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Measurement of light pollution at the Iranian National Observatory

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Abstract. The problem of light pollution became important mainly since 1960, by growth of urban development and using more artificial lights and lamps at the nighttimes. Optical telescopes share the same range of wavelengths as are used to provide illumination of roadways, buildings and automobiles. The light glow that emanates from man made pollution will scatter off the atmosphere and affects the images taken by the observatory instruments. A method of estimating the night sky brightness produced by a city of known population and distance is useful in site testing of the new observatories, as well as in studying the likely future deterioration of existing sites. Now with planning the Iranian National Observatory that will house a 2-metre telescope and on the way of the site selection project, studying the light pollution is propounded in Iran. Thus, we need a site with the least light pollution, beside other parameters, i.e. seeing, meteorological, geophysical and local parameters. The seeing parameter is being measured in our four preliminary selected sites at Qom, Kashan, Kerman and Birjand since two years ago using an out of focus Differential Image Motion Monitor. These sites are selected among 33 candidate sites by studying the meteorological data obtained from the local synoptic stations and the Meteosat. We measured and used the Walker's law to estimate the Sky brightness for three of these sites

The data obtained using an 8-inch Meade telescope with a ST7 CCD camera for above sites are consistent with the estimated values of the light pollution mentioned above.

Keywords. Light pollution, sky brightness, Iranian National Observatory

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1. Introduction

Among 33 candidate sites at the central part of the country, 4 sites namely Kashan, Marzi, Kerman, and Birjand are selected using meteorological and geophysical data. A typical annual wind rose are shown in Fig. 1 for these four sites. To find the best observatory site at the each region, different places (shown by circular spots in Fig. 2) are examined by at least two nights of DIMM data [1] and finally the mountains Sardar in Kerman, Kolahbarfi in Kashan, Fordoo in Marzi and Mazarkahi in Birjand were selected for further site testing (shown by square spots in Fig. 2). The seeing parameter is measured for these sites and two full years of data have already been collected. Now among those four candidate sites only Marzi and Kashan are remaining, due to their seeing values.

We started to study and prepare measuring the sky brightness of these sites by one and a half years ago. Light pollution makes the level of sky brightness higher and results in less signal-to-noise ratio. With low S/N we have to build larger telescopes beside the bad effect of light pollution on them. By studying the effect of light pollution on famous telescopes we can see horrible conclusions [2].

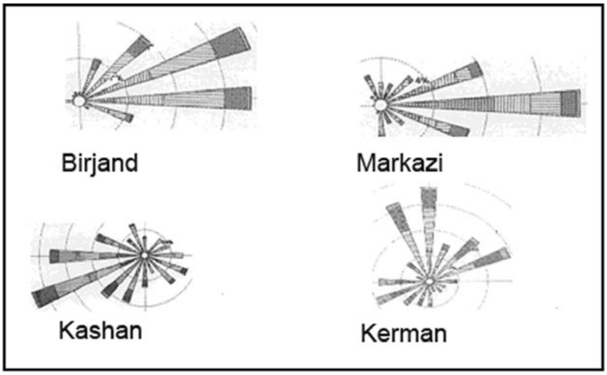

Figure 1. Histogram of wind roses of 4 candidate sites.

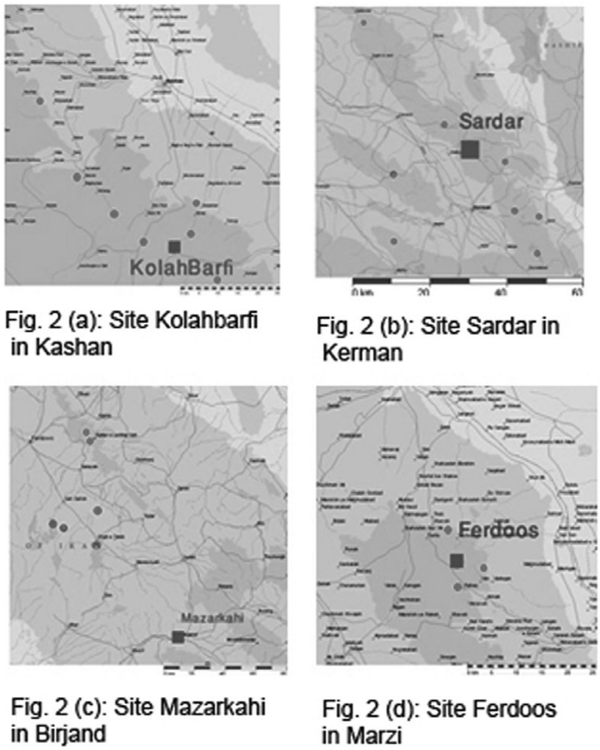

Figure 2. Locations of the four sites

We had studied many numerical and experimental methods. We had gathered sample photometric data with a SBIG ST/7E CCD and the V Johnson filter to define the sky brightness exactly.

2. A brief review on concepts of sky brightness and light pollution

Astronomy is suffering from rapidly growing environmental problems. One of these is light pollution. Urban sky glow is taking away the prime view of the stars and the universe. Many things can bring light pollution to us, such airglow, artificial sources as urban lights, zodiacal light, and solar wind as aurora and of course moon light!

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The Earth's atmosphere causes the light coming from sources in an urban area to scatter, creating the halo of light visible over the city even from great distance. Even single birth sources in a dark local can be a source of local sky glow.

There are four negative factors often found with outdoor lighting that we say GLUT (GLUT = Glare + Light Trespass + Up light + Too Much Light) Fig. 3 [3].

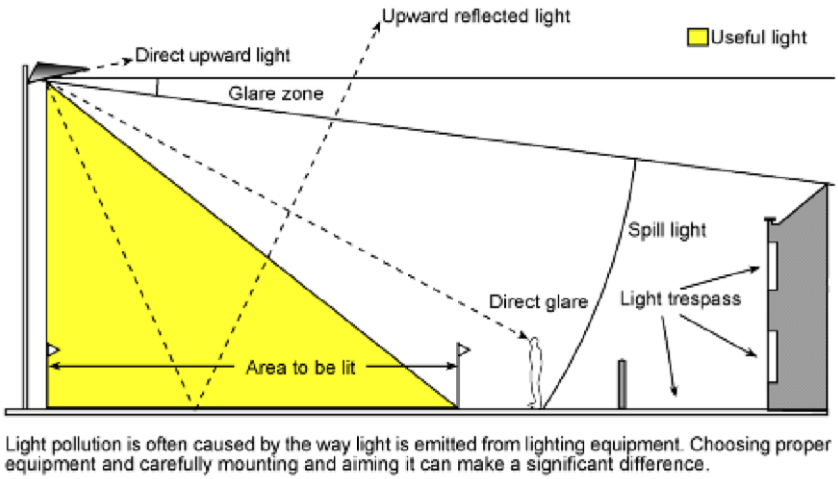

Figure 3. Four negative factors found with outdoor lighting

The natural sky brightness near the zenith for V band is 21.60 (mag), for B band is 22.40 (mag) and for R band is 20.5 (mag) [4]. But we can see the measured sky brightness for observatories is less than this. The capabilities of optical observatories are continually eroded by urban growth and its harmful accompanying sky illumination. As an example percent of original value for the 4-m telescope on Kitt Peak is 93% and for the 5-m telescope at Mount Palomar is 39%! [2].

3. A brief review of previous modelling effects

A number of people have modelled light pollution in various ways. The first model made by Walker (1970) [3]. This model was a important step to start modelling the sky brightness of the sites, which other modelling base is that too. After that Treanor [4] and Berry [5] modified the model. Tomas, Modali and Roosen (1973) [6] reported calculations using a Monte Carlo method. Yocke, Hogo and Henderson [7] applied an approximate treatment of radiative transfer to a study of the effect of a proposed nuclear waste depository on the night sky brightness as seen from sites in Canyonlands National Park. As an example, Garstang (1986) has done detailed calculations for a number of observatory sites, creating maps showing how the sky glow varies at different altitudes and azimuths from each site. Burton (2000) is analyzing satellite data from the Defence Meteorological Satellite Program (DMSP; run by the U.S. Air Force) to estimate sky glow in the close vicinity of urban areas. This has the advantage of considering actual satellite data at high resolution, both spatially and in terms of intensity. However, limited consideration is given to atmospheric scattering, especially over large distances.

Table 1. Measuring excess sky brightness percentage of the Kashan site using Walker's law.

Town name	Distance from site (km)	Population	Excess sky brightness (per cent)
Marvand	12	3000	0.06
Jahak	13.2	700	0.01
Zanjan Fard	13.4	700	0.01
Gazaan	14	4000	0.05
Bon Rood	14	4000	0.054
Kom Jan	16.5	1500	0.01
Kamoo	22	3 000	0.01
Kashan	47	400 000	0.02

Table 2. Measuring excess sky brightness percentage of the Marzi site using Walker's law.

Town name	Distance from site (km)	Population	Excess sky brightness (per cent)
Bichegan	12	485	0.097
Ferdo	14	3339	0.045
Khaveh	15	1412	0.016
Voshnaveh	15	2088	0.023
Virg	18	6603	0.048
Kahak	24	7344	0.026
Delijan	27	30 000	0.079

4. Measuring of sky brightness of Iranian observatory sites

To have the largest effective aperture for the telescope we need to reduce the sky brightens as much we can. In this case, we are measuring the level of sky brightness of our candidate sites to act on the needed works. In the first step we estimated the sky brightness by Walkers law. The results are given in Tables 1 and 2.

We also measured the sky brightness of the four sites by photometry of the Landolt stars.

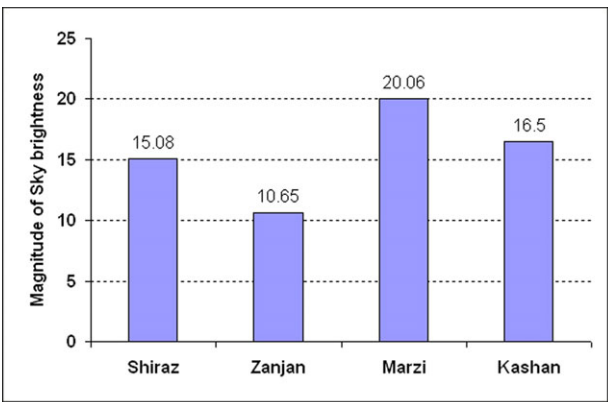

Figure 4. The measured magnitude of sky brightness of four sites.

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5. Conclusion

Three years ago the Iranian Astronomical Society proposed the national observatory project that was approved by the government. Since then the site selection for this observatory started and four preliminary sites were selected by meteorological and geophysical studies. The seeing measurements immediately began and are still being continued. In addition to the different site selection parameters, the sky brightness measurement is implemented, too. This parameter is estimated for the aforementioned sites by numerical methods. The required instruments for measuring of this parameter are set up and data acquisition is currently done.

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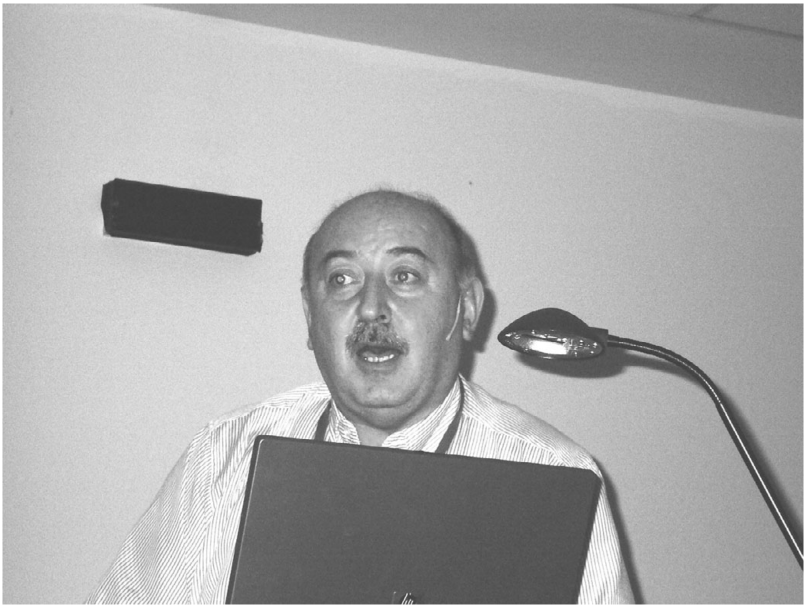

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