DOPPLER SHIFTS MEASUREMENTS OF THE ZODIACAL LIGHT AT THE PIC MIDI OBSERVATORY.

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Abstract: At the Pic-du-Midi Observatory, we have started a program to observe the spectrum of the zodiacal light in the region of the b absorption lines of MgI. We use a 1 meter spectrograph with a holographic grating followed by a focal reducer to obtain a 19 Å/mm dispersion over the micro-channel plate camera. Calibrated spectra obtained with an exposure time of 10 minutes systematically show earth atmospheric emission lines attributed to both NI and OH. The temporal variability of these emissions prevents an accurate determination of the line profiles. Our best processed measurements of Doppler shifts obtained during five nights do not allow to descriminate between circular and hyperbolic orbits of the interplanetary dust.

I - INTRODUCTION.

The first attempts to measure Doppler shift effects in the Hβ line of the spectrum of the zodiacal light using a Fabry-Perot etalon were reported by Ring et al. (1964), Reay and Ring (1968), and James and Smeethe (1970). Unfortunately the presence of a faint Hβ emission line due to the geocoronal emissions spoiled the measurements; the b-lines of MgI were subsequently favoured.
Recently Fried (1978) used a Griffin type spectrograph to produce the best results presently available. He found that, for elongations smaller than 60° the measured shifts imply velocities larger than those expected for Keplerian circular or elliptical orbits.
A point which seems to be well established is the prograde motions of the zodiacal cloud confirmed by all published measurements.
Since 1981, we have started Doppler shifts measurements of the zodiacal cloud at the Pic du Midi Observatory.

II - THE INSTRUMENT AND THE METHOD.

The observations are performed with a conventional Czerny-Turner type spectrograph of 1m focal length (entrance slit 1x80mm; holographic grating 160 x140 mm^2, 2400 gr/mm, 1st order).
The primary spectrum is re-imaged beyond a field lens using an image

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reducer (effective aperture F/2) to produce a 19 Å mm^{-1} dispersion in the plane of the entrance window of the detector package. Several image tubes and photon counting system were tested, see Robley et al.(1982a). The best compromise was found with a 70mm photo-camera equiped with a zero distorsion proximity focused dual micro-channel plate with a S-20 photocathod. 103 aG film was used. The whole instrumental set-up is pointed directed to the morning or evening zodiacal cloud using an al-tazimutal mount in order to direct the $1x80mm^2$ entrance slit accross the main axis of the cloud.
On each frame a calibration spectrum produced by a Mg hollow cathode lamp is recorded on both sides of the zodiacal light spectrum which extends over a 275 Å interval centered on the Mg I triplet. A sufficient signal to noise ratio is obtained with a 10 min exposure time when observing near the ecliptic plane. Several methods have been tested to measure the Doppler shifts, Robley et al. (1982a,1982b) and two of them have been retained:

1 - Optical measuring machine routinaly used for stellar radial velocities.
2 - Analog cross-correlations between calibration and zodiacal light spectra.

III - RESULTS AND DISCUSSIONS.

For ground-based observations several components are superposed along the line of sight, see Koutchmy et al. (1981), including a parasitic emission spectrum from the Earth atmosphere. Our observations systematically reveal a complexity and a variability of this component which seem to have been underestimated in the past.
The spectral internal observed is filled by the rotation-vibration spectrum of OH, especially the spectrum of the vibrational transition (9,2) corresponding to the 2 foundamental states $^2\Pi_{3/2}$ and $^2\Pi_{1/2}$. In addition, the well known emission of NI near 5200 Å is always present during the whole night, see figure 1 and seems to be distorded by an OH emission line.
All these night sky emissions appears to fluctuate in time over a scale of order of our exposure time that is 10 min. Consequently, the Fraunhofer spectrum of the zodiacal light is distorted, complicating the measurements of the shifts and leading to rather large error bars. Figure 2 shows an example of a spectrum used from a sequence obtained on the morning of Sept.8, 1983.
The whole set of our measurements is displayed in figure 3. The quiet large scatter of the data points is mainly due to the effects introduced by the OH emissions. It is the superiority of our technics to show simultaneously the F-spectrum of the zodiacal light together with the contaminating lines.As a consequence of this scatter it is not possible with the present data to infer the nature of the orbital motions of the interplanetary dust.

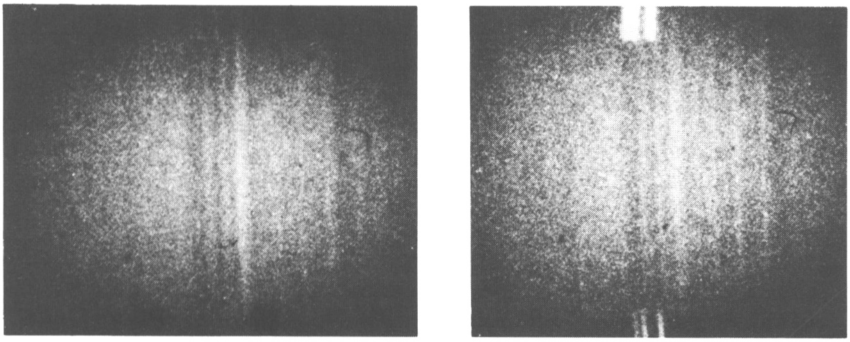

Figure 1 - Prints of the spectra N° 2 and 20 obtained during the night of September 3-4, 1983, in the direction of the north pole (h = 22°) showing the large variations of the OH emission lines near the MgI triplet (in absorption).

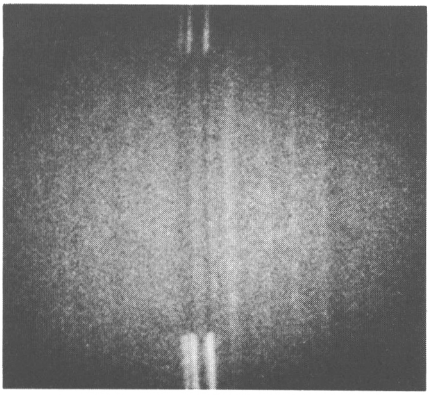

Figure 2 - Print of a typical spectrum obtained on the morning zodiacal light on Sept. 8, 1983 (East direction); the exposure time is 10 min.

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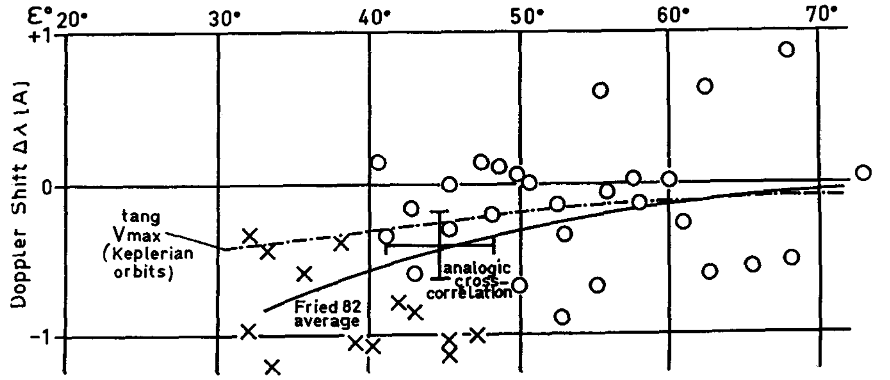

Figure 3 - Diagram displaying the whole set of Doppler shift measurements:O are for the morning observations (with reversed sign) and x for the evening ones. The result obtained using the cross-correlation method is shown with error bars. The heavy line is for the average results of Fried (1978) and the dashed line represents the theoritical result for Keplerian circular orbits.

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