AN UNUSUAL PHOTOELECTRIC PHOTOMETER FOR SMALL TELESCOPES

Hideo Satoh
Institute of Astronomy, University of Tokyo
Mitaka, Tokyo 181, Japan

Presented at the First European Meeting of the AAVSO
Brussels, July 24-28, 1990

Abstract

A photometer that simultaneously measures sky and star-plus-sky and automatically subtracts sky background has been built. This paper describes its construction.

We have constructed an unusual photon-counting photometer to observe relatively bright intrinsic variable stars and eclipsing binaries. The photometer is equipped with an EMI 6256B or other suitable photomultiplier and Corning U, B, and V filters.

In conventional photoelectric observation, the photometer's diaphragm admits light from the star and a small area of the sky surrounding the star. To remove the contribution of sky light, the same diaphragm is used to measure the light from an adjacent patch of starless sky. The sky-only photometer count is then subtracted from the star+sky count to obtain a net count for the star alone. Observational efficiency is rather low, with less than half of the observing time used to measure the object of interest.

In order to avoid such a time-consuming procedure, we have constructed a photoelectric photometer that is able to measure the star and an adjacent patch of sky simultaneously. For this purpose, we use a unique rotating sector system. The rotating sector is made of plane parallel optical glass placed in the optical path at a 45-degree angle (Figure 1, and enlargement in Figure 2). This rotating sector has four clear windows of constant curvature which are positioned to observe the brightness of star+sky ("star side") and sky-only ("sky side") successively.

Our photometer uses diaphragm pairs of various sizes. The diaphragms in each pair are the same size. A diaphragm pair is placed at right angles to the optical axis in the telescope's focal plane. Of the rotating sector's four windows, the two inside windows are allocated to measure the brightness of the "star side" and the two outside windows to measure the "sky side" light, respectively. Light is admitted alternately through the two diaphragms by the rotating sector, and then proceeds through a Fabry lens, neutral density and color filters, and a relay lens to the photomultiplier (Figure 1).

To determine which diaphragm of the pair has been used, two infrared photosensors are attached to the rotating sector's micro-motor to detect the position of the sector windows that are used for "star side" and "sky side" respectively. On the basis of sensor signals, observation time (gate time) is measured to determine accurate photon counting time (Figure 2).

The rotating sector is directly connected to the DC micro-motor, which has a speed of 3000 rev/min (20 milli-sec/rev). Consequently, each diaphragm is observed alternately almost every 5 ms. If it happens that the speed deviates a little from the proper rate, a "phase lock loop" (PLL) servo-mechanism works automatically and the speed can be adjusted immediately. The observer is alerted by an indicator light on the front panel of the observation control system cabinet.

The timing system in our photometer, which includes the PLL circuit, is distributed with high accuracy by the 50 Hz and 10 MHz frequencies of a cesium clock oscillator. Two counters store the observational data of "star side" and "sky side", and each count number is read out to the memory system of a personal computer.

During alternate changes of the optical path by a rotating sector, the aperture of each diaphragm is covered or uncovered from edge to edge gradually. It is therefore necessary to begin the photon counting only after the diaphragm is completely uncovered and to stop counting just before the sector begins to block the diaphragm.

This "delay time" and the gate time are governed by the diaphragm size. The relation between diaphragm size and the delay and gate times has to be checked beforehand empirically. The delay and gate times can be controlled by the sector-sensing and gate control circuits, respectively, and if we set up a large value of gate time, a forced reset mechanism is immediately activated by the signal of a photosensor from the computer. In this way, the light from the "star side" and "sky side" is divided by the rotating sector.

In conclusion, we can measure the brightness of the star+sky and sky-only light with high precision. By using this system we can efficiently observe stars that change brightness rapidly. Our system is also powerful for photometric observations under brighter or unstable sky conditions because the sky brightness can be measured and subtracted continuously.

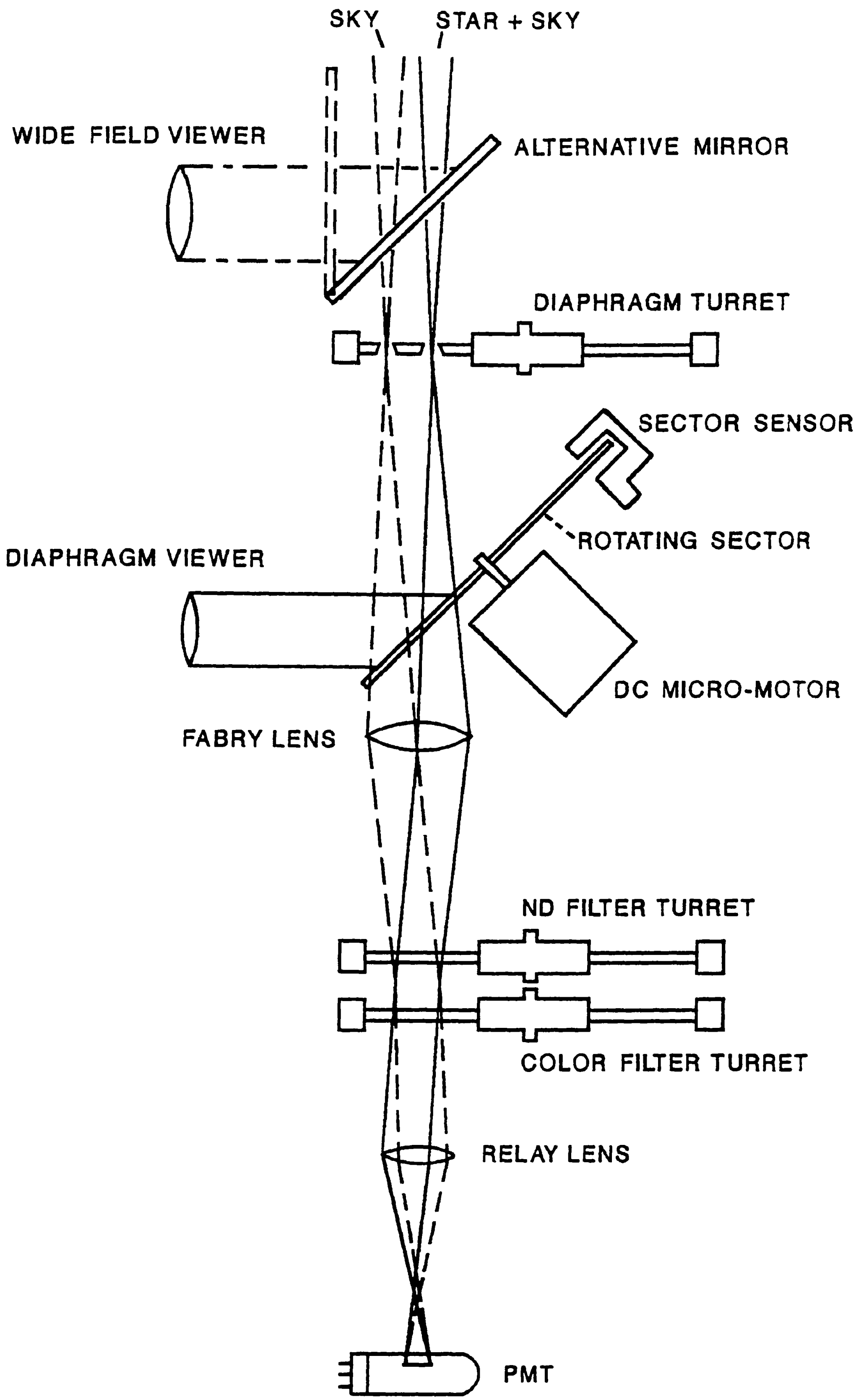
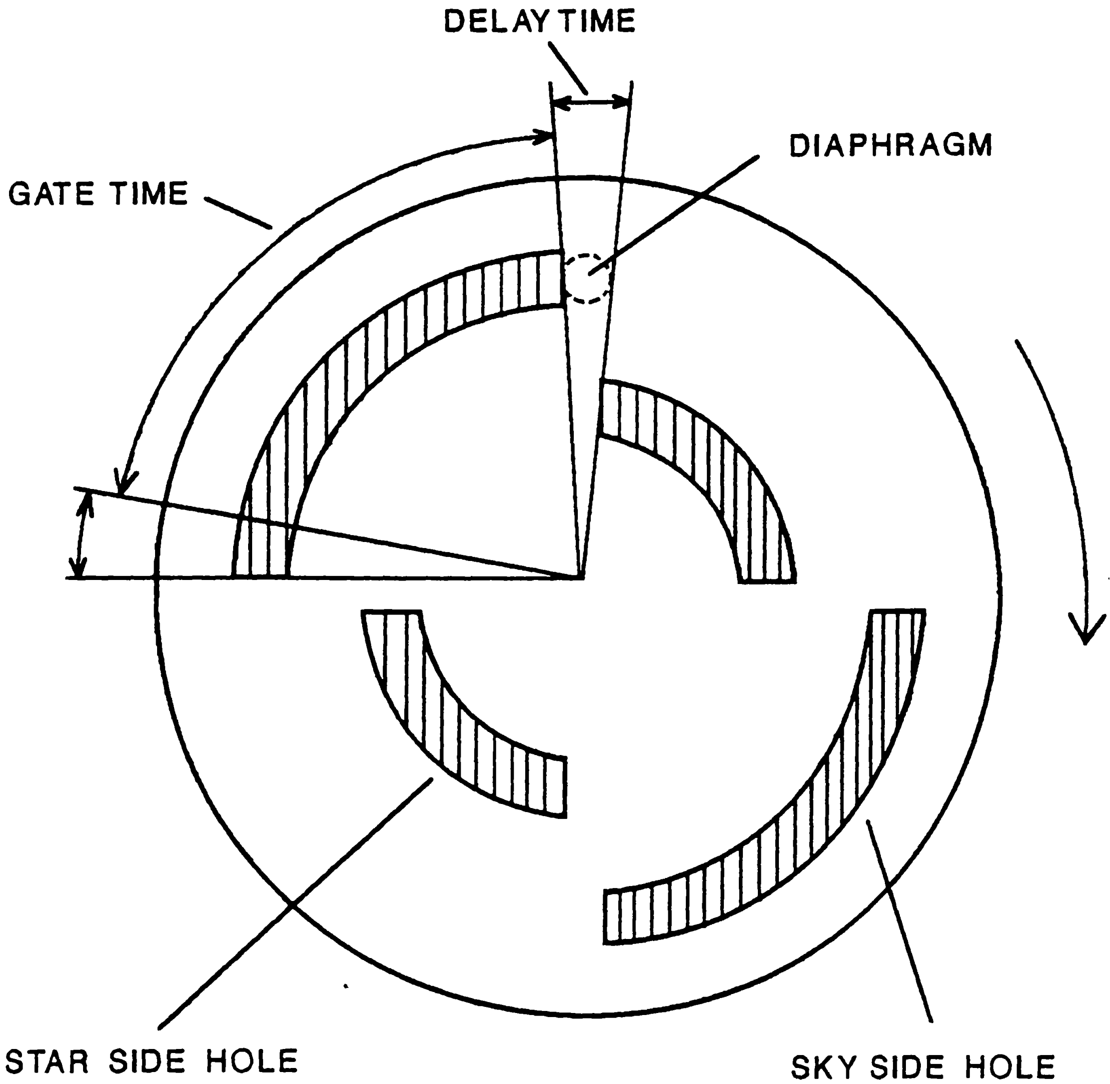


Figure 1. Schematic diagram of the photometer.



Sector rotates at 3000 r.p.m.
Material: Optical plane-parallel glass (with aluminum spattering)

Figure 2. Rotating sector of the photometer.