COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS

Number 5571

Konkoly Observatory
Budapest
20 October 2004

HU ISSN 0374 – 0676

XX OPHIUCHI IN DEEP MINIMUM AFTER 37 YEARS

SOBOTKA, P. [1,2]

[1]Astronomical Institute, Academy of Sciences of the Czech Republic, 251 65 Ondřejov, Czech Republic.

[2]MEDUZA group, N. Copernicus Observatory, Kraví hora 2, 616 00 Brno, Czech Republic;
e-mail: `petr.sobotka@astro.cz`

The first spectrum of XX Ophiuchi (= HD 161114, SAO 141834, BD–6.4638), obtained by Mrs. Fleming in 1907 (see Fleming and Pickering 1908), showed the well marked emission line of Hβ. Annie Cannon in Henry Draper Catalogue classified the spectrum as Bep, so the star seemed to belong to the group of Be stars. However, substantial differences in the spectra were found by Merrill (1924), who noted a lot of emission lines of ionised iron (Fe II). Merrill described that the enhanced line spectrum is presented in greater purity than in any ordinary laboratory source, so since that time the star has been called *Iron Star*. In 1925, however, the absorption lines of the enhanced titanium spectrum were the dominant feature (Merrill 1926).

The optical variability of XX Oph was noted for the first time by Woods in 1921 (see Cannon 1922). Most of the time the brightness of XX Oph slowly varies around the mean value of $V = 9$ mag. As can be seen from the historical light curve of Prager (1940), constructed from the measurements on Harvard plates obtained from 1890 to 1939, XX Oph undergoes occasional one magnitude deep and one to three years long minima. Such an optical behaviour is well described in R Coronae Borealis stars. In spite of that, XX Oph does not belong to this group as no traces of carbon were observed in the spectra.

Lockwood et al. (1975) introduced a cool companion to the spectrum because the spectral energy distribution could be represented by the contributions of a B0III star and an M6III star. XX Oph has been considered to be a mass-exchanging binary star since Lockwood et al. (1975). This was confirmed by Evans et al. (1993), with a slight change of the spectral types of the components – B0V and M7III.

Interestingly, the optical variability does not seem to be correlated with the spectral variability. XX Oph underwent a deep and wide minimum between 1921 and 1922 but the spectrum remained unchanged. On the contrary, the strong absorption lines were discovered in 1925 during the constant phase at maximum (Merrill 1932).

Spectra of some O and B supergiants in the Magellanic Clouds show some similarities to XX Oph. These supergiants belong to LBV stars (Luminous Blue Variables). However, XX Oph is not so luminous because it is a giant.

Recently, XX Oph has been observed in a deep minimum after 37 years of the maximum brightness. These variations are presented in Figure 1.

Observations presented in this paper are of two kinds, CCD and visual. CCD observations consist of the HIPPARCOS data (Perryman et al. 1997) from March 1990

(JD 2447960) to March 1993 (JD 2449060), ROTSE (Wozniak et al. 2004) from May 1999 (JD 2451318) to October 1999 (JD 2451482), ASAS–3 (Pojmanski 2002) from February 2001 (JD 2451947) to October 2004 (JD 2453280), and ESA INTEGRAL Optical Monitoring Camera (OMC) from April 2003 (JD 2452753) to March 2004 (JD 2453077). Unfiltered ROTSE data were shifted by +0.5 mag to match the other measurements. Visual data were taken from the following organizations: AAVSO (USA), AFOEV (France), MEDUZA (Czech Republic and Slovakia) and HAA VSS (Hungary).

The light curve is plotted in Figure 1. Visual data obviously do not attain the precision of the CCD observations. However, when averaged and smoothed, visual observations are a useful tool to judge the long-term optical changes. In this case, I used 20-day bins.

Seven deep minima have been observed in XX Oph since 1890. Approximate timings derived from the historical light curve are given in Table 1. The brightness of XX Oph slowly varied from 8.3 to 9.3 mag between 1968 and March 2004, when the gradual fading by 0.2 mag per month started. It seems that the fading stopped on 2nd September 2004 and reached $V = 10.15$ mag. The star has never been in maximum for such a long time (see Table 1).

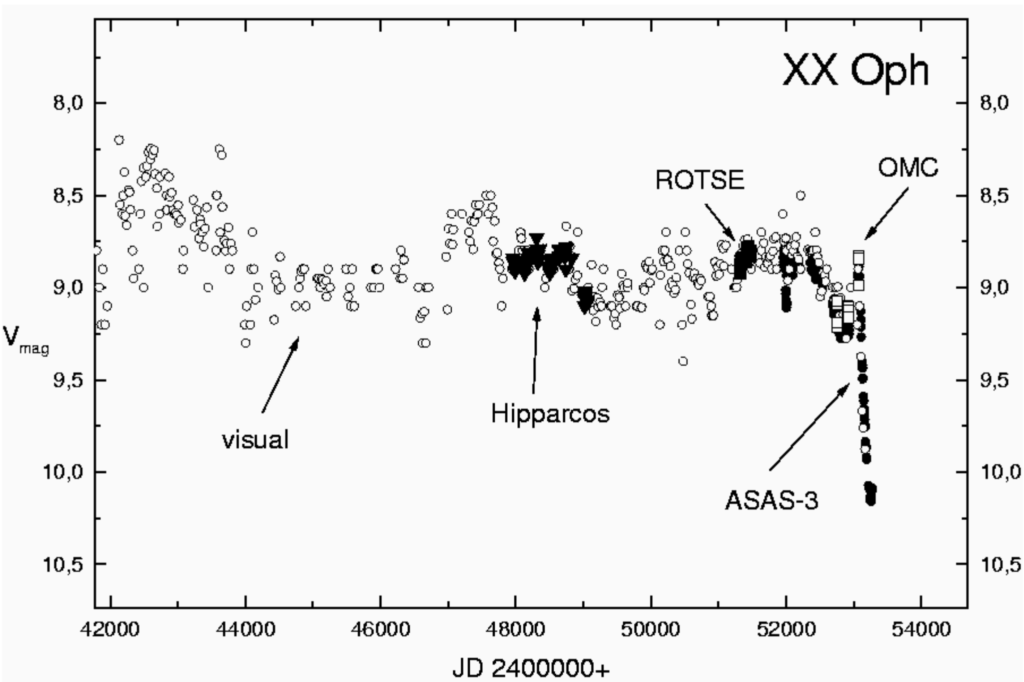

Figure 1. Light curve of XX Oph from 1974 to 2004. Filled circles represent CCD V-filtered observations of ASAS–3, filled squares are CCD unfiltered observations of ROTSE, the HIPPARCOS magnitudes are plotted as filled triangles, while INTEGRAL OMC V-filtered data are plotted as open squares. Averaged visual observations with 20-day bins of AAVSO, AFOEV, MEDUZA and HAA VSS are shown as open circles.

We are now experiencing the first possibility to observe XX Oph in minimum in modern era. Instrumentation and observing techniques have significantly improved in the last 37 years, thus we have an unique opportunity to understand XX Oph. The minima of brightness are probably caused by sudden weakening of the stellar wind (that is common in LBV stars, see Conti 1984) and this is our chance to see the stellar atmosphere. Mainly spectroscopic observations may reveal important information.

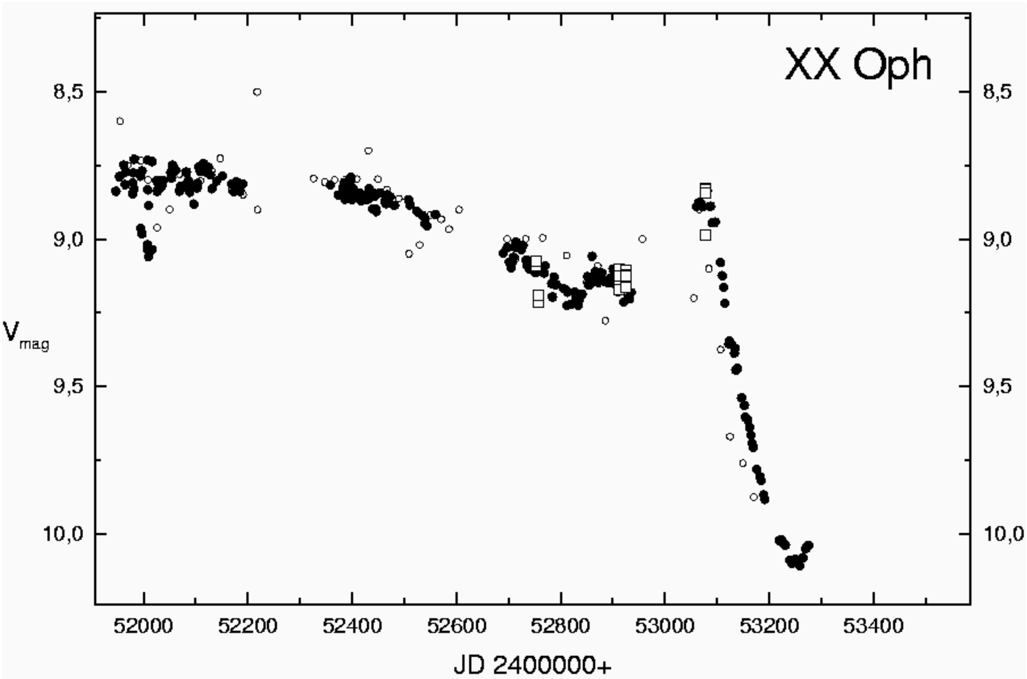

Figure 2. Detailed light curve of the past four years from 2001 to 2004. The symbols are the same as in Figure 1.

Table 1. Approximate timings of the deep minima of XX Oph.

$T_{\rm min}$ (year)	$T_{\rm min,i} - T_{\rm min,i-1}$ (years)	note	data source
1889	-		Prager 1940
1901	12		Prager 1940
1915	14		Prager 1940
1921-22	06	(double minimum)	Prager 1940
1931	09		Prager 1940
1947	16		Burnham 1977
1967	20		this paper
2004	37		this paper

Acknowledgement. Based on observations with INTEGRAL, an ESA project with instruments and science data centre funded by ESA member states (especially the PI countries: Denmark, France, Germany, Italy, Switzerland, Spain), Czech Republic and Poland, and with the participation of Russia and the USA. I acknowledge the collaboration with the OMC Team, INTA, Madrid, on use of INTEGRAL OMC light curves, as well as collaboration within the INTEGRAL Cataclysmic Variables Working Group. This work made use of the SIMBAD database, operated at CDS, Strasbourg, France. I acknowledge with thanks the variable star observers from the AAVSO (`http://www.aavso.org`), AFOEV (`http://astro.u-strasbg.fr/afoev`), MEDUZA (`http://www.meduza.info`) and HAA VSS (`http://vcssz.mcse.hu`) databases.

References:

Burnham, R., 1977, *Burnham's Celestial Handbook*, ISBN: 048623567X
Cannon, A.J., 1922, *HarCi*, **231**
Conti, P.S., 1984, *IAUS*, **105**, 233
Evans, A., et al., 1993, *A&A*, **267**, 161
Fleming, W., Pickering, E.C., 1908, *HarCi*, **143**
Lockwood, G.W., et al., 1975, *ApJ*, **195**, 385
Merrill, P.W., 1924, *PASP*, **36**, 225
Merrill, P.W., 1926, *PASP*, **38**, 45
Merrill, P.W., 1932, *ApJ*, **75**, 133
Perryman, M.A.C., et al., 1997, *A&A*, **L323**, 49, The Hipparcos Catalogue
Pojmanski, G., 2002, *AcA*, **52**, 397, The All Sky Automated Survey
Prager, R., 1940, *BHarO*, **912**, 17
Wozniak, P.R., et al., 2004, *AJ*, **127**, 2436, Northern Sky Variability Survey: Public Data Release