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POSSIBLE EXPLANATION OF THE 300-SECOND TYPE OSCILLATION IN THE SOLAR CHROMOSPHERE

If we restrict our attention to heights larger than 1000 km above $\tau_{5000} = 1$, there is the possibility that the oscillations of the 300-sec type in the solar atmosphere discovered by Leighton (1960) may be explained by the Väisälä (1925) mechanism.

The mechanism is as follows: an element of gas shifted out of the rest position in vertical direction by some disturbance will be forced back to this position by the buoyancy force if the atmosphere is convectively stable. The element will overshoot this rest position and oscillate with the Väisälä frequency. This frequency is (Whitaker 1963)

$$\omega_v = \left[\frac{g}{T}\left(\frac{dT}{dz} - \frac{dT'}{dz}\right)\right]^{1/2}, \tag{1}$$

where T is the temperature, dT/dz the temperature gradient, dT'/dz the temperature gradient of the element, and g the gravitational acceleration at a given point in the atmosphere. At heights larger than 1000 km above $\tau_{5000} = 1$, the period of oscillation is small against the radiative decay time (Noyes and Leighton 1963). Here the element oscillates adiabatically, and we have

$$\frac{dT'}{dz} = -\frac{\gamma - 1}{\gamma H} T, \tag{2}$$

where H is the scale height and γ is the ratio of specific heats.

To see how this may explain the observed oscillations we take, for example, the line Ca II $\lambda 8542$ which is formed at a height of about 1700 km and has an oscillation period of about 200 sec (Noyes and Leighton 1963). Assuming $T = 6500°$ K and $dT/dz = 5°$/km, we obtain with $dT'/dz = -18.7$ °/km a period of 200 sec, and with $dT/dz = 10$ °/km a period of 180 sec.

There are further points in favor of the Väisälä mechanism.

1. Because the radiative decay time is large compared with the oscillation period at heights larger than 1000 km, the Väisälä mechanism has the character of a resonance. Jensen and Orrall (1963) and Noyes (1967) report this resonance character. The oscillations start suddenly and die out or change phase abruptly. Evans and Michard (1962) and Edmonds, Michard, and Servajean (1965) have observed that some time after a maximum in the continuum brightness fluctuation an oscillation starts at one height and still later at a greater height. This again points toward the picture of a local resonator being kicked on or out of phase by a propagating disturbance.
2. The Väisälä oscillations are vertical, which is the same for the observed oscillations at greater altitude (Evans and Michard 1962; Noyes 1967).
3. The observations (Evans, Main, Michard, and Servajean 1962; Jensen and Orrall 1963; Noyes 1967) that the maximum of the brightness oscillation occurs one quarter period before the upward maximum of the velocity oscillation is also exhibited by the Väisälä oscillations. Noyes and Leighton (1963) have proposed traveling waves to account for the observed velocity oscillations. But for traveling waves there is no phase shift between brightness and velocity oscillations (Whitney 1958).
4. The Väisälä mechanism provides a continuous change of period with height in the sense that the greater the height the smaller the period because dT/Tdz is expected to increase in the chromosphere. This fits the observations more naturally than the discrete frequency spectra which Bahng and Schwarzschild (1963) and Uchida (1965) have ob-

tained by fitting standing waves into the analogues of an open and closed pipe, respectively. The pipe-type mechanism would lead moreover to a superposition of standing waves of fairly different frequencies at a given height which is not observed.

5. The influence of magnetic field is such that the oscillation frequency (eq. [1]) is decreased (Kuperus 1965) by a factor of $[c^2/(c^2 + c_a^2)]^{1/2}$, where c is the sound velocity and c_a the Alfvén velocity. A marginal indication of this has been observed by Orrall (1966).

To summarize I want to state that the Väisälä mechanism might be very useful in explaining oscillations and for measuring heights of line formation in the solar atmosphere. On the basis of this mechanism it seems that oscillations should occur also at much greater altitude.

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