D. H. Mellor Q009 (765 words)

CAMPBELL, NORMAN ROBERT

Campbell made important contributions to philosophy of science in the 1920s, influenced by Poincaré, Russell and his own work in physics. He produced pioneering analyses of the nature of physical theories and of measurement, but is mainly remembered for requiring a theory, e.g. the kinetic theory of gases, to have an 'analogy', i.e. an independent interpretation, e.g. as laws of motion of a swarm of microscopic particles.

1 Physical theories

The British philosopher of science Norman Robert Campbell (1880–1949), who became a Fellow of Trinity College Cambridge in 1904, was also an experimental physicist, who worked on the research staff of the British General Electric Company from 1919 to 1944. His main contribution to philosophy is his account, published in 1920, of how physical theories explain laws. It maintains an absolute distinction between laws relating observable properties of objects, on which agreement can be achieved, and theories used to explain them. It could allow a weaker distinction, letting accepted theories come to state laws needing further explanation. But only an implausible view of the significance of the distinction can save its claim that theories need analogies.

Campbell's account of theories credits them with three components, illustrated by a simplified version of the kinetic theory of gases. First there is a theory's 'hypothesis': its mathematical propositions, empirically uninterpreted. Then there is a 'dictionary', linking terms of the hypothesis to observable terms used to state the laws the theory explains. Thus in his example the dictionary identifies the volume V, mass M, pressure P and absolute temperature T of a gas with combinations of constants and variables postulated by the hypothesis: e.g. $V= l^3$, where $\underline{l}$ is a constant, M=*nm*, where *m* is a constant and 3*n* the number of variables dependent on the independent variable $\underline{t}$ (time). This hypothesis and dictionary entail the perfect gas law, $PV \propto T$.

But arbitrarily many formal systems, suitably interpreted, would also entail this law. To *explain* it, 'the propositions of the hypothesis must be analogous to some known laws': here 'the laws which would describe the motion of … [*n*] infinitely small and highly elastic particles [of mass m] … in a cubical box [of side l]' (*Physics: the Elements*, pp. 128–9). Thus for Campbell an analogy is an essential part of a theory, not a dispensable aid to its formation: 'to regard analogy as an aid to the invention of theories is as absurd as to regard melody as an aid to the composition of sonatas' (p. 130).

The importance of Campbell's main distinction, between propositions linking a theory's terms to each other and those linking them to others in the laws it explains, is now widely accepted if differently expressed. (E.g. Ernest Nagel uses 'calculus' for Campbell's 'hypothesis' and 'correspondence rules' for his 'dictionary'.) But few now accept that a theory needs an analogy (Nagel: 'model'), a thesis that falls between two stools. First, a theory needs no analogy on an instrumentalist reading of it as a formal device linking laws statable in other terms: for then, since its hypothesis states nothing either true or false, its terms need no interpretation. But nor does it need an analogy on a realist reading of its hypothesis as consisting of true or false propositions. For then what these propositions state if true are not merely *analogous* to laws governing (e.g.) the motion of particles: they are laws governing the motion of the particles which the kinetic theory says compose a gas. Only if a hypothesis comprises propositions that are true or false but different in kind from those that state laws is Campbell's case for analogy tenable; but his – basically epistemological – argument for this was always weak and has been weakened further by later work on the meaning of theoretical terms in science.

2 Measurement

Although most physical laws relate measurable quantities, measurement remains an underrated topic in philosophy of science. Campbell was one of the first philosophers to recognise its importance, observing that physics 'might almost be described as the science of measurement'. He saw that measurement itself depends on laws, like those giving physical sense to functions (addition, subtraction, multiplication) of the numbers used to measure quantities like length. His systematic account of this dependence, of the difference between fundamental and derived magnitudes, of the significance of units and dimensions, and of errors of measurement, set the agenda for later theories, which remain indebted to it.

List of works

* Campbell, N.R. (1920) *Physics: the Elements*, Cambridge: Cambridge University Press (republished in 1957 as *Foundations of Science*, New York: Dover Publications). (Part I contains Campbell's account of theories, Part II his account of measurement.)

------ (1921) *What is Science?*, Cambridge: Cambridge University Press (republished in 1952, New York: Dover Publications). (An introductory book on the scope of science, laws, measurement, mathematics in science, and its applications.)

------ (1928) *An account of the Principles of Measurement and Calculation*, London: Longmans. (The final version of Campbell's account of measurement.)

References and further reading

Kyburg, H.E., Jr. (1984) *Theory and Measurement*, Cambridge: Cambridge University Press. (A recent account of measurement, drawing on Campbell's work.)

* Nagel, E. (1961) *The Structure of Science*, New York: Harcourt, Brace & World, chs 5 (II–III) and 6 (I). (These sections of this classic work discuss Campbell's account of theories.)

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