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TRANSFORMATION OF EXTINCTION VALUES NEAR THE K-BAND

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ABSTRACT

We calculate theoretical isochrones in a consistent way for five filters near the K-band, K, K', K_s, F205W, and F222M. Even when displayed in the same Vega magnitude system, the near-infrared colors of the same isochrone can differ by up to 0.18 mag at its bright end, depending on the filter. We analyze isochrones for several different extinction values, and find that a care is needed when comparing extinction values that are estimated by different filter sets, in particular when comparing those between atmospheric and space filter sets. To alleviate this problem, we present an "effective extinction law" for each filter set and isochrone model, which describes extinction behaviour of isochrones in the observed color-magnitude diagram.

Keywords: Hertzsprung-Russell diagram, infrared photometry

1. INTRODUCTION

There are at least five different filters near the K-passband: three atmospheric filters $K, K', \& K_s$, and two space filters F205W & F222M. The transmission functions of these five filters are quite different from each other, but it is often assumed that stars have the same magnitude or color at these filters, which may not be a reasonable assumption in some cases. In the present proceedings, we present and analyze theoretical isochrones that are calculated in a consistent way for the five filters near the K passband.

2. STELLAR SPECTRAL LIBRARY & EVOLUTIONARY TRACKS

For the spectra of synthetic stellar atmospheres, we adopt Kurucz ATLAS9 no-overshoot models caluclated by Castelli et al. (1997). The metallicities of these models cover the values of [M/H] = –2.5 to +0.5, but we make use of [M/H] = –2.0, –1.0, 0.0, & +0.5 models only. A microturbulent velocity $\xi = 2$ km/s, and a mixing length parameter $\alpha = 1.25$ are adopted.

For the temporal evolution of Teff and L of stars as a function of mass, i.e., stellar evolutionary tracks, we adopt the "basic set" of the Padova models (Girardi et al. 2002). We calculate isochrones for Z = 0.0001, 0.001, 0.019, & 0.03. Since the metallicity values of the stellar spectral library and stellar evolutionary tracks do not exactly match, we matched models with the closest metallicity values.

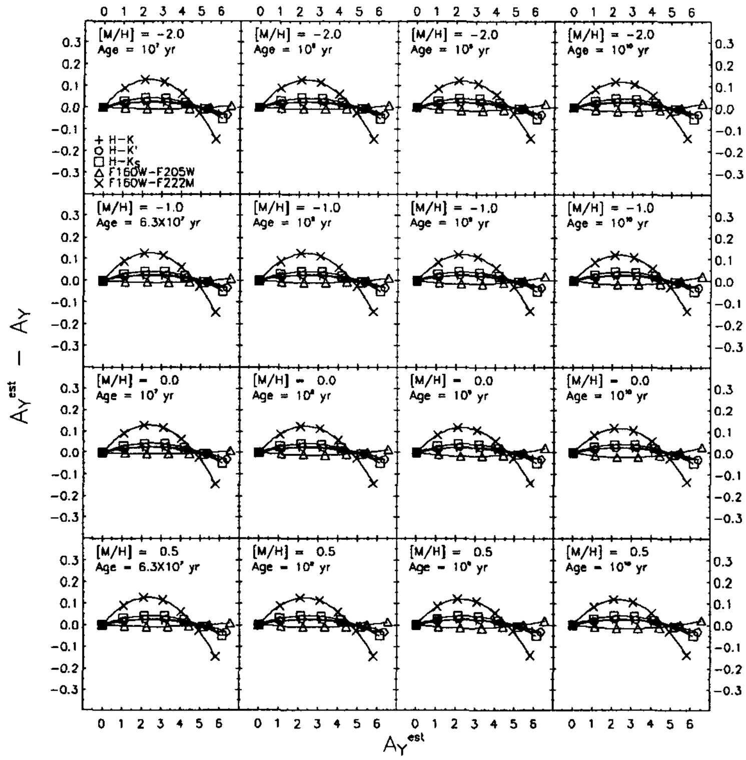

Figure 1. The difference between the extinction values that are estimated by Equation (2) with the colors from our reddened isochrones and the actual extinction values. A constant value of 1.55 is used for in Equation (2).

3. ISOCHRONES

We calculate isochrones with extinction of up to 6 mag at K band. For extinction A_λ, we adopt a power-law extinction law implied by Rieke, Rieke, & Paul (1989) for wavelengths between H and K passbands:

$$A_\lambda = A_0(\lambda/\lambda 0)^{-\alpha} \tag{1}$$

where we choose $\lambda_0 = 2.2\mu$m, and A_0 is the extinction at λ_0. When assuming that the transmission functions of H and K filters are Dirac delta functions centered at 1.65 μm and 2.2 μm, respectively, the extinction law by Rieke et al. (1989) gives $\alpha = 1.55$. However, as discussed later in this section, the extinction behaviour of isochrones in the CMD can be different from the actual extinction law, due to non-zero width and asymmetry of the filter transmission functions. We find that $\alpha = 1.62$ makes the isochrone for [M/H] = 0.0, Age= 10^9 yr model behaves in the CMD as if it follows an extinction law with $\alpha = 1.55$. We choose this particular isochrone model with an assumption that the stars used in Rieke et al. (1989) to derive their extinction law, which are the stars in the central parsec of our Galaxy, can be represented by such metallicity and age.

When one estimates the amount of extinction from an observed near-infrared CMD, where isochrones are nearly vertically straight, one converts an observed color excess to an extinction value following an assumed extinction law, which usually has a form of power-law.

When one has photometric data for two filters, X and Y, the amount of extinction can be esti-

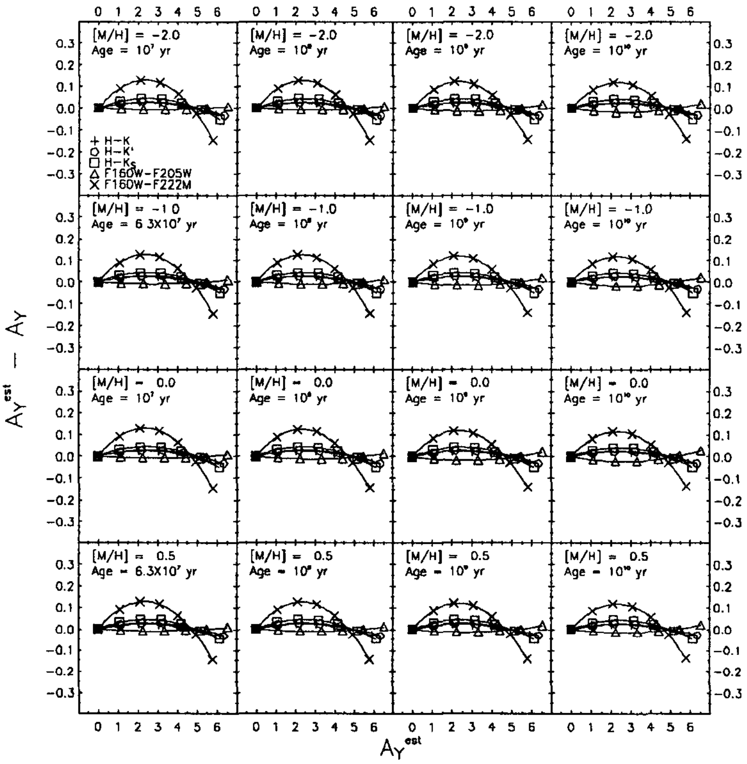

Figure 2. Same as Figure 1, but using $\alpha_{\rm eff}$ for Equation (2).

mated by

$$\begin{aligned} A_Y^{est} &= [(m_X - m_Y) - (m_X - m_Y)_0]/[A_X/A_Y - 1] \\ &= [(m_X - m_Y) - (m_X - m_Y)_0]/[(\lambda_X/\lambda_Y)^{-\alpha} - 1] \end{aligned} \qquad (2)$$

where $m_X \& m_Y$ and $\lambda_X \& \lambda_Y$ are the magnitudes and the central wavelengths of the two filters, respectively, and subscript 0 denotes the intrinsic color. For the estimation of extinction from our isochrones, we first use $\alpha = 1.55$ as this is the value that the extinction law of Rieke et al. (1989) appears to have between H & K. Figure 1 shows the difference between the extinction values that are estimated by Equation (2) with the colors from our reddened isochrones and the actual extinction values. Here, the extinction of each isochrone has been calculated with the mean color and mean magnitude of the reddened isochrone data points whose intrinsic K band magnitudes are between –6 and 0 mag. As the figures show, the difference between estimated and actual extinction values are larger for the space filter sets in general. The largest relative difference is $\sim$ 9 %, and the largest absolute difference is 0.29 mag, for the extinction values we try in the present proceedings (A_0 =6 mag).

The problems seen in Figure 1 can be alleviated by finding an "effective extinction law" for each filter set. We calculate the effective slope of the extinction, α_{eff}, by

$$\alpha_{eff} = -\log(1 + 1/b)/\log(\lambda_X/\lambda_Y), \qquad (3)$$

where b is the slope of the straight line that fits the distribution of mean magnitudes vs. mean colors of isochrones with A_0 value of 0 to 6 mag. When finding the best-fit straight line, we forced the line to pass We find that α_{eff} values range from 1.485 to 1.577, which are 8.4 % to 2.7 % smaller than the original α value we adopted for extinction, 1.62. As seen in Figure 2, extinction values estimated by Equation (2) with α_{eff} are now very close to the actual values, except for filter set F160W-F222W, whose extinction behaviour in the CMD is found to be poorly described by a straight line.

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