

WASHINGTON CCD PHOTOMETRY OF THE OLD OPEN CLUSTER TOMBAUGH 2

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ABSTRACT

We have estimated a metal abundance of $[Fe/H] = -0.48 \pm 0.14$ dex, a reddening of $E(B-V) = 0.30$ mag, an age of 2.0 ± 0.4 Gyr, and a distance of 7.9 ± 0.8 kpc for Tombaugh 2 using the Washington filter system.

I. INTRODUCTION

Tombaugh 2 is a faint old open cluster, located in the anticenter disk far from the Sun. The metal abundance and distance of Tombaugh 2 obtained from previous researches show a large range because of uncertain reddening value ranging from $E(B-V) = 0.1$ mag to 0.4 mag (Table 1).

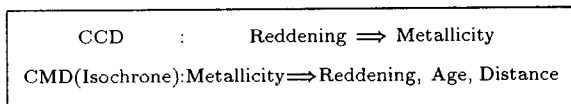
We have estimated the metal abundance, reddening, age, and distance of Tombaugh 2 using the Washington filter system that is efficient and accurate for determining metallicities of late-type giant stars.

II. OBSERVATION

The CCD images of Tombaugh 2 were obtained using the TI#2 CCD camera and 0.9 m telescope at CTIO on 19th September 1989.

III. RESULTS

We have determined simultaneously the reddening, metallicity distance and age of Tombaugh 2 using an iterative method with the photometry data and theoretical isochrones.



A reddening of $E(B-V) = 0.30$, an abundance of $[Fe/H] = -0.48 \pm 0.14$ dex, an age of 2.0 ± 0.4 Gyr, and a distance of 7.9 ± 0.8 kpc were derived for Tombaugh 2 (Fig. 2, Fig. 3). Corresponding galactocentric distance is $R_{GC} = 14.7$ kpc.

Fig. 4 displays the distribution of metal abundances of old open clusters with respect to galactocentric distances. Fig. 4 shows that the metallicity of Tombaugh 2 is consistent with the metallicity gradient of other old open clusters.

REFERENCES

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 Brown, J. A., Wallerstein, G., Geisler, D. 1993, BASS, 25, 1445

Table 1. Comparison of our study with previous studies

	Method	E(B-V) (mag)	Distance (kpc)	Age (Gyr)	[Fe/H] (dex)
Adler & Janes 1982	BV pg	0.08	13.2	0.8	metal poor
Lynga 1987	Lund Catalogue	0.08	13.2	1	
Geisler 1987	Washington pe	0.1			-1.2
Kubiak et al. 1992	BVI CCD	0.4	6.3	4.0	-1.2
Brown et al. 1993	Spectrosc.	0.3-0.4			-0.3
Friel & Janes 1993	Spectrosc.	0.2			-0.6
Carraro & Chiosi 1994	Age			1.74	
Phelps et al. 1994	Age			2.5	
this study	Washington CCD	0.30	7.9 ± 0.8	2.0 ± 0.4	-0.48 ± 0.14

Carraro, G., & Chiosi, C. 1994, A&A, 287, 761
 Friel, E. D., 1995, ARA&A, 33, 381
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 Kubiak, M., Kaluzny, J., Krzeminski, W., & Mateo, M. 1992. AcA. 42, 155
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 Phelps, R. L., Janes, K. A., & Montgomery, K. A. 1994, AJ, 107, 1097
 Wee, S. O., & Lee, M. G. 1996, in preparation.

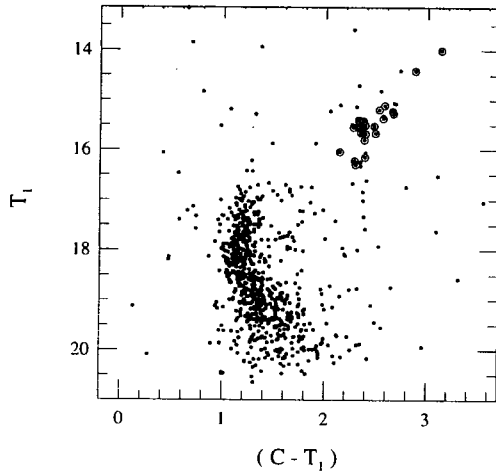


Fig. 1.— Color-magnitude diagram of Tombaugh 2. The open circles with a dot in the upper-right part are 24 red giant stars that are used for the estimate of metallicity of Tombaugh 2.

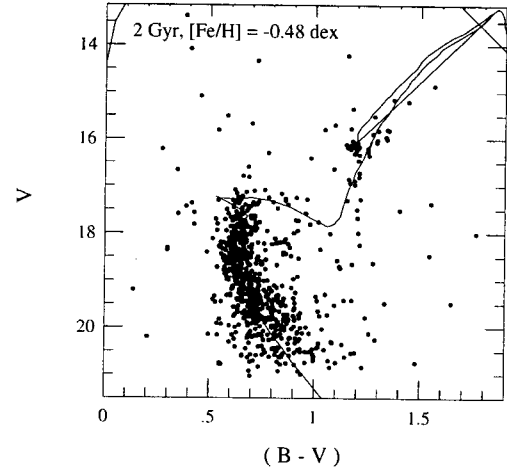


Fig. 3.— Isochrone fits for Tombaugh 2 in the BV CMD converted from Fig. 1. The ischrone (solid line) for the age of 2.0 Gyr and $[Fe/H] = -0.48$ dex matches well the CMD. The ischrone was shifted according to $E(B-V) = 0.30$ and $(m-M)_0 = 14.5$.

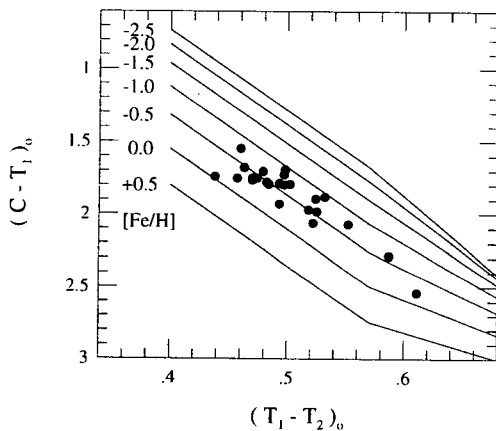


Fig. 2.— Color-color diagram of 24 red giant stars of Tombaugh 2. This is one of the four CCDs that we used to estimate the metallicity of Tombaugh 2. The mean metallicity is estimated to be $[Fe/H] = -0.48 \pm 0.14$ dex using these 4 CCDs.

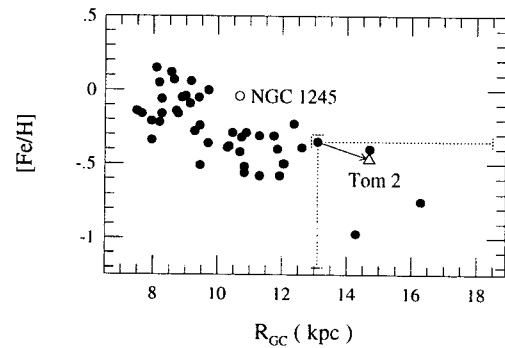


Fig. 4.— Radial abundance gradient for old open clusters. Filled circles correspond to the old open cluster data compiled by Friel (1995). The point of NGC 1245 (open circle) is updated by Wee and Lee (1996). The triangle represents the results of this study. The error bars of Tombaugh 2 represent the range of previous estimates.