

4 DISCUSSION

The mean diameter of the smallest artificial point detected in the eyesight test measures 19.3 arcsec. This is 4.3 arcsec more than the mean umbral diameter of the smallest sunspot detected in the network survey. We think that this difference is real (in spite of the statistical error of 2.3 arcsec), because during the eyesight test no observer could detect points smaller than 18 arcsec. In addition, our result agrees remarkably well with the threshold-size of 18 arcsec given by Siedentopf (1950) for the same background surface brightness.

What is the cause of this difference then? We should consider that all the spots detected in the observational experiment consist of an umbra and a penumbra, whereas the artificial points of the eyesight test represent dark spots comparable to sunspots consisting of an umbra only. If we assume that the 'darkness' per unit area of the artificial points of the eyesight test is equal to the 'darkness' per unit area of a sunspot umbra, then the total darkness D_T of a test point with an area A_T is $D_T = A_T D_U$. Real sunspots on the other hand consist of an umbral area A_U with a darkness per unit area D_U and a penumbral area A_P with a darkness per unit area D_P . The total darkness of the sunspot then is $D_S = A_U D_U + A_P D_P$. The total darkness of the smallest artificial test point D_T must be equal to the total darkness of the smallest sunspot D_S :

$$A_T D_U = A_U D_U + A_P D_P.$$

By solving this equation with $A_P = \pi D_P^2/4 - A_U = 1143 \square''$, $A_U = 177 \square''$ and $A_T = 293 \square''$ we find an umbra-to-penumbra darkness ratio of

$$\frac{D_U}{D_P} = \frac{A_P}{A_T - A_U} = 9.85$$

This means that the umbra is per unit area 9.85 times darker than the penumbra. Using average properties as given in Allen (1973) we arrive at the centre of the Sun's disk to an umbra-to-penumbra intensity ratio of 0.108. This means that the intensity of the umbra is per unit area 9.25 times lower than the intensity of the penumbra. So we conclude that the 'loss' of umbral darkness in the sunspot survey is fully compensated by the darkness of the surrounding additional penumbra.