THE BRIGHTNESS AND COLOURS OF THE LOIANO SKY

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ABSTRACT. The sky brightness at Loiano, observing site of Osservatorio Astronomico di Bologna, was measured during moonless and clear nigths in the years 1986-1998. Most of the measures were carried out in the V and B Johnson broad photometric bands at the zenith or close to the zenith. Any conclusion about an increase of light pollution cannot be reached during these years, due to the large spread of the measurements.

The mean value of sky brightness in Loiano is about 20.2 magnitude/sq.arcsec in the visual band and 21.1 in the blue band with a standard deviation of 0.4 in both filters.

1. Introduction

During the past years man made lighting has caused an important addition to the natural light of the sky. This contribution, called sky glow, increases everyday: theoretical studies model this increasing of the sky pollution produced by the continuus expansion of the cities (Garstang 1986) and relationships have been proposed to describe the dependence among sky-brightness, increasing of the population and the distance of the cities (Walker 1977). The consequence is the progressive erosion of the dark zones (Walker 1988) endangering the activity of existing observatories. Optical observatories and the astronomical community, try to take measures for the safeguard of the sky: sky light spectra were obtained as well spectra of street lamps to study the possibility to reduce the contamination due to the lines over the astronomical spectrum (Osterbrock 1976). Long term observing campaign have been carried out at several observatories to determine the natural sky background as well as to monitor the level of sky pollution by artificial lighting (Mattila 1996, Walker 1988).

After the first study of light pollution in Italy, presented by Bertiau (Bertiau et al. 1973) and Treanor (Treanor 1973) several years ago, in the italian astronomical community realized the need to monitor the actual situation in order to find solution before reaching an irrevocable degradation of the sky.

In this paper I report a series of sky brightness measurements obtained during the past decade at the Loiano Observatory. The sky brightness values were obtained as by-product of long-term programs: monitoring of AGNs or light curves of variable stars. The observations are described in section 3, in section 4 there are the plots and the discussion of the sky brightness.

2. The site

The Loiano Observatory is the astronomical observing station of the Osservatorio Astronomico of Bologna. It is located 2 Km south of Loiano town, at an elevation of 785 m on the Appennini mountains (West Longitude= $-11^0 20' 12"$, Latitude= $44^0 15' 32"$).

The Loiano town is located 35 km south of Bologna. It is recheable following the Futa road (SS 65). In this site two telescopes are operating: 152 cm and 60 cm with diameter respectively. These two telescopes are surrounded by extensives areas of woods, about 23 hectare, to reduce the albedo of the ground. Nevertheless the Loiano sky is affected by the artificial light of the surrounding centers: Monghidoro, 7 Km south of Loiano, Monzuno to the West. These similar small towns, with few hundreds habitants during the winter, are summer resort places and their population can triplicate in July and August. The big city of Bologna (see figure 1) and their surrounding towns dominate the north direction.

Some limited measures have adopted in Loiano to reduce sky contamination. No limitation to the sky light pollution has been obtained in the other and most important towns.

3. Observations

To the aim of computing the Loiano sky brightness, we used an observing database with the direct images collected to study the light curve of AGN and carried out at the 152 cm of Loiano during the years 1986 to 1989. The other values are a by-product of photometric nigths allocated to study variable stars. In both cases the observations are done in the B and/or V broad band Johnson filter (Johnson 1951).

The sky magnitudes, by-product of AGN observations, are derived from CCD frames of standard fields used to calibrate the magnitudes, exposures are available in both B and V Johnson band. Only observations having air mass between 1 and 1.2 were selected. For these observations the exposure time ranges between 5 and 10 minutes. A small area close to the standard star, in the same ccd field, and free from any visible star is selected to compute the sky magnitude, the magnitude of the standards in the ccd field giving the zero point, after to have applied the mean monthly extinction coefficients . Most of the adopted standard field are open cluster. The computed sky value is a mean value of several number of sky values computed in the same frame, and the standard deviation gives the internal precision of this measurement, tipically a few percent.

The sky magnitudes derived from the observations of variable stars are from ccd frames or traditional standard photometry. In this case the standard stars were used to compute both extintion and magnitude calibration.

Table 1 lists the used night and the computed sky brightness reduced under atmosphere: the first three row show the data. The row 4 and 5 list blue sky brightness and its r.m.s. dispersion. Several sky brightness are obtained as mean value of different values computed using different frames in the same nights, in this case the computed standard deviation is reported. In the rows 6 and 7 the values for the visual band are listed. Detailed comments are reported in the following section.

Fig. 1. A map of Loiano and neightborhood.

3.1. Comments to table 1

Year 1986: the data are from standard fields obtained in a extensive survey of AGNss, selecting only observations of dark nights.

March: one night available and two observations in visual, one in blue.

May: 3 nights are available. The 10 night is somewath cloudy, the magnitude is a mean value of 3 independent values. For the 13 and 28 nights the mean value of 2 different measurements are reported.

The data of June is a mean value of 2 measurements.

Year 1987: it was a year with several failures in the telescope and only one night is available with a mean value of 6 measurements in the same frame.

Year 1988: February show the mean value of 2 independent observations.

March show a mean value from 6 measurements in the same frame. In the following months are reported the magnitudes computed as mean value of different obnservations.

Year 1989: in January the value is the mean value of several measurements in the same frame. October has single computed magnitudes.

Year 1990: the magnitude for the day 30 is from one single computed magnitude, the magnitude for the day 31 is a mean value of several values.

Year 1992: the magnitude is a mean value of several value in the same frame.

Year 1993: March data is a single value from a standard star, the April data is from a photoelectric observation.

Year 1994: the measurements of January and February are from photoelectric photometry and not from ccd, for this only B filters are done, since the B filter present the same response curve of the standard Johnson's B. The other points are from very clear photometric sky.

Year 1995: from very clear photometric sky.

Year 1998: the observation is 3 days after a snow, with the telescope pointed at west direction, were the sky is very dark. In this case it is peak up a rare very photometric night, this value is the best limit of this year.

4. Monthly sky brightness

In figure 2 are plotted the B sky brightness and the computed r.m.s., when available for independent computed values of sky brightness, as reported in table 1, vs the year. Different symbols are adopted for each observed year.

Even if the table report only observations in dark clear nights, in the plot are indicated also the local computed sky brightness values for full moon nights and for cloudy nights for the Loiano sky. It is also reported the sky brightness for one of the best astronomical sites in the world: La Silla.

Looking the figure, the scatter of the measurements larger than one magnitude is apparent. This could be explained with the different atmospherical conditions. In fact the observation of January 1988 is done tree days after a a light snow fall, faster melted; it is likely that snow did clean the local atmosphere from the aerosols.

The plotted observations are done in different positions of the sky and not in the same sky position each night: the resulting large scatter can be an indicator of the

Tab. 1 - The available data

month	day	year	Sky b	σ_b	Sky V	σ_v	Notes
3	5	1986	21.24		20.56	0.06	
4	9	1986	21.25		20.25		
5	10	1986	20.81	0.30	19.93		
5	13	1986	21.15	0.31	20.45	0.11	
5	28	1986	20.90	0.24	20.23	0.06	
6	2	1986	20.98	0.08	20.21	0.05	
7	10	1986	21.10		20.21		
8	9	1986	21.3				
5	30	1987	22.10	0.06	20.73	0.03	a)
2	21	1988	21.18	0.6			
3	25	1988	20.38	0.02	20.20	0.01	a)
7	22	1988	20.97	0.05	20.11	0.03	
7	23	1988	21.46	0.44	20.67	0.49	
9	5	1988	20.50	0.15	19.44	0.11	
9	9	1988	21.03		20.18		
11	6	1988	21.45	0.07	20.48	0.09	
12	11	1988	21.2		20.3		
1	8	1989	21.64	0.06	20.69	0.11	a)
10	5	1989	21.02		20.40		
10	6	1989	20.71		19.19		
5	30	1990	20.62		20.06		
5	31	1990	20.94	0.02	20.18	0.02	a)
5	9	1992	20.51	0.02	19.15	0.01	a)
3	29	1993			19.94		c)
4	23	1993	22.5				b)
1	31	1994	20.0				b)
2	1	1994	20.7				b) extra lights
3	18	1994	21.2				b)
4	28	1994			20.53		c)
4	30	1994			19.50		c)
5	19	1994			19.66		c)
6	15	1994			20.53		c)
6	18	1994			20.04		c)
9	12	1994	22.2				b)
12	7	1994	20.5				b)
1	3	1995			19.51		
2	6	1995			21.10		
3	7	1995			20.70		
3	22	1995			20.5		
6	6	1995			19.9		
7	22	1995	21.20	0.36	20.19	0.25	
1	17	1997	21.90				
1	31	1997			19.96	0.03	d)
2	27	1997			19.8		d)
1	28	1998	21.90	0.2	20.7	0.2	d)

a) mean value of several standards in the same ccd frame
b) from photoelectric photometry, not ccd
c) photometric sky
d) very photometric sky, after snow

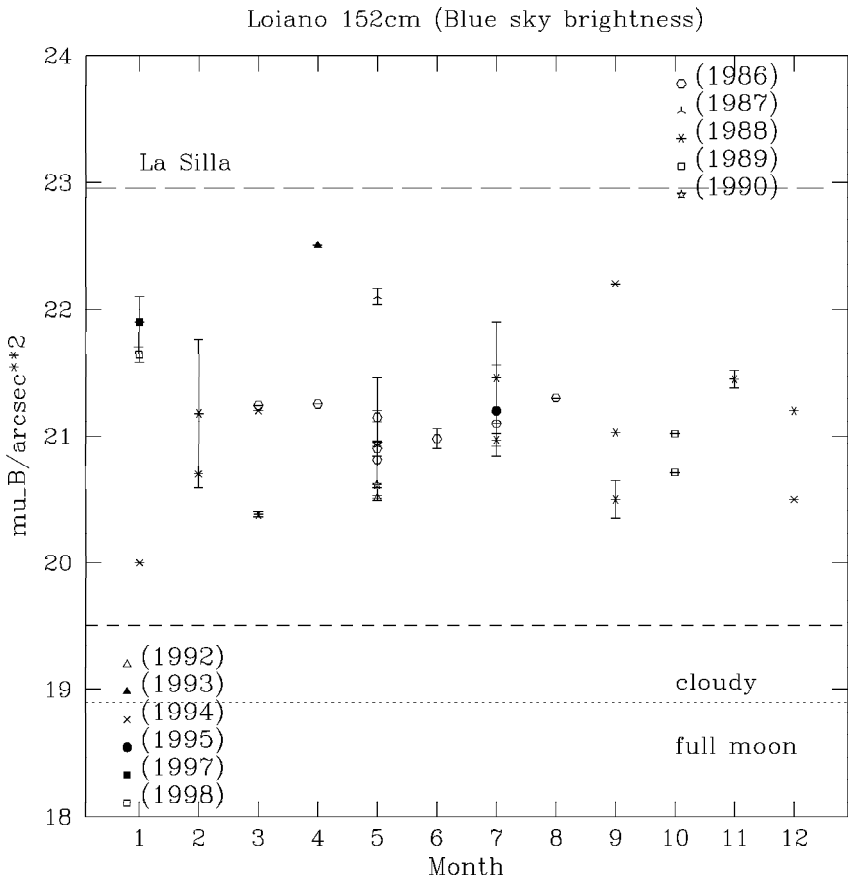

Fig. 2. The Loiano B sky brightness.

amount of the variation of the Loiano sky brightness.

The computed mean value for the B band is 21.14 with a r.m.s of 0.5 mag/sq.arcsec., starting with a mean value, for the year 1986, of 21.03.

Figures 3 shows the sky brightness in V filter.

In this filter it can be seen a marginal long term increase of the sky pollution: in fact the mean value of 20.5 in the year 1986 become the best value for the point of the year 1998, the night with the optimal atmospheric condition for the photoelectrical photometry. A few cloudy nights can affect the average sky brightness in the V band, whereas is insensitive the effect in the B band.

The computed mean value for the V band is 20.17 with a r.m.s of 0.4.

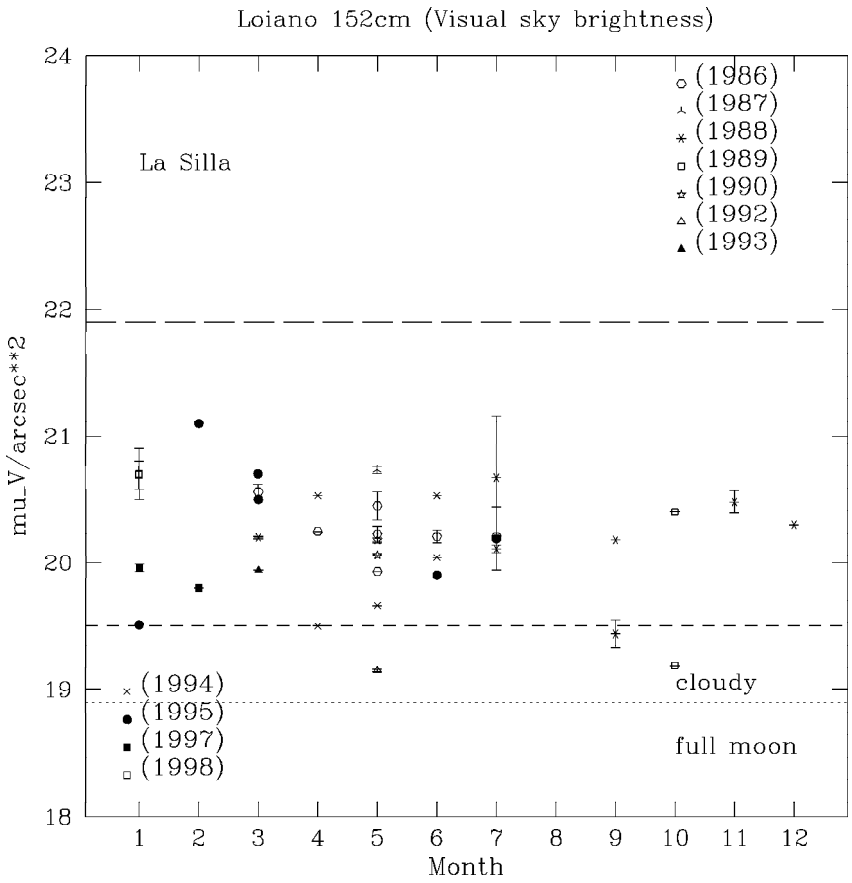

Fig. 3. The Loiano V sky brightness.

5. Annual sky brightness

The sky brightness, for the B band, as a function of the epoch is plotted in figure 4.

No clear evidence can be obtained in this B band of an increasing of light pollution during the years. The plot seems to show an increase of the brightness in the first 6 years, but this trend seems not to extended to the more recent years, where the data show an increase of the scatter. These last data are obtained as single measure for each year and not as mean value of several magnitudes. It is possible, for the last two years, to have been lucky and to have meat the very rare photometric nights (clear sky, low humidity, good seeing, etc.). Can this be a confirmation of the degradation of the sky conditions? More statistic is needed to reach any conclusion in this sense.

Figure 5 shows the same plot for the V band.

Also in this band the scatter increases after the year 1995, even if there is a marginal

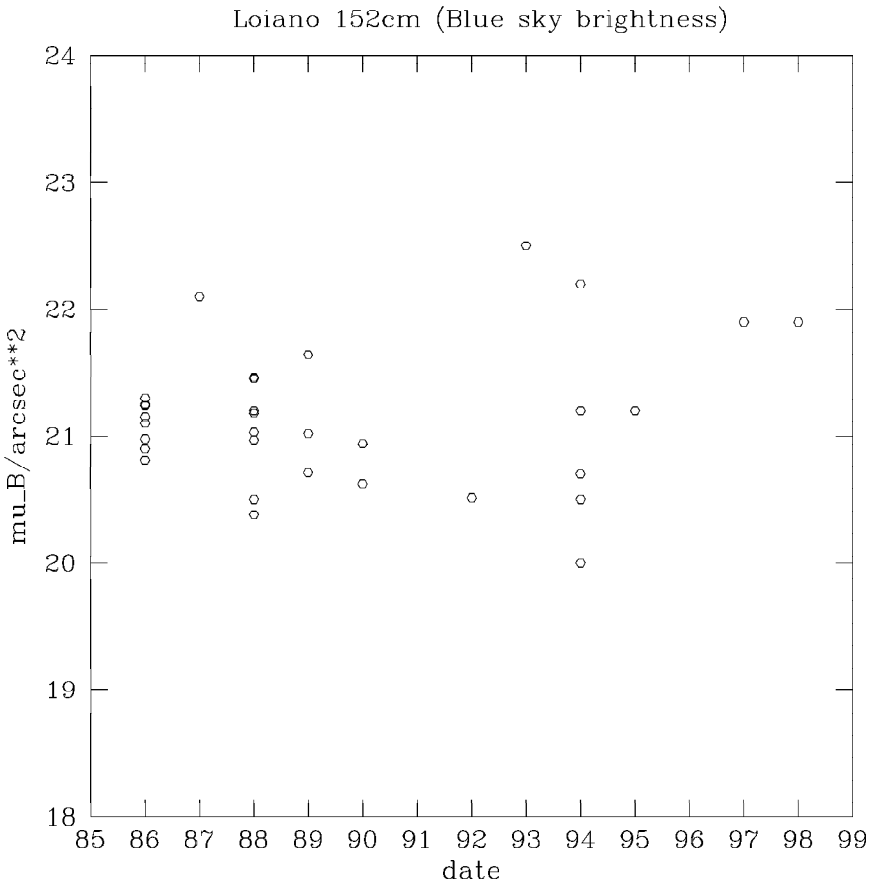

Fig. 4. The Loiano B sky brightness plotted as function of date.

evidence of a decreasing of sky brightness.

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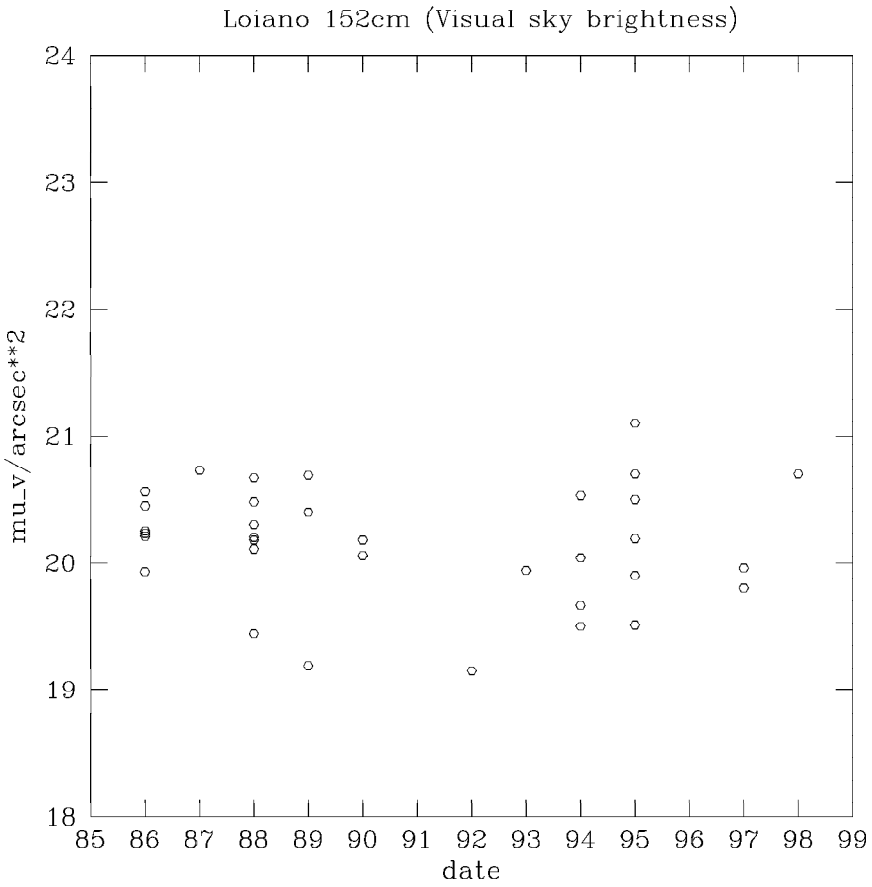

Fig. 5. The Loiano V sky brightness plotted as function of date

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