EARTH BASED OBSERVATIONS OF SOLAR LUMINOSITY OSCILLATIONS

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ABSTRACT. Earth based multichannel photometry of integral sunlight has been obtained at Izaña (Tenerife) during 1984-1986. Power spectra of the solar luminosity variations of individual days show power in the 5 minute interval above noise at a level comparable to SMM data(1). When combining contigous days of data the signature of p mode solar oscillations spectrum appears, although individual peak identification is difficult.

1. INTRODUCTION AND OBSERVATIONS

As a consequence of solar dynamic oscillations, luminosity oscillations are produced and they were measured, for the first time, by the Active Cavity Radiometer (ACRIM) aboard the Solar Maximum Mission (SMM) spacecraft. In the data provided by the satellite, the p mode spectrum was detected (1) which clearly confirmed previous findings in the velocity signal (2).

It is known that the earth's atmosphere is a limiting factor for the detection of solar luminosity variations from ground based observations. Up to now, some approaches have already been made in order to detect the solar intensity oscillations from ground and none of them have achieved the required noise level to detect the oscillations.

For this purpose, a full disc direct sunlight quadruple photometer (3) (with an integration time of 13 seconds) was set up at the Observatorio del Teide (Izaña, Tenerife), from 1984-1986. Four different wavelenghts were employed centered at 680,1060,500 and 870 nm (from now on referred to, in this text, as channels #1,#2,#3 and #4). Raw data for the 17rd of February 1986 is shown in Figure 1.

2. ANALYSIS

After correcting the daily trend due to the earth's atmosphere the residuals are calculated. A slow "moving mean" has been passed to the residuals to smooth out variations larger than 22 minutes which could mask the signal at the range of interest (see figure 2), and the power

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spectrum is then obtained (4). A maximum of 2048 points, for each of the series were used which give a frequency resolution of 37.6 μHz.

When the individual power spectra had been calculated, the "good" days were selected (on the basis of low standard deviation of the residuals), and their spectra averaged in order to increase their statistical significance (Figure 3). These measurements show that there is power above statistical and atmospheric noise in the p-mode oscillations frequency region.

To increase the resolution a set of 6 contiguous days are analysed and the power spectrum is calculated with a resolution of 2 μHz. The assymptotic theory provides a clear signature of the p-mode oscillation spectrum: when dealing with modes of n >> 1, the modes of different n and equal l are equally spaced in frequency. This condition is fulfilled in the 5 minute range and an analysis is made from 2.1 mHz to 3.4 mHz searching for this frequency spacing. Figure 4 shows a folded spectrum with a 135 μHz folding frequency; peaks that correspond to the l=0 and l=1 modes and their one day window sidebands are found. Notice that the l=2 mode lies near to one of the l=0 sidebands. The presence of other peaks of similar power indicates that the noise level is a limiting factor for individual mode identification, which can only be done if the spectrum is known before hand.

3. RESULTS AND CONCLUSIONS

The power density levels measured in solar irradiance mentioned in the four broad band wavelengths, obtained during 1984-1986, are lower than those usually quoted as Earth atmospheric transparency limits, and much lower than the ones obtained in previous attempts at ground level. When compared to the ACRIM data on SMM, they appear to be at a nearly equal level using a substantially shorter time string. Although the detection limit levels remained just above the required threshold for individual peak identification, the analysis of the best series of days has shown that there are peaks equally spaced at a frequency of 135 μHz, showing evidence for a p-mode like power spectrum.

To improve the signal to noise level at the 5 minute frequency interval a correlation method will be implemented. A second instrument, identical to the one used, has been completed and is installed at Mt. Veleta (Sierra Nevada, Spain).

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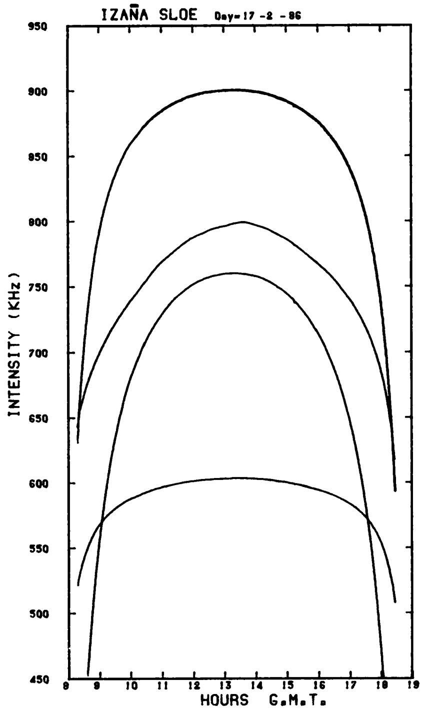

Figure 1. Solar intensity during the observation day 17 February 1986. #1,#2,#3 and #4 stand for channel 1(680 nm),channel 2(1060 nm),channel 3(500 nm) and channel 4(870 nm) respectively.

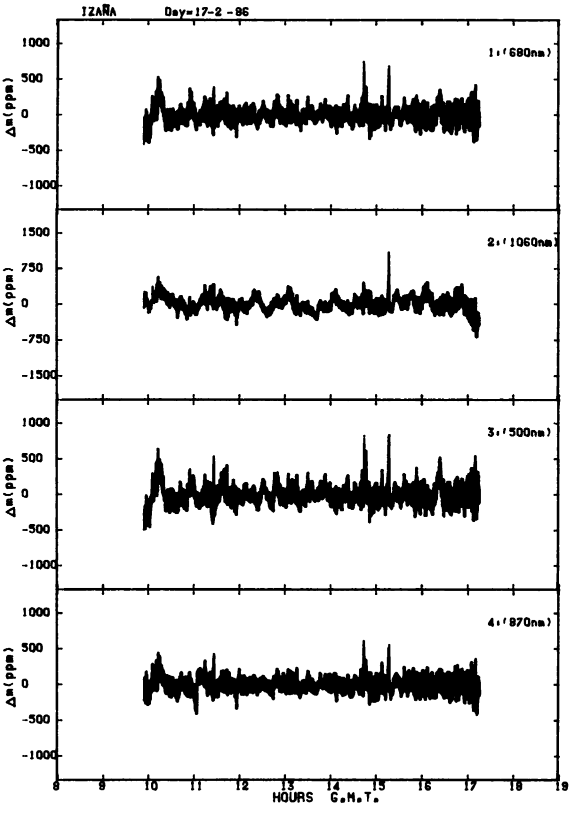

Figure 2. Series of residuals (instrumental magnitude as a function of time)of 17 February 1986 for the four channels.

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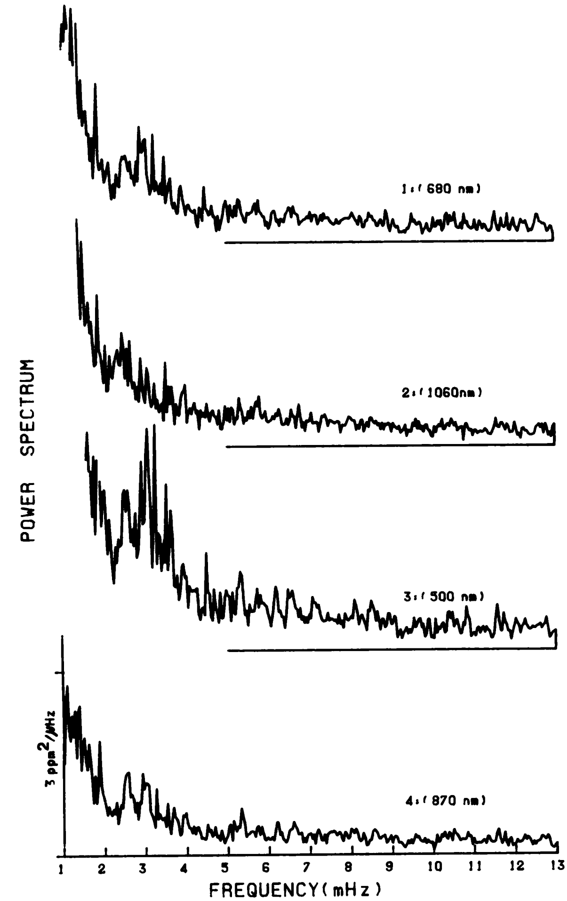

Figure 3. Average power spectrum of the best 6 days obtained in 1986 for the four measured channels. The mean power level in the 5 minutes region (actually defined from 2 to 5 mHz) divided by the one of the region from 6 to 13 mHz is of 2.76 for #1, 2.61 for #2, 3.4 for #3 and 2.42 for #4, the mean noise levels being of 0.32,0.33, 0.46, and 0.27 ppm^2/μHz respectively.

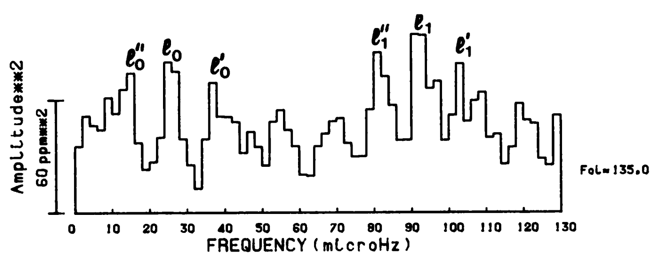

Figure 4: Folded spectrum from 2.1 to 3.4 mHz of a time series of three consecutive days with a folding interval of 135 μHz. Peaks that correspond to the l=0 and l=1 modes and their one day window sidebands (primed and double primed peaks) are found; the l=2 mode lies near to one of the l=0 sidebands.