NIGHT SKY BRIGHTNESS FROM VISUAL OBSERVATIONS II. A VISUAL PHOTOMETER

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Abstract

The bright night sky above the Van Vleck Observatory, located on the Wesleyan University campus, has prompted a program to monitor the skyglow visually and photoelectrically for a decade. Portable visual photometers were developed which can measure sky brightness in the field; they show that the skyglow is very local.

1. Introduction

It is surprising that a subject as important as the luminosity of the night sky should continue to be as little understood as it is, especially in view of its importance to visual observers and amateur astronomers. Even now, measures of the night sky are not of sufficient extent to form and test a reliable model for its luminosity. It remains largely the province of photoelectric photometry to record the sky brightness, but the precision of this method is offset in part by its lack of flexibility and portability. This study is intended to raise the prospect of a much wider geographic coverage than is possible from photoelectric methods. It introduces a simple, inexpensive visual photometer which can record replicable sky brightness readings from any accessible site and transfer them into absolute physical intensity units.

2. Photometer Design

The concept of the visual photometer is an old one, going back in principle to the previous century. In this version a screen is illuminated by a small light source shining through a photographic wedge, movable along teflon rails mounted on a light aluminum frame. The teflon allows the wedge to be moved slowly and smoothly yet keeps it in place without slipping whenever the unit is held in the vertical position aimed at the Zenith. The level of illumination is controlled by a rheostat calibrated against a milliammeter mounted on the frame. The screen is mounted inside the frame, which is otherwise open. One looks through a peephole at one end at the screen and the open aperture and adjusts the position of the screen until it matches the illumination from the sky beyond.

Figure 1 shows the prototype of the photometer, which weighs 3.5 pounds with batteries. The wedge and meter can be seen, as can the peephole at the closer end. The chief source of error in its use is the inability of the observer to adjust the illumination to a constant level. This difficulty is surmounted by the installation of a neutral density filter of about one magnitude optical depth. The filter can be moved into and out of the light path at will. It allows readings on the arbitrary scale to be calibrated over a wide range of sky brightness by a method long used by photographic photometrists before the advent of photomultiplier devices. The method is described in detail in a review article by Stock and Williams (1962) and the unit itself is schematically illustrated by Pike and Berry (1978).

3. Observational Program

A program to measure the sky brightness in the region surrounding Middletown, Connecticut, has been started by the author. Two sites are used as calibration points from which photoelectric measures have been obtained. These sites are indicated on the map shown in Figure 2 and have been described in the first paper in this series (Upgren 1991, henceforth referred to as Paper I).

In Paper I this method was used for a number of stars lying near the southern horizon in order to determine, among other things, the relative clarity of the night sky from one year and one season to the next. It is being extended to the entire sky in order to test a simple model for brightness proposed by Schaefer (1986), in which the luminosity at any zenith distance is a function only of the limiting magnitude visible at the zenith and a linear extinction coefficient.

Paper I concludes that the repeatability of the visual results over seasons and years is good and that color and seasonal effects are minimal. It is important to note that the data of Paper I were collected only on moonless nights judged to be quite free of clouds and haze. Therefore, the influence on atmospheric clarity by seasonal haze patterns such as the summer haziness over the eastern United States reported by Husar *et al.* (1981) would be minimized by this selection procedure.

Other findings have also been reported in Paper I. The provisional estimates of 18.5 and 20.5 magnitude per square arcsecond appears realistic for clear haze-free moonless nights, for the Van Vleck Observatory and Laurel Hill sites, respectively. Since the two sites are only 3.5 km apart, this indicates that very local lighting is relatively more predominant than is accounted for in most sky brightness models (see, e.g., Garstang 1991) and that the most intense layers of aerosols may lie closer to the ground that is commonly believed.

A useful part of the program is the intercomparison of the measures made with the visual photometer with two other methods of matching versatility. The first employs the concept of the limiting visual magnitude and is familiar to many variable star observers. Stars of known magnitude are looked for and the faintest seen determins the sky limit. Many visual observers are familiar with the *Handbook for Visual Meteor Observations* (Roggemans 1989), in which the stars within each of 20 regions throughout the sky are listed by apparent magnitude. The number of stars visible in each area can be translated directly into the magnitude limit in that part of the sky.

A second method has been used extensively by Kosai and Isobe (1991) throughout Japan and is being extended to the United States (Crawford 1991). It is now being used at the two sites mentioned above and will be extended to others. It involves direct photography of the night sky surrounding Vega and Aldebaran using 35-mm cameras with standardized focal settings, film, and exposure times. By intercomparing all of the methods simultaneously on clear moonless nights, the usefulness and limitations of each will become apparent. It is anticipated that the visual photometers will remain useful, owing to their ability to be immediately calibrated in absolute flux units, and their portability.

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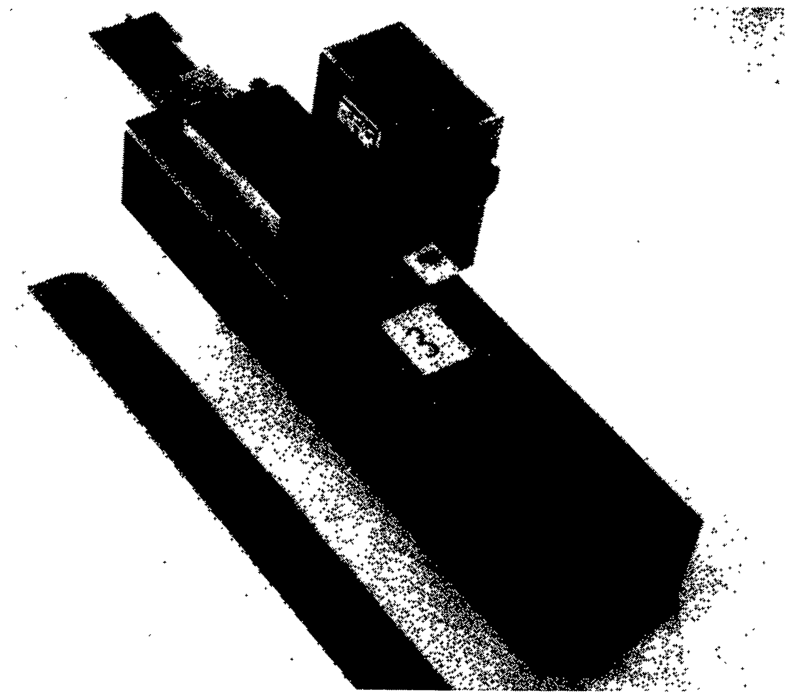

Figure 1. Visual photometer, weight 3.5 pounds, showing peephole at the right and sliding photographic wedge at the top.

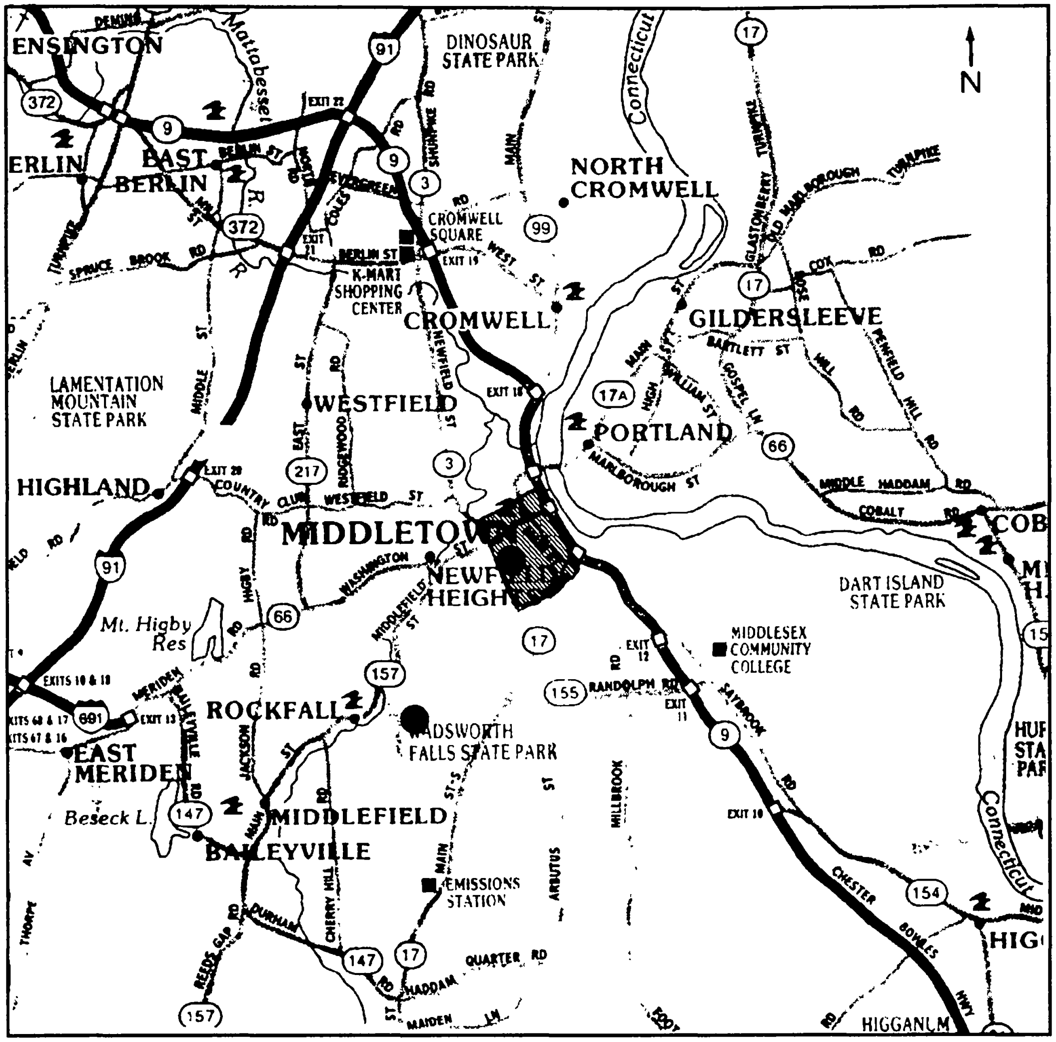

Figure 2. Map of Middletown, Connecticut, showing area of intense outdoor lighting (shaded area) which includes the city center and the Wesleyan University campus. The large dots within the shaded area and to the Southwest show the locations of the Van Vleck Observatory and the Laurel Hill site, respectively. The dots are separated by 2.2 miles (3.56 km) and North is at the top.