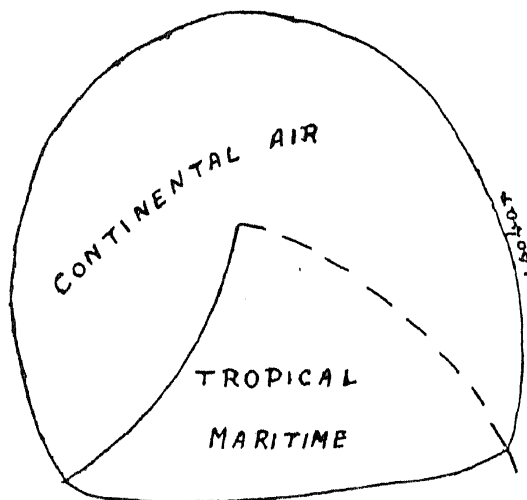


sectors and moved into China Seas. Then the same simplification as made by the author in the book and this note results.

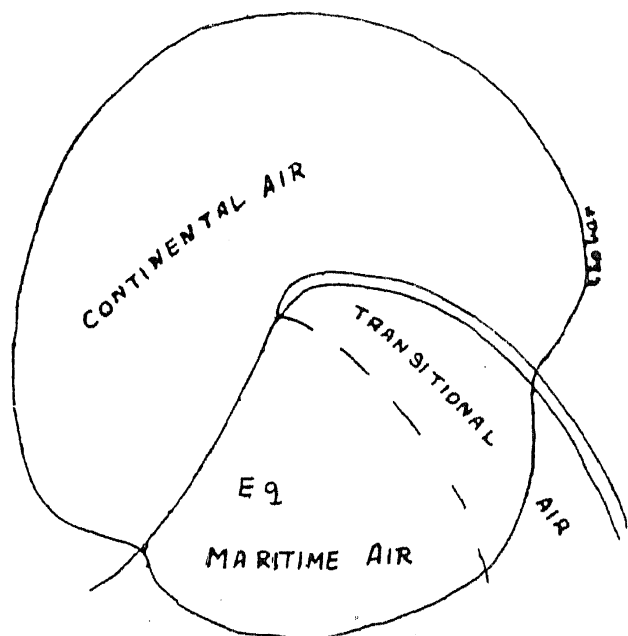
It has been pointed also that the "source" of energy of a tropical cyclonic storm is the equatorial maritime air and the "sink" is the continental dry air or tropical continental air, and that the role of the far-eastern air is to delay the cycle of operations till sufficient vorticity is developed (the earth's rotational effect being smaller in equatorial latitudes, the time required to develop vorticity would necessarily be greater). In the extra-tropical depression the "source" of energy is the tropical maritime air.

In the regions where depressions form near the equator and in the seasons, the easterly and westerly winds at levels from 4 to 8 kms. are well known, and for India were worked out by H. C. Banerjee and K. R. Ramanathan.† The hypothesis and the available diagrams all



2. Recurved Cyclone or Extratropical Depression

show that the direction of movement of the tropical cyclonic storms is determined by the upper air in the equatorial maritime air so long as there are three air masses and by the tropical maritime air when there are only two air masses. To conclude, it follows that the air mass which acts as the energy "source" for the depression seems to control the direction of motion of the depression. The result can be generalised, as a suggestion, that even for a low pressure wave the upper air motion at about 6 kms. in the "source" air mass must determine its direction of motion in addition to all other factors that may be responsible for its movement. When a pulse moves from south of the equator to the north carrying fresh monsoon air often one finds that the surface air is northerly. But the upper air at higher levels give a west south-westerly or even southerly direction, which permits the flow of air under suitable conditions. Further work is in progress.



1. Tropical Cyclonic Storms (Northern Hemisphere)

†Deppermann, "Are there warm sectors in Philippine Typhoons: Bureau of Printing", Manila, 1937.
[*Sc. Notes Ind. Met. Dept.* 13, p. 21.]

APPLICABILITY OF THE PLACZEK'S THEORY OF RAMAN SCATTERING AT HIGH TEMPERATURES

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THE polarisability $\alpha(q)$ of a molecule may be expanded as a series

$$\alpha(q) = \alpha_0 + \sum_j \left(\frac{\partial \alpha}{\partial q_j} \right)_0 q_j + \frac{1}{2} \sum_j \left(\frac{\partial^2 \alpha}{\partial q_j \partial q_k} \right)_0 q_j q_k + \dots, \quad (1)$$

where the suffix 0 refers to the equilibrium configuration. q_j, q_k , etc., are the various normal co-ordinates of the molecule and a particular set of values of q_j, q_k , etc., define a configuration q of the molecule.

The first term α_0 which is independent of the nuclear vibrations is responsible for Rayleigh scattering, while the term in $\left(\frac{\partial \alpha}{\partial q_j} \right)_0$ gives rise

to Raman effect. The aggregate intensities of the Stokes and the anti-Stokes Raman lines according to the Placzek's theory of Raman scattering are given by (2) and (3) respectively.

$$I_{(\nu - \nu_j)} = \frac{64 \pi^4}{3 c^3} (\nu - \nu_j)^4 \{ 4 A_{1j}^2 - 7 B_{1j} \} \frac{1}{1 - e^{-\frac{h\nu_j}{kT}}} \quad (2)$$

$$I_{(\nu + \nu_j)} = \frac{64 \pi^4}{3 c^3} (\nu + \nu_j)^4 \{ 4 A_{1j}^2 - 7 B_{1j} \} \frac{1}{e^{\frac{h\nu_j}{kT}} - 1} \quad (3)$$

where A_{1j} and B_{1j} are the invariants of the symmetric tensor $\left(\frac{\partial \alpha}{\partial q_j} \right)_0$. The ratio of the intensity of the Stokes Raman line to that of

the corresponding anti-Stokes line is given by (4).

$$\frac{I(\nu - \nu_j)}{I(\nu + \nu_j)} = \left(\frac{\nu - \nu_j}{\nu + \nu_j} \right)^4 e^{\frac{h\nu_j}{KT}} \quad (4)$$

The following are the main features of the Placzek's theory of Raman scattering.

(1) The intensity of the Stokes lines increases with the increase of temperature.

(2) The intensity of the anti-Stokes lines increases more rapidly than the Stokes lines with the rise of temperature.

(3) The intensities of the Stokes and the anti-Stokes lines become very large at high temperatures and tend to meet each other at infinite intensity.

(4) The ratio of the intensities of the Stokes and the anti-Stokes lines is given by the relation

$$\left(\frac{\nu - \nu_j}{\nu + \nu_j} \right)^4 e^{\frac{h\nu_j}{KT}}$$

From the investigation carried out by the author, both in solids and liquids, the following observations can be made:—

(1) The intensity of the Stokes lines decreases with the rise of temperature, the decrease in the case of calcite is more rapid for the low frequency lines.

(2) The intensity of the anti-Stokes lines, in general, increases with the increase of temperature, except in calcite, but not to the extent as is expected by the Placzek's theory.

(3) The intensities of the Stokes and the anti-Stokes lines tend to meet each other at some finite value with increasing temperature.

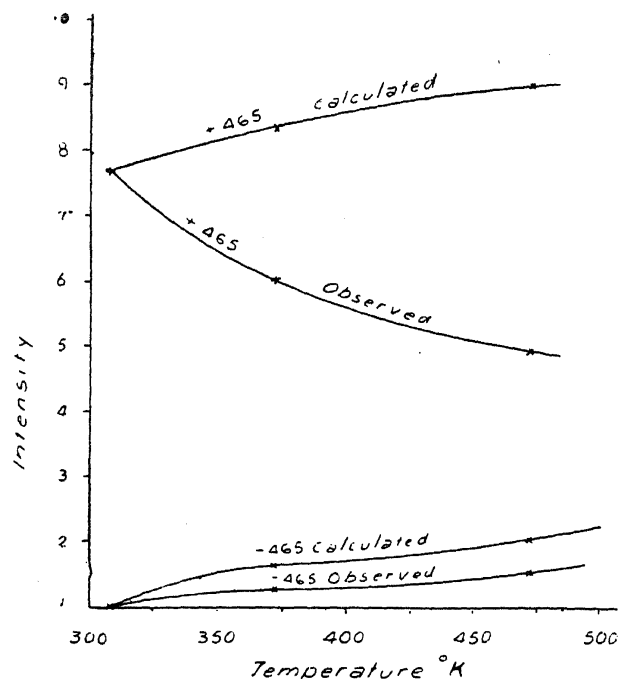
(4) The ratio of intensities of the Stokes and the anti-Stokes lines, at all temperatures, is in agreement with the result expected from the Placzek's theory. The ratio approaches more and more towards unity with the increase of temperature.

The observed and calculated intensities of the Stokes and anti-Stokes lines at 465 cm.⁻¹ in quartz, at different temperatures, are shown in Fig. 1.

One obvious criticism of the Placzek's theory is that he has taken only the first term $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ and not the higher order terms to determine the intensities of the fundamental Raman lines. The author has tried the next higher order term but has obtained the contribution of it as very small. Hence the observed result, namely, the decrease in intensity of the Stokes lines with increase of temperature, cannot be explained by taking the higher order terms also into consideration.

It can be seen from expression (2) that the inference that the Stokes lines increase in intensity with the increase of temperature is due to the exponential factor, namely, $\frac{1}{1 - e^{-\frac{h\nu_j}{KT}}}$

taking the other factor as constant at all temperatures. We can take the term $\frac{64 \pi^4}{3 c^3} (\nu - \nu_j)^4$ as constant. The other term $(4 A_{21j}^2 - 7 B_{Aj})$ comes out from $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ and if we take that as



constant it means we are taking $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ as constant at various temperatures. The Taylor's expansion is valid only in the close vicinity of the equilibrium configuration. But as the temperature is increased the amplitudes become larger and larger and we can no longer take the Taylor's expansion, which is taken in the close neighbourhood of the equilibrium configuration, as valid. Therefore $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ cannot be taken as constant. It will decrease rapidly with the increase of the temperature. In Placzek's theory it was customarily taken as constant.

In the case of the Stokes lines, the increase due to the exponential factor is not very large but as the decrease due to the diminution in $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ with the increase of temperature is considerable, the net result will be a decrease in the intensity. For anti-Stokes lines, the increase due to the exponential factor is very large but due to the other factor it is pulled down to a certain extent, the result being an increase but not to the expected extent. In the case of calcite, the decrease in intensity of the Stokes lattice lines is very large which shows that the diminution of $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ with rise of temperature is correspondingly very large. Hence it becomes predominant in the case of the anti-Stokes lines, the result being a decrease in the intensity of the anti-Stokes lines also. The ratio of intensities of the Stokes and the anti-Stokes lines is, however, unaffected by this variation in $\left(\frac{\partial \alpha}{\partial q_i} \right)_0$ with temperature.

The author is thankful to Prof. S. Bhagavantam for the interest he has taken in this work.