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ORIGINAL ARTICLE

A method for the simultaneous estimation of the fundamental atmospheric parameters using the photometric indices in the BVRI and JHK color systems

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Abstract This is the second paper in a series reporting a new method developed to estimate the fundamental atmospheric parameters of effective temperature, surface gravity, and metallicity simultaneously. In the first paper three parameters were estimated using only photometric indices in the *uvby* color system. Whereas, in this paper, we use BVRI and JHK color systems. Using the model atmosphere grids, all three parameter values were estimated with respect to both [(B–V):(V–R)] and [(B–V):(R–I)], as well as [(V–K):(H–K)] and [(J–K):(H–K)] pair indices. It was confirmed that (B–V) and (V–K) indices are good temperature indicators, but all color indices for the BVRI and JHK systems are very poor indicators of metallicity and surface gravity. This new method was applied to a number of field dwarfs and giants, and the results were compared with those from the *uvby* color system. We found that the JHK color system can compete with the *uvby* system only in the estimation of temperature.

Keywords Stars: atmosphere · Stars: fundamental parameters

1 Introduction

In order to understand the physical characteristics and evolution of stars and stellar systems, the three atmospheric fundamental parameters of effective temperature ($T_{\rm eff}$), surface gravity ($\log g$), and metallicity ($[Fe/H]$) need to be determined as accurately as possible. Hence, enormous efforts have been focused on determining them as precisely as possible for many years, and numerous methods have been developed for their determination. All methods can be classified as either photometric or spectroscopic, and each method has its own advantages and disadvantages (see Kim and Moon 2011, hereafter Paper I).

Photometric methods are relatively simple, and several different relationships between photometric indices and atmospheric parameters have been derived for different color systems and for different type of stars. Below two examples are the empirical relation derived to estimate $T_{\rm eff}$ by Blackwell and Lynas-Gray (1994) and $[Fe/H]$ by Nissen (1980) where δm_0 is the Strömgren metallicity index in the $uvby\beta$ system.

$$T_{\rm eff} = 8906 - 2625(V-K) + 363.2(V-K)^2$$

$$[Fe/H] = -[10.5 + 50(\beta - 2.626)]\delta m_0 + 0.16.$$

Besides the calibrated relations, atmospheric model grids are widely used. In this case, $[Fe/H]$ should be known prior to the estimation of $T_{\rm eff}$ and $\log g$. Actually the parameter values of fundamental calibration stars adopted to derive the relationships are based on spectroscopic methods.

Uncertainty due to photometric observational errors, calibration error, and inaccurate color excess, etc. of the results in the photometric methods are, therefore, larger than those in the spectroscopic methods. Although spectroscopic methods (see Kim and Moon 2012; Gray and Brown 2001 and references therein) promise more reliable results than photometric methods, their procedures are complicated and time–consuming. One difficulty is determining initial values of atmospheric parameters for iteration process.

Therefore, in our previous paper (Paper I), we developed a method that makes it possible to determine the three parameters simultaneously. As an initial step, our method was

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