VERTICAL VELOCITIES AND OSCILLATIONS IN QUIESCENT FILAMENTS

ZHANG YI and ODDBJØRN ENGVOLD

Institute of Theoretical Astrophysics, University of Oslo, Blindern, N-0315 OSIslo 3, Norway

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Abstract. Analysis of He I 10830 Å spectral observations of a large, quiescent filament reveals a pronounced oscillatory behaviour of the vertical mass motion. The filament is situated in a quiet region more than 15° away from the nearest active region.

It is concluded that the magnetic field of the quiescent filament, which occurs in the form of long thin flux ropes, moves with the gas and that there is no net mass flow perpendicular to the most frequently observed horizontal field lines. The oscillatory motion is accompanied by phase dependent variation of the He I line intensity which could possibly imply wave induced compression of the plasma.

1. Introduction

The small-scale, line-of-sight motions of quiescent prominences observed at the limb of the Sun are typically a few km s⁻¹. References to recent observations are given in a review by Schmieder (1989). At the prominence edges, or edges of its sub-structure, appreciably higher velocities are detected (Engvold, Malville, and Livingston, 1978; Vial et al., 1979). Recent studies suggest that these horizontal motions are oscillatory (Tsubaki, 1988, and references given therein).

The general downward motion often seen in filtergram observations of prominences at the limb (Dunn, 1960; Engvold, 1976) is not confirmed by Doppler measurements in quiescent disc filaments. Mein (1977), Malherbe, Schmieder, and Mein (1986), Simon et al. (1986) show a dominant blueshift in Hz. Similarly, Engvold and Keil (1986) found a predominance of blueshift in the He I 10830 Å line in quiescent disc filaments. Studies by Kubota, Tohumura, and Uesugi (1988) detected both up- and downward motions in observations of the Ca II K line, and the authors conclude that ‘downflows’ are associated with ‘legs’ of the prominence. Kubota, Tohumura and Uesugi (1989) found also that the Hz line shifts were remarkably stable over several hours. You and Engvold (1989) compared simultaneous observations in Hz, Ca II H and K in a large disc filament and found consistent values for the line shift.

In conclusion, the vertical mass motions are found to be directed both upwards and downwards, and the measured velocities range generally between -4 km s⁻¹ and +5 km s⁻¹.

Very recently, also the vertical motions were found to show oscillatory behaviour with periods in the range 5 to 15 min (Yi Zhang, Engvold, and Keil, 1991). At the same time, Thompson and Schmieder (1991) detected short period oscillations (3–4 min) in two Hz filaments. These new results may very likely shed light on the apparent paradox of vertical mass motion perpendicular to the predominantly horizontal magnetic fields of quiescent prominences (Leroy, 1989; Schmieder, 1989). The present study investigates...
observationally whether or not the vertical mass motions of quiescent filaments (prominences) could represent oscillatory motions of matter trapped in a horizontal magnetic field.

2. Observations and Data Processing

A total of 17 different filaments were observed during the period May 3 through May 9, 1981, using the main spectrograph of the Vacuum Tower Telescope of NSO Sacramento Peak (Dunn, 1969). Six of the filaments were observed on two or more days. The present study focuses on the longest two sequences from May 3 and 4 of one large quiescent filament. This filament was situated in a quiet area in south latitude between 8° and 27°, and at longitudes E 39° and E 26°, respectively, on May 3 and 4 (see Solar Geophysical Data, Nos. 442–444). Its angle of inclination with the N–S direction was about 21°. The nearest active regions, Hale Plages Nos. 17630 and 17631, were situated about 15° away, in the eastward direction.

Our observations during the 6-day period, as well as the much longer time base of the Solar Geophysical Data, show that the filament was very stable. It belonged to a section of a filament channel that passed the meridian on April 9, May 6, and June 2, 1981. The filament possibly underwent a fracturization on May 6, but it resumed its previous shape the next day.

Each series of scans consist of 60 spectral frames recorded in rapid succession while the solar image drifted across the entrance slit of the spectrograph. The time difference between successive scans is 140 s. The slit positions of adjacent exposures are barely overlapping, and the data covers an area on the Sun of 76 × 100 arc sec². A 100 × 100 pixel CCD camera was used to record 100 arc sec by 6.0 Å spectral sections centred on the chromospheric He I λ10830 Å line. Each spectral exposure also contains the photospheric Si II λ10827.109 Å line, and the atmospheric water vapour line at λ10832.109 Å. Both lines were used for calibration of the wavelength scale (cf. Breckinridge and Hall, 1973). Standard procedures were applied to correct the CCD images for variable pixel sensitivity and dark current.

In summary, 76 × 100 arc sec² images giving continuum and line intensities, Doppler shifts in the filaments, as well as at the photospheric level, were constructed from the series of spectral recordings.

Further details on the data processing are given by Yi Zhang, Engvold, and Keil (1991).

3. Results

3.1. Velocity Profile of the Fibril Structures

The oscillatory character of the Doppler velocity of quiescent filaments is discussed in the paper by Yi Zhang, Engvold, and Keil (1991). Individual fibrils of the quiescent filaments observed on 3 and 4 May, 1981 could be identified as elongated areas