tapes) for the delay and fringe rate that gives the highest correlation between the signals. But typically one can integrate the signal coherently for only 10 minutes, compared with 12 hours or more for conventional instruments. Thus, even experiments using several of the largest radio telescopes cannot approach the sensitivity of the Very Large Array in New Mexico.

The dynamic range of VLBI maps has been improved greatly as more radio observatories have acquired VLBI equipment, improving the sampling of the Fourier transform of the radio map. Up to 18 independent groups now routinely record compatible data simultaneously. Often experiments involve telescopes in Europe and North America and occasionally telescopes in countries whose governments are not on speaking terms.

The resolution limit is set by the number of wavelengths that fit on the Earth's diameter. Unfortunately the technical problems worsen rapidly as one tries to work at shorter wavelengths. Nevertheless, VLBI fringes have been observed successfully at wavelengths as short as 3.4 millimetres, and the paper by Bartel *et al.*[1] in this issue from eight participating observatories, reporting the production of a real map of a radio source at 7-millimetre wavelength with a resolution of 10^{-4} arcseconds, is something of a landmark. The source is NGC1275, an unusual radio galaxy whose active nucleus is among the brightest milliarcsecond structures in the sky at 7 millimetres. It is relatively near (redshift 0.018) so that the linear resolution is 0.05 parsec. That is still very large compared with the galaxy's central engine according to black-hole-based models (the Schwarzschild radius for a 10^8 solar-mass black hole is 10^{-5} parsec), but the radius of the surrounding accretion disk is quite uncertain and there might be some direct evidence for the disk at this resolution.

The original drive for VLBI came from the strange behaviour of some quasars and radio galaxies whose flux density varied faster than expected, suggesting relativistic expansion. The 'superluminal motion' that was discovered was even stranger: it seemed that a lumpy jet was escaping from the (presumed) nucleus at 5–15 times the speed of light. Many explanations have been proposed, including relativistic beaming, gravitational lensing, and non-cosmological redshifts for quasars. Further complexities have become apparent, including bent jets and jets with knots that are stationary (or moving backwards, depending on one's interpretation).

NGC1275 is itself unusual in that it expands, but with an apparent speed less than the speed of light; if its nucleus ejects highly relativistic jets as postulated in the standard model, they are either directed at a ridiculously small angle to the line of sight or (more plausibly) we are watching some feature such as a shock front that does not move as fast as the matter.

Many other uses have been found for VLBI. Geodetic uses are described by Thomas A. Herring on page 102 of this issue[3]. Within our Galaxy, VLBI can distinguish the OH and H_2O maser spots in nebulae and near the surfaces of giant stars and measure their relative motions; there are very luminous 'megamasers' that can be measured even in other galaxies. At the longer wavelengths, the small-scale structure of the interstellar medium of our Galaxy is revealed in distorted VLBI images of small sources beyond. The interstellar medium of remote galaxies that lie on the line of sight to distant quasars can be studied by hydrogen absorption at 21 centimetres. And efforts are being made to measure the expansion of recent supernovae in nearby galaxies (which, together with emission-line profiles, could give new distance estimates) and to detect the proper motions of the nuclei of nearby galaxies.

Surprisingly, VLBI observations are limited less by telescope time than by the supply of Mark-III system tapes; the most important advance now in progress is the 12-fold increase in track density on the tape-recording heads. In the longer term, a dedicated VLBI array, of ten 25-metre telescopes in North America, usable up to 43 gigahertz, should come into full operation in 1993. Still better resolution will be achieved by reducing the wavelength (as more millimetre-wave telescopes acquire VLBI terminals) and probably also by increasing the physical baseline. Fringes from an Earth-to-satellite interferometer have already been demonstrated[4]. In Europe, QUASAT will be in competition with other projects for approval by the European Space Agency in October this year. This would put a 15-metre telescope operating at frequencies up to 22 gigahertz into an orbit extending to 8 Earth radii. Radioastron (Soviet Union) and VSOP (Japan) are other space VLBI projects in an advanced planning stage.

Finally, the new ideas about interferometry are being returned to their original domain as radioastronomers take up VLBI at micrometre and submicrometre wavelengths. Seventy years on, the Michelson stellar interferometer is coming back to the optical band. □

1. Bartel, N. *et al. Nature* **334**, 131–135 (1988).
2. Readhead, A.C.S. & Wilkinson, P.N. *Astrophys. J.* **223**, 25–36 (1978).
3. Herring, T. *Nature* **334**, 102–103 (1988).
4. Levy, G.S. *et al. Science* **234**, 187–188 (1986).
5. Noordam, J.E. & de Bruyn, A.G. *Nature* **299**, 597–600 (1982).
6. Pedlar, A., Booler, R.V. & Davies, R.D. *Mon. Not. R. astr. Soc.* **203**, 667–675 (1983).
7. Wilkinson, P.N., Readhead, A.C.S., Anderson, B. & Purcell, G.H. *Astrophys. J.* **232**, 365–381 (1979).
8. Backer, D.C. in *Superluminal Radio Sources* (Zensus, J.A. & Pearson, T.J.) 76–82 (Cambridge University Press, 1987).

Peter Scheuer is in the Department of Physics, University of Cambridge, Madingley Road, Cambridge CB3 0HE, UK.

Daedalus

Perfected markets

THE stock-market crash of 1987 has been blamed on the deficiencies of current computer-trading programs. So Daedalus is improving them by strict darwinian methods. He is setting up a big computer model of the stock market: a simulated arena in which rival trading programs can compete. Some will rapidly go bankrupt; Daedalus will mutate the survivors in search of still greater efficiency, and ultimately an optimum program will emerge. The whole process mimics the emergence of the 'evolutionarily stable strategy', or ESS, that governs competition between animals of the same species. Once an ESS is widespread in a population, no mutant alternative can ever defeat it. Similarly, the winner of Daedalus's computer contest should be a quite unbeatable financial ESS, or FESS. DREADCO will then sell copies of FESS, at a suitably vast price, in the financial community at large.

Like the ESS's of the animal kingdom, FESS will have a cautious, shifty, opportunistic character. Always alert to seize small, safe gains, it will rapidly shuffle away from major threat or challenge, avoiding serious gambles in favour of living to fight another day. Faced with FESS, more defensive programs will slowly bleed bankrupt by small losses; more heroic risk-takers may soar triumphantly above it for a while, but will ultimately crash just as spectacularly.

Once it becomes clear that nothing can beat FESS, all institutions will adopt it. FESS computers will take over the market, and the whole parasitic tribe of market dealers will have to find more productive employment. But FESS will not stabilize the market; indeed, it will probably gyrate more wildly than ever. A perfect market is based on pure fashion: no program has any basis for the value it assigns a share or currency, other than the equally baseless opinions of identical competing programs. Such a totally introverted system could drift indifferently between stock market indices of one, or a thousand, or a million. Some stability may be introduced by objective information (like dividends of firms whose shares are being traded), which would have to be transmitted to all FESS players simultaneously, to avoid bias or insider dealing.

A fully FESS-computerized stock market will lose its hypnotic importance. But all FESS players will still make steady money, from an inevitable fringe of mavericks trying to beat the system: in just the way that the bookmaking community makes steady money from those romantics who, irrationally entranced by long odds, persist in placing their doomed money on hopeless outsiders. David Jones

© 1988 Nature Publishing Group