LETTERS TO THE EDITORS

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Geometrical Representation of Thermal Transitions of Higher Order

As is well known, geometrical interpretations of Λ-type thermal transitions have been proposed on the assumption that, in a transition of the first order, the $G = f(p,V,T)$ surfaces intersect at a finite angle; for transitions of the second and higher orders, the $G = f(p,V,T)$ surfaces make contact. Contacts of the first order, second order, etc., are held to correspond with thermal transitions of the second order, third order, etc.[1]. Although this interpretation permits a formal representation of Λ-type transitions in terms of geometrical relationships between the free-energy functions G_1 above and G_2 below the transition point, it is not easy to correlate with structural changes accompanying these transitions.

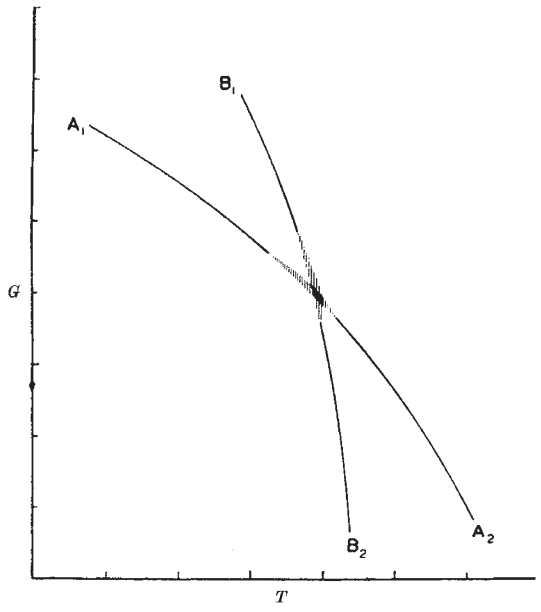
It is now suggested that, in reality, instead of making true geometrical intersection or contact at the transition point, the free-energy surfaces may exhibit an 'indeterminacy thickening' in the transition region. On this basis, it is not necessary to assume that the surfaces G_1 and G_2 make true contact at a transition point to explain Λ-phenomena. When the indeterminacy thickening is appreciable, even what would be an intersection with true surfaces becomes a region of overlap, which in many ways could simulate geometrical contact between infinitely thin surfaces.

The origin of this indeterminacy thickening can, in principle, vary according to the atomic framework of the system under investigation. In transitions in crystals which are accompanied by a volume change, the lattice can incorporate a certain amount of strain-energy by juxtaposition of regions which have, and have not, undergone the transition. To describe the local free energy of the crystal completely, it is necessary to introduce a local variable strain parameter π [2,3]. The function $G = (p,V,T,\pi)$ can assume a narrow range of values according to the values of π the crystal can withstand without breaking. Provided the relaxation time of the strain is large compared with the time of an experiment, this leads to a thickening of the free-energy surface, which is illustrated in section in the accompanying graph, where, of course, the difference of slopes is exaggerated to avoid excessive blurring of the overlap region in printing. Generally, a variable strain parameter will raise G_1 considerably and can scarcely lower it, so that the thickening from this cause almost lies wholly to one side of the limiting G curve. π can also be an order parameter expressing the degree of positional order of the atoms on the lattice sites, or in orientational transitions it may represent the coherence of orientation of the molecules on various lattice sites. When the thickening arising from a range of possible values of π with large relaxation time is appreciable, the phase rule is modified from the classical form:

$$F = C - P + 2,$$

to

$$F = C - P + 2 + \Sigma\pi,$$



where $\Sigma\pi$ represents the number of independent 'structural' contributions to the free energy[2], such as state of lattice strain, positional order in solid solutions, or orientational order in transitions which involve randomization of molecular orientation in the crystal.

An extension of this indeterminacy interpretation of 'contact' between free-energy curves may be suggested in the much-studied Λ-phenomena which accompanies the 'transition' from helium I to helium II. In the case of a liquid with freely mobile molecules, it does not seem likely that the free energy can include a strain or order parameter, which can assume a small range of values near the transition to another state. But in view of the low temperature and high zero-point energy, it is possible that the G_1 and G_2 curves for helium I and helium II show a quantum indeterminacy thickening, and consequent overlap, near the transition where another phase has practically the same free energy. The effect of this overlap would be geometrically similar to overlap effects accompanying structural transitions in solids; but the Λ-phenomena in the two cases would have a very different origin.

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[1] cf. References in Jaffray, J., *Ann. Phys.*, **3**, 5 (1948).
[2] Ubbelohde, A. R., *Proc. Roy. Soc.*, A, **159**, 301 (1937).
[3] Dinochert, *Helv. Phys. Acta*, **17**, 388 (1944).

A Possible Genetic Explanation and Understanding of Migration of Continuous Brooded Insects

THE observations of D. and E. Lack[1] on a southerly migration of insects in October 1950 at Port de Gavarnie in the Pyrenees, which has since been confirmed in October 1951 by Messrs. D. W. Snow and K. F. A. Ross[2] and others, makes possible a hypothetical interpretation of migration on a genetic