MATERIAL WITNESS

Extreme gels

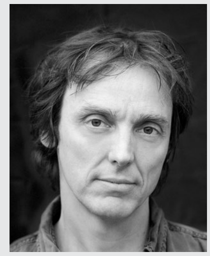
Statistical physics has been allied with the social sciences since the early days of both. In developing his kinetic theory of gases, James Clerk Maxwell was encouraged by the work of social theorists such as Thomas Henry Buckle showing that regularities can emerge out of the averaging of random fluctuations. In turn, the statistical thermodynamics of J. Willard Gibbs supplied the equilibrium concepts central to Paul Samuelson's microeconomic theory; Samuelson was a student of Gibbs's protégé Edwin Bidwell Wilson. (Some might now see that as economics' loss, given that the assumption of equilibrium in markets is debatable.) And Einstein's work on random walks was famously anticipated by Louis Bachelier in 1900, working under Henri Poincaré on the theory of fluctuating prices of stocks and shares.

All this means that social, economic and political phenomena are often found to have analogies in the properties of materials. In the 1950s the fluid dynamicist James Lighthill developed a theory of traffic flow that likened it to fluid flow down a pipe; in 1971 L. F. Henderson applied ideas from Maxwell's kinetic theory to crowd movements[1]. The lattice model devised by economist Thomas Schelling to describe social segregation[2] is basically a model of phase separation appropriate to alloys and immiscible fluids. Models of voting and opinion formation describe the way the 'orientation' of individuals is influenced by that of near neighbours using principles derived from the Ising model of magnets[3]. Batty and co-workers have used a model based on diffusion-limited aggregation to study the growth of cities[4].

Manrique and colleagues now supply an intriguing addition to this materials-based view of social phenomena by suggesting that the theory used to describe gelation via the aggregation of particles can be adapted to help understand how extremist groups gather supporters online[5]. By allowing for the probability of linkages between 'particles' (standing in for human agents or groups) to depend on their degree of similarity (homophily), the researchers develop a model of clustering that agrees well with the observed dynamics of pro-ISIS extremist networks on the European social-media platform VKontakte. There is a universality in the growth of individual groups — power-law growth towards a 'gel point' with an exponent of −5/2 — over a wide range of different sizes. The model can also describe the online dynamics during the later stages and decay of such networks[6].

One of the benefits of finding analogies like this is that they allow experience acquired in one domain to be extended to another. For example, the appearance of 'empty' neighbourhoods at the boundaries of, but not within, separate domains in Schelling's model of urban segregation is easily rationalized by anyone familiar with surface tension. Likewise, models that predict first-order phase transitions in social behaviour (such as criminality) might also be expected to display the metastability and nucleation phenomena characteristic of the corresponding physical systems.

Another attraction is that casting a materials-related theory in a new context could suggest interesting new directions for research. Gelation typically involves particles of rather uniform properties (beyond, perhaps, size dispersion). But the analysis of



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Manrique et al. shows how some interesting phenomena can arise when that uniformity is relaxed — for example, by giving particles a graduated range of interaction potentials. This wouldn't necessarily be an academic exercise, since such heterogeneity is common in living systems — for example, a range of hydrophobicities of proteins in the cell, where aggregation (in neurodegenerative plaque formation, say) can have dramatic consequences. And in the same way that acoustic, optical and condensed-matter experiments have been used as analogue systems to explore aspects of general relativity that are beyond the reach of direct experimentation[7], might we hope to see tailor-made materials that can furnish 'physical simulations' of society? ❐

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