*New Perspectives on Solar Prominences, IAU Colloquium 167*
*ASP Conference Series, Vol. 150, 1998*
*David Webb, David Rust, and Brigitte Schmieder (eds.)*

# Infrared Doppler Oscillations in a Solar Filament

R. Molowny-Horas

*Observatoire de Paris, Section de Meudon, 5 Place Janssen, F-92195 Meudon, France*

R. Oliver and J. L. Ballester

*Departament de Física, Universitat de les Illes Balears, E-07071 Palma de Mallorca, Spain*

F. Baudin

*National Solar Observatory, National Optical Astronomy Observatory, P.O. Box 26732, Tucson, AZ 85726, USA*

**Abstract.** We present the results of a high spatial resolution investigation of Doppler oscillations in a solar filament, using the He I 10830Å infrared line. Fourier power spectra of Doppler shifts reveal the presence of periodic signals. Two features, showing oscillations at 2.7 min and 12.5 min, have been studied. The use of the so-called wavelet analysis enables us to estimate the size of both features at 2.7 arc sec and 4.75 arc sec, respectively. Their approximate lifetimes are 10 min and 20 min.

## 1. Observations and Data Processing

A time series of CCD spectra of a solar filament (S44°, CM0.0) was recorded on October 15, 1996 in the infrared line He I 10830Å at the VTT (Vakuum-Turm-Teleskop) telescope of the Observatorio del Teide on the Canary Islands. The time interval between consecutive images was 7 sec, and the observations started at 10:31 UT and lasted for 72.3 min, giving a total of 620 CCD frames.

The slit of the spectrograph was placed approximately along the major axis of the filament. The slit width of the spectrograph was 150 $\mu$m, corresponding to 0.69 arc sec on the Sun. After a $2 \times 8$ spatial $\times$ spectral on-line binning was performed, the final scale per frame was 0.19 arc sec and 0.027Å respectively. During the acquisition, the IAC-KIS correlation tracker (Ballesteros et al. 1996) was operated simultaneously.

Line bottom position was calculated via a 6th-degree polynomial fit to the line profile, which included some continuum on both sides. Following Gheonjian et al. (1989), we have restricted our analysis to the investigation of oscillatory signals in Doppler velocities only.

## 2. Results

A temporal Fourier periodogram at each spatial location is plotted in Figure 1. At position **a** power is seen at a frequency of $\approx$ 6.2 mHz (2.7 min). A Lomb-Scargle analysis demonstrates the high significance ($\geq$ 99.99%) of this power peak. At the **b** location, significant power is also observed at a frequency of $\approx$ 1.33 mHz (12.5 min). We have restricted our investigation to points around slit positions marked **a** and **b**, although other slit points also show significant power at various frequencies.

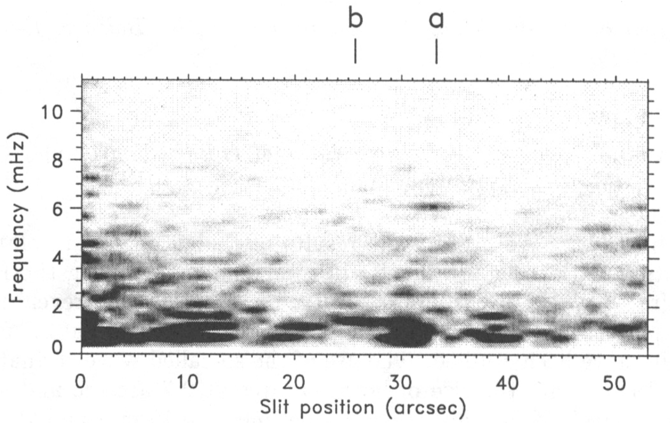


Figure 1. Fourier periodogram at points along the slit. Notice that the colour gray table has been reversed, i.e. darker areas define higher power. Labels **a** and **b** at the top refer to slit positions as explained in the text.

Time/frequency diagrams of the signal at the slit location **a**, calculated with the so-called wavelet analysis (used for example by Bocchialini and Baudin 1995), are shown in Figure 2. We especially notice the evolution of the 2.7 min signal, starting at T$\approx$ 40 min, and ending at T$\approx$ 50 min.

The wavelet diagrams in Figure 2 allow us to estimate the size of feature **a** at $\approx$ 2.67 arcsec. For the perturbation **b**, we estimate from the wavelet analysis (not shown) a size of $\approx$ 4.75 arcsec.

From the wavelet diagrams it is also straightforward to infer a typical lifetime for the perturbations **a** and **b**, which are $\approx$ 10 min and $\approx$ 20 min, respectively. This is in good agreement with a previous similar study (Molowny-Horas et al. 1997).

The relative Fourier phase of the signals labelled **a** and **b** in Figure 1 are shown in Figures 3a and b, respectively. Both signals are seen to vary approximately linearly along the slit.

From the phase diagrams, we can set an upper limit to the actual wavelength of the perturbation, assuming a plane wave propagating in the filament (for details, see Molowny-Horas et al. 1997). For feature **a** we obtain $\lambda \leq 46,000$ km, whereas for feature **b** our estimate yields $\lambda \leq 31,000$ km.

https://doi.org/10.1017/S0252921100047461 Published online by Cambridge University Press

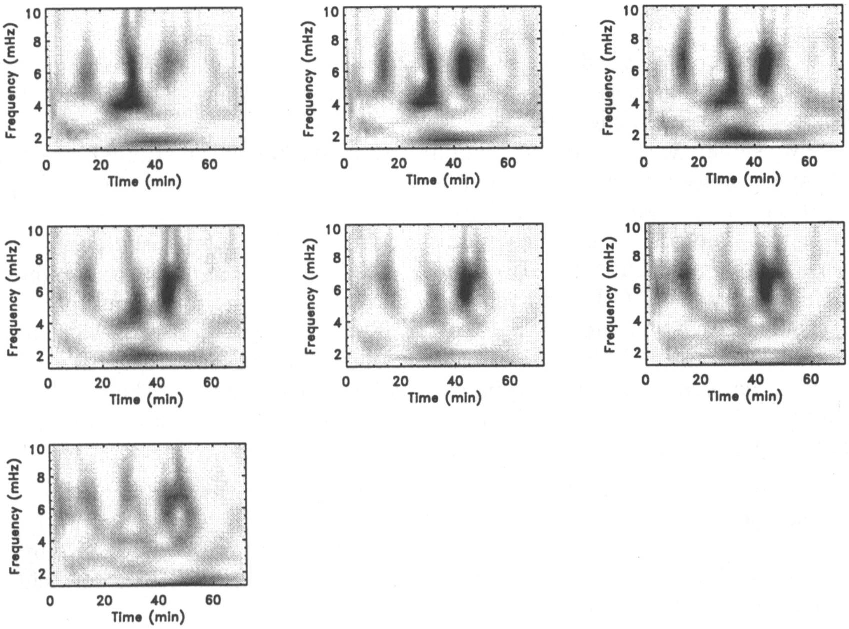


Figure 2. The wavelet diagrams above correspond to consecutive points within the region of the slit labelled **a** in Figure 1. The colour scale has been reversed, i.e., darker colour tones mean greater power.

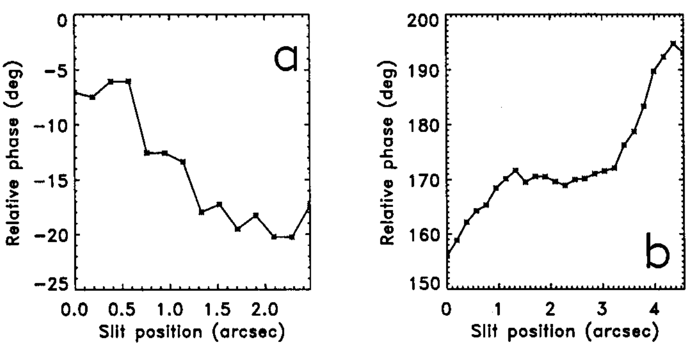


Figure 3. Relative phase difference corresponding to slit locations **a** (upper plot) and **b** (lower plot) of Figure 1.

https://doi.org/10.1017/S0252921100047461 Published online by Cambridge University Press

## 3. Conclusions

Evidence has been found of the existence of oscillatory plasma motions in a solar filament. Our work agrees with previous investigations (Zhang et al. 1991; Thompson and Schmieder 1991).

Two signals with periods 2.7 min and 12.5 min have been studied. It should be noticed, however, that other signals, which may also represent periodic perturbations, have been observed. With the aid of the wavelet analysis it has been shown that the oscillations occur during limited time intervals. The present results also demonstrate the advantages of the use of an on-line image stabilizer (in this study, the IAC-KIS correlation tracker) to reduce image motion.

Future work will include a comparison of the present results with previous observational and theoretical calculations. The spatial orientation of the observed filament, however, may make it difficult to determine the MHD mode responsible for the reported periodic signals (see Oliver and Ballester 1998, these proceedings, and Joarder et al. 1997).

**Acknowledgments.** RMH thanks the THEMIS telescope for supporting his post-doctoral position at the Observatoire de Meudon through a CIES grant. The Vakuum-Turm-Teleskop (VTT) is operated on the island of Tenerife by the Kiepenheuer-Institut für Sonnenphysik in the Spanish Observatorio del Teide of the Instituto de Astrofísica de Canarias.

## References

Ballesteros, E., Collados, M., Bonet, J.A., Lorenzo, F., Viera, T., Reyes, M., and Rodríguez Hidalgo 1996, A&AS, 115, 353

Bocchialini, K., and Baudin, F. 1995, A&A, 299, 893

Gheonjian, L.A., Klepikov, V.Yu., and Stepanov, A.I. 1989, Hvar Obs. Bull. 13 No. 1, pp. 147

Joarder, P.S., Nakariakov, V.M. and Roberts, B. 1997, Solar Phys., 176, 285

Molowny-Horas, R., Oliver, R., Ballester, J.L. and Baudin, F. 1997, Solar Phys., 172, 181

Thompson, W.T. and Schmieder, B. 1991, A&A, 243, 501

Zhang, Y., Engvold, O., and Keil, S.L. 1991, Solar Phys., 132, 63