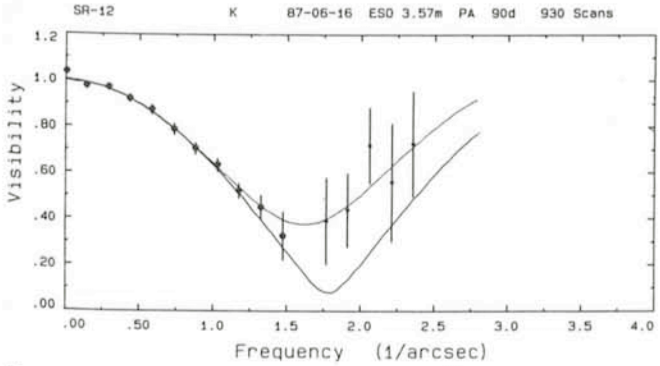

Figure 2a: *SR-12 E-W at K*
Bottom curve: fit to the data constrained by the measured lunar occultation flux ratio R (SR-12E/SR-12W) = 0.85. The resulting E-W separation is 0.28 arcsec.
Top curve: unconstrained fit to the data. In this case the resulting E-W separation is 0.30 arcsec.

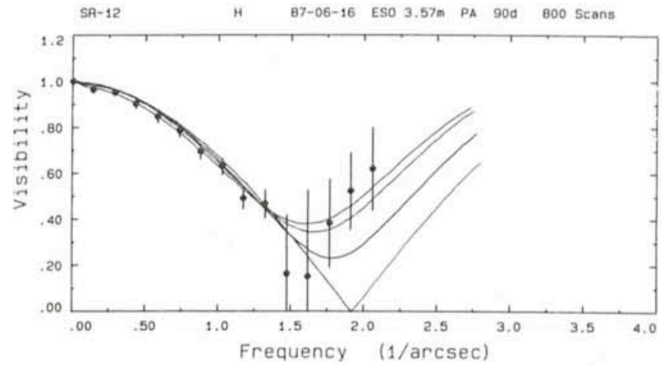

Figure 2b: *SR-12 E-W at H*
Top curve: fit where the separation was fixed at 0.30 arcsec.
Bottom curve: fit where the separation was fixed at 0.26 arcsec.
2nd curve from top: fit where both the flux ratio and the separation were free parameters.
2nd curve from bottom: fit where the separation was fixed at 0.28 arcsec (this is the value found at K under the constraint discussed in Fig. 2a/bottom curve).

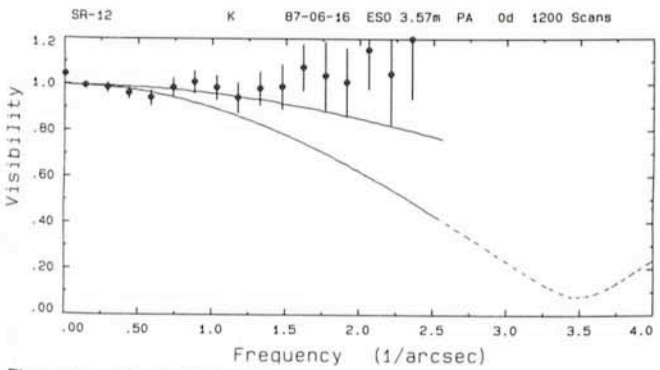

Figure 2c: *SR-12 N-S at K*
Bottom curve: fit to the data constrained in the same way as in Fig. 2a (bottom curve). The resulting N-S separation is 0.14 arcsec.
Top curve: fit to the data (unconstrained) yielding a N-S separation of 0.09 arcsec ($\chi^2 = 1$).

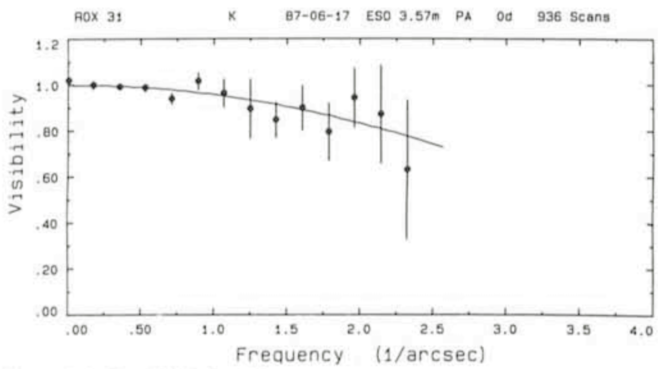

Figure 2d: *Rox 31 N-S at K*
The fit to the data gives a N-S separation of (0.09 +/– 0.05) arcsec.

Let us recall that the projected binary separation s is defined in the following way:

$$s = \left(\frac{1}{f^2_{1\,(E\text{-}W)}} + \frac{1}{f^2_{1\,(N\text{-}S)}} \right)^{1/2}$$

where f_1 denotes the spatial frequency of the minimum of the visibility function and the index E-W and N-S refers to the respective orthogonal scan directions. Figure 2 shows the 4 visibility functions that we obtained (for SR-12: K (E-W), H (E-W), K (N-S); for ROX 31: K (N-S) only). Table 2 summarizes the results.

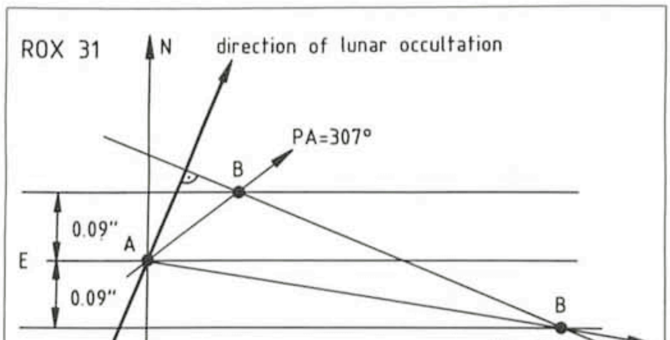

Figure 3: *The two solutions for Rox 31B The ambiguity is due to the 180° phase uncertainty for Rox 31B in the N-S speckle data, indicated by the two parallel horizontal lines 0."09 N and S of Rox 31A. Rox 31A at the origin is the brighter component at K of the Rox 31 binary system.*

TABLE 2: *Data inferred from all observations (speckle and lunar occ.)*

	proj. sep.	P.A.	K (E-comp.)	K (W-comp.)	H-K (east)	H-K (west)
SR-12	0."29	86	9.34	9.17	0.44	0.09
ROX 31	0."15*	307*	8.72	9.00	–	–

Notes to Table 2:
(i) The statistical error for the projected separations is 10%.
(ii) The position angles (east of north) should be accurate to about 10 degrees.
(iii) The K magnitudes are quite accurate (≤ 0.05 mag), while the colours are more uncertain (by 0.15–0.25 mag). The H-data for Rox 31 were too noisy to derive an H-K colour.
* There is a second (perhaps less likely) solution for Rox 31: proj. sep. = 0."55 and PA = 261 degrees (see Fig. 3).

Lunar Occultation Versus Speckle Observations

Finally we should summarize the relative merits of speckle observations versus lunar occultation observations:

(a) Lunar occultation observations can resolve binaries with separations as small as a few milli-arcsec (the limit comes from the orbital speed of the moon and the limitations of fast photometry for faint sources). It is practically an order of magnitude superior in angular resolution over speckle (speckle reaches 0.13 arcsec – the diffraction limit of a 4-m size telescope at 2.2 μm). However, it must be emphasized that higher resolution can be reached with speckle given high S/N data and a priori knowledge about the structure of the source (for example, if we knew the object was a spectroscopic binary, speckle interferometry might be capable of resolving it down to half the diffraction limit). On the other hand, it should be noted that there is an upper limit in separation (~ 0."5) for which lunar occultation yields useful results.

(b) Lunar occultation observations cannot find the projected separation since the method is intrinsically 1-dimensional while speckle observations get around this by scanning in two orthogonal directions so that the position angle and the projected separations can be found.

(c) Lunar occultation observations often cannot be repeated (for years) while speckle observations, if they fail due to poor weather, can be repeated (at most a year later). Speckle observations also can be carried out sequentially in several filters while multi-filter observations in a lunar occultation experiment must be done in parallel. As far as we are aware, such a difficult IR-experiment has not been tried yet for binaries but would be very useful since it is easier to obtain good flux ratios of the components in lunar occultation observations than from speckle data.

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When Dark is Light Enough*: Measuring the Extragalactic Background Light

K. MATTILA, Helsinki University Observatory, Finland, and
G. F. O. SCHNUR, Astronomisches Institut der Ruhr-Universität Bochum, F. R. Germany

1. Introduction

The extragalactic background light (EBL) is an observational quantity of fundamental interest in several fields of cosmology. Questions involved are the decision between different cosmological models, the existence of luminous stellar matter between the galaxies, the emission by intergalactic gas, and evolutionary effects in the luminosity and the number of galaxies. Early theoretical studies of the problem by Loys de Chéseaux (1744) and Olbers (1823) led to the result which was much later coined by Bondi (1952) with the name of Olbers' Paradox: *in a static, homogeneous and infinite universe the sky background would be as bright as the Sun's surface.* Since already the crude observational fact that the sky is dark during the night has led to very deep consequences for our understanding of the universe, it is to be expected that a measurement of the intensity of the EBL will be of fundamental importance for cosmology. Such a measurement is, however, hampered by great difficulties due to the weakness of the EBL and the complexity of the composite light of the night-sky.

2. How to Separate the EBL

We have been developing for several years a method for the measurement of the EBL which utilizes the screening effect of a dark nebula on the background light (Mattila, 1976; Schnur, 1980; Mattila and Schnur, 1983). A differential measurement of the night-sky brightness in the direction of a high galactic latitude dark cloud and its surrounding area, which is (almost) free of obscuring dust, provides a signal which is due to two components only:

(1) the extragalactic background light, and
(2) the diffusely scattered starlight from interstellar dust.

The large foreground components, i.e. the zodiacal light, the airglow and the atmospheric scattered light are completely eliminated (see Fig. 1a). The direct starlight down to ~ 21st magnitude can be eliminated by selecting the measuring areas on a deep Schmidt plate. At high galactic latitudes ($|b| >$ 30°) the star density is sufficiently low to enable blank fields of ~ 2′ diameter. Galaxy models show that the contribution from *unresolved* stars beyond this limiting magnitude is of minor importance. If it could be assumed that the scattered light from the interstellar dust is zero (i.e. the albedo of the interstellar grains a = 0), then the difference in surface brightness between a transparent comparison area and the dark nebula would be due to the EBL only, and an opaque nebula would be darker by the amount of the EBL intensity (dashed line in Fig. 1c).

Unfortunately, however, the scattered light is not zero. A dark nebula above the galactic plane is exposed to the radiation field of the integrated galactic starlight, which gives rise to a diffuse scattered light (shaded area in Fig. 1c). Because the intensity of this scattered starlight in the dark nebula is expected to be equal or larger than the EBL, its separation will be the main problem in the present method.

The separation method utilizes the difference in the shape of the spectral energy distributions of the EBL and the galactic light around the wavelength λ = 4000 Å (see Fig. 1d).

* See Gingerich (1987)

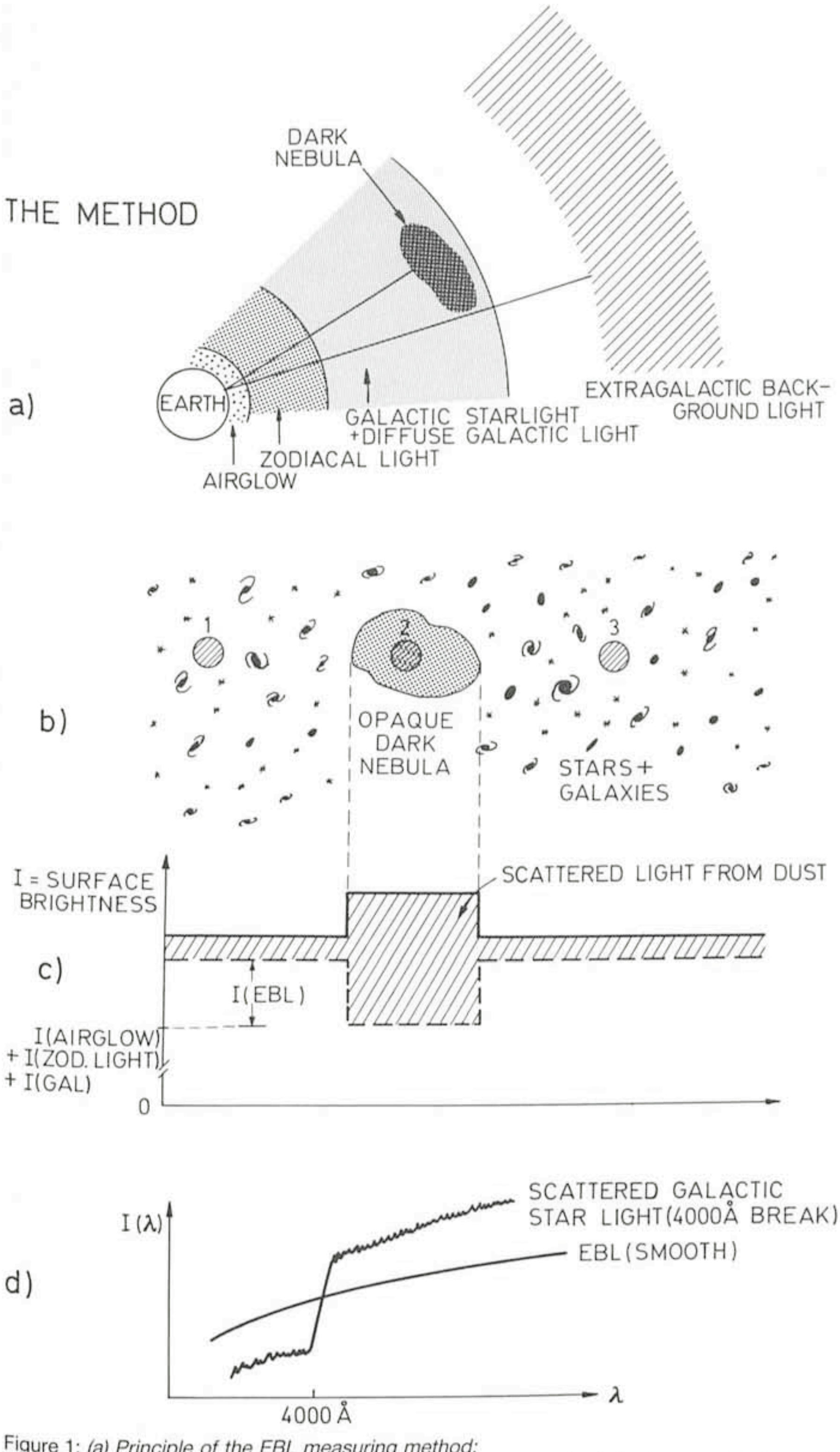

Figure 1: *(a) Principle of the EBL measuring method;*
(b) Opaque dark nebula is shown in front of a high-galactic-latitude background of stars and galaxies. Measuring positions within the nebula (# 2) and outside (# 1 and 3) are indicated;
(c) Schematic presentation of the surface brightness distribution across the dark nebula;
(d) the difference in spectral distributions of the galactic starlight and the EBL.

(1) The spectrum of the integrated starlight can be synthesized by using the known spectra of stars representing the different spectral types, as well as data on the space density and distribution in the z-direction of stars and dust. Synthetic spectra of the integrated starlight have been calculated by Mattila (1980). The most remarkable feature in the spectrum is the abrupt drop of intensity shortward of $\lambda = 4000$ Å. The shape of the integrated starlight spectrum and especially the size of the 4000 Å discontinuity have been found to depend only weakly on the galactic latitude and the imagined z-distance of the observer.

(2) It is possible to draw some conclusions about the spectrum of the EBL by using plausible theoretical arguments: Radiation from galaxies and other luminous matter over a vast range of distances, from $z = 0$ up to $z \sim 3$ at least, contribute to the EBL. Therefore, any sharp spectral features of the source spectrum – lines or discontinuities – are washed out. For the present study it is important to recognize that the discontinuity at 4000 Å, although present in all galaxy spectra, does not occur in the integrated background light.

Figure 2 illustrates how the spectral energy distribution of the observable surface brightness difference *dark nebula minus surroundings* changes for different assumed values of the EBL intensity. It can be seen that the drop at 4000 Å increases when more EBL is present. (For a more quantitative description of the method, see Mattila, 1976.)

The result of the first application of the above described method to the dark nebula L 134 gave an unexpectedly high EBL intensity of $10 \pm 4\ S_{10}$ (10^m stars per □°) at 4000 Å (Mattila, 1976). Later on, the same method was used again by Spinrad and Stone (1978) at the same nebula; they obtained an upper limit of 2.6 S_{10} to the EBL.

3. Scattered and Thermal Radiation

The present authors have continued the measurements of the EBL with the dark cloud technique using the tele-

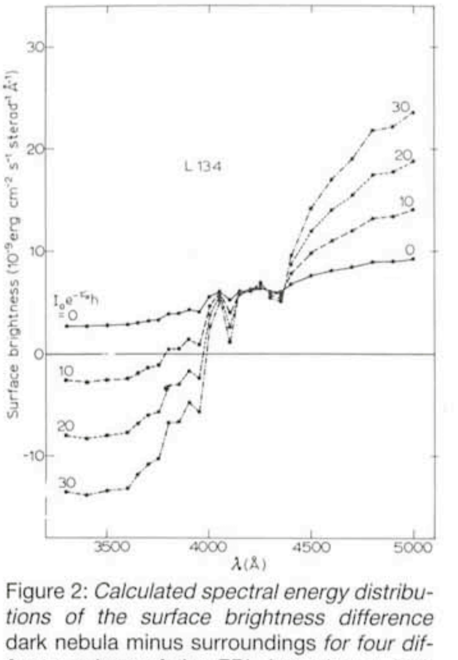

Figure 2: *Calculated spectral energy distributions of the surface brightness difference* dark nebula minus surroundings *for four different values of the EBL intensity as indicated. The numerical values refer to the observations of L 134.*

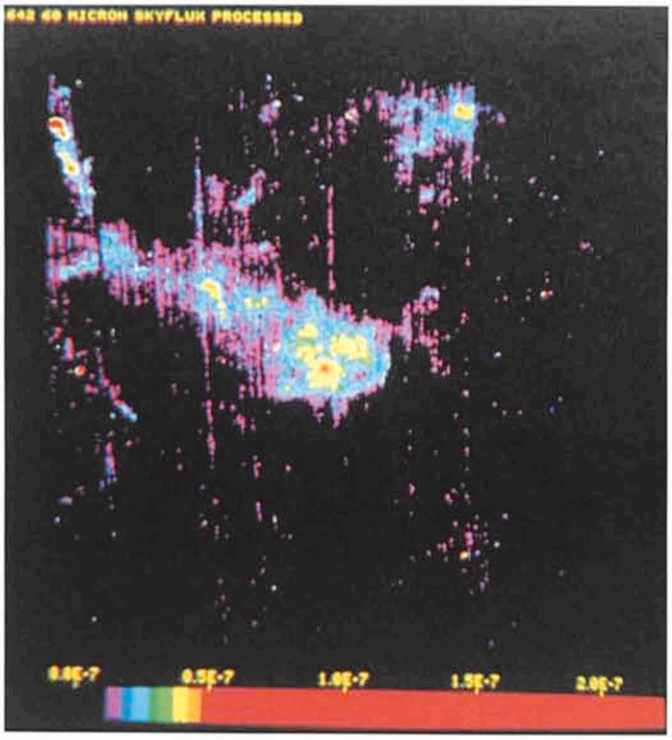

Figure 3: *Infrared (IRAS) surface brightness distribution at 60 μm in the area of L 1642. The marked area is shown in the optical image in Fig. 4. (This picture was kindly provided by R.J. Laureijs, Space Research Laboratory, Groningen.)*

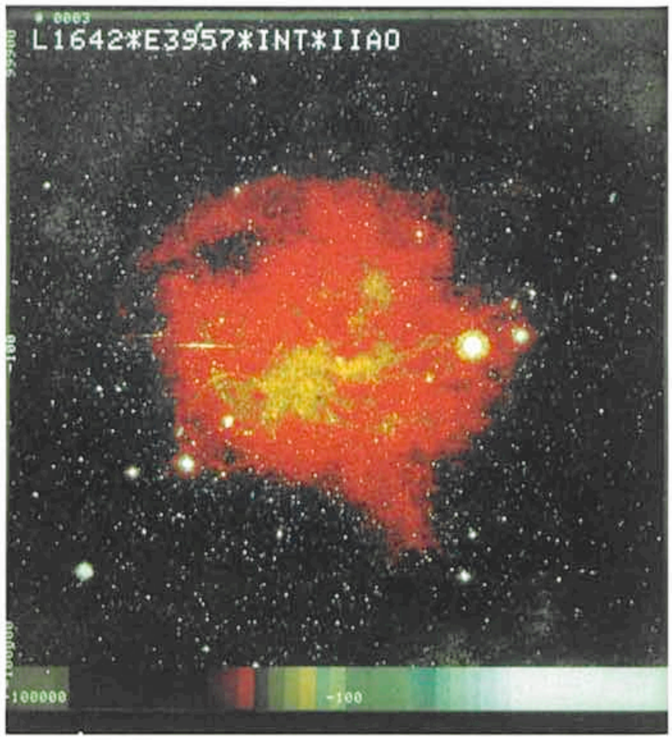

Figure 4: *Optical (blue) surface brightness distribution in the area of L 1642.*

scopes of the European Southern Observatory on La Silla since 1979. For these observations the southern dark nebula L 1642 at l = 210°.9, b = −36°.5 was selected in addition to L134. Based on our observations in 1980 and data available from IRAS we have recently completed a comparative infrared and optical surface brightness investigation of L1642 (Laureijs, Mattila and Schnur, 1987). Through the IRAS data we have a very effective method to determine the column density along each line of sight in and near the nebula. The 100 μm surface brightness distribution in the L 1642 area is shown in Fig. 3. For comparison we show in Fig. 4 the optical surface brightness distribution in the same area, measured on a blue (IIa-O) ESO Schmidt plate. It can be seen that high latitude dust clouds are effectively detected also by means of their scattered light, seen on deep photographic plates down to about the same levels as the thermal emission seen by IRAS. The lowest contours of both maps correspond to an extinction of ~ 0.2 magnitudes.

This investigation is a byproduct of the EBL measurements, but it is useful also on its own right:

From the relationship between the optical and infrared brightness in L 1642 we were able to derive e.g. the optical albedo of the dust and the ratio of visual to 100 μm opacity, which are important constraints to grain models.

4. New Measurements

In December 1987 we could spend again seven nights on L 1642 at the ESO 1-m and 50-cm telescopes under excellent sky conditions. By using the IRAS data we were this time able to considerably improve our measuring programme, since we had better means of identifying near the dark nebula regions which are free or almost free of dust. Guided by the IRAS data and our previous photometry we have also been able to locate probably the darkest and most opaque spot in the centre of L 1642 which provides the best zero point for the EBL measurement.

The photoelectric surface photometry of weak extended objects is hampered by the time variability of the airglow. One has to repeat normally in single beam photometry the ON and OFF source measurements after each other. We have been using a method in which the airglow fluctuations are eliminated by using simultaneous parallel observations with a monitor telescope (see Fig. 5). The efficient elimination of the airglow variations is demonstrated by Figs. 6a and b which show the sky brightness for a "standard position" in L 1642 as measured with the 1-m telescope through an 88″ diaphragm in u and y during the night 15/16 December 1987. Also shown is the ratio of the 50-cm signal to the 1-m signal. As can be seen the ratio remains constant to within ± 1% of the signal, which is the pure photon noise for the 40 sec integrations at the 1-m telescope.

The reductions of the observations are still going on at the moment. How-

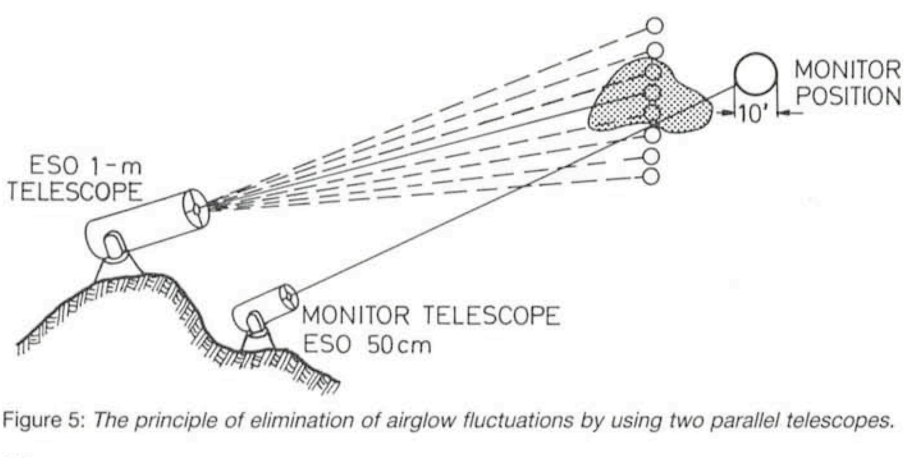

Figure 5: *The principle of elimination of airglow fluctuations by using two parallel telescopes.*