

## Variable stars in the intermediate-age open cluster NGC 2301

Kim, S.-L.<sup>1</sup>, Park, B.-G.<sup>1</sup>, Lee, S.H.<sup>2</sup>, Sung, H.<sup>1</sup>, Chun, M.-Y.<sup>1</sup>,  
Ann, H.B.<sup>2</sup>, Lee, M.G.<sup>3</sup>, Jeon, Y.-B.<sup>1</sup>, Yuk, I.-S.<sup>1</sup>

<sup>1</sup> Korea Astronomy Observatory

<sup>2</sup> Department of Earth Science, Pusan National University

<sup>3</sup> Department of Astronomy, Seoul National University

We present the results of CCD photometry for the intermediate-age open cluster NGC 2301, which has performed as a part of the long-term project on time series observation of open clusters. Main purposes of the project are to search for variable stars and investigate their physical characteristics. We focus on short-period pulsating stars such as  $\beta$  Cephei stars, SPBs,  $\delta$  Sct stars and  $\gamma$  Dor stars which are recognized as important objects in studying stellar structure and testing evolution theory of an intermediate-mass ( $1.3 \sim 15 M_{\odot}$ ) main sequence star.

The observations were made by the 1.8m telescope of Bohyunsan Optical Astronomy Observatory (BOAO). We have obtained a total of 212 V frames for six nights from February 6th to 13th, 1999, with the SITe 2048 $\times$ 2048 CCD. The photometric seeing (FWHM) was less than 2". We also carried out the UBVI photometry on a very clear night (March 13), in order to estimate the physical parameters of the cluster.

We obtained the color-color and color-magnitude diagrams of NGC 2301 from the UBVI CCD photometry. The best fit of the ZAMS (Sung & Bessell 1999, MNRAS, 306, 361) in the color-color diagram gives a reddening value of  $E(B-V) = 0.04 \pm 0.03$ , with  $E(U-B)/E(B-V) = 0.72$ . We also estimated the distance modulus of  $(V-MV)_0 = 9.6 \pm 0.1$  and the age of  $\log t = 8.4$ , from the ZAMS and isochrone fitting in the color-magnitude diagram.

Using the V time series data, we carefully examined light variations of 923 stars, fainter than 10.m0, and then discovered nine variable stars ; three  $\gamma$  Dor stars, five eclipsing binary stars and one field SPBs. We obtained the periods of variable stars using the multiple frequency analysis and phase match technique. Our main results of CCD time series photometry are summarized in Table 1.

Table 1. Basic parameters of nine variable stars discovered in NGC 2301.

ID	V	B-V	Period	Max. $\Delta V$	Epoch <sup>†</sup>	Type	$P_{\mu}$ <sup>†</sup>	Remark
V1	10. <sup>m</sup> 864	0. <sup>m</sup> 095	0. <sup>d</sup> 332	$\sim 0.m04$	2451216.97	Field SPBs	0.00	
V2	11. <sup>m</sup> 621	0. <sup>m</sup> 341	0. <sup>d</sup> 352	$\sim 0.m03$	2451216.17	$\gamma$ Dor	0.91	multi-freq.
V3	12. <sup>m</sup> 562	0. <sup>m</sup> 387	0. <sup>d</sup> 299	$\sim 0.m02$	2451216.06	$\gamma$ Dor	0.96	
V4	12. <sup>m</sup> 708	0. <sup>m</sup> 368	0. <sup>d</sup> 340	$\sim 0.m04$	2451216.02	$\gamma$ Dor	0.93	
V5	14. <sup>m</sup> 452	0. <sup>m</sup> 922	0. <sup>d</sup> 778	$\sim 0.m08$	2451216.01	Eclipsing	-	
V6	15. <sup>m</sup> 872	0. <sup>m</sup> 925	1. <sup>d</sup> 102	$\sim 0.m15$	2451216.95	Eclipsing	-	
V7	15. <sup>m</sup> 975	0. <sup>m</sup> 910	0. <sup>d</sup> 642	$\sim 0.m17$	2451216.18	Eclipsing	-	
V8	16. <sup>m</sup> 075	1. <sup>m</sup> 097	0. <sup>d</sup> 250	$\sim 0.m09$	2451216.09	Eclipsing	-	
V9	16. <sup>m</sup> 605	1. <sup>m</sup> 041	0. <sup>d</sup> 873	$\sim 0.m12$	2451216.17	Eclipsing	-	

<sup>†</sup>: maximum brightness for pulsating stars and minimum for eclipsing binary stars.

<sup>†</sup>: from the open cluster database (<http://obswww.unige.ch/webda>) by J.-C. Mermilliod.