PHOTOMETRIC OBSERVATIONS OF COMET C/2009 P1 (GARRADD)

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Introduction: G.J.Garradd discovered a comet of which magnitude 17.5 mag with 0.5 m-Uppsala Schmidt on August 13, 2009[1]. This comet was officially named as C/2009 P1 (Garradd) (hereafter , C/2009 P1 briefly). C/2009 P1 became brighter in 2011, and it could be observed even by small-diameter telescopes. We performed multi-color photometric observations of the C/2009 P1 with 0.2 m-reflector attached with cooled CCD camera. We report *V*-band magnitudes and color indices of C/2009 P1 in 2011.

Observations: We performed multi-color photometric observations of C/2009 P1 using the 0.2 m-refractor on multiple nights from September to November of 2011 at Sanda Shounkan high-school. The 0.2 m-refractor was used with an electric-cooled CCD camera (SBIG ST9XE 512×512 pixels at 20 microns) and the resultant pixel scale is 5.15 arcsec pixel^{-1} and Broad-band ("*B*", "*V*", "*R*", and "*I*") filters are used with the CCD camera. The *V*-band magnitudes of C/2009 P1 were obtained by comparing the observations of comet with observations of nearby three standard stars listed in the Tyco-2 star catalogue[2]. For other bands , we took other four standard stars that are solar analogue stars (the color indices of these stars are similar to the Sun listed in Landolt star catalogues[3]. We observed these standard stars with the same airmass at which C/2009 P1 was observed at that night. Depending on weather conditions, we took 5 - 10 frames for each field.

Analysis: All raw images were dark-subtracted and flat-fielded as usual manner. The flat frames were obtained by taking sky in twilight. The aperture of photometry is determined by Makali`i software distributed from National Observatory of Japan for astronomical image processing.

V-magnitude We determine the *V*-band magnitude of C/2009 P1 by referring to the Tyco-2 star catalogue. We compared C/2009 P1 with three standard stars in Tyco-2 catalogue. We determined the *V*-magnitude of C/2009 P1 based on the average of the magnitudes of three standard stars.

Color index We choose the four standard stars form Landolts standard star catalogue. The color indices of the standard stars are similar to the Sun (*B*-*V*=0.65) . We chose the four standard stars that can be taken simultaneously within the field-of-view of the CCD camera. The magnitude correction for atmospheric extinction is also considered.

Table 1. The variation of the *V*-magnitude

Date(JST)	9/14	9/23	9/24	10/18	10/26	10/31
V-mag	7.69	7.41	7.26	7.94	7.88	8.59

Results and Discussion: Table 1 shows the temporal change in *V*-magnitude of C/2009 P1 determined from our observation.

The total magnitude of cometary coma with respect to the observational conditions (heliocentric and geocentric distance) can be described by the power-low formula as [4]:

$$m_1=H_0+5\log_{10}\Delta+k\log_{10}r$$

where m_1=apparent visual magnitude of the coma, Δ=geocentric distance in astronomical units(AU) and r=heliocentric distance in AU. The constant H_0 is the absolute magnitude of a comet, and k is the power index which describes how the comet's luminosity varies as a function of r. These constants are derived to be H_0=3.85 and k=10.0 based on our observations. Yoshida(2011) reported that the constants H_0=3.5 and k=10.5[5]. These results are almost shows our results of our observation are exact.

We found that the color indices of C/2009 P1 is (*B*-*V*)=0.88 and (*V*-*R*)=0.55 from our data. The color indices of comet 6P/d'Arrest are (*B*-*V*)=0.78 and (*V*-*R*)=0.54 while those of comet 143P/Kowal-Markos are (*B*-*V*)=0.84 and (*V*-*R*)=0.58[6]. In spite of C/2009 P1 is a dynamically new comet, the color indices of C/2009 P1 from our observation are similar to those of short period comets. There are three possibility; (1) existence of large amount of large-sized dust grains in the coma,(2) contribution of strong emission lines from molecules in longer wavelength region such as NH_2 (parent or daughter molecules) and (3) both of large dust particles and molecules. Comparing with the spectroscopic observations in optical during the same period would be great help to interpret our results.

References:

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