate mean (J-H) and (H-K) for them.

3.*Conclusions*.Near Infrared colors are important for investigation of young stars and circumstellar discs around them. We used the already known catalogs with data on near infrared J, H, K colors of stars, on their spectral types and luminosity classes. We constructed color-color (J-H)/(H-K) diagrams for the stars with $B<11^m$. In the previous paper we gave color-color diagrams for the luminosity classes I, Ia, Ib, II, and III. In this paper we present color-color diagrams for luminosity classes IV (sub giants) and V (main sequence stars). In all diagrams there is a tendency of increasing of the values of J-H and H-K along the sequence O-B-A-F-G-K-M. In the diagrams for GIV and GV there are two concentrations of stars, rather definite for GIV and less visible for GV. B type stars of luminosity classes III, IV and V, on the color-color diagrams cover almost the same area. It is the same for A type and F type stars. What concerns K type stars, the areas on the diagrams, covered by luminosity classes IV and V, are almost the same, but the stars of luminosity class III cover larger area. The amount of K type stars of class III is much more than of classes IV and V. The area covered by the stars of spectral type M and luminosity class III is much larger than by the stars of the same spectral class and luminosity class V (and there are much more stars in class III). For other spectral types, except K and M, the most stars are concentrated in luminosity class V.

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