STELLAR VARIABILITY

Proceedings of the A.F.O.E.V. international
Conference on Variables Stars

Bourbon-Lancy, France
26-28 August 2002

Edited by
Dominique PROUST
Michel VERDENET
Joël MINOIS

Achevé d'imprimé sur les presses de l'imprimerie
4AB-N Athanassopoulos, Athènes

Dépôt légal : 10/2003

ISBN : 2-912616-18-2

PHOTOGRAPHIC AND CCD-OBSERVATIONS OF X-RAY SOURCE GY CNC = RX J0909.8+1849

S.Yu. Shugarov[1], N.A. Katysheva[1], P. Kroll[2]

1 Sternberg State Astronomical Institute, Russia
[2] Sonneberg Observatory, Germany

I. Introduction

Les variables cataclysmiques sont des étoiles binaires à très courte période dans lesquelles une étoile naine rouge à faible masse K-M (l'étoile secondaire) transfère de la matière à une naine blanche (étoile primaire). Les étoiles variables cataclysmiques se répartissent en plusieurs sous-classes, comprenant les novae naines (dNe) et les variables "nova like" (NLs) et d'autres groupes. Les dNe ordinaires ont des sursauts de 2-6m qui se poursuivent plusieurs jours et recommencent après quelques semaines, mois ou années.

Cataclysmic variables (CVs) are binary stars of very short orbital periods, in which a low-mass red K–M dwarf star (the secondary star) transfers mass to white dwarf (the primary star). Cataclysmic variables (CVs) subdivide into some sub-classes, including the dwarf novae (dNe) and nova-likes variables (NLs) and other groups. Ordinary dNe have $2–6^m$ outbursts, which continue several days and recur over weeks to month or years.

RX J0909.8+1849 = GY Cnc ($\alpha_{2000} = 09^h09^m50.^s56$, $\delta_{2000}=+18°49'47.''2$) was identified as possible cataclysmic variable by Bade et al. (1998). Also this star was known as HS 0907+1902 from Hamburg survey. The magnitude of this object is 16.4. An outburst of GY Cnc till of 12 mag was independently detected in February 2000 by Gänsicke et al. (2000) and VSNET–team (Kato et al., 2000).

The photometric observations during the outburst were provided by VSNET–team (Kato et al., 2000) and Gänsicke et al. (2000) immediately. In April 2000 Thorstensen (2000) studied this star spectroscopically during quiescence. Photometric investigations detected the eclipsing nature of the object (Vanmunster, 2000; Gänsicke et al., 2000; Kato et al., 2000).

Gänsicke et al. (2000) observed the object during 7 nights: JD 2451471, 581, 585, 589, 590, 597 and 599. They found the eclipse depth is ΔB=3.0, ΔV=2.6 and ΔR=2.1 mag and pointed out that there are no humps on the light curve during the outburst, but the usual for quiescence flickering with amplitude $\Delta m \sim 0.^m4$ exists. Their ephemeris is:

$$\text{Min (mid-ecl, HJD)} = 2451581.8263(1)+0.175446(3)E.$$

VSNET–team provided an observational unfiltered set (Kato et al., 2000) and obtained the following ephemeris:

$$\text{Min (HJD)} = 2451586.21266(10)+0.1754457(38)E.$$

They classified GY Cnc as a possible SS Cyg-type dNe and emphasized that one of the features of GY Cnc is the strong X-ray emission. Only a few dwarf novae have an X-ray emission, for example, EX Dra.

Shafter et al. (2000) obtained multicolor (BVRI) observations of GY Cnc and analyzed them.

Some parameters of the system (a distance d, a spectral class of the secondary) and a piece of information about the comparison star are done in Table 1.

Table 1.

d, pc	*Sp2*	Comparison star	V	References
		Tycho 2: 1404+1852 α=09:09:5; δ=18:49:0	11.08	Kato et al.
320±100	*M4*	Tycho 2: 1404+1852 α=09:09:5; δ=18:49:0	11.08	Gänsicke et al.
	M3±1.5	USNO A2.0 α=09:09:57.8; δ=18:49:03.07	13.8	Thorstensen
200–250	M3–4	star A: 102″E, 45″S star B: 16″W, 55′N	13.64 16.57	Shafter et al.

II. Observations.

Evidently the outburst activity on the long-term timescale was not studied.

We examined 730 plates from Sonneberg plate collection from 1930 to 1990 to value outburst activity of GY Cnc. They were gained with patrol cameras with object-glass diameter to 55 mm and with the limit magnitude $13–14^m$. The star is seen only during its outbursts and it is not visible in quiescence ($\sim 17^m$). At least 24 outbursts of this star have been observed (18 are certain and 6 – uncertain). In maximum it reaches $12.^m5$. The magnitudes of comparison stars in blue photographic system pg (close to B) are given in Table 2.

Table 2

GSC	pg	GSC	pg	GSC	pg
1404.0735	12.30	1404.0771	13.95	1404.0438	15.85
1404.1852	12.54	1404.0557	14.08	star I 16.7 α(2000)= $09^h09^m49.^s355$ δ(2000)=+19°50′42.″06	
1404.1716	12.72	1404.1815	14.31		
1404.0703	13.38	1404.0713	14.63		

The photographic light curve of the summary outburst is given in Fig.1.

It was gained by the shift of individual light curves in time. The outburst is very fast and continues 5 days. The outburst curve shows very sharp rise (about 1 day), a plateau (2 days) and a decline (2÷4 days) to 14^m. It's very difficult to estimate the outburst cycle because of very rare observations. But the minimum outburst interval we found is about 60 days. Below (in Table 3) we wrote Julian dates of the bright states (":" – the uncertain value, "*" – minimal interval between two outbursts):

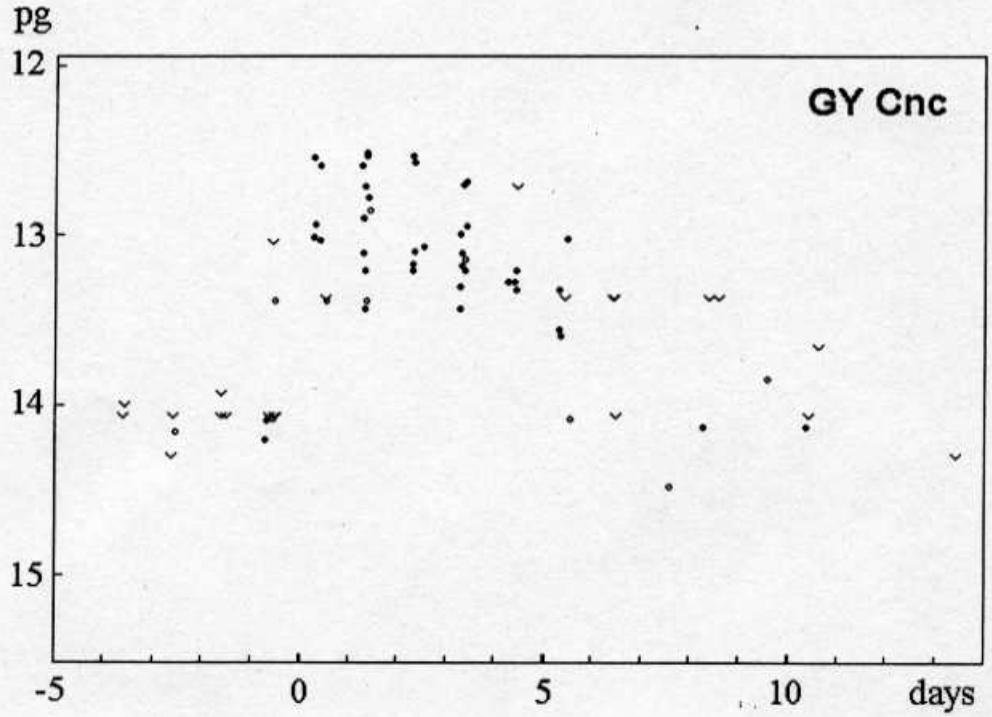


Fig.1. Photographic light curve of the summary outburst. The positive observations are shown by filled circles, the uncertain ones – by open circles, and the ticks signify the limiting magnitude of the plates.

Table 3

The dates of outbursts		
JD 2400000+		
27924	39024	47238
33330	39579	47852 :
34120	42149	48361
35209	45017	48691 :
35870	45760	48986 :
36246	46079	49029 *
36631 :	46437	*49090* *
38502 :	46871	49722

We began our CCD-observations of GY Cnc after receiving of the VSNET message in February 2000 and continued to observe this star during 2000 and in autumn 2001 in quiescence. The dates of our observations: JD 2451586–591, 627–629, 633–635, 839, 862, 863, 869, 878, 879, 881, 882, 2452015, 017, 020, 231, 242, 246. In general, our runs have been done at Crimean Laboratory of Sternberg Astronomical Institute. We used 38-cm, 60-cm and 125-cm telescopes equipped by SBIG ST–7 and ST–7 CCD-cameras. The reduction of the observations was made using an aperture photometry package developed by Vitaly Goranskij. The star used by Thorstensen (2000) was chosen as a comparison star.

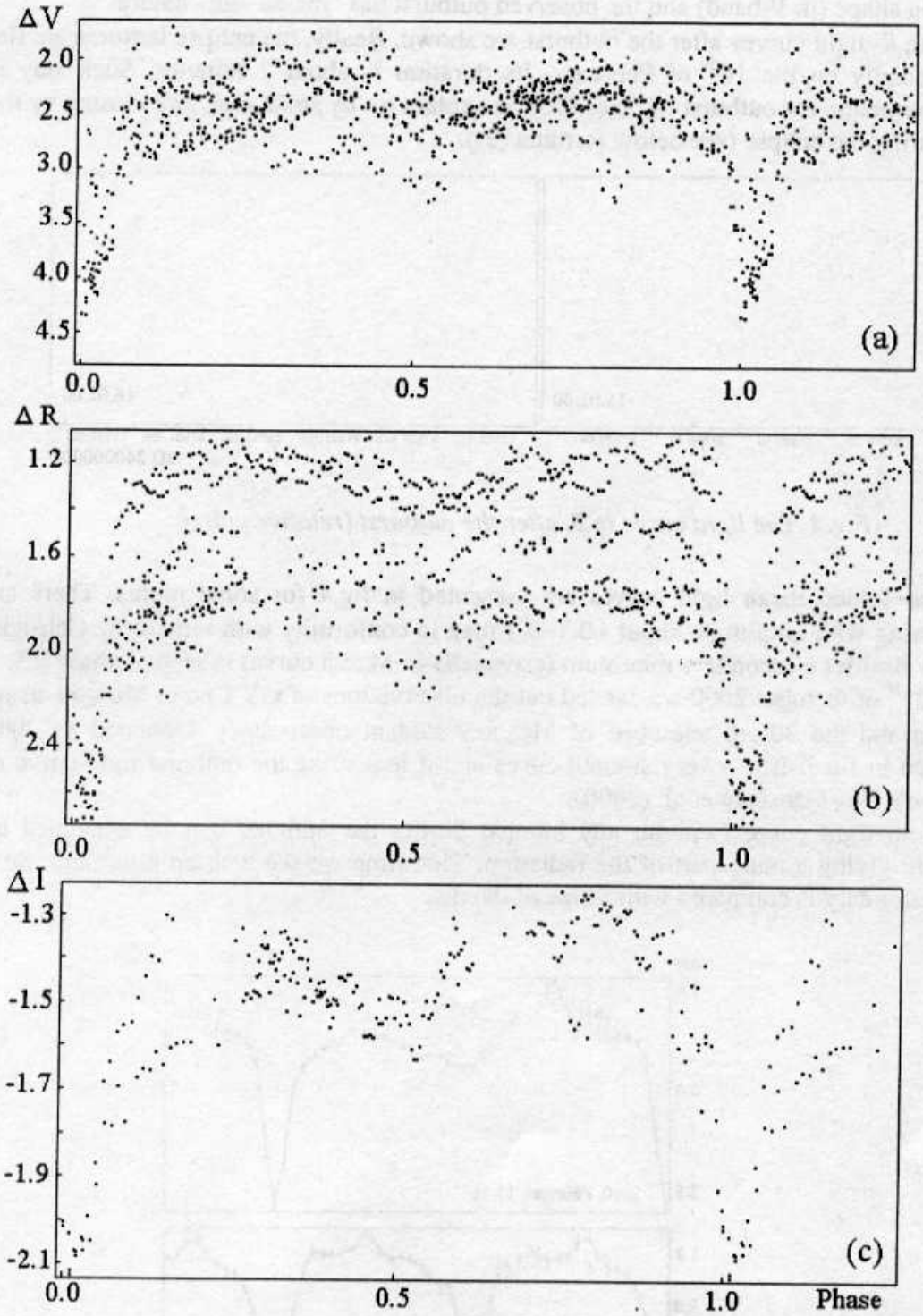


Fig.2. VRI-data folded with the period 0.175443 d (relative units).

Fig.2 presents data in filters *V*, *R* and *I* folded with period $0.^{d}175443$ (V – (a), R – (b) and I – (c)). For construction of the R–light curve we used only February data. The separate light curves in R-band are not displayed and reflect a state of activity: the high curve corresponds to decline of the outburst.

Gänsicke et al. (2000) pointed out that the eclipse profiles during the outburst are variable in shape (in *V*-band) and the observed outburst has "inside–out" nature.

In fig.3 the *R*–light curves after the outburst are shown. Really, the eclipse bottoms are flat enough, especially on the 16th of February. Its duration is about 7 minutes. Such stay is unusual phenomenon for outburst of dNe. We can explain it by small disc size closing by the secondary during the eclipse (see below formula (2)).

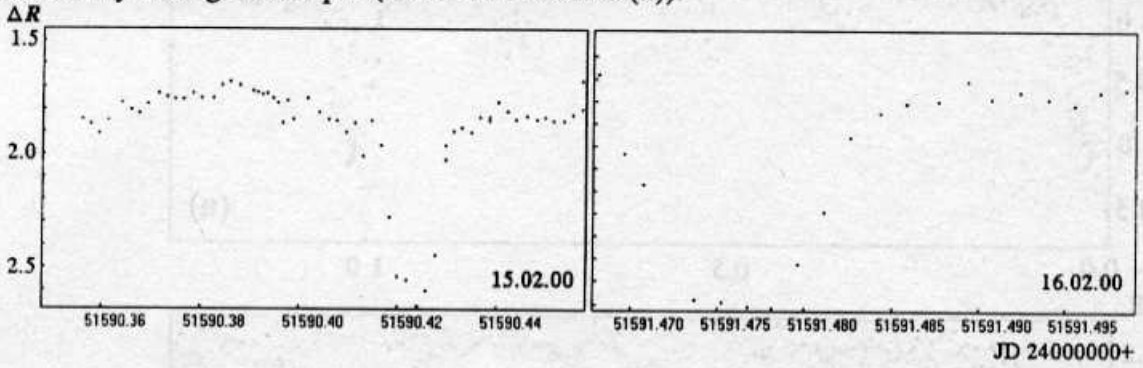


Fig.3. The light curve in R *after the outburst (relative units).*

The phase–folded mean light curves are presented in fig.4 for some nights. There are strong flickering with amplitude about ~0.3–0.4 mag in conformity with remark by Gänsicke et al. (2000). Besides a secondary minimum (especially in March curve) is seen at phase 0.5.

On the 21st of October 2000 we carried out the observations of GY Cnc in Moscow using ST-6 camera and the 30-cm telescope of Moscow student observatory. Obtained *R*– light curve is given in fig.5. It is a very smooth curve and it looks like the outburst light curve of 2000, February 7 by Gänsicke et al. (2000).

The smooth light curve (without any humps) during the outburst can be explained by enlarging disc giving a main part of the radiation. That time we see a sharp minimum. So a size of the secondary is compared with a size of the disc.

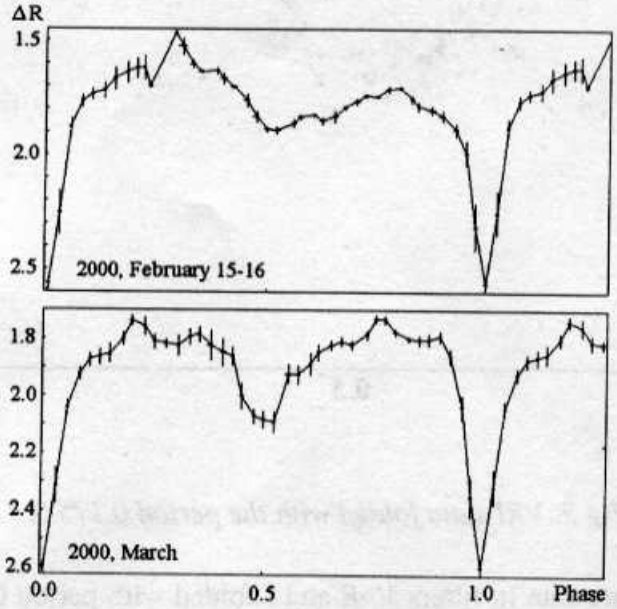


Fig.4. The mean light curve of GY Cnc in R-band after outburst (top panel) and in quiescence (bottom panel).

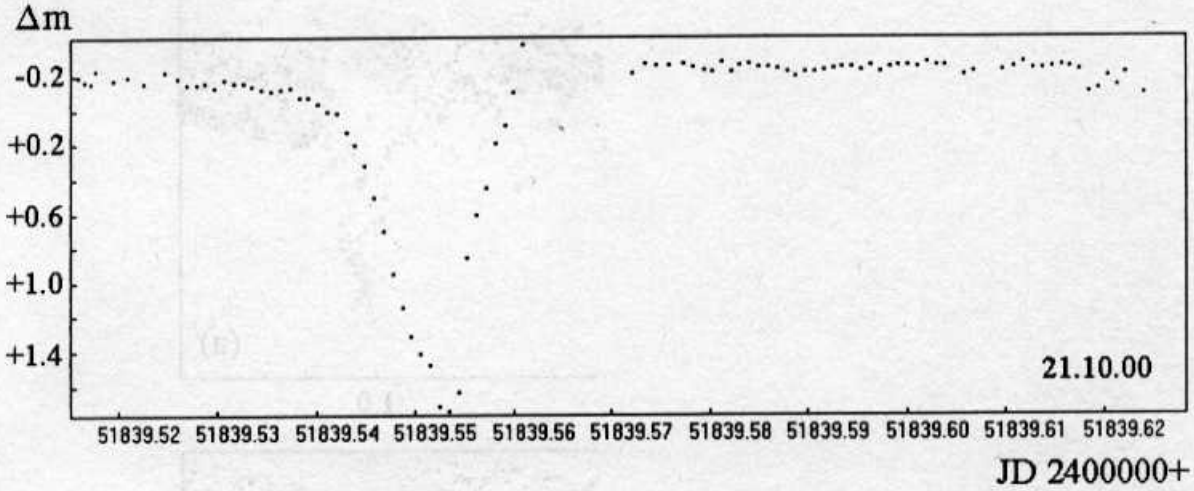


Fig. 5. The light curve of GY Cnc on the 21.10.00 (relative units).

At first disc covers by the secondary and begins to appear at once. If we take the masses of the components from Thorstensen (2000) (M_1~$1M_{sun}$, M_2=$0.38M_{sun}$) we have from Kepler's third law a distance between the components a=$1.4R_{sun}$. The width of the eclipse from the beginning of ingress to the end of egress is 0.13 of a period (or 32 minutes) during the outburst. Hence it follows that a total size of the red dwarf and a disc is about

$$D_2+D_d = 0.13 \cdot 2\pi a = 1.2\ R_{sun}. \quad (1)$$

In quiescence the eclipse duration is 0.08–0.09 of a period (20 min, see fig. 2, 4) in average, so a sum size is only $0.8\ R_{sun}$. One day (fig.3) we saw a very fast fall and rise (7–8 minutes) after the outburst. It corresponds to a diameter of the disc

$$D_d = 0.12\ R_{sun}. \quad (2)$$

On the 16th of February 2000 (fig.3) a stay at minimum lasted about 0.06 of a period. So a quantity

$$D_2 - D_d = 0.54\ R_{sun}. \quad (3)$$

From (2) and (3) it is possible to value a diameter of the red star as

$$D_2 = (0.12+0.54)\ R_{sun} \sim 0.7\ R_{sun}, \quad (4)$$

or $R_2 \sim 0.35R_{sun}$. It is very close to Roche lobe size for the mass ratio

$$q = M_2/M_1 = 1/3 \text{ and } a = 1.4\ R_{sun}.$$

From (1) we can estimate radius of outburst disc $0.25\ R_{sun}$. Out-of-outburst disc radius is about $0.1R_{sun}$. Our values are close by the values by Shafter et al. (2001). Our approximation was made for inclination $i=90^o$.

After the outburst such sources of the radiation as a gas stream and a hot spot begin to play a part, disc grows (from 0.1 up to 0.25 R_{sun}) and we can observe the fluctuations of a gas stream.

In quiescence there is a secondary minimum especially in R and in I-bands where the contribution of a red star (the secondary) is large. A few times we observed a depression at the phase 0.75 (see fig.1). The nature of this phenomenon is not clear yet.

III. Summary

We can summarize our results as follows:

a) Possibly the outbursts of GY Cnc happen once per two months.
b) The mean outburst length is about of 5 days.
c) The size of the disc undergoes strong changes decreasing after outburst and increasing up to the next outburst.
d) There is a depression in the *R* and *I* –light curves of an unclear origin.

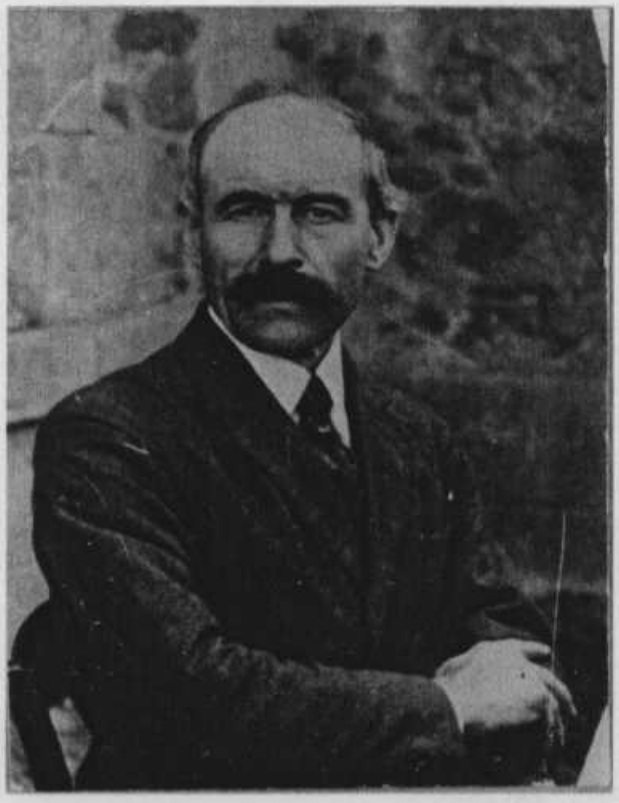
Of course, this star needs the further detailed analysis as during its outbursts as in quiescence.

S.Sh. and N.K. are very grateful to LOC and SOC for the support and hospitality. This work was partially supported by RFBR grants 02–02–16462, 02–02–17524 and 00–15–96553.

REFERENCES

Bade, N., Engels, D., Voges, W., et al. 1998, *Astron. & Astroph. suppl.*, **127**, 145.
Gänsicke, B.T., Fried, R.E., Hagen, H.-J. et al. 2000, *Astron. & Astroph,* **356**, L79.
Kato, T., Uemura, M., Schemeer, P. et al. 2000, *IBVS*, No 4873.
Shafter, A.W., Clark, L.L., Holland, J., Williams, S.J. 2000, *Publ. Astron. Soc. Pac.*, **112,** 1467.
Thorstensen, J.R. 2000, *Publ. Astron. Soc. Pac.*, **112,** 1276.
Vanmunster, T., 2000, *vsnet-alert circ.*, No. 4184, 4189, 4210, available at http://www.kusastro.kyoto-u.ac.jp/vsnet/Mail/vsnet-alert/

Table des matières



Antoine BRUN
1881-1978
Fondateur de l'AFOEV
Founder of the AFOEV

Couverture : La Nova 1901, découverte par T. Anderson le 21 février 1901, qui occupe le centre de cette illustration est maintenant connue sous le nom de GK Per. L'observation de cette étoile fut à l'origine de la vocation de variabliliste d'Antoine Brun.

Cette reproduction est extraite de la planche 13 de l'Atlas Brun. Antoine Brun a fait cet atlas en 1910 en partant de la Revised Harvard Photometry (Vol. 50) pour les étoiles de magnitude visuelle inférieure à 6,50 et de la Harvard Durchmusterung pour les étoiles de magnitude visuelle comprise entre 6,5 et 7,5. Brun attendit 1948 pour le publier.

Photo de couverture :

ISBN : 2-912616-18-2
www.burillier-uranie.com