connue suivant l'équateur de la planète ou en effectuant un pas en différence de marche. Ces deux calibrations fournissent le même résultat, à condition toutefois que la bande spectrale contienne le minimum de raies telluriques.

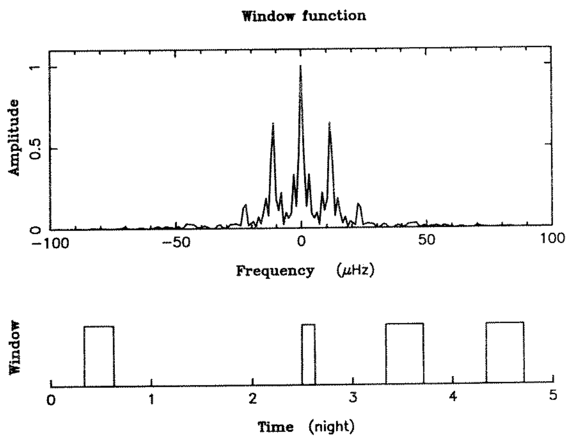

Figure 19: Fenêtres produites par les observations de Jupiter de Janvier 1991. La deuxième nuit a été perdue à cause de problèmes techniques, et une grande partie de la troisième à cause du mauvais temps. En haut, la fonction fenêtre avec tous ses pics secondaires par laquelle se trouve convolué le spectre des oscillations.

La réduction des données, effectuée à Nice par D. Mékarnia, consiste en la création d'un fichier unique de vitesse en fonction du temps dans lequel se trouvent raccordées toutes les séquences d'observation, après élimination des points aberrants et calibration. Le spectre en puissance de ce fichier final est le document (fig. 18) sur lequel il faut essayer d'identifier les nombreux pics présents, tâche ardue menée en priorité par B. Mosser (Meudon). L'alternance jour-nuit et les autres causes d'interruptions accidentelles forment une fonction faite de créneaux successifs qui multiplie l'enregistrement de vitesse. Le spectre des oscillations se trouve donc convolué par la transformation de Fourier en puissance de cette fonction (fig. 19). Ceci a pour effet de générer de nombreux pics parasites dans le spectre. D'autres méthodes, classiques en sismologie solaire aident à mener cette identification, en particulier l'établissement de *diagramme échelle* pour rechercher l'équidistance des pics. Dans le cas de Jupiter, cette équidistance qui correspond à un dédoublement des modes est une information importante. Elle résulte de la structure même de la planète avec un noyau central similaire à la Terre et l'enveloppe d'hydrogène et d'hélium. Elle peut être reliée à la fréquence caractéristique des oscillations. Une équidistance de 136 μHz avait été proposée d'après les observations avec la cellule de sodium. La même valeur a été mesurée sur les données FTS confirmant par une méthode complètement indépendante ce résultat. Une équidistance des modes comprise entre 150 et 190 μHz est prévue par les modèles de l'intérieur de Jupiter. Ceci implique une révision profonde de ces modèles qui est en cours de discussion car elle suppose de réexaminer les approximations faites avant de proposer des conséquences pour l'intérieur de Jupiter. D'autres résultats sont encore à tirer, par l'identification plus complète des modes. D'autres observations pourraient être nécessaires maintenant que la méthode est maitrisée pour lever des ambiguités qui subsistent, et surtout améliorer la fonction d'appareil des spectres.

L'exploitation du FTS dans ce mode est à ses débuts. L'extension à la sismologie stellaire dont on a signalé l'intérêt astrophysique est une voie à explorer. Comparé aux autres méthodes depuis le sol l'interféromètre présente plusieurs avantages:

- une plus grande luminosité par ses propriétés multiplex qui permet d'utiliser l'information Doppler d'un grand nombre de raies,
- l'existence d'une calibration interne en vitesse
- l'absence de contraintes strictes sur les dates d'observation comme c'est le cas avec la cellule à sodium.

J.-P. Maillard

δ Scuti Variables: Detection of High-degree Modes by Time Series Analysis

Theory predicts the presence of a multitude of modes and periods or δ Scuti stars but these are rarely seen in photometric investigations. The sensitivity of high resolution spectroscopy to high-degree nonradial pulsations (NRP) is yielding some answers. Ultimately, the promise of multiperiodicity in δ Scuti stars is in the art of stellar seismology to determine global properties of the stars. But more basic questions must be answered first. With more than half the stars in the δ Scuti Instability Strip apparently constant photometrically, could many of these 'constant' stars be variable with only high-degree NRP or do these modes only occur in the presence of low-degree modes? Do rotation rate and spectral type play a role in mode determination? For δ Scuti stars the factors which determine their modes of oscillation are still not well understood.

Classically, variability within the δ Scuti Instability Strip has been determined photometrically, which is sensitive only to modes of low degree. However, using high-resolution (2.4Å/mm) Reticon spectra from CFHT, we found that *all* four rapidly rotating ($v \sin i \approx 100$ km s^{-1}) δ Scuti stars we observed (21 Mon, κ^2 Boo, *v* UMa, o^1 Eri) displayed travelling features in their absorption lines (at 1% of the continuum) which were interpreted as high degree ($|m| \geq 8$) nonradial pulsations (NRP) (Walker, *et al.,* Ap.J. **320**, L139, 1987). I have extended their analysis by simulating the observed line profile variations with a geometrical NRP model which generates line profiles from A- and F-type synthetic spectra. The technique was successfully applied to the singly periodic star κ^2 Boo and owes much of its success to the richness of the spectra. I identified both the low-degree mode (from radial velocity variations) and a high-degree mode (l $|m| = 12$) with a period of variation in the corotating frame of 1.7 hours which is consistent with pressure-driven oscillations.

The identification of multiple modes and periods is much more challenging and requires extensive data strings. Our spectroscopic observations of the three stars ε Cep, θ^2 Tau, and τ Peg at CFHT (October, 1990) confirmed the presence of the line profile variations we had already seen in low-resolution data. The time series of ε Cep was interrupted by fog but we managed to obtain 5 and 7 hour data strings of θ^2 Tau and τ Peg. Known to be multiperiodic from photometric data, the detection of additional high-degree modes is of particular interest in these stars. Additional observations were made on 97 Tau which proved to be variable and 14 Ari, a suspected (photometrically) constant star in the δ Scuti instability strip.

The new data are being analyzed as two-dimensional Fourier transforms in the temporal and spatial (across the profile) domains to simultaneously identify frequencies and modes of oscillation. Rotation introduces wavelength shifts of the light from different positions on the stellar surface to produce a one-dimensional mapping of the surface in each line profile (an effect known as Doppler imaging). The space-time map of θ^2 Tau shown in Figure 20 was constructed from the residual line profile variations calculated by subtracting from each profile the mean for the series. The corresponding Fourier transform is presented in Figure 21. Intensive photometric campaigns (Breger *et al*, Astron. Astrophys., **214**, 209, 1989) have detected several unidentifiable low-degree modes at frequencies near 13.5 cycles/day. These individual frequencies are not resolved in our data but we find the power at this frequency can be identified with an $|m| = 3$ mode. Additional power is associated with an $|m| = 10$ mode at $f = 15.5$ cycles/day. The sensitivity to both low- and high-degree modes demonstrates the enormous advantages offered by high resolution spectroscopy as a tool for mode identification of nonradially pulsating stars.

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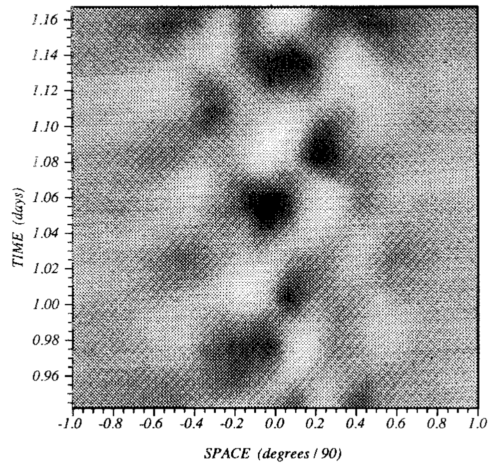

Figure 20: The line profile variations of θ^2 Tau are shown as a grey-scale map on a space-time grid. The map was interpolated from a time series of 52 observations. The position within the line profile (in units of velocity) has been transformed into angular coordinates on the stellar surface.

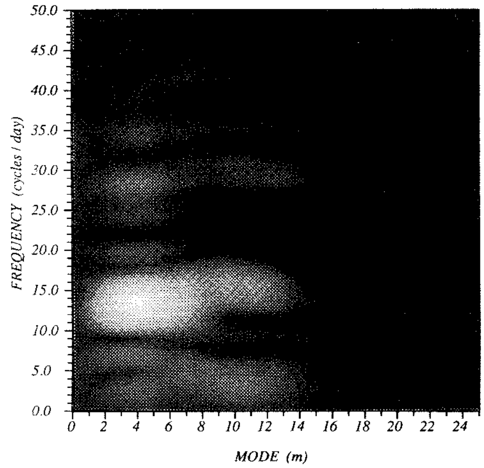

Figure 21: A two-dimensional Fourier transform calculated from the line profile variations of θ^2 Tau is used to simultaneously identify modes and frequencies of oscillation of the star.

DIRECTORS' CORNER

Staff Changes

Mel Yanos who has been serving as accountant at the Waimea headquarters for the last two years, has accepted a new position at the Kona Village Resort in last March. He has been replaced by DeeDee Warren who already has an 8 years business management career behind her. Deedee has spent 7 years at the St-Louis School in Honolulu and the last six months as controller at the Kaneohe Marine Corps base.

Roland Bacon, who spent one year at Waimea on leave from the Observatoire de Lyon, went back to his home institute in last March. He shared his vast experience of TIGER observation and reduction procedures with the CFHT staff and paved the way for the implementation of this observing mode in MOS-SIS.

CFHT has now a complete staff in the optics group. The last vacant position has been filled by Wendy Harrison. Wendy has accumulated an impressive experience as senior research engineer for AVCO RESEARCH at the Maui Satellite Tracking Station for the last 5 years. She will be technician in charge of the new f/4 coudé spectrograph. Her experience will also be put to contribution in the new CFHT adaptive optics project.

1990 CFHT Refereed Staff Publications

Arsenault, R., Roy, J.-R., Boulesteix, J. "Large-Scale Formation of Massive Stars in the Spiral Galaxy NGC 4321," *Astron. Astrophys.*, **234**, 23.

*Bender, R., **Nieto, J.-L.** "Internal Kinematics of Low-Luminosity Elliptical Galaxies," *Astron. Astrophys.*, **239**, 97.

Boesgaard, A.M., Friel, E.D. "Chemical Composition of Open Clusters. I. Fe/H from High-Resolution Spectroscopy," *Astrophys. J.*, **351**, 467.

***Bouvier, J.** "Rotation in T Tauri Stars. II. Clues for Magnetic Activity," *Astron. J.*, **99**, 946.

Davidge, T.J. "Two Micron Spectroscopy of the Nucleus of M32," *Astron. J.*, **99**, 561.

Davidge, T.J., Maillard, J.-P. "Two Micron Spectroscopy of the Blue Compact Dwarf Galaxy Haro 2," *Astrophys. J.*, **351**, 432.

Davidge, T.J., "Two Micron Spectroscopy of Galactic and M31 Globular Clusters," *Astrophys. J. Letters*, **351**, L37.

Davidge, T.J., Alloin, D., Jablonka, P. "Absorption-Line Gradients in the Optical Spectrum of the M31 Globular Cluster Vetesnik 42," *Astrophys. J. Letters*, **358**, L1.

Davidge, T.J. "CO and CN Absorption in the Near-Infared Spectra of Luminous M31 Globular Clusters," *J. Roy. Astron. Soc. Can.*, **84**, No.3, 166.

Davidge, T.J., De Robertis, M.M., Yee, H.K.C. "Long-Slit Spectroscopy of Near-Ultraviolet NH Absorption in the Nuclei of M31," *Astron. J.*, **100**, 1143.

Davidge, T.J., Pritchet, C.J. "The Nature of Bright Giants in the Halo of NGC 253 and Implications for the Distance Scale," *Astron. J.*, **100**, 102.

Friel, E.D., **Boesgaard, A.M.** "Chemical Composition of Open Clusters. II. C/H and C/Fe in F Dwarfs from High-Resolution Spectroscopy," *Astrophys. J.*, **351** 480.

Hammer, F., **Le Fèvre, O.** "High Spatial Imaging of 10 3CR Galaxies with $z \geq 1$ and Statistical Evidence for Selection Effects from Gravitational Amplification," *Astrophys. J.*, **357**, 38.

Le Fèvre, O., Hammer, F. "3CR 208.1: A Radio-Loud Quasar at $z = 1.02$ Gravitationally Amplified by a Foreground Seyfert Galaxy at $z = 0.159$," *Astrophys. J. Letters*, **350**, L1.

Nieto, J.-L., McClure, R., Fletcher, J.M., Arnaud, J., Bacon, R., Bender, R., Comte, G., Poulain, P. "The Core of the Elliptical Galaxy NGC 7052," *Astron. Astrophys. Letters*, **235**, L17.

***Nieto, J.-L.**, Aurière, M., Sebag, J., Arnaud, J., Lelièvre, G., Blazit, A., Foy, R., Bonaldo, S., Thouvenot, E. "The Optical Counterpart of the X Ray Binary in the Globular Cluster NGC 6712," *Astron. Astrophys.*, **239**, 155.

Nieto, J.-L., Bender, R., Davoust, E., Prugniel, P. "The Low- Mass Extension of the Fundamental Plane of Elliptical Galaxies," *Astron. Astrophys.*, **230**, L17.

Pècontal, E., Adam, G., Bacon, R., Courtès, G., Georgelin, Y., **Monnet, G.** "Observation of the Central Region of NGC 5728 with the Integral Field Spectrograph TIGER," *Astron. Astrophys.*, **232**, 331.