

Part 2

Threats to Optical Astronomy

Light Pollution: Changing the Situation to Everyone's Advantage

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Abstract. There is no question of the need for outdoor lighting to improve the effectiveness of our night-time environment. However, too much of the lighting installed to try to meet this need actually compromises the purpose, and it too often adversely affects the night-time environment, including our view of the stars and of the Universe above us. This urban sky glow severe impacts on all of astronomy, amateur and professional, as well as those of the public who enjoy and profit by the beauty offered by a prime dark sky. In the present paper, I review the issues involved and suggest guidelines to minimize these negative aspects of poor night-time lighting. With good outdoor lighting we all win.

1. Introduction

Outdoor lighting is an essential component of our night-time environment. There are few places in the world today where it is not widely used. The reasons are rather obvious, but they all relate to improved visibility at night. While the eye is a marvelous instrument, and very sensitive over a wide range of lighting levels, we often need to supplement the existing light so as to improve visibility. (It is remarkable, though, how well we can see even by moonlight or less if there are no sources of glare to compromise our vision and the adaptation level of the eye.) The improved visibility we are seeking is for the purpose of moving around safely at night, walking or driving. We can see the ground better, as well as any obstacles such as curbs, unexpected holes, stones, or other objects. In addition, we feel safer, especially in our cities where today the fear of crime can be high. By being able to see better, we expect to be safer, and sometimes we are.

For these reasons we light our streets, walkways, building entrances, parking lots and other areas. The problem comes when we choose, for whatever reason, to do the lighting with a poor choice of lighting fixture or installation. Too much of our night-time lighting worldwide is of poor quality, of poor design, or with no design at all. As such, it then compromises our goals, even to the extent of lowering visibility. Real safety is less, and we ruin the night-time ambience as well. In addition, since we are wasting a good deal of light, we waste expensive energy.

Quality lighting has none of these problems. It exists in many locations, and all good lighting designers and engineers (and most other people when they are aware of the issues) know the difference between good and bad lighting.

While quality lighting might sometimes be more expensive than poor lighting, it is worth any such difference by the increased visibility, safety, security, and energy savings. It usually has a rapid payoff period. Good lighting has great value. There is no excuse for poor lighting. With good lighting, we all win.

2. Why is Astronomy Interested in Night-Time Lighting?

Think of the adjective “*astronomical*”. What does it mean? There are two definitions: “having to do with astronomy”, and “mind-boggling” (overwhelming the mind). We see it used in the media all the time in the latter context. We astronomers deal with mind-boggling things!

Astronomy is the Science of Extremes. Who can wrap their minds around distances of 15 billion light years, with light travelling at 186,000 miles a second. Eight minutes from the Sun, 5 years from the nearest other star. Our Galaxy, the Milky Way, is 100,000 light years in diameter; it is 2 million light years to the nearest galaxy, and over 15 billion light years to the farthest galaxies and quasars that we can observe. And we deal with the astronomically small too: atoms and nuclei. But not much in between. The same holds for temperatures: the highest in the Universe in the centres of some stars, and the lowest, in interstellar space. So it is with densities: some material in stars where an amount the size of my finger tip weighs more than all the people on Earth, and interstellar space where there are only a few atoms per cubic centimeter.

Black holes, quasars, cosmic rays, pulsars, even automobiles and computers get named after these things. Astronomy is an extremely interesting field. The public loves it. Do you know that there are more than 1000 times the number of amateur astronomers as there are professionals? How many amateur physicists or chemists do you know? Or amateur lighting engineers? There is something about astronomy in the press or on television almost every day. The media eats it up. Astronomy conferences have large press rooms and much coverage. How much coverage does street lighting get, unless there is a collision with a utility pole? Astronomy is a small field, but one with high visibility.

In addition to being a science and a frontier technology, astronomy is in many ways also a philosophy and an art, full of beauty and philosophical thinking. Where did we come from? What does the future hold? What does it all mean? These questions have been in front of humankind for millennia. And they always will be. It is fundamental and exciting stuff, truly mind-boggling. And think also of the potential for intelligent life elsewhere.

There are many beautiful images of things “out there”. They regularly show up in the press and in magazines and on television. The Hubble Space Telescope as well as telescopes on the ground such as the VLT and the Keck telescopes have produced many stunning pictures, as well as fundamental research. Even small telescopes, even amateurs’ telescopes, can do wonderful things. Essentially no one is so blasé as not to be positively affected by these images and by many of the things going on in astronomy.

One of these mind-boggling things is how faint we work. On a human hand in a typical room there are about 1,000,000,000,000,000 photons falling every second. With our telescopes for the faintest objects, we count photons one at a time and are almost always photon-limited in our studies. It is truly

a frontier field of research. We are also at the cutting edge of technology, of course, for sensitive detectors and image processing. Much of this technology has applications to everyday life, such as in television and photometric applications.

So in relation to outdoor lighting, Astronomy is really the “Canary in the Mine”. We notice the adverse impacts of bad lighting well before almost anyone else, and are strongly affected by such lighting. Two things in particular impact us: urban sky glow and local glaring sources. The latter is a major item for amateurs and the former for both amateurs and professionals. I will discuss both of these in some depth in the following sections of the paper.

Do dark skies have value? I think so. I think almost everyone else does too. Can we afford to lose our view of the stars and of the Universe? Can we toss away this heritage to our children and their children? No we cannot. It is sad to think that the only place most people can see a dark sky today is in a planetarium. The real thing is much better. Light pollution is definitely an environmental issue. Where are the environmentalists? Most have lost sight of the fact that the “day” is more than 12 hours long, that night is a key part of the environment.

In addition, over millenia humans have developed with a day-night cycle. By turning the night into day, we have added a psycho-social stressor to our system. Think about it. Do we need the break of the night? The contemplation of the stars and the Universe that our ancestors had? Too many of us have lost touch with nature, seeing it only on television or in the movies. There are things worth preserving and the dark sky is one of them.

The nice thing is that dark skies and quality lighting are compatible. The sad thing is that there is far too much bad lighting everywhere.

3. Why the Problem?

Simply put, there is a lot of bad night-time lighting. Far too much of it, everywhere. And such bad lighting is growing rapidly almost everywhere, much faster than the population.

What is bad lighting? We can define it by the following characteristics:

(i) **Glare.** Glare never helps visibility, yet is common in most outdoor lighting. Glare is never good. We should never tolerate it. It is not necessary. It can be avoided with good lighting design, in any installation.

(ii) **Obtrusive lighting,** or light trespass. This is our neighbor’s light bothering us, or the local automobile dealer who has bad lighting, or the local sports complex with bad flood-lighting. There is far too much light trespass, obtrusive lighting. This lighting can even be offensive.

(iii) **Clutter and confusion.** This is light that does not add to the night-time ambience. It is a fact that too much of our night lighting actually helps to ruin the night-time environment. Many of us look forward to the time when we can bring back the beauty of the night that existed for many of our ancestors.

(iv) **Wasted light and urban sky glow.** There is far too much up-going light, totally unused light, the major cause of our urban sky glow. In addition, there is the myth of “The More the Better”. More light is not always better, no more than more salt is, nor more noise, nor more of almost anything. Certainly there are many locations with inadequate light, but there are also many with too much. The issue of transient adaptation (switching lights on only when they are actually needed, for example using motion sensors) is an important one and we must consider such possibilities in our lighting installations.

(v) **Energy waste.** Lots of energy (and money) is lost by all this wasted light and by inefficient lamps and fixtures. Billions of dollars, literally an astronomical amount, are wasted lighting up the sky and blinding us with glare.

4. Why is There so Much Bad Lighting?

The basic reason for so much bad lighting is that there is little awareness of the problems. Even though night lighting is all around us, most people actually see little of it. The bad stuff has crept up on us, little by little, with little notice, just like a cancer can creep up on us. Once we have begun to notice the problem, it is hard to do anything about it.

Then there is the additional problem of apathy, or perhaps we should call it inertia. Too many people have the attitude that poor lighting is there now and we can't do anything about it, or that it is too hard to change existing standards, or there is not time to be involved in the issues, or many other reasons. None of these reasons is good enough. The International Commission on Illumination (CIE) has addressed these issues, as have many national lighting organizations and their standard practices and recommendations are changing. Good lighting has great value and we must recognize it and market it. We can and should get rid of the old bad stuff and we should use only good lighting for all new installations. It is worth the difference in initial cost, if any. The long-term costs of new quality lighting are always lower than for the bad lighting.

While many push hard for more and brighter lighting as the key to solving the crime and security problem in our cities, we must note that all efforts in this direction so far have failed to solve the problem. In fact, the more we add light, the more crime seems to increase. The correlation between the increase in lighting and the increase in crime in most locales is excellent! But still we add more lighting in an attempt to do better. Maybe we are just adding more bad lighting, not helping. Good lighting can help, I am sure, but there is too little of it. All new recommendations from lighting organizations emphasize *good* lighting, not *more* lighting. Astronomers do not argue for *no* light, but for *good* lighting.

5. What can be Done?

It is impossible to go into the many details here. Let me just review the solutions. They all go a long way to minimize light pollution and preserve dark skies without compromising in any way night-time safety, security, or utility.

1. Use night lighting only when necessary. Turn off lights when they are not needed. Timers can be very effective. Use the correct amount of light for the need, not overkill.
2. Direct the light downward, where it is needed. The use and effective placement of well-designed fixtures achieves excellent lighting control. Whenever possible, retrofit present poor fixtures. In all cases, the goal is to use fixtures that control the light well and minimize glare, light trespass, light pollution and energy usage.
3. Use energy efficient lighting and consider the use of low-pressure sodium (LPS) light sources, especially in the vicinity of major observatories. This is the best possible light source to minimize adverse sky glow effects on professional astronomy. LPS is especially good for street lighting, parking lot lighting, security lighting and any application where colour rendition is not critical. With creative design, it has even been used to illuminate new car dealerships.
4. Establish outdoor lighting ordinances that promote the use of quality lighting. Such controls do not compromise safety and utility. Lighting ordinances have been enacted by many communities worldwide and in several of the states in the USA, all designed to enforce the use of effective night-time lighting and good design standards.

All of these solutions to the problem say: “Do the best possible lighting design for the task. Always consider and minimize all the relevant adverse factors, such as glare, light trespass and urban sky glow.” All the solutions needed for protecting astronomy have positive side benefits of maximizing the quality of the lighting, improving visibility and saving energy. We all win!

6. Conclusions

There is a problem.

The problem is for all of us, not just astronomers.

The problem is still getting worse almost everywhere.

Why do we tolerate it?

Lack of awareness. Apathy. Too many laws.

So bad now that nothing can be done.

No time to work on it.

None of these reasons is good enough!

None will help us solve the problem or get solutions.

We must do something now!

We know that working solutions exist.

Awareness and education are the keys to getting action.

Quality lighting is the key!

It is an issue in which everyone can win.

Why shouldn't we do it?

The Goals:

- Dark skies.
- Quality lighting, with better visibility at night, hence better safety and security.
- Better night-time ambience.
- Considerable energy savings.

Let's do it!

References

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- Isobe, S. and Hirayama, T. (Eds.) 1998, *Preserving the Astronomical Windows* Astronomical Society of the Pacific Conference Series, Volume 139.
- See the IDA Web Page <http://www.darksky.org/ida> for much additional information and for links to other resources.