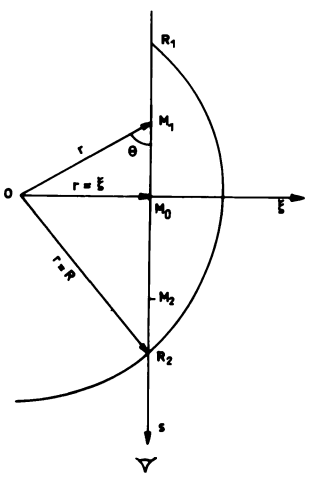
VARIATIONS OF THE SOLAR LIMB BRIGHTNESS WITH THE OSCILLATIONS

B. Schmieder and P. Mein
Observatoire de Paris - Section de Meudon
92 195 Meudon Principal Cedex

ABSTRACT. The aim of this work is to compute the amplitude of the limb darkening fluctuations due to oscillations in order to compare with the observations made with the heliometer at the Pic du Midi (Rösch and Yerle 1983 - 1984). It is shown that 5 min oscillations lead to variation in the brightness gradient of less than 2 %.

1. INTENSITY PROFILE AT THE SOLAR LIMB



The intensity profile I (ξ) of the solar limb (figure 1) has been calculated assuming a spherical geometry based on the ValC model and using a ray tracing model (Leung 1975). Hydrodynamic waves in the atmosphere are simulated by introducing temperature and density fluctuations in the model calculation. In figure 2 are represented profiles of the solar limb for different values of temperature fluctuations corresponding to maximum amplitudes of the waves.

Figure 1. Spherical model for limb profile calculations

J. Christensen-Dalsgaard and S. Frandsen (eds.), Advances in Helio- and Asteroseismology, 429–432.

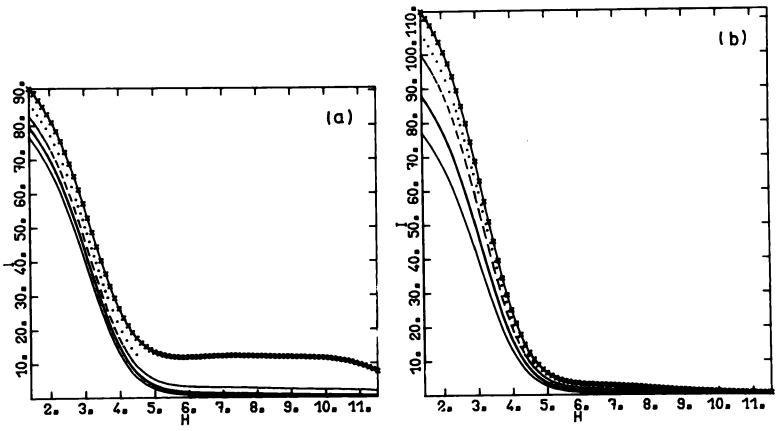


Figure 2. Profiles of the solar limb versus the altitude H in the atmosphere for different amplitudes of the T fluctuations.
in two cases a) propagating waves ($P \sim 140s$)
b) evanescent waves ($P \sim 300s$)

The gradient Δm_T is increasing with the amplitude of the fluctuations (figure 3). More details are presented in an other paper (Schmieder and Mein 1986).

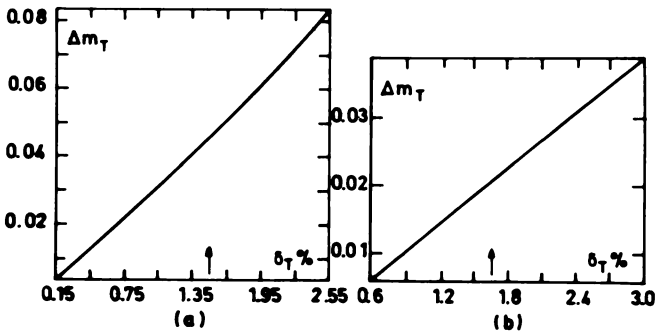


Figure 3. Variation of the limb brightness maximum gradient Δm_T versus $\Delta T/T$ a) propagating waves
b) evanescent waves.

https://doi.org/10.1017/S0074180900158486 Published online by Cambridge University Press

2. AMPLITUDE OF THE VELOCITY OSCILLATIONS

If we take into account all the modes observed from the entire disk of the sun in the 3 mHz frequency range (about 10^7), we can define a maximum value of the velocity amplitude $v \simeq 0.6$ kms^{-1} assuming 20 ms^{-1} for an individual mode (Christensen - Dalsgaard and Gough 1982). The observations made by the heliometer have geometrical constraints which limit the observable range of the 5 min oscillations. It is shown in Figure 4 that only a quarter of the modes can be observed. The amplitude of the observed velocity then is reduced to 0.3 kms^{-1}. For higher frequencies, the velocity amplitude is too low because of the wave reflection in the upper chromosphere. (Schmieder 1979).

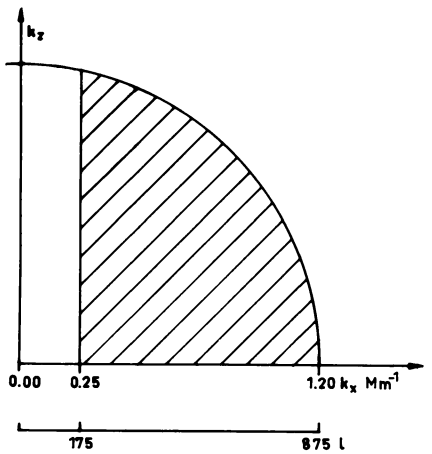


Figure 4. A (kx, ky) diagram corresponding to 5 mn oscillations. Hatched part defines the non observable range for the heliometer of the Pic du Midi due to observing geometry.

3. FLUCTUATIONS OF TEMPERATURE

Thermodynamical fluctuations are correlated to the velocity amplitude as it was shown in a previous work (Schmieder 1977). The upper limit of the ratio between the temperature perturbations $\Delta T/T$ and the velocity v is 0.2 in the case of evanescent waves (3 mHz) so that the expected fluctuations of temperature $\Delta T/T$ are around 1.1 % . We can deduce the fluctuations Δm_T of the gradient of the limb brightness corresponding to evanescent waves. The arrow in Figure 3b shows that the fluctuation reaches 2 %.

The limb brightness fluctuation amplitudes observed with the heliometer show peaks of 10 %. They are difficult to explain by p mode waves.

https://doi.org/10.1017/S0074180900158486 Published online by Cambridge University Press

REFERENCES

Christensen - Dalsgaard, J., Gough, D.O. : 1982, Monthly Notices Roy. Astron. Soc. 198, 141

Leung, C.M. : 1975, Astrophys. J. 199, 340

Rösch, J. and Yerle, R. : 1983, Solar Phys. 82, 139

Rösch, J. and Yerle, R. : 1984, The Hydromagnetics of the Sun (ESA SP-220, ESTEC), p. 217

Schmieder, B. : 1977, Solar Phys. 54, 269

Schmieder, B. : 1979, Astron. Astrophys. 74, 273

Schmieder, B. and Mein, P. : 1986, Astron. Astrophys. 161, 7

https://doi.org/10.1017/S0074180900158486 Published online by Cambridge University Press