(McLaughlin 1934), but an earlier study by Schlesinger (1910) gave originally $-45.0$ km/sec. Sahade and Hernandez recomputed the orbit from Schlesinger's observations and found $\gamma = -43.4$ km/sec. They pointed to differences between the wavelengths used by them and those listed by Schlesinger for the stellar lines as an explanation of the large difference of $\gamma$ yielded by Schlesinger's observations and theirs.

Although the numerical differences of wavelengths are very closely the right amount and of the correct sign to account for the velocity difference, this agreement is completely fortuitous. In comparing old and modern observations it is necessary to examine critically into the systems of wavelengths used. The wavelengths listed by Schlesinger are in the old Rowland system, which was widely used at that time. Since his comparison lines (Schlesinger 1907) were also on the same system, his determinations of radial velocity would contain no appreciable error due to this cause. The differences of wavelengths, 0.16 to 0.18 Å, that Sahade and Hernandez list are very closely those that could be read from the plot of differences between Rowland and International wavelengths on page vii of the Revision of Rowland's Preliminary Table of Solar Spectrum Wavelengths (St. John et al. 1928). We must therefore seek elsewhere for the cause of the differences of $\gamma$ for $\delta$ Librae.

A large part of the difference may be due to Schlesinger's method of measurement. This opinion was held by the late R. H. Curtiss (personal communication). Schlesinger and Curtiss (1908) both measured the same set of spectrograms of Algol, and the values they derived for $\gamma$ differed by about $+5$ km/sec in the sense Curtiss minus Schlesinger. Curtiss measured in the conventional manner, with the plate "direct and reversed" on the measuring engine. Schlesinger, on the other hand, simply reversed the measuring engine without altering the relationship of the plate to the screw and microscope (Schlesinger and Curtiss 1908, p. 32).

There is still, of course, a possibility that a part of the difference found in $\delta$ Librae may be due to a real change in the center of mass velocity.

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REFERENCES

——. 1910, ibid., p. 123

ON THE OSCILLATIONS OF THE SOLAR ATMOSPHERE

Evans and his co-workers suggest in a recent paper (1963) that the oscillations which they and Leighton (1962) have observed are associated with the transient phase of a sonic disturbance that is produced by an underlying granule. During the life of the oscillation, its character changes from that of a progressive wave to that of a standing oscillation at the resonant frequency of the atmosphere.

The purpose of this note is to demonstrate, on the basis of a simple model, that this hypothesis is capable of explaining some puzzling features of the observations. Specifically, the observed height variation of the period and the transition from a progressive to a standing wave become understandable.
Imagine an isothermal atmosphere supported against the force of gravity by a rigid piston which represents a granule. Initially, the piston and the atmosphere are at rest. Then at some time \( t = 0 \), the piston suddenly begins to move upward at the uniform velocity \( V \). The velocity, \( v \), of a gas element originally at the altitude \( Z \) above the initial position of the piston satisfies the wave equation

\[
v_{tt} - \frac{1}{H} v_x = \frac{1}{a^2} v_{tt},
\]

with the initial condition \( v(Z, 0) = 0 \) and the boundary condition \( v(0, t) = V \). We are considering an infinite atmosphere. Hence, at \( Z = \infty \), only outward-moving waves will be present.

Lamb (1908) found general Fourier integral solutions applicable to this problem. We chose, however, to apply the Laplace transform method (McLachlan, 1955). We find that the velocity \( v \) as a function of height \( Z \) and of time \( t > z/a \) is

\[
v = Ve^{\pm aH} \left[ 1 - \frac{a}{2H} \int_{z/a}^{t} J_1(\alpha \gamma / 2H) \frac{1}{\gamma} \, d\gamma \right], \quad y = \sqrt{\alpha - (z/a)^2}.
\]

This solution is valid so long as the displacement of a particle is small compared with its original altitude.

### Table 1

**Oscillation at Two Heights**

<table>
<thead>
<tr>
<th>Max</th>
<th>Min</th>
<th>Time of Arrival</th>
<th>Time Lag</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( Z_1 )</td>
<td>( Z_2 )</td>
<td>( t_2-t_1 )</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>40(^s)</td>
<td>72(^s)</td>
<td>32(^s)</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>340</td>
<td>345</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>641</td>
<td>644</td>
<td>3</td>
</tr>
</tbody>
</table>

The front of the disturbance propagates at the velocity of sound \( a \), and leaves in its wake a train of oscillations. As seen at a fixed point in the atmosphere, the period of these oscillations increases with time and within a few cycles approaches the resonant period \( P = 4\pi(H/\gamma g)^{1/2} \). The velocity amplitude damps rapidly as the velocity at the fixed point approaches the final value, \( V \).

An interesting aspect of these oscillations is the time change of the phase difference between two heights. A numerical example will serve to illustrate this feature. Take \( T = 5000° \, K \), \( \gamma = 1 \), \( g = 2.74 \times 10^4 \). Evans and Michard (1962) observed a time lag of 40 seconds between the appearance of a bright granule and the beginning of an oscillation in \( \lambda 5173.5 \). This result fixes \( Z_1 = 40a = 260 \, \text{km} \). The velocity amplitude of this same oscillation was twice as large when measured at the height \( Z_2 \) at which \( \lambda 5172.7 \) is formed. If \( \rho a^2 = \text{constant}, \) this result fixes \( Z_2 - Z_1 = H \ln 4 \) or \( Z_2 = 475 \, \text{km} \).

Table 1 shows the theoretical time of arrival of successive maxima and minima at the two heights. From these we have computed the time lags and the intervals between successive maxima and successive minima. The time intervals between minima are inclosed in parentheses. We label these intervals as the "period," in conformity with the practice of observers, although, of course, the phenomenon we describe is only quasi-periodic.