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OPTICAL MONITORING OF NGC4151 DURING 110 YEARS

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ABSTRACT. We present the historical light curve of NGC 4151 for 1906–2016. The light curve (Oknyanskij and Lyuty, 2007) is primarily based on our published photoelectric data (1968–2007, about 1040 nightly mean measurements (Oknyanskij and Lyuty, 2007)) and photographic estimates (mostly Odessa and Moscow plates taken in 1906 – 1982 (Oknyanskij, 1978, 1983), about 350 measurements). Additionally, we include all data obtained prior to 1968 (de Vaucouleurs and de Vaucouleurs, 1968; Barnes 1968; Sandage, 1967; Wisniewski and Kleinmann, 1968; Fitch et al., 1967) in total, 19 photoelectric observations from 1958–1967, were reduced by us to the same diaphragm aperture as that used in our measurements) as well as photographic data (Pacholczyk et al., 1983) (Harvard and Steward observatories' patrol plates taken in 1910–1968, about 210 measurements). The light curve includes our old and new photometrical data obtained during last years at SAI, ShAO and Weihai Observatory as well as other published data (Roberts and Rumstey, 2012; Schnülle et al., 2015). All these data were reduced to an uniform photometric system.

Applying Fourier (*CLEAN* algorithm) we have found periodic component ~16 years in the 110 years light curve. 40 years ago about the same "period" was firstly reviled from Odessa's photometrical data (Oknyanskij, 1977; 1978). This “period” seen in the light curve was then found independently in the spectral variability and interpreted as a case of the supermassive binary black hole (Bon et al., 2012). We interpret these circles as some accretion dynamic time.

Keywords: AGN, optical variability, historical light curves

1. Introduction

NGC4151 is one of the most popular and well studied AGNs, it is most bright and high variable object, which is very often used as an example object: typical Sy1, typical Sy1.5, typical object changing classification type between Sy1 and Sy1.9. Now about the same cases of changing spectral classification types were found for several tens of AGNs. So it is more likely typical than untypical option for AGNs and it has to be explained in some unification model.

NGC 4151 – is one of the several Seyfert galaxies which were firstly discovered at 1967 as variable in optical region (Fitch et al., 1967). Shortly after that (at 1968) the photoelectric UBV monitoring of NGC 4151 object was started at Crimean Laboratory of Sternberg Astronomical Institute (Lyuty, 1977). Variability of the object before 1967 can be investigated only from the archive photographic observations and an insignificant number of isolated photoelectrical observations. First long term optical variability investigations using photographic archive data (Harvard plates taken in the years 1932–1952 and Steward plates taken in the years 1956–1968) were published (in graphic form only) by Pacholczyk (1971). Our long term photometry of NGC 4151 using Odessa plates (1952–1975) was published in table and graphic forms Oknyanskij (1978). Subsequently, Pachalczyk et. al. (1983) published more complete photometrical data started from 1910 (in table form). Finally, variability of NGC 4151 during 1906–1911 years was investigated using old Moscow plats (Oknyanskij, 1983). The longest uniform series of photometric observations were obtained by one of us (Lyutyi, 1977), and so all other observations, as far as possible, were reduced to the system of the series (see details at Lyuty and Oknyanskij, 1987). Long-term historical light curve, including photographic and photoelectric data, was published by Lyuty and Oknynskij (1987), and then continued for the more than 100 years (Lyuty 2006; Oknyanskij and Lyuty, 2007; Oknyanskij et al. 2012; 2013). In Oknyansky et al., (2014) we add to the light curve published data of Roberts and Rumstey (2012) reduced to our system. Our data were reproduced at historical light curves many times (for example by Czerny et al. (2003).

2. Historical light curve for 1906–2016

At the present work we continue the optical monitoring of NGC 4151. Our new data after 2010 (~200 nights) include the photoelectric *UBV* and CCD photometry with the same telescope 0.6-m and equipments at the Crimean Astronomical Station of the MSU (see details in Oknyanskij and Lyuty, 2007; Oknyanskij et al., 2013), CCD data, which

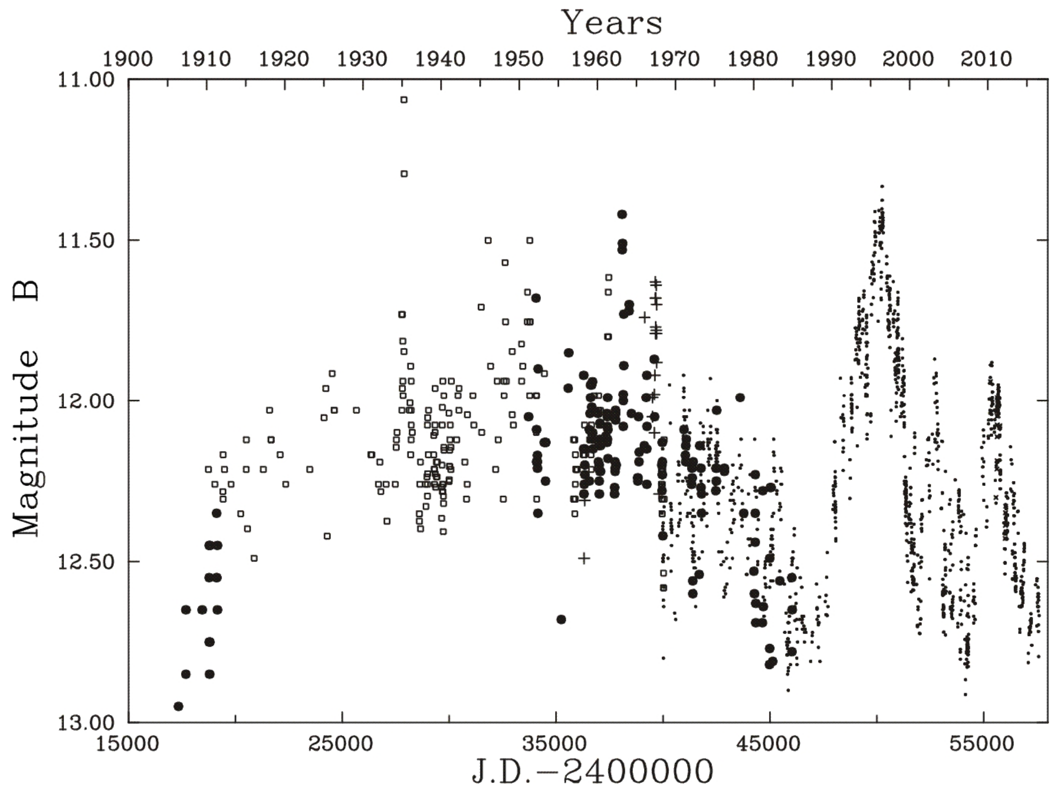

Figure 1: The historical light curve of NGC 4151. Filed circles – our photographic data, open circles – Pacholszyk et. al. (1983), pluses – photoelectric data obtained before 1968, dots – Crimean photoelectric monitoring, our new photoelectric and CCD data, other published CCD data transferred to our system (Roberts & Rumstay, 2012; Schnülle at al., 2015). The errors are of the order of 0.2 mag for Pachalcsyk's data, 0.1 mag or better for our photographic points, and ~0.02 mag or less for out photoelectric and CCD data.

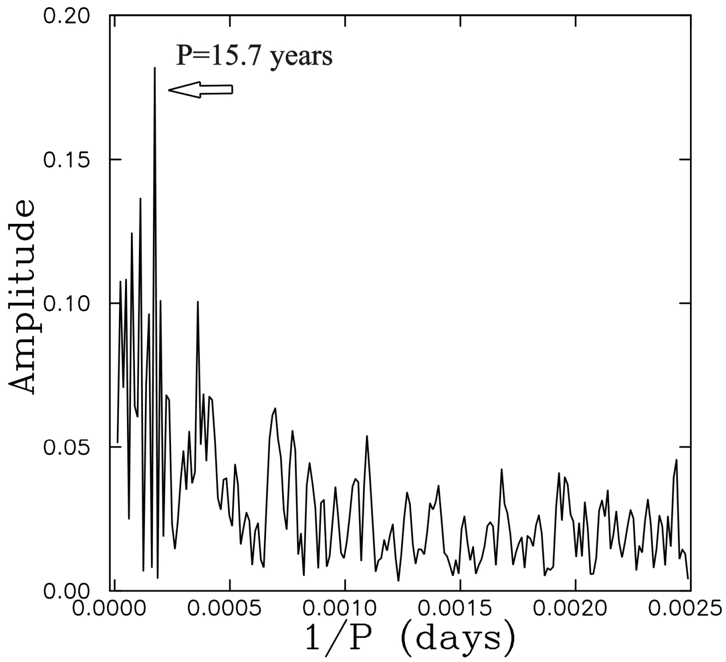

Figure 2: Relationship between the trial period P and its amplitude (in mag) obtained by the *CLEAN* method (Roberts et al., 1987). The regular component about 16 year which was firstly found 40 years ago (Oknyanskij, 1977) is most significant still in the variability during past 110 years.

were obtained with 0.6-m telescope at ShAO and the 1.0-m telescope at Weihai Observatory of Shandong University. We also added 29 points from Schnülle at al. (2015) reduced from *z* to our system in *B*.

The historical light curve for 1906–2016 years is presented at Fig. 1. At the light curve (Fig. 1) we can see different variable components: 1 – fast variations with time about tens of days, 2 – slow variations with time about several years, 3 – very slow component with time about tens of years. It is clearly seen that after minimuma at 1984 the type of variability is not the same as it was before: the amplitude of the fast variations become smaller compared to the slow ones. The most significant and long bright state during 1987–1997 happened just once during 110 years and can be connected with some unusual situation in the object, which increased the accretion rate very significantly.

2. Periodicity analysis

Applying Fourier (*CLEAN*) algorithm (Roberts et al., 1987) to the data from 1906 till 2016 (smoothed with steps of 100 days), we found out the periodical component P~15,7 years in 110 years light curve (see Fig. 2). Only on the base of the Odessa photometrical data (Oknyanskij 1977; 1978) nearly such period was revealed 40 years ago for the first time. Then presence of this periodic component was confirmed by us several times (Lyutyj and Oknyanskij, 1981; 1987; Oknyanskij and Lyuty 2007; Oknyanskij et al., 2007, 2013), and also, it was found independently from about the same data sets by Fun and Su (1999) and Guo et al. (2015). This "period" seen in the light curve was then found independently in the spectral variability and interpreted as a case of the supermassive binary black hole (Bon et al., 2012).

3. Summary

We present the historical light curve of NGC4151 for 1906–2016 which is longest known light curve among the variable Seyfert galaxies. The interval 1906–1966 is mostly presented by photographic estimates that were obtained using Moscow, Odessa, Harward and Stewart old plates collections. All these data can be combined together and reduced to the same system as photoelectrical *B* observations just using magnitudes obtained with Odessa plates because these observations are overlap with photoelectric and other photographic data. The Pacholczyk (1983) magnitudes need some very big corrections in scale and zero point before plotting them together with other photometric data.

The historical light curve shows different components in variability. Very high and long active state during 1987–1998 was happened just once during 110 years. We again confirm the presence of the regular component about 16 years.

We interpret these circles as some typical accretion dynamic time for the object.

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References

Barnes T.G.: 1968, *Ap. Lett.*, **1,** 171.
Bon E. et al.: 2012., *ApJ,* **759***,* 118.
Czerny B. et al.: 2003, *MNRAS,* **342**, 1222C.
de Vaucouleurs G., de Vauculeurs A.G.: 1968, *Publications University of Texas, Series II*, **7**, 1.
Guo D.F. et al.: 2015, *RAA*, **14**, 923.
Fan J.H., Su C.Y.: 1999, *ChA&A*, **23**, 22.
Fitch W.S., Pacholczyk A.G., Weymann R.J.: 1967, *Astrophys. J.*, **150**, L67.
Lyutyi V.M., Oknyanskij V.L.: 1987, *Soviet Astronomy*, **31**, 245.
Lyuty V.M.: 2006, *ASP Conference Series*, **360**, 3.
Lyutyi V.M.: 1977, *Soviet. Astron*., **21**, 655.
Lyutyj V.M., Oknyanskij V.L.: 1981, *Soviet Astron. Lett.,* **7,** 364.
Lyutyj V.M., Oknyanskij V.L.: 1987, *Soviet Astronomy*, **31**. 245.
Oknyanskij V.L.: 1977, *Astron. Tsirkulyar*, **944**, 2.
Oknyanskij V.L.: 1978, *Perem. Zvezdy Pr*, **21,** 71.
Oknyanskij V.L.: 1983, *Astron. Tsirkulyar*, **1300**, 1.
Oknyanskij V.L., Lyuty V.M.: 2007, *Peremen. Zvezdy Prilozhenie*, **7**, 28.
Oknyanskij V.L., Lyuty V.M.: 2007, *Odessa Astron. Publ.,* **20,** 160.
Oknyanskij et al.: 2012, *Odessa Astron. Publ.,* **25,** 179.
Oknyanskij et al.: 2013, *Odessa Astron. Publ.,* **26,** 212.
Oknyansky et al.: 2014, *Astron. Lett., **40**,* 527.
Pacholczyk A.G.: 1971, *ApJ*., **163**, 149.
Pacholczyk A.G. et al.: 1983. *Ap. Let.*, **23**, 225.
Roberts D.H., Lehar J., Dreher J.W.: 1987, *AJ.,* **93**, 968.
Roberts C.A., Rumstay K.R.: 2012, *JSARA*, **6**, 47.
Schnülle K. et al.: 2015, *A&A,* **578**, 57.
Sandage A.: 1967, *ApJ*, **150**, L177.
Wishnievski W.Z., Kleinmann D.E.: 1968, *ApJ,* **73***,* 866.