49 plants, a warm autumn led to delayed flowering the following spring; an increase of 1 °C for one of the months falling 6–8 months before flowering retarded flowering by 3–4 days.

The analyses must inevitably lead to questions about the possible impact of climate change, and the simple conclusion is that a warming of climate will certainly affect the flowering dates of most species in such locations (lowland, oceanic, temperate) as those of the survey. The specific effects, however, will depend on the time of year when any such warming is experienced. A uniform rise of, say, 1 °C would delay the flowering of *P. spinosa* and *Acer pseudoplatanus* by between 10 and 32 days, but would advance the flowering of *Quercus robur* and *Alnus glutinosa* by between 13 and 23 days. It is difficult to predict whether and how such changes would affect the general ecological balance of a community. The plants would presumably remain generally synchronized in their flowering, but insect-pollinated species might find themselves embarrassed by a lack of appropriate vectors just when they most needed them. Extended seasons could also lead to early seed-set and germination, resulting in an increase in winter mortality.

The Fitter records will by no means answer these questions, but they form a unique contribution of biological grist to the modeller's mill. □

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1. Fitter, A. H., Fitter, R. S. R., Harris, I. T. B. & Williamson, M. H. *Funct. Ecol.* **9**, 55–60 (1995).
2. Ray, P. M. & Alexander, W. E. *Am. J. Bot.* **53**, 806–816 (1966).
3. Ellenberg, H. *Vegetation Ecology of Central Europe* 4th edn (Cambridge Univ. Press, 1988).

OBITUARY

Hannes Alfvén (1908–95)

HANNES Alfvén, Nobel Laureate in physics for 1970, died at the age of 86 on 2 April at his home in Djursholm, Sweden. One of the more original figures in physics this century, Alfvén is generally credited with founding the field of magnetohydrodynamics and making it enormously useful to astrophysics.

Because of his radically different approach to physics, Alfvén's ideas were always at variance with more conventional views. He was generally controversial in his presentation of ideas, which were often introduced in an unpolished state that antagonized the workers in the field. In fact, they usually appeared at first sight to be wrong. This was attributed to his lack of comprehension of the standard theory. But more times than not, his ideas prevailed.

Alfvén received his doctorate from the University of Uppsala in 1934, and, after his graduation, became intrigued by the problem of the aurora. To understand better the motion of particles into the Earth from the Sun, he developed the guiding centre approach to the motion of charged particles in a magnetic field. This approach was much simpler than the complicated orbital solutions of Störmer that were formerly used. In fact it is this formulation that underlies all modern work in plasma phyics. But because his approach to the aurora was not generally accepted by the geophysical community he was forced to publish his results in a rather obscure journal. It was not until the publication of his book, *Cosmical Electrodynamics*, that the method became widely known.

Using his approach he was the first to discover the adiabatic invariance of the magnetic moment of charged particles in magnetic fields. This is the fundamental concept underlying the mirror machine approach to magnetic fusion, and the acceleration of cosmic rays. Shortly afterwards, in the early 1940s, Alfvén proposed that the interstellar medium is probably filled with magnetic field lines which confine the cosmic rays. He showed that the currents necessary to sustain this field on cosmic scales were so small that they could easily be produced by the interstellar medium, a fact not appreciated at the time.

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I feel that his most significant discovery was that in highly conducting plasmas the magnetic field lines are frozen into the conducting fluid. Thus, they were endowed with a reality that up to this time was discounted by all physicists knowledgeable in electrodynamics. This intuitive idea at one stroke enables one to grasp the complicated behaviour of magnetohydrodynamics. Without it, it would be almost impossible to comprehend the complicated solutions of the three-dimensional fluid equations interacting with electromagnetic fields. For example, with this concept it is easily seen that there must be waves in a magnetohydrodynamic medium that propagate by vibrating the magnetic lines of force as if they were strings. These waves are now known as Alfvén waves.

Perhaps the conversation with Alfvén that I most clearly remember is one in which he described a visit to Chicago just after the Second World War. He told me that he had spent several hours trying to convince Fermi of the reality of these waves, apparently without success. As he was about to leave the United States three weeks later to return to Sweden, he received a postcard from Fermi with the simple message, "You are right!" Apparently this conversation was an important factor in inspiring Fermi's theory of the origin of cosmic rays.

Throughout his life, Alfvén continued to put forth ideas in conflict with conventional scientific thinking. For example, he placed great weight on the importance of double layers, two electric charge layers between which a strong electric field exists. The double layers appeared to me to be absurd, but they are turning out to be important in theories of the aurora and elsewhere.

In spite of his gruff scientific style, Alfvén himself was a warm and kind personality, encouraging and helpful to his colleagues, and particularly to younger scientists. I think it very appropriate that the waves he discovered are named after him. The occurrence of Alfvén waves permeates almost all branches of plasma physics, not merely magnetohydrodynamics. They are mentioned several times a day by nearly every plasma physicist working in the field that Alfvén founded. He is thus immortalized whether he is admired or not. It was my great honour and good fortune to know him, and I will miss arguing with him.

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