REFERENCES

1. Lighthill, M. J. *Proc. R. Soc.*, **A 267**, 147, 1962.
2. Moore, D. W., Spiegel, E. A. *Astrophys. J.*, **139**, 48, 1964.
3. Unno, W., Kato, S. *Publ. astr. Soc. Japan*, **14**, 416, 1962.
4. Kato, S. *Publ. astr. Soc. Japan*, **15**, 204, 1963.
5. Lighthill, M. J. *Proc. R. Soc.*, **A 211**, 564, 1952.
6. Curle, N. *Proc. R. Soc.*, **A 231**, 505, 1955.
7. Proudman, I. *Proc. R. Soc.*, **A 214**, 119, 1952.

DISCUSSION

M. Kuperus. Does the interference between the various multipole radiation fields occur in a constructive or a destructive way?

W. Unno. The interference between quadrupole and monopole radiations is mainly destructive. The interference of dipole radiation with quadrupole radiation and that with monopole radiations seems to cancel each other mostly.

P. A. Sturrock. Dr Unno's analysis is valid for that part of the spectrum with $\omega > \omega_0$, where $\omega_0 = (c/2H)$. This part couples into travelling waves. However, that part of the turbulence spectrum with $\omega < \omega_0$ still couples into evanescent acoustic waves. Although the $\omega > \omega_0$ part is important for the heating of the upper chromosphere and corona, the $\omega < \omega_0$ part is probably important for the heating of the low corona. This part of problem therefore merits analysis.

W. Unno. Yes, I agree.

8. TRAPPED WAVES IN THE SOLAR ATMOSPHERE

F. D. Kahn

(University of Manchester)

The temperature of the solar atmosphere passes through a minimum at a certain layer in the photosphere. The speed of sound increases with distance from this layer, both above and below. Rays of sound tend, therefore, to be refracted back into the layer. For rays travelling at not too large an angle with the horizontal this leads to a continual refocusing of disturbances, at about 5-minute intervals. The approximations made are such as to render this description valid only for waves of small wavelength.

REFERENCES

Kahn, F. D. *Astrophys. J.*, **134**, 343, 1961; **135**, 547, 1962.

DISCUSSION

M. P. Souffrin. How is the picture modified in the three-dimensional case, when refocusing occurs not at a point, but along an annulus? Is the characteristic size of the picture still given by the wavelength introduced by Dr Kahn?

F. Kahn. Linear disturbances can always be analysed into plane waves. Having dealt with the behaviour of plane waves by ray theory we can now build up solutions by superposition.

We would expect that a bunch of rays focused at a point should 5 minutes later refocus in a ring some 2000 km in radius.

R. Michard. I am ready to assume that high frequency sound waves can indeed be trapped as described by Dr Kahn. But it seems that such considerations cannot explain the observed oscillations of the solar atmosphere: in the observations points of maximum correlation are not displaced.

F. Kahn. Perhaps one can relate the observed Doppler shifts with these focused waves as follows. When waves are well focused in a particular volume element, this leads to an increase in the energy content of the gas, which then becomes more buoyant and tends to rise. In between focusing periods the element must fall again: perhaps this explains the observed anti-correlation.

P. A. Sturrock. An alternative explanation of the 5-minute resonance is that the group velocity of acoustic waves is zero for this frequency.

A. H. Cook. Dr Kahn's proposed mechanism for producing vertical motions is similar to Longuet-Higgins mechanism for generating microseism to vertical pressures on the sea-flow from interference of progressive waves. If so, there is a factor of 2 between the period of progressive waves and that of the vertical motions.

9. GENERATION AND PROPAGATION OF OSCILLATORY MOTIONS IN THE SOLAR ATMOSPHERE

F. Meyer and *H. U. Schmidt*

(High Altitude Observatory, Boulder, Colorado, and Sacramento Peak Observatory, Sunspot, New Mexico; on leave from Max-Planck-Institut für Astrophysik, Munich.)

It seems reasonable to assume that single photospheric granules are the proper sources of the periodic vertical motions in the solar atmosphere observed by Evans and Michard (1). A granule may be thought of as a small upwelling of photospheric matter which settles down to its normal position at the end of the lifetime of the visible granule. This lifetime is by no means negligible compared with the average periods or lifetimes of the observed coherent oscillations. This implies that we deal with an inhomogeneous boundary value problem, where the inhomogeneity at the boundary, i.e. the granule, influences the solution throughout the interesting range of time. Therefore a superposition of many modes fitting realistic initial and boundary values is needed. Such a superposition might easily explain the observed time lags of the oscillations in different spectral lines or heights. E.g. if we restrict ourselves to one dimension, i.e. to a purely vertical propagation of the waves, and if we assume an initially quiet isothermal atmosphere under gravitation, which is pushed from below by an upward moving piston beginning its movement at t_0, we get a very reasonable propagation of phases, though not of the amplitudes as was shown earlier (2). In this model the maxima and minima of the oscillating velocity at different heights exhibit clearly a decreasing vertical time lag approaching zero and an increasing period of time between subsequent maxima approaching the resonance value of 300 seconds.

The observed oscillations generally exhibit frequencies within the non-propagating range of the dispersion relation discussed by Moore and Spiegel (3). We believe that they are built up asymptotically by the neighboring propagating wave modes which can be excited by the