Time-Frequency Analysis of Shadow Bands During Recent Solar Eclipses

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The atmospheric phenomenon of shadow bands, sometimes visible during total solar eclipses as grey ripples moving over the ground a few minutes before and after the totality was subjected to detailed data analysis.

Scintillation theory as explanation for this phenomenon given by Codona J. L., 1986 was tested during three solar eclipses. A time-frequency analysis was carried out for three different colour ranges (red, blue, green) defined by the CANON Hi8 video camera system as well as for a radio wavelength of 3 cm. The geometrically rectified pictures of a white screen with bands, carefully oriented north-south were Fourier-analyzed for the considered colour-ranges, yielding a catalogue of intensity contour-plots in the two-dimensional spatial frequency-space. These stacked contour-plots represent the time-evolution of the shadow bands in the three colour ranges.

During the solar eclipse of August 11^{th}, 1999 a wavelength of the phenomenon of 20 cm before totality and 25 cm after totality was determined from an Austrian observation point (Bad Fischau). A similar experimental setup during the eclipse of June 21^{st}, 2001 in Lusaka/Sambia resulted in a detectable wavelength of 5 cm before and 10 cm after totality, obviously depending on the different altitudes of the scintillation-band producing turbulence layers.

For the first time an airborne experiment was performed which used three SHARP BS1R 6EL 100W universal LNB (commercial) satellite receivers together with modified LNB satellite finders. The signals were recorded with three 3890 DT USB VOLTCRAFT multimeters and sent to a SONY Vaio notebook. The aircraft was following the centre line of the annular eclipse on May 31^{st}, 2003 from Akureyri/Iceland to Greenland at an altitude of 12600 m. Intensity variations were recorded in the radio band.

The problem was that at a receiver wavelength of 3 cm the contrast of the bands proved to be only 0.5 %. According to Stolle C. et al., 2001 scintillation effects for radio waves at short wavelengths are generated in the ionosphere at altitudes between 80 and 1000 km. To better understand the partly disturbed signals in the aircraft travelling at significantly higher speed than the shadow bands, with a receiver of undoubtedly not optimally suited sensitivity, simulated data were generated. When compared to these data, a wavelength between 20 m and 120 m resulted.

References:

Codona J. L., 1986, Astronomy and Astrophysics, Vol. 164, No. 2, p. 415 – 427

Stolle C. et al., 2001, http://www.uni-leipzig.de/∼jacobi/docs/2001_DACH_1.pdf