– easy access to the engineering interface.

Thanks to the modular system structure, duplication of development effort is avoided and the number of programmes to be maintained is minimized. The new software has been developed as a by-product of the on-going instrumentation projects, with the aim of rationalizing the instrument software. While it is believed that this goal has been successfully achieved, some areas could still be further improved. In particular some work will have to be done to make instrumentation software suitable for remote control, even on a relatively low-speed computer-to-computer telephone link.

Acknowledgements

The authors would like to thank F. Middelburg for the additions to IHAP which have allowed easy interface to the new data-acquisition system. The on-line availability of IHAP considerably increases the power of the whole instrumentation software.

A special word of thanks is due to H. Pedersen for his recommendations and for his belief in fully computerized observing programmes, the Danish telescope CCD being the first example of this; and to M. Cullum for his careful reading of the manuscript.

Pulsating Stars, Spectroscopy and Shock Waves

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The pulsating stars constitute an important group of variable stars. They show in their spectra a large number of variations (intensity, shape, emission) which are very well observed with high-resolution spectrographs equipped with modern receptors. These spectral variations are the consequence of the dynamic state of the pulsating atmosphere of the star and their study can certainly give some fundamental information. Here, in the first section, we give a rapid review of the observations of emission lines and their interpretation by the propagation of a shock wave through the atmosphere of various types of pulsating stars. Later, the Hα emission of Mira Ceti, the brightest Mira star in the sky, is analysed. It is shown that the

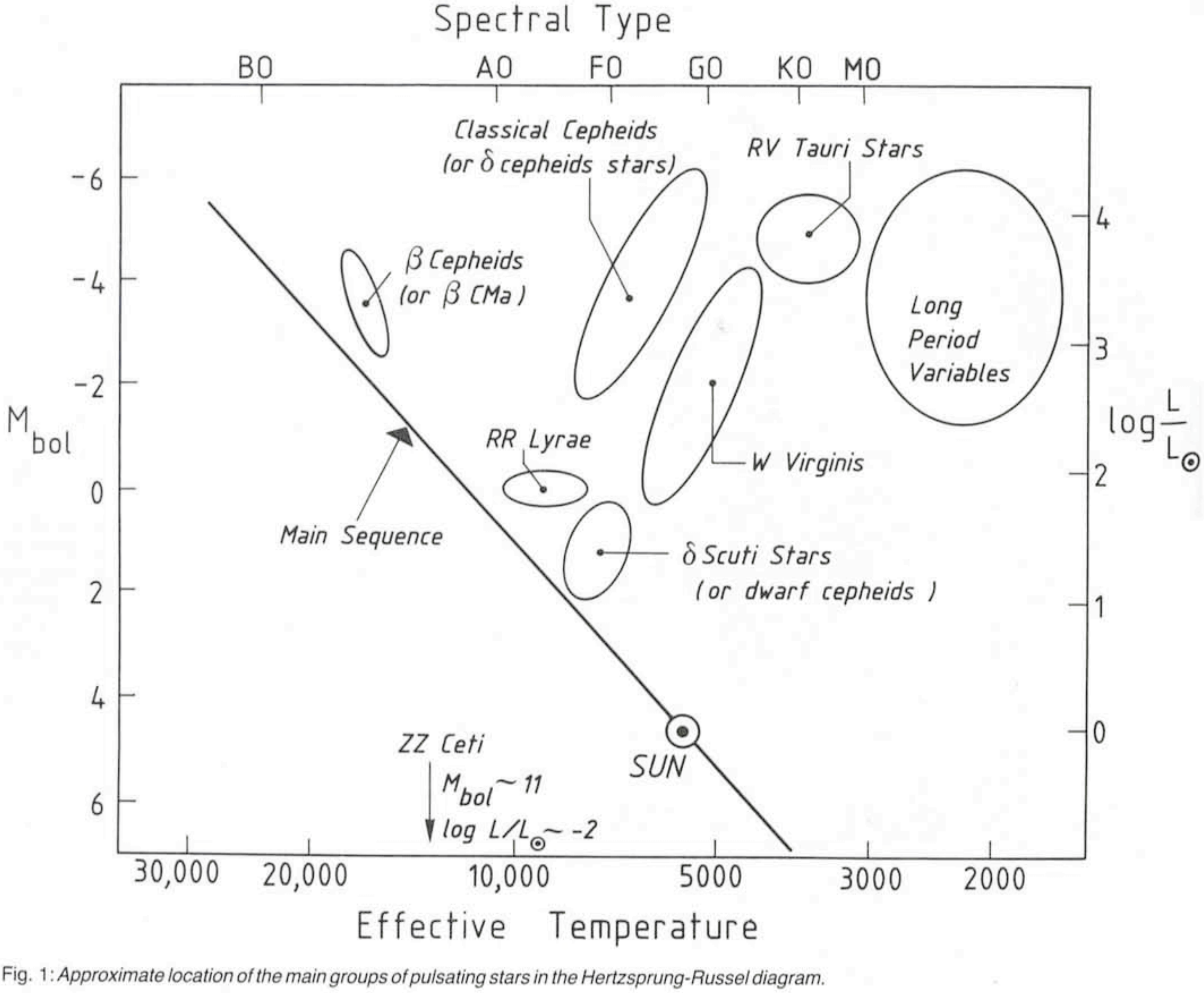

Fig. 1: *Approximate location of the main groups of pulsating stars in the Hertzsprung-Russel diagram.*

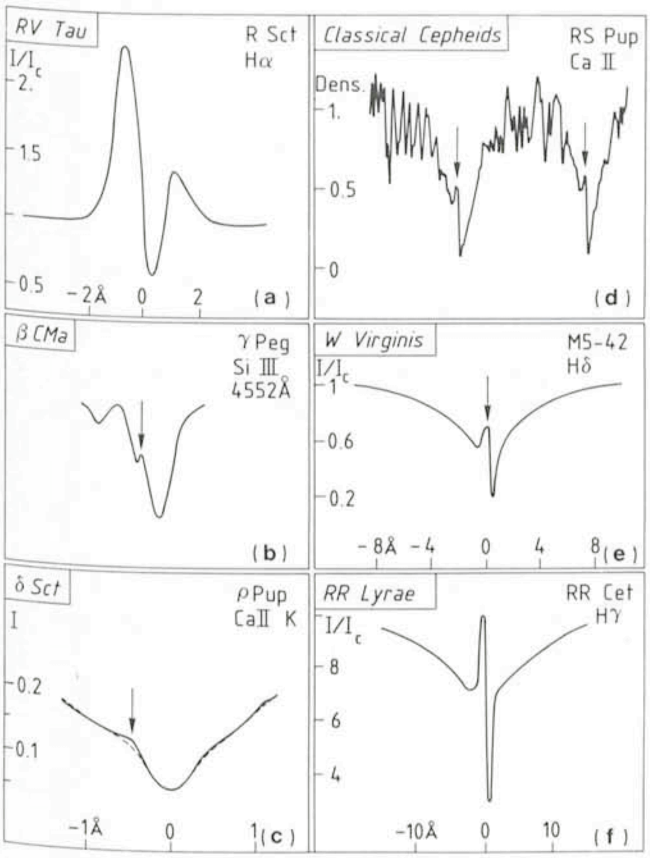

Fig. 2: *A few examples of emission lines supposed to be produced by shock waves propagating through the atmosphere of pulsating stars. All these pictures are adapted from references (a) to (f).*

intensity of the emission profile can be very different in each period.

Pulsating Stars and Shock Waves

Fig. 1 shows the classical Hertzsprung-Russell diagram. The approximate position of different groups of pulsating stars is given. A comprehensive list of their characteristics can be found in Dürbeck and Seitter (1982). Apart from ZZ Ceti stars (variable white dwarfs of short period), the pulsating stars are in majority "above" the main sequence, i.e., in regions where the nuclear activity is relatively rapid. Their luminosity varies with a period between 100 s to 1,000 days and with an amplitude between 0.01 and 8 magnitudes. When the star undergoes, by gravity, a compression, the temperature and the pressure of the atmosphere increase and the hydrogen and, principally, helium, by their ionization, stock potential energy. When the recombinations occur, the radiation pressure increases and exerts pressure on the outer layers of the star. This mechanism (the motor of the pulsation) in which the energy dissipated by the pulsating motion is replenished by the effect of the changing of the opacity due to the ionization, counterbalances the damming process and thus perpetuates the pulsations.

During the pulsating motion, the atmospheric gas undergoes accelerations and decelerations. Thus, it is possible, in principle, that shock waves are created. There are at least two observational features in favour of these waves. The first is the presence of discontinuities within the radial velocity curve and the second, the existence of emission lines. However, these facts are not compelling as other mechanisms are possible. Fig. 2 gives a few examples of emission lines interpreted as the consequence of a shock propagating through the atmosphere. The case of Long Period Variables (LPV) is certainly the most famous example and will be analysed in the next section.

The RV Tauri stars are characterized by spectral types F, G or K; luminosity class Ib or Ia; and pulsation periods of 30 to 150 days with an amplitude of 3 magnitudes. The Hα profile of R Sct (Fig. 2a) has an inverted P Cygni profile with a red-side emission. A few double absorption lines and He I emission are also observed. This latter emission is important because it means that the shock has a large intensity, provided, of course, the shock produces this line. The shock wave "explanation" has been lately discussed for AC Her by Baird (1982).

The β Cephei stars have a spectral type B and a luminosity class II, III or IV. The period range is from 0.13 to 0.3 day and the amplitude up to 0.2. LeContel and Morel (1982) have observed a small emission component within Si II (see Fig. 2b) and Mg II in γ Peg, and Goldberg et al. (1974) have detected in the spectra of β Cep an asymmetric sharpening of the red wing of Hα. These emissions are interpreted by the propagation of a shock wave.

The δ Scuti stars or dwarf cepheids (see Breger, 1979, for a discussion of these names) have spectra between A and F; luminosity class between III and V; periods between 0.03 and 0.2 day, and amplitudes which do not exceed 0.8 magnitude. Dravins et al. (1977) have observed a very small emission (see Fig. 2c) within Ca II K absorption of ϱ Pup. The dashed reference profile is the average of the profiles from 30 plates. These authors explain this phenomenon by the propagation of a shock through the atmosphere.

Finally, the set of cepheids (classical cepheids, W Virginis stars and RR Lyrae) show also a few emission lines (see Figs. 2d to f). The two first groups are characterized by spectral types F to K with high luminosity class I a or II. The period range is from 1 to 50 days and amplitudes between 0.1 and 2 magnitudes. The spectral type of RR Lyrae is A or F and the luminosity class is III. Their amplitude is approximately the same but the period is shorter (0.2 to 1.2 days). The emission lines in W Virginis and RR Lyrae are also interpreted by the propagation of a shock through the atmosphere. However, the classical cepheid stars show only lines with a weak excitation potential (Ca II) and a shock explanation is also proposed (Hutchinson et al., 1975).

Thus, RV Taurus, W Virginis and RR Lyrae stars show clearly hydrogen emission interpreted by shock wave models. βCMa stars show also emission lines with high excitation potential but weaker. The shock wave interpretation has also been proposed. Only the classical Cepheids with the same pulsating amplitude as the W Virginis stars and the δ Scuti stars are without emission lines with high excitation potential such as hydrogen. The intensity of the shock is certainly smaller for these two last groups than for the other ones.

In general, within a gas, motion of matter with a velocity larger than the sound velocity $a_s \sim 11700 \sqrt{T_o}$, where T_o is the temperature of the unperturbed atmosphere, gives a shock wave (for $3{,}000 \lesssim T_o \lesssim 30{,}000$ K one has $5 \lesssim a_s \lesssim 20$ km/s). An upper limit of the temperature T_s just after the shock front is $T_s \lesssim 3\ 10^{-9}\ v_s^2$, i.e. the temperature of the de-excitation zone in the wake of the shock is very approximately 5 or 20 times smaller. Thus, a velocity of the order of 40 km/s will certainly be sufficient to produce the emission of hydrogen. How can a pulsating motion with a subsonic velocity produce a motion with a supersonic velocity? Is the pulsating motion at the origin of the shock wave or the shock wave at the origin of the pulsating motion? Is there an acceleration mechanism of the pulsating motion? When the matter is falling back from the previous cycle, can the shock be produced by the interaction of this matter with the advancing one from the next pulse or by its reflection on the dense stellar core?

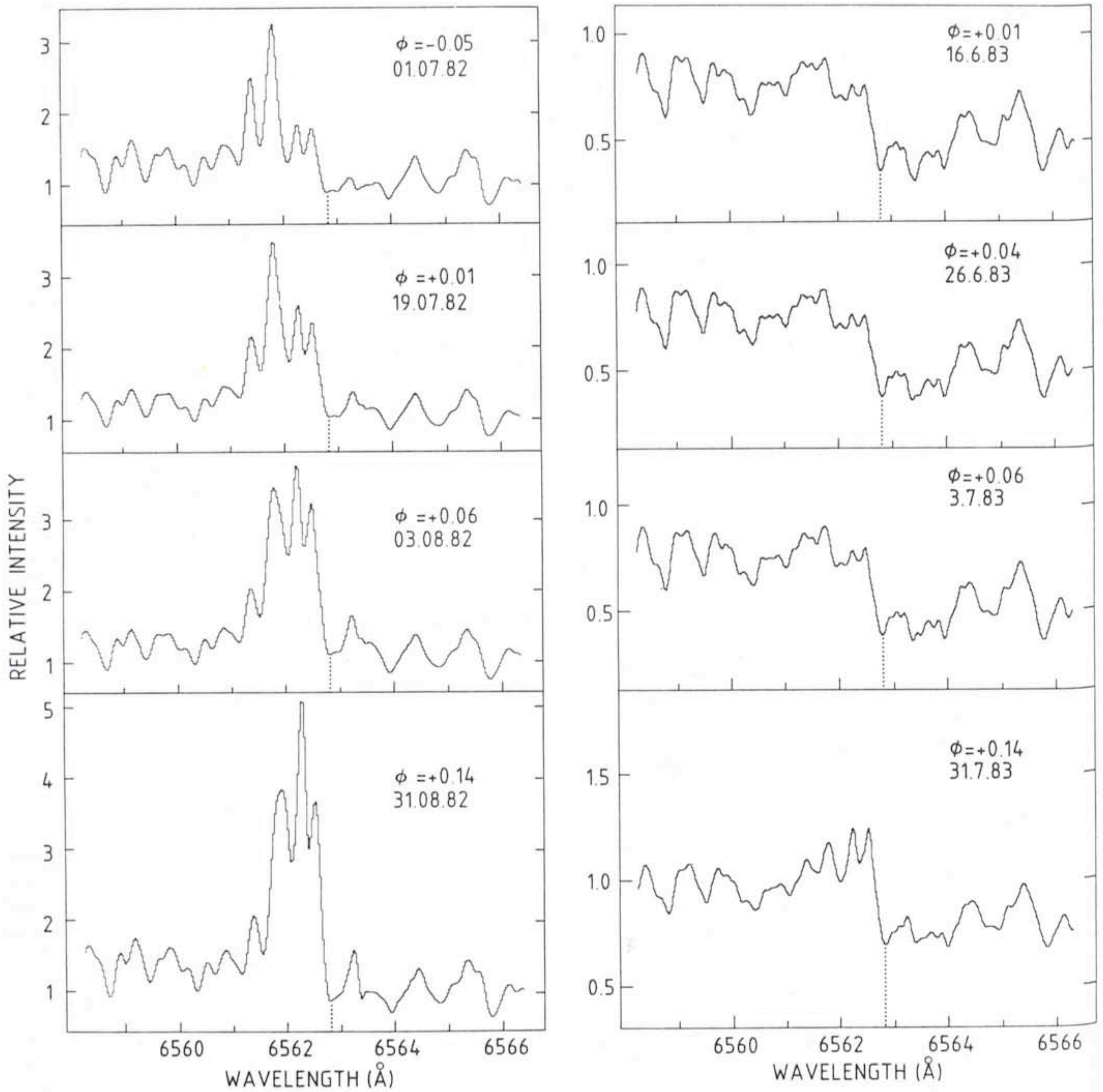

Fig. 3: *Hα profile of Mira near luminosity maximum in 1982 and 1983. The wavelengths are measured in the rest frame of Mira. The relative intensity refers to the mean level of the "continuum" between 6564 Å and 6572 Å. The wavelength of Hα at zero velocity in Mira's rest frame is marked by a dotted line. In this presentation the individual pixels are visible, each pixel being 30 m Å wide, corresponding to a resolving power of 10^5. The signal-to-noise ratio is between 300 to 500.*

The Shock of Mira Not on Schedule

The Long Period Variables are composed of three groups. The first two, semi-regular variables and irregular variable stars whose amplitudes do not exceed 2 magnitudes, do not present hydrogen emission lines. Only in a few cases are there some metallic emission lines present and these are perhaps the consequence of a chromosphere. Only Mira stars, the third group of LPV, have hydrogen and an important number of ions in emission during a large fraction of the period. Their amplitude is between 2 and 3 magnitudes. All these stars are of spectral type M, S or C and have luminosity class II or III. The period range is from 50 to 500 days and more than 1,000 days for a few semi-regulars.

The idea that one shock wave crosses the atmosphere at each period and produces the emission lines is well accepted. Thus the correlation between the pulsation period and the shock is assumed to be important. What is the exact origin of the shock? Since the beginning of this century a large number of studies have been based on the Mira stars, but there is no clear and quantitative answer to this last question. The velocity of the front is typically between 50 and 70 km/s, i.e., 10 or 15 times the sound velocity. How can a pulsation motion create a wave propagation to Mach 10 or 15?

Fig. 3 shows two sets of Hα emission profiles of Mira Ceti in 1982 and 1983 near luminosity maximum. All these spectra have been obtained with the Coudé Echelle Spectrometer of ESO. The resolution is about 60 m Å and the signal-to-noise ratio between 300 and 500. The shock seems weaker in 1983 than in 1982. The emission from the shock appears near phase $\Phi = 0.14$ in 1983 while the emission was already important at phase –0.05 in 1982, i.e., 63 days before the phase +0.14. Another explanation of this delay is that the shock has been created lower within the photosphere or also that the opacity of the latter shock was higher in 1983. The relative depth of absorption lines was lower in 1983 than in 1982. It is possible, perhaps, to understand this phenomenon by a lower luminosity of Mira in 1982 than in 1983. Finally, it is interesting to see that the three absorptions at approximately 6561.6 Å, 6562.0 Å and 6562.4 Å within the assumed emission profile at phase +0.14 have again not received a correct explanation. However, the first three profiles of Fig. 3, perhaps without emission, show five small absorptions.

Finally, these observations show that the phase of apparition of the Hα emission can be very different from one luminosity period to the next. This phenomenon is perhaps a consequence of the modification of the shock intensity and it may be that there is also a direct correlation between this fact and the slight variation of the period and amplitude (~ 5 %) of Mira stars. The 1983 profiles of Fig. 3 give perhaps the sequence of Hα emission caused by the shock.

Acknowledgements

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Blizzard at La Silla

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In the beginning of July 1983, an unusual snowstorm somewhat perturbed the life on La Silla. Here are the records:

Thursday, July 7, 1983: bad weather with symptoms of a development to the worse.
Friday, July 8, 1983: snow-storm, power-failure, evacuation of the mountain, 30 trapped.
Saturday, July 9, 1983: storm continues until midnight.
Sunday, July 10, 1983: bright weather, snow-sweeping, repairs.
Monday, July 11, 1983: half of the crew returns, preparations of equipment.
Tuesday, July 12, 1983: return to full work.

Things like that always happen on Friday, a fact confirmed by long experience. Just when the majority of the people are anxious to leave the mountain and to see their families.

You imagine what it then means when the road is blocked by mud and landslides! This time the event was quite extraordinary, otherwise it would not be worthwile to write its story. We do have snow on La Silla, sometimes. We also do have strong winds, even very strong ones, from time to time. But both extremes together? May be some elder ones remember.

The symptoms were unequivocal: a high dark cloud stratification, a second one lower than the Observatory, squalls whip the fog upwards the valleys, temperature decreases. Fog envelopes first the ware-house, then the work-shops, the hotel and the dormitories and eventually the highest top with the 3.6 m telescope. Clouds rush from the north-east over the La Silla ridge. It is already rather uncomfortable outside. Rain turns to snow in the evening hours. This was on Thursday.

Next morning a little snow on the roads, vehicles are stuck, drivers are scratching ice from the panes. However, they do not get very far. But nobody is really apprehensive as yet. This will start only one hour later. Wind speed increases, snow fall is so intensive that the visibility is only a few meters. In a few places feverish activity develops in spite and because of the nasty weather: snow chains are prepared for the vehicles, equipment is covered with plastic foils for water protection, a car goes to Pelícano to inspect the road conditions, the porter there reports heavy rain fall.

Shall we now send the people down to La Serena? What becomes of the air-plane passengers? Who remains on the mountain? Lots of other questions! Here the decisions: the bus leaves at 11 o'clock taking also the air passengers to La Serena, from there they shall continue by ground transport, only a small emergency group of a dozen persons shall stay.

Suddenly the electric power supply of the whole Observatory fails. There is no possibility to locate the failure, a short circuit somewhere. We know only it is not in the new high tension line, but the rest is dead. The snow-storm prevents the access to the switching stations, so there is no means to isolate the defect. The snow-plough shall open a way! Sorry, it is since a long time busy on the road to Pelícano, far away.

From now on the characteristic events will be recorded as episodes, not quite in chronological order, but characteristic.

Shivering and soaked people gather in the dining-room waiting for transport to the car workshop from where the bus will leave to La Serena. Hundreds of questions! Especially by the visitors, astronomers, Garching staff. Some want to leave, others not. Can I leave my equipment behind? How is the road condition? Why does the telephone not work? How can I come to Santiago? Is there a bus from La Serena?

Wind velocities are registered on Friday morning up to about 120 km/h. But then nothing more. No electricity means no signal transmission and nobody thought of standing out in the horizontally drifting snow holding up an anemometre.

The passenger bus said to be ready to start is lacking gasoline. Also there is no electricity. Some mechanics work