SOLAR DIAMETER(S)*

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Abstract. Because of the renewed attention now paid to the solar diameter, its variations from equator to pole, or its secular or long-period changes, the question: what is a solar diameter? is not meaningless. Two kinds of definitions may be given: either astrophysical, each one relating to a specific physical parameter, or observational, relating to a given quantity to be measured. Only the second kind is directly accessible, and astrophysical definitions should be linked to these quantities, once they are determined with the highest possible accuracy. In practice, all the programs under way refer to the point of the limb where the brightness gradient is maximum, or to a higher order approximation of the shape of the profile. Two of them are compared: the Pic-du-Midi experiment, using fast scans of the limb to define the inflection point after a correction for the blurring effect of the atmosphere, and the SCLERA experiment, using the algorithm called FFTD to eliminate this correction. The advantage of a fast scan is emphasized, and the remark is formulated that, once the signal is digitized and stored, FFTD or any processing of it can be performed. In collecting day-long one-limb scans to calibrate the blurring correction, the authors have found fluctuations of the maximum brightness gradient which provide a new entry to the field of solar oscillations.

1. Introduction

The idea was born already ten years ago, while the controversy around the solar oblateness announced by Dicke and Goldenberg (1967) was very active, on both observational and theoretical sides, to undertake solar diameter measurements at Pic-du-Midi. The good observing conditions already proven, together with a straightforward method, could be expected, indeed, to afford some valuable data in the matter. For a number of cumulative reasons, although the principles had been laid down from the beginning, the program progressed very slowly, and it is not before 1978 that it really began to develop. As a counterpart, several facts occured in the meantime which did not make it obsolete, but rather enhanced its interest, and even caused a branching towards two different goals, as will be seen.

These facts are:

– the publication in 1975 by the SCLERA Group (Hill et al., 1975) of results contradicting Dicke's ones but indicating pulsations of the solar diameter, later on interpreted as photometric fluctuations in the limb profile;
– the extensive development of theoretical and observational work on solar oscillations;

– the attention recently paid to possible secular variations of the solar diameter (Eddy and Boornazian, 1979), which could represent long period oscillations, and lead to the need for absolute measurements of the angular diameter of the Sun (Parkinson et al., 1980);

– and finally, from our own side, the observation, on daily measurements of the maximum brightness gradient of the solar limb, of oscillations resembling those found in Doppler or brightness measurements.

This last point caused the splitting of our program into diameter measurements on one hand, and limb oscillation studies on the other one. The present paper will deal mostly with the first part, starting with a preliminary question.

2. What Does Solar Diameter Mean?

Perhaps some thinking on this point could help in clarifying the controversies of the last decade.

The Sun is not a stainless steel ball like those in the bearings. Nobody argues about the significance of the diameter of such a ball, because it is physically defined with an accuracy of the order of the dimension of iron atoms, and we are far from being able to measure it, in practice, with such an accuracy.

The situation has been the same for the Sun as long as everybody believed it to appear with a 'very sharp' edge (something like the surface of the ocean as seen at the horizon), and as long as the observational uncertainties were largely predominant; various authors found various values of the 'diameter', but, admittedly, all of them were measuring the same thing.

Now the scene is completely different. It has been theoretically and observationally proved that nowhere, from the center to the outer corona, does a zero exist in the density and emissivity of the solar atmosphere, so that no infinite brightness gradient is to be observed on the limb. On another hand, sensitivity and accuracy of the observational techniques have gained orders of magnitude, and the effects of the terrestrial atmosphere, which were, if not ignored, at least unexplored as late as fifty years ago, are now seriously taken into account.

Clearly, as soon as the non-existence of a 'vertical' edge is established, a definition of what is to be called 'solar diameter' is required.

3. Two Kinds of Definitions of the Solar Diameter

It would be nice to define the radius of the Sun by the level in its atmosphere where a given physical parameter has a specified value or a particular property. It could be, say, the level of the temperature minimum. That would probably lead to make use of different definitions, according to the astrophysical problem under consideration. To change numerically from one kind of radius to another would need a model of the atmosphere. For instance, what is the relationship between the locus of temperature minimum and an equipotential surface of the gravitational field of the Sun, the oblateness of which was