EXPERIENCES FROM IDM MEASUREMENTS AT THE TEST BASE OF THE GEODETIC INSTITUTE OF UPPSALA UNIVERSITY

S-G. Mårtensson
Geodetic Institute
Uppsala, Sweden

ABSTRACT

IDM measurements carried out in Uppsala sometimes show violent changes in refraction over short periods of time.

The explanation for these changes might be found if the dynamics of atmospheric turbulence is taken into consideration.

It is too early to make scientific conclusions from the material collected so far, but observations show the way this particular problem can be handled in the future.

The paper presented, reflects some of the turbulence effects achieved by the IDM instrument constructed by prof. E. Tengström.

INTRODUCTION

From measurements carried out on the Björklinge - Flogsta refraction base in Uppsala, it seems as if the refraction contains of two (for IDM detectable) essential spectral parts. One part with a high frequency and the other one with a low frequency.

The high frequency spectrum is caused by the atmospheric turbulence and the low frequency spectrum corresponds to the refraction obtained, for instance by vertical angle measurements (or atmospheric models), (fig. 1).

This is, of course, nothing new. It is a wellknown phenomenon and has been mentioned in the literature by several authors, among others by G. Dietze (Dietze, G.: 1957), who tried to explain the turbulence spectrum by convection theories only. Today we know, from micrometeorologists, more about turbulence in the atmosphere, e.g. that convection is not the only contributor but probably responsible for the dominating part when dealing with vertical refraction.

E. Tengström and G. Teleki (eds.), Refractional Influences in Astrometry and Geodesy, 241–247.

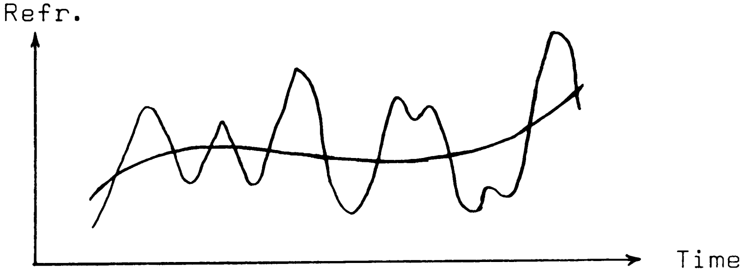

Fig. 1 High and low frequency spectrum of refraction.

The new and interesting thing is that parts of the high frequency spectrum have been detected by IDM measurements in Uppsala, and the contents of this paper deal with certain properties of that spectrum.

GENERAL

The detectings of the atmospheric turbulence became reality when the light sources were exchanged from mercury lamps to lasers. The intensive light of the lasers decreased the exposure times from a question of minutes to a question of seconds and even to parts of a second.

When the registrations were in the "minute area", the high frequency spectrum averaged out to the low frequency spectrum, a fact which is documented in the Niinisalo measurements in 1971 (Tengström, E.: 1974), where the IDM measurements fit very well to the refraction computed from an atmospherical model.

In the "second area", which is the operating area of today, the high frequency spectrum dominates. Measurements carried out in this exposure time area indicate sometimes violent amplitudes of the spectrum. The greatest amplitude detected so far is 1140 cc (on 20 km) in 20 minutes of time. This is an extreme value, normally detected amplitudes seem to be about 150 - 250 cc.

Some measurements indicating this will be given in the next part.

MEASUREMENTS

Fig. 2 shows observations carried out on a very turbulent evening. The theodolite readings (by a Wild T3) show a change in refraction from 565 cc to 870 cc during 1 hour 40 minutes. IDM observations during the first part of the evening indicates even greater amplitudes, a change from 123 cc to 1263 cc during 20 minutes of time! (Refraction obtained from a standard atmospheric model gives a refraction value of 140 cc on the 20 km base). All IDM observations were performed with He-Ne red (6328 Å) and Ar blue (4880 Å) lasers and with 1/2 sec. exposure time.

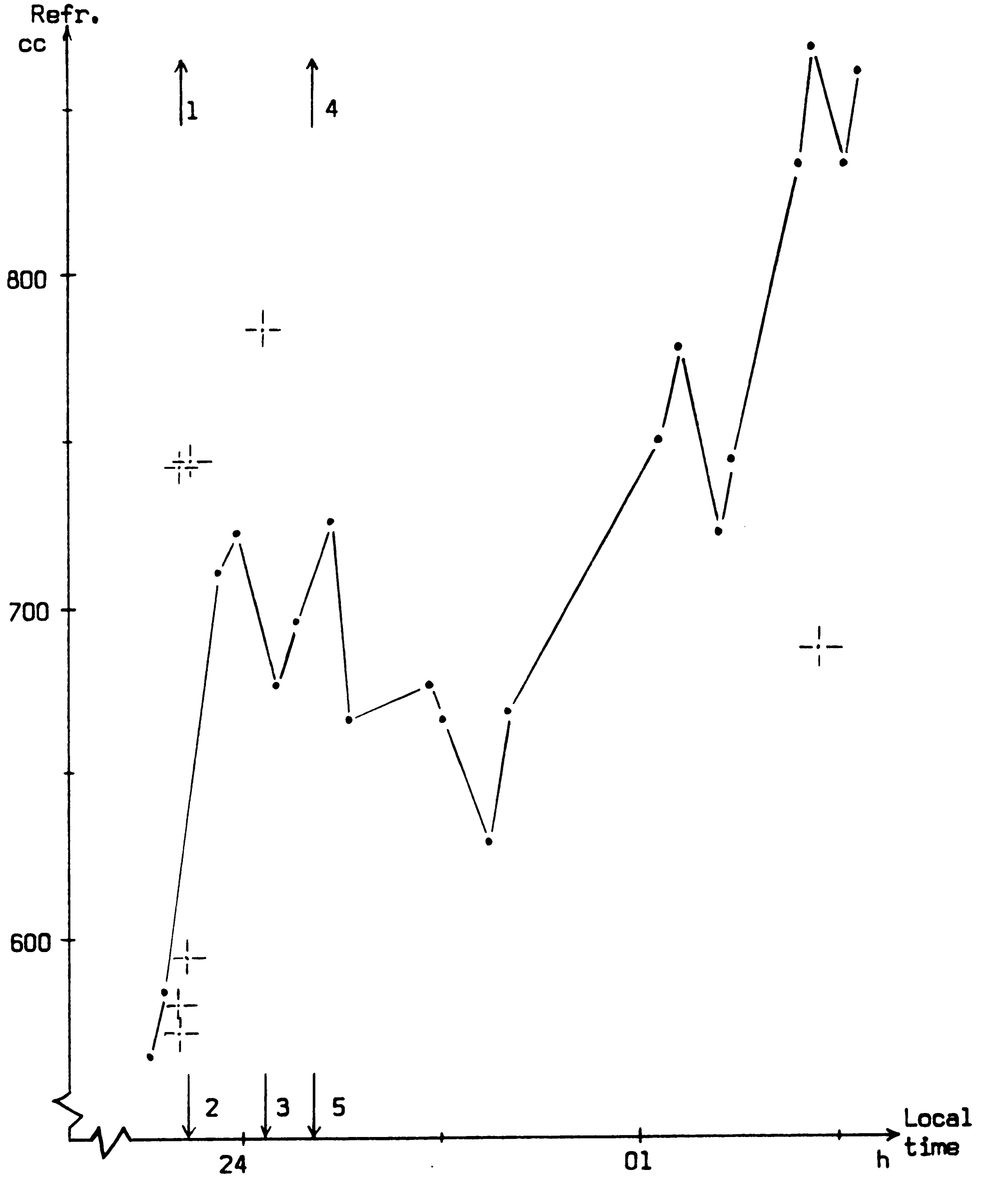

Fig. 2 Refraction computed from • vertical angle measurements and -¦- IDM measurements, 1976-08-16.

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Additional IDM measurements that do not fit the range of fig. 2 (arrows in the figure indicating the time):

1) 903 cc, 950 cc, 965 cc
2) 431 cc, 209 cc, 123 cc
3) 427 cc
4) 1211 cc, 1263 cc
5) 231 cc

Fig. 3 shows observations performed under much more favourable atmospheric conditions (at least from a geodesists point of view). The vertical angle readings were very stable (within 10-20 cc) and the refraction computed from those readings does not differ too much from the "standard refraction value".

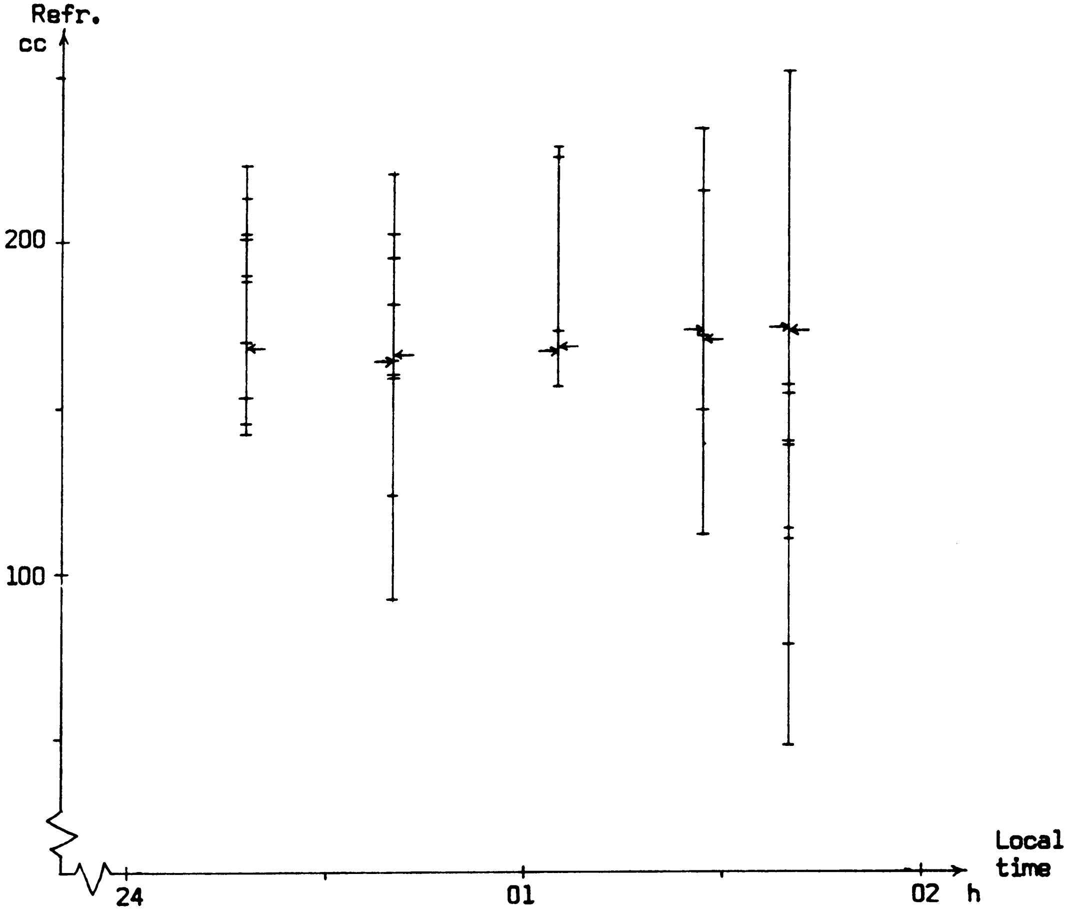

Fig. 3 Refraction computed from ← mean of four vertical angle measurements, † IDM measurements (1/2 sec. exp.time) and → IDM measurements (5 sec. exp.time), 1977-06-21.

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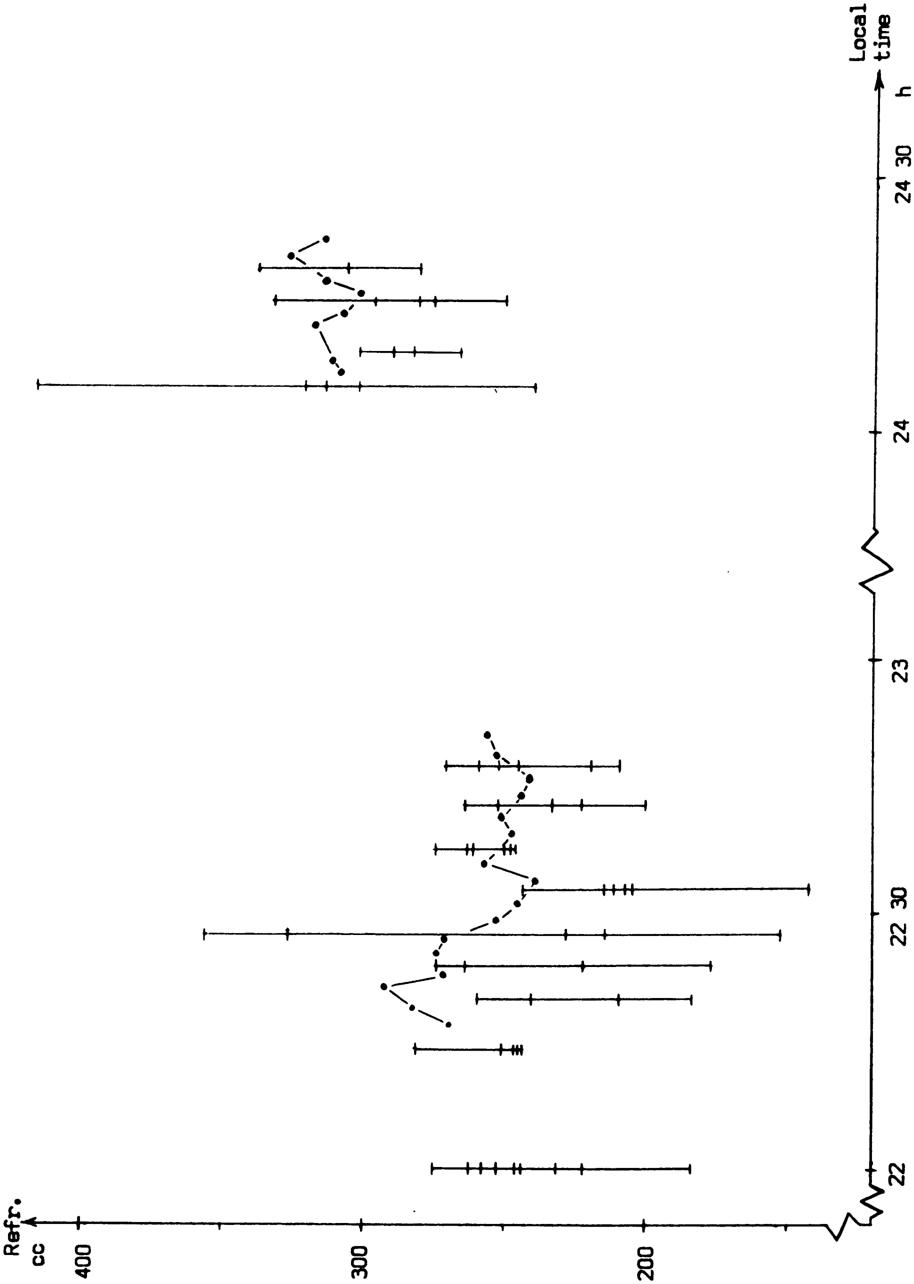

Fig. 4 Refraction computed from • vertical angle measurements and ┼ IDM measurements, 1978-06-15.

Although the IDM observations show quite different values, they differ from 48 cc to 250 cc during a time period less than 30 sec. The IDM observations were performed with He-Ne red and He-Cd UV (3250 Å) lasers and the exposure times were mainly 1/2 sec. except for a few observations which had an exposure time of 5 sec. These observations are very interesting, because it looks as if the 5 sec. exposure times were enough to give a good integration of the high frequency spectrum. It can be seen from figure 3 that the 5 sec. exposures fit very well to the values achieved by vertical angle readings, in fact better than 3 cc.

Fig. 4 shows observations performed in the middle of June 1978. The interesting thing is, that this particular evening an integration time as long as 20 sec. was not enough to give an agreement with the vertical angle readings. The time interval between two succesive exposures was 5 sec. He-Ne red and He-Cd lasers were used.

DISCUSSION

The exposure times in the "parts-of-a-second-to-several-seconds" area seem to be too short. For geodetic refraction studies it is necessary to bring them back into the "minute area" again.

This can be done in several ways, some of which may probably, by the present method, decrease the accuracy in obtaining the dispersion. To maintain the required accuracy on long time exposure observations and to avoid subjective measurements, densitometer readings in combination with Fourier analysis will be used (see paper presented at this symposium by J. Milewski).

The possibility that the light rays travel through different turbulent media when the lasers are separated, as in our case by one meter, should not be excluded. However, preliminary studies of this problem do not indicate any apparent differences.

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DISCUSSION

D.G. Currie: I think in both this case and Williams' presentation there may be part of the problem on the instability, maybe correctable with an instrument, which measures both the angle and the dispersion at the same time. It may very well be that a large part of the motion or jumping around that you are seeing, is actually a change in dispersion and a change in refraction, so that an instrument which was tracking this would find that when refraction increased the dispersion also increased. That is one thing at least on the astronomical side that seems like it may be necessary, if we have to deal with trying to remove the high frequency components.

S-G. Mårtensson: Yes, I think you are right. It is necessary to examine if and when there is a correlation between dispersion and refraction. Both Williams and I have seen, that if we have a big refraction we also have a poor correlation between the red and the blue images. But if we have a small refraction, there seems to be a much better correlation. I think this is important, and I think it must be examined when and where we have correlation between dispersion and refraction.

E. Tengström: We have to look at two types of averaging - we have to try spatial averaging and we have to try time averaging. Both must be investigated, and we are going to do that.