PHYSICS

Re-entrant Motion in Special Relativity

A RECENT communication[1] describes three methods of measuring the peripheral velocity of a disk rotating with fixed angular velocity. The purpose here will be to examine methods 'B' and 'C' in a little detail.

Let us suppose that a number (n) of closely spaced fiducial marks are made in the laboratory system all around the periphery of a rotating disk; these are numbered consecutively from 1 to n in the direction of disk rotation. At the location of each mark is a clock. These clocks are synchronized by some convention; the conclusions drawn here are convention-independent, but we may suppose that the usual (Einstein) convention is used. By t_0 will be meant a time at which a single fiducial mark on the disk coincides with mark n in the laboratory, as recorded by the clock located at mark n; by t_i, $i=1, \ldots, n$ will be meant the time first following the coincidence at time t_0 at which the mark on the disk coincides with mark i, as recorded by the clock located at mark i.

Method B may presumably be applied in connexion with any two adjacent marks to find the disk-edge speed v_B. Furthermore, the value obtained for v_B should not depend on which pair of marks is used. Hence it follows that the distance (measured in the laboratory) between adjacent marks i–1 and i (where mark n is also called mark 0) is given by:

$$d_i = v_B(t_i - t_{i-1}),\ i=1, \ldots, n$$

If this is summed from $i=1$ to n, there follows:

$$\Sigma_i d_i = v_B(t_n - t_0)$$

On the other hand, the speed v_C obtained by method C is related to the circumference of the disk $2\pi r$ by:

$$2\pi r = v_C(t_n - t_0)$$

But $2\pi r$ also equals $\Sigma_i d_i$, according to the definition of circumference. Hence v_C equals v_B, contrary to the conclusion reached by Dr. Phipps.

It should now be apparent that Dr. Phipps's analysis of circular motion, based on the assumption that $v_C \neq v_B$, cannot easily be supported by analysis consistent with elementary mathematics; moreover, that a non-equality of v_B and v_C would be most disturbing, in view of the great similarity in the operational definition of the two velocities. Few doubts should remain, for there is nothing in this communication to disprove the applicability of special relativity (with all its traditional idealizations) to problems of re-entrant motion.

This work was supported by the U.S. Atomic Energy Commission.

JOHN G. FLETCHER

Lawrence Radiation Laboratory,
University of California,
Livermore,
California.

[1] Phipps, T. E., *Nature*, **196**, 886 (1962).

A Fundamental Extension of Einstein's Diffusion–Mobility Relationship

Many readers will no doubt have observed that the concepts of particle-diffusion force and gained energy, which were put forward recently[1] under the above title in these columns, are long familiar in the field of irreversible thermodynamics.

The Einstein relation between diffusion coefficient and mobility is theoretically valid in the limiting case of an infinitely low concentration of diffusing solute. In this limit the 'gained energy' is exactly the chemical-potential difference per particle. The particle-diffusion force is the gradient of chemical potential which at constant temperature is proportional to the generalized thermodynamic force of Onsager[2] conjugate to diffusive flux.

These basic concepts, as is suggested in ref. 1, are indeed essential in the investigation of transport phenomena and have, in fact, a much wider range of validity than has the Einstein relationship. Generalized thermodynamic forces are defined for concentrated and multicomponent solutions, and not only for diffusive transport, but for any irreversible fluxes of energy or particles. Such fluxes J_i are related in a conjugate manner to forces X_i by a calculation of the rate of production of entropy σ in their presence:

$$\sigma = \sum_i J_i X_i$$

For diffusive flux:

$$X_i = -\frac{1}{T}(\text{grad}\ \mu_i)_T$$

where μ_i is the chemical potential of species i.

The thermodynamics of irreversible processes, as a phenomenological theory, has been brought to a satisfactory state of formality over the past thirty years, and there are several excellent texts[3] available. It seems, however, to occupy a 'no-man's land' between chemistry and physics and is not as widely disseminated in schools of either chemistry or physics as it might be. It would provide useful material for a first-year graduate course, and, as a statistical–mechanical theory, is a new and rapidly expanding field for research.

E. R. PIKE

Royal Radar Establishment,
Great Malvern,
Worcs.

[1] Melehy, M. A., *Nature*, **198**, 980 (1963).
[2] Onsager, L. A., *Phys. Rev.*, **38**, 2265 (1931).
[3] See, for example, De Groot, S. R., and Mazur, P., *Non-Equilibrium Thermodynamics* (North Holland, Amsterdam, 1962).

Suppression of Dust

WHILE examing the beneficiation of fine coal from the Bulli seam, New South Wales, by froth flotation, the hydrophobic characteristics of the coal were observed. Air-borne dust from this seam had an average composition of fixed carbon 60 per cent, volatiles 26 per cent, ash-forming constituents 12·5 per cent and moisture 1·5 per cent. This dust contained a high proportion of vitrain.

Methods of dust suppression which had been examined included water infusion into both pillar and solid coal, water sprays and wetting agents. These methods had proved to be unsatisfactory, and in addition it was considered that their practice would interfere with subsequent beneficiation. It was decided that methods of suppression which made use of the coal characteristics and which may also be useful in subsequent beneficiation work should be examined.

Since the coal was hydrophobic, it appeared that three methods could be used to induce suppression.

Laboratory investigations were carried out using a dust chamber in which dust counts could be made at selected intervals of time to compare the effectiveness of suppression in treated coal. The first method utilized reagents commonly used as depressants in coal flotation to induce hydrophilic surface properties on the coal particles, thereby inducing wettability and subsequent suppression by sprays. Reagents used included potassium permanganate, but results were generally unsuccessful as this coal was difficult to depress. Results using other oxidizing reagents