

The variability and periods in the BL Lac AO 0235+164

J. H. Fan^{1,2}, O. Kurtanidze³, X. Liu⁴, Y. Liu^{1,2}, H. T. Wang⁵,
Y. H. Yuan^{1,2}, J. M. Hao^{1,2}, D. X. Wu^{1,2}, W. Cai^{1,2}, H. B. Xiao^{1,2}
and Z. Y. Pei^{1,2}

¹Center for Astrophysics, Guangzhou University, Guangzhou 510006, China
email: fjh@gzhu.edu.cn

²Astronomy Science and Technology Research Laboratory of Department of Education of
Guangdong Province, Guangzhou 510006, China

³Abastumani Observatory, Mt. Kanobili, 0301 Abastumani, Georgia

⁴Xinjiang Astronomical Observatory, Chinese Academy of Sciences, Urumqi 830011, China

⁵Faculty of Physics and Electronic Information, LangFang Teacher's College, China

Abstract. Variability is one of the extreme observational properties of BL Lacertae objects. AO 0235+164 is a well studied BL Lac through the whole electro-magnetic wavebands, it is violently variable in the optical bands. In the present work, we show its optical R band photometric observations carried out during the period of Nov. 2006 to Dec. 2012 using the Ap6E CCD camera attached to the primary focus of the 70 cm meniscus telescope at Abastumani Observatory, Georgia. It shows a large variation of $\Delta R = 4.88$ mag (14.20 - 19.08 mag) during our monitoring period. When periodicity analysis methods are adopted to its R observations from our Abastumani monitoring programme and those in the literature, the signs of some periods, $P_1 = 8.26$ yr, $P_2 = 0.55$ yr, $P_3 = 0.85$ yr, $P_4 = 1.99$ yr are found.

Keywords. galaxies: BL Lacertae Objects: individual (AO 0235+164): photometry

1. Introduction

The BL Lac AO 0235+164, located at $z = 0.94$ is a well studied object. It is observed from radio to X-rays bands, and even high energy γ -ray regimes. It shows variability timescale from a few days to several years (Webb *et al.* 1998, Romero *et al.* 2000, Chen & Jiang 2001, Fan *et al.* 2002, Peng & de Bruyn 2004, Gupta *et al.* 2008, Rani *et al.* 2009, and Wang 2014). Raiteri *et al.* (2001) analyzed about 25 years of observational data in optical and radio bands during the period from 1975 to 2000, and found a quasi-periodicity of the main radio (and optical) outbursts on 5.7 years time scale. Periodicity analysis is also performed to its light curves by us (Fan *et al.* 2002; Wang 2014). The long-term quasi-period in the light curve perhaps suggests existence of a binary black hole system at its center (Romero *et al.* 2003; Ostorero, Villata & Raiteri 2004). AO 0235+164 is one of the monitored objects in our monitoring programme at Abastumani Observatory, Georgia (Kurtanidze *et al.* 2009, Nikolashvili & Kurtanidze 2007 and Fan *et al.* 2014).

2. Observations and results

Abastumani Observatory is located at the top of Mt. Kanobili in the South-Western part of Georgia. Observations are made using a 70 cm meniscus telescope ($f/3$), to which a Peltier cooled ST-6 CCD imaging camera was attached to the Newtonian focus from March 1997 to Sept 2006. All our observations are made using the filters combined of

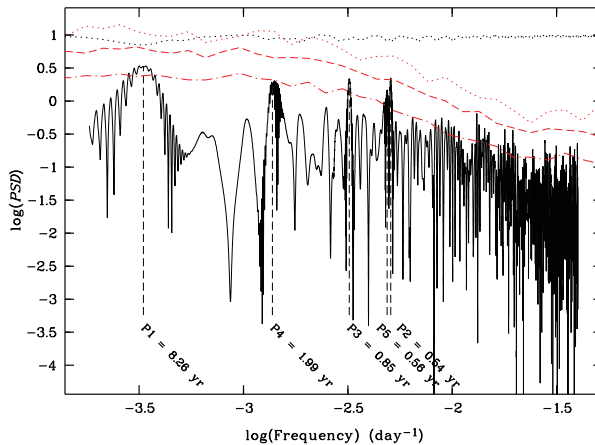


Figure 1. Periodicity analysis results for AO 0235+164.

glasses. Those filters matched with the standard B, V (Johnson), R_C and I_C (Cousins) passbands.

Variation: The magnitude determinations is described in our recent paper (Fan *et al.* 2014). The photometry results indicate the largest variation of 4.88 mag from $R = 14.20$ to $R = 19.08$ mag.

Periodicity Analysis: We performed a Power Spectral Analysis (PSA, or Fourier Analysis, or power-density spectrum analysis) to detect possible harmonic components, and gives some quantitative criterion for the detection of a possible periodic signal as we did in our previous papers (Fan *et al.* 2006; Fan *et al.* 2014). Our results show periods: $P_1 = 8.26$ yr, $P_2 = 0.55$ yr, $P_3 = 0.85$ yr, $P_4 = 1.99$ yr; see Fig. 1.

Acknowledgements

The work is partially supported by the National Natural Science Foundation of China (NSFC 10633010, NSFC 11173009, NSFC 11203007, NSFC 11403006), GDUPS(2009) and (10A027S), and supports for Astrophysics Key Subjects of Guangdong Province and Guangzhou City. The Abastumani team acknowledges the financial support of the project FR/639/6-320/12 by the Shota Rustaveli National Science Foundation under contract 31/76. Thanks are given to Profs. J. S. Chen and Y. Y. Zhou for useful discussions.

References

- Chen, Y. J. & Jiang, D. R., 2001, *A&A*, 376, 69
 Fan, J. H., Kurtanidze, O., Liu, Y., *et al.* 2014, *ApJS*, 213, 26
 Fan, J. H., Lin, R. G., Xie, G. Z., *et al.* 2002, *A&A*, 381, 1
 Fan, J. H., Tao, J., Qian, B. C., Gupta, A. C., & Liu, Y. 2006, *PASJ*, 58, 797
 Gupta, A. C., Fan, J. H., Bai, J. M., & Wagner, S. J., 2008, *AJ*, 135, 1384
 Kurtanidze, O. M., Tetradze, S. D., Richter, G. M., *et al.* 2009, *ASPC*, 408, 266
 Nikolashvili, M. & Kurtanidze, O. 2007, *IAUS*, 238, 419
 Ostorero, L., Villata, M., & Raiteri, C. M. 2004, *A&A* 419, 913
 Peng, B. & de Bruyn, A. G. 2004, *ApJ*, 610, 151
 Rani, B., Wiita, P. J., & Gupta, A. C. 2009, *ApJ*, 696, 2179
 Romero, G. E., Cellone, S. A., & Combi, J. A. 2000, *A&A*, 360, 47
 Romero, G. E., Fan, J. H., & Nuza, S. E. 2003, *ChJAA (RAA)*, 3, 513
 Wang, H. T. 2014, *Ap&SS*, 351, 281
 Webb, J. R., Smith, A. G., Leacock, R. J. *et al.* 1998, *AJ*, 95, 374