Nature (*London*) **145** 147 (1940)

The α-β transformation of quartz

As is well known, the ordinary form of quartz which has trigonal symmetry changes over reversibly to another form which has hexagonal symmetry at a temperature of 575° C. Though the transformation does not involve any radical reorganization of the internal architecture[1] of the crystal and takes place at a sharply defined temperature, it is nevertheless preceded over a considerable range of temperature (200°–575°) by a progressive change in the physical properties of 'low' quartz which prepares the way for a further sudden change, when the transition of 'high' quartz actually takes place. The thermal expansion coefficients, for example, gradually increase over this range of temperature, becoming practically infinite at the transition point and then suddenly dropping to small negative values[2]. Young's moduli in the same temperature range fall to rather low values at the transition point and then rise sharply to high figures[3]. The piezoelectric activity also undergoes notable changes.[4,5]

In the hope of obtaining an insight into these remarkable phenomena, a careful study has been made of the spectrum of monochromatic light scattered in a quartz crystal at a series of temperatures ranging from that of liquid air to nearly the transition point. Significant changes are observed which are illustrated in the accompanying illustration, reproducing part of the spectrum excited by the 4358 A radiation of the mercury arc. A fully exposed spectrum at room temperature indicates fourteen different normal modes of vibration of the crystal. At liquid air temperature, the three most intense lines correspond to the frequency shifts 132, 220 and 468 cm^{-1} and are all about equally sharp. As the crystal is heated over the temperature range 200°–530°, notable changes occur. The 220 cm^{-1} line (marked with an arrow in the reproduction) behaves in an exceptional way, spreading out greatly towards the exciting line and becoming a weak diffuse band as the transition temperature is approached. On the other hand, the other intense lines having both larger and smaller frequency shifts continue to be easily visible, though appreciably broadened and displaced.

The behaviour of the 220 cm^{-1} line clearly indicates that the binding forces which determine the frequency of the corresponding mode of vibration of the

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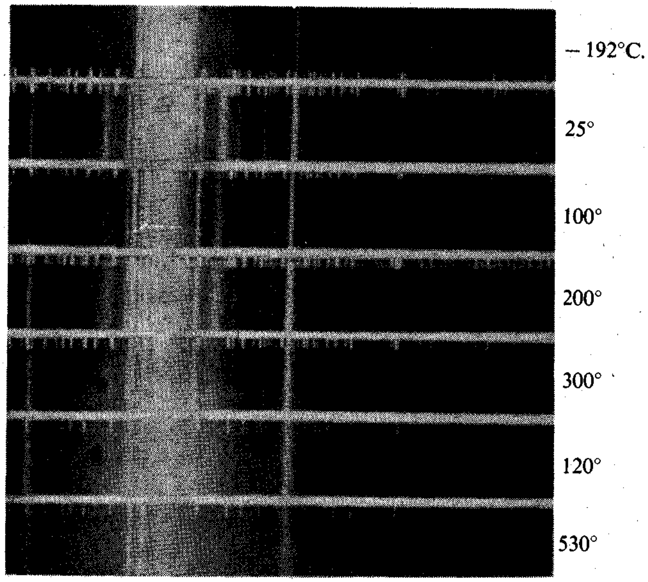
[1] Bragg and Gibbs, *Proc. Roy. Soc.*, A, **109**, 405 (1925).

[2] Jay, *Proc. Roy. Soc.*, A, **142**, 237 (1933).

[3] Perrier and Mandrot, *C.R.*, **175**, 622 (1922).

[4] Osterberg and Cookson, *J. Frank. Inst.*, **220**, 361 (1935).

[5] Pitt and Mckinley, *Canad. J. Res.*, A, **14**, 58 (1936).



Light scattering in quartz.

crystal lattices diminish rapidly with rising temperature. It appears therefore reasonable to infer that the increasing excitation of this particular mode of vibration with rising temperature and the deformations of the atomic arrangement resulting therefrom are in a special measure responsible for the remarkable changes in the properties of the crystal already mentioned, as well as for inducing the transformation from the α to the β form.

C V RAMAN
T M K NEDUNGADI

Department of Physics
Indian Institute of Science, Bangalore
11 December