SPECIAL SESSION ON SPACE OBSERVATIONS OF STELLAR OSCILLATIONS

Although the majority of the attendents to the Conference were solar physicists, it had seemed worthwhile to devote a session to stellar seismology, with the specific intent of discussing the need for space observations. The interest for this topics had been triggered by the talk presented by Fossat, and his comparative estimates of the sources of noise and of the ultimate noise level to be reached from the ground.

The session took place, chaired by F.L. Deubner, and included the following contributions :

1) Stellar projects proposed to ESA
2) Photometric limits of ground based observations
3) Short contributions and General Discussion
4) Prospective of future actions

Presentation of the space projects submitted to ESA in november 1982

F. Praderie reported on the PSIVA concept (PSIVA = Probing Stellar Interiors through Variability and Activity), a project born in France, whose leader is A. Mangeney from Paris-Meudon Observatory (Mangeney et al., 1982). The aim of the proposed space mission is to provide long series of continuous observations (i) in photometry, i.e. in a broad white light band, at the precision level of the photon noise, (ii) in a spectrographic mode, i.e. in four channels selected to follow along time the magnetic activity variations at chromospheric and transition zone levels. The photometry channel of the experiment would allow the detection of solar-type non radial oscillations in the frequency range 10^{-2} to 10^{-6} Hz, with amplitude of order of the micromagnitude per mode, and adequate frequency separation, provided long enough time is spent over the same object (~20 days with a 40 cm telescope and for a V=7 star). The spectrographic channel would permit to study rotational modulation of emission in solar type stars, as well as the level of emission which, at chromospheric altitude, is a measure of the magnetic flux. The two major hopes of the proposed mission are therefore : 1) to benefit of the progress in helioseismology, both observational and theoretical, to extend to stars the same type of extremely fruitful diagnostics of the internal structure 2) to obtain a view, in the same stars, of the average magnetic field intensity at chromospheric and transition zone altitude, as well as of the size of the active regions structured by the magnetic field, in view of putting more constraints on the dynamo mechanism generating this field within the convective zone. A first examination led the proposers to consider the observation of about 50 stars in two years, with a 40 cm telescope, stabilized to 10" (absolute precision).

G. Isaak then introduced his project for space stellar seismology (Isaak, 1982). He first argued that detection of stellar oscillations from radial velocity (V_R) measurements, i.e. in spectroscopy, was certainly within reach from the ground, because instrumental problems are less than in the solar case, in particular one would not suffer from variations of transparency across the disk, because the star is seen in full disk.

However, very large telescopes are needed for this purpose, because one needs enough photons in narrow enough spectral intervals.

This is why brightness fluctuations studies are a more precious tool. One aims at photon statistics precision, and wants to measure with confidence fluctuations of 10^{-6} magnitude per frequency band. The latter figure emerges in particular from the findings of Woodard and Hudson (1983) on the Sun. The philosophy of the project is to look at a few stars at depth. To reach precision photometry at the 10^{-6} level, and to have enough resolution so that rotational splitting can be seen, one needs 3 months observation per star. The frequency range would be 0-10 mHz, the resolution in frequency 0.1 μHz. Hence, in what Isaak considers a very unusual mission, about 10 stars would be observed in a 2 to 3 years time. However, the challenge is immense to place the theory of stellar structure on experimental basis.The proposed experiment would require a 1m class telescope, on a stabilized platform. The telescope could be made of light material, with no strong requirements on the optical performance specifications.

What can be achieved from the ground ?

In an introduction preceding invited remarks on the relative merits of ground-based and space observations, G. Isaak reconsidered the figures given by Fossat for the permormances to be expected from ground. Indeed Fossat had claimed that a fluctuation of order 10^{-5} can be visible near 0.3 mHz at a 3σ level if the object is observed from the ground during 3 months, provided the signal is coherent over this period of time. To reach 10^{-5} amplitude fluctuation, while being definitively limited by the atmospheric turbulence, will make the case difficult to detect solar type oscillations ; Isaak concluded that he is not optimistic as to the possibility to ever do it from the ground.

F.L. Deubner reported on broad band photometric measurements performed at La Silla on two solar-like stars (HD 1273 and HD 4308) each of which was observed on four consecutive nights with the Dutch 92 cm telescope. During fair seeing conditions a r.m.s. noise level of the individual readings of 1.3 to $1.7.10^{-3}$ was achieved, yielding a noise level of $2.5.10^{-5}$ per frequency interval in the range of interest. Extrapolating to an observing time of 3 months the noise level would be lowered to about $0.6.10^{-5}$ which still appears insufficient to detect any solar-like signals. However, the result encourages the ground based search for low-l p mode oscillations in F-type main sequence stars.

P. Delache reported that he and Hudson had proposed to NASA to use the star trackers, directed toward the guiding stars, on any future space mission, to record the light fluctuations of these stars. The value of the project is based on the results of SMM, which gave a "serendipity bonus" to the measurement of the solar constant, by registering its variations along time. P. Delache also presented the ground based project of the Nice group (Le Contel et al) who is designing a closed-structure, ground based telescope to be installed at the South Pole for continuous photometric night observations of stars. The acronym of the project is EVE. The

telescope will be a completely automatic 60 cm. Four objects will be monitored simultaneously through two narrow band filters, one centered around λ 3500 Å and the other one around λ 4700 Å. The four selected objects could be a variable, two comparison stars and the sky. It is expected to reach a 10^{th} magnitude B type star in 100 sec with a signal over noise of 10^3. In answer to a question, it was agreed that the aurorae would be a constraint for these observations, except if one observes in fairly narrow filters.

N. Dolez exposed his experience in observing very short period variable stars, the ZZ Ceti white dwarfs, which present the advantage (for us) to vary over several periods during one night. However, their variability is itself variable in amplitude, and long sequences of observations, which would be easily obtained from space, are required to understand the specific characteristics of those stars' pulsations.

General discussion

The discussion addressed two types of topics : 1) Should we monitor stellar variability in radial velocity or in brightness fluctuations measurements ? 2) What are the chances of a space mission to be ever approved by any of the agencies ?

Various techniques to measure radial velocities were mentioned. Righini quoted a limit of 1m s^{-1} obtained on the Sun with a Fabry-Perot, and stressed the advantages of this system over resonance cell spectrometers.

Roca Cortes drew attention to work performed at Imperial College, London, on δ Scuti stars, with a Michelson interferometer. They have also a laser stabilized Fabry-Perot, which has not yet given results, but they hope to achieve the 1m s^{-1} level.

A mention was made to the absolute astronomical accelerometer recently studied by P. Connes ("a variable path interferometer whose channeled spectrum is constrained by a servo loop to track the Doppler shifted astronomical spectrum ; then a tunable laser tracks the interferometer. The ultimately measured quantity is the beat frequency between tunable laser and a stabilized one", P. Connes, 1983).

The FH cell device of Campbell (Campbell and Walker, 1979) whose principle is to superpose the laboratory FH spectrum on the stellar one, was quoted to provide V_R to 10 m s^{-1} in its present version, and in one night observing.

The Fourier tachometer of T. Brown (Beckers and Brown, 1979) can work on a large number of lines at a time.

M. Smith's technique, which compares the stellar spectrum to the telluric one was presented by Soderblom ; Isaak pointed out that this technique suffers from sensitivity to upper atmospheric winds as well as the earth's rotation.

As a general come out of these interventions, it seemed clear that in a near future, stellar seismology through V_R measurements will have been tried in a number of places, but the detection limit, even if brought to 1m s^{-1}, is still 10 to 100 times larger than what is required, following existing solar results. No one has demonstrated that ground based observations are impossible, they are just difficult.

The chances of a space mission devoted to the study of brightness fluctuations were then examined. Roxburgh expressed the fear that the present community supporting stellar seismology from space is too narrow. One should then either design an instrument which can observe more stars, or bring a new community in (solar-terrestrial, for instance), or introduce guest investigators in a too strictly problem-oriented mission.

Rodono supported the idea of monitoring jointly variability and activity in stars, and suggested not to restrict to the sole seismology objective. Actually, both research objectives require just the extensive monitoring times that can be achieved by using space born instruments. This approach is not only feasible and scientifically fruitful, but is essential because stellar activity phenomena typically produce sizable fluctuations in brightness (cf. Byrne and Rodono,1983 ; Stenflo,1983) that might affect seismology observations. Effects of spots and other activity phenomena have to be taken into account (cf. Andersen, this volume), since high photometric accuracy is needed for seismology studies. Moreover, the advantage of attracting to the proposed space project the large scientific community, presently involved in stellar activity programs, is obvious and should not be overlooked.

The american approach to the problem of photon-noise limited photometry from space was briefly presented : an All Sky Survey Photometric Explorer is presently planned by Hudson, it involves a spinning satellite with a number of small size telescopes organized in a circle around the spinning axis.

Future plans

In spite of Cassandra warnings on the possibility to ever track stellar oscillations from a space platform, plans were devised to build a small european interest group around the question of stellar seismology. A close calendar mark is provided by the next call for proposals to be issued by the European Space Agency. As both projects presented in 1982 (Mangeney et al, Isaak) were postponed by the expert group AWG on the mere argument that the interested community is too small (but not on a feasibility argument), it would be profitable 1) to join the two projects 2) to further discuss in detail the major arguments supporting the need of a space platform, to conceive an instrument (or two on a same platform) which meets the requirements, and to write a new document associating a number of european specialists in stellar seismology and activity. This discussion at depth, with an enlarged stellar community relative to that present in Catania, could take place during a specialized workshop. F. Praderie proposes to hold it in Meudon Observatory in the name of the nucleus of an organizing committee, whose chair has been accepted by Prof C. de Jager. The dates of Feb 29, March 1 and 2 1984 are considered, and

seem to fit both the expectations of the audience and the ESA calendar for depositing new proposals in the planning cycle.

The alternatives for a context of realisation are then shortly examined : a contact will be taken with H. Hudson ; some possibilities of flights within the soviet space program or may be in a collaborative european-japan program are also mentioned.

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