Catastrophe theory

Catastrophe Theory: Selected Papers 1972–1977. By E. C. Zeeman. Pp. 675. (Addison-Wesley: Reading, Massachusetts, 1977.) Hardback \$26.50; paperback \$14.50.

THE strange union of mathematics, philosophy and methodology that has come to be called catastrophe theory sprang entirely from the totally original mind of René Thom. But its widespread popularisation, and its detailed application to the most diverse subjects, is largely the work of Christopher Zeeman. Their writings provide a perfect example of the contrast between the Gallic and Anglo-Saxon intellectual styles–while Thom is grandiose, poetic, elliptic, allusive, impatient with practical detail, sceptical about the possibility that his theory can be put to experimental test, Zeeman is pragmatic, painstaking, pedagogic, tirelessly fashioning ingenious falsifiable models of particular experimental situations, confident that catastrophe theory will form part of the mainstream of applied mathematics.

Thom's great book *Structural Stability and Morphogenesis* has been available since 1972, but Zeeman's most important work has appeared in conference proceedings or journals that are often difficult to obtain. Therefore this publication of a collection of twenty-two of his papers is a very welcome event—all the more so because Zeeman's work has recently come under strong critical attack. Now readers can study the original material and arrive at an informed opinion on the subject.

The mathematics gets steadily more difficult as the book progresses, the culmination being a proof of Thom's theorem (on the classification of singularities of gradient maps—the 'elementary catastrophes') which will be heavy going even for pure mathematicians. The bulk of the book, however, is devoted to applications of the theorem, and it is fortunate that it is possible to understand what it states, and to apply it, without knowing anything of the proof. In restricting himself to applications of the classification theorem (particularly the cusp catastrophe), Zeeman differs from Thom himself, whose speculations often invoke 'generalised catastrophes' the mathematics of which hardly exist as yet.

Space prevents my giving more than a brief indication of the range of Zeeman's applications. At the 'softest' level, they consist of dramatic pictorial encapsulation of the sense of proverbs using the cusp catastrophe; my favourite is "more haste less speed", where haste and skill are conflicting influences (control parameters) on speed (behaviour variable). Then there are highly developed but still qualitative applications to biology, sociology and psychology. One example is the analysis of the development of the nervous disorder *anorexia nervosa* in terms of the cusp, the hysteresis of which, increasing with the 'splitting factor', models sufferers' sudden alternations between fasting and gorging; a clever invocation of the extra stable sheet of the butterfly catastrophe enables Zeeman to describe the way in which trance therapy can effect a seemingly miraculous cure. In two models (for the onset of prison riots and the impairment of driving skill by alcohol), quantitative data are presented; these are supposed to fit cusp catastrophes, but the points scatter so much that I suspect most readers will share my reaction of being impressed by Zeeman's ingenuity while remaining unconvinced by the evidence.

The 'hardest' applications are in physics. His use of the cusp to describe phase transitions is equivalent to Van der Waals' theory which is well known to fail at the critical point. Of this he writes: "since density is an averaging device, the shape of the equilibrium surface very near the critical point is slightly distorted". By implication, this dismisses a flourishing area of theoretical physics aimed at understanding the deep reasons for this failure, and such naiveté is likely to cause physicists to think that catastrophe theory can make only trivial contributions in their subject; and that would be a pity. Two of the best chapters in this book, however, also concern classical physics. The first is the elegant and powerful summary of elastic buckling theory. The second is the masterly analysis of the stability of ships, where Zeeman blends the qualitative and the quantative in an inimitable blend of orthodox naval architecture, topology, group theory and seamen's lore.

My opinion is that for readers interested in applications of catastrophe theory this is the best currently available introduction to the subject.

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Ion-containing polymers

Ion-Containing Polymers: Physical Properties and Structure. By A. Eisenberg and M. King. Pp. 287. (Academic: New York and London, 1977.) \$27.50; £19.55.

THIS second volume in Academic's new series on Polymer Physics presents the first unified treatment of the physical properties and structure of *Ion-Containing Polymers*, which, according to the authors' definition, embraces polymer systems that contain ions and those to which ions can be attached. As one would expect, the book has been thoughtfully planned, no mean feat in a rapidly growing field. It is prefaced by a useful list of symbols; each chapter has a good bibliography; and there are separate author and subject indexes. The format is attractive and the print clear; the vast majority of figures are also excellent but good eyesight is needed to discern detail in a few; CGS units are used.

An introductory chapter describes current knowledge and gives a useful general classification scheme for ion-containing polymers subdivided into two main groups—polymers of low ion content, including Nafion-type systems and ionomers, and polyelectrolytes.

Chapter 2 deals with supramolecular structure and glass transitions. Theories of and experimental evidence for multiplet and cluster formation are treated in some detail, although not to mathematical excess. Clustering is seen to be akin to microphase separation and to result in many characteristics normally associated with crystalline systems.

Chapters 3 and 4 on the viscoelastic properties of homopolymers and copolymers respectively deal broadly with polyphosphates and silicates; low molecular weight salts in polar polymers and charge transfer complexes; polyelectrolytes; non-crystalline copolymers of high T_g (including perfluorinated ionics, rubber-based ionomers and crystalline copolymers mostly based on ethylene); and polyelectrolyte complexes.

Amongst the properties detailed are stress relaxation, creep compliance, modulus, mechanical loss, specific viscosity, zero shear viscosity, dynamic viscosity, normal stress coefficient and dielectric constant.

The final chapter (5), on configuration-dependant properties, discusses polyelectrolyte dimensions in solution, rubber elasticity, and dilute solution viscosity.

A valuable state-of-the-science book for the research worker in, or wishing to enter, the field of ion-containing polymers, as well as for the professional academic or industrialist.

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0028–0836/78/0271–0486 \$01.00