the time that the signal spent evolving in the first gradient. The result of doing the two Fourier transforms is a two-dimensional picture. In principle, the technique can also be applied to three dimensions, by varying the time during which two gradients are on before the third observing period commences.

Mansfield and his collaborators at Nottingham have been developing a number of nmr imaging techniques. The line scanning techniques uses selective excitation. A magnetic-field gradient is applied and then a long rf pulse—that is, one that only excites the signal over a narrow frequency range. This corresponds to confining the signal to a small region of the sample. Then one turns off the first gradient, turns on another gradient and watches the evolution of the signal in the second gradient. By controlled selective excitation and observation in different magnetic-field gradients, one can in principle completely define the three-dimensional distribution. The Stony Brook group has also been active in selective excitation. More recently Mansfield and I. L. Pykett have been developing ultra high-speed imaging techniques—so-called "planar imaging methods," in which signals from all regions throughout a plane are received simultaneously and differentiated. Images have been produced in one second or so by this technique.

Damadian's approach to nmr imaging, which he described to us, consists of shaping the dc magnetic field to define a small volume called "the resonance aperture," which would give an nmr signal while the remaining volume gave none. In this method a parabolic gradient is developed with a field shape that qualitatively simulates the field shape of a solenoidal magnet but can be added to it. The rf band of the exciting radio pulse is chosen so that resonance occurs for values of H_0 occupying the plateau of the field parabola, where the skirts of the parabola are too steeply graded to produce signal. The size of this resonance aperture is regulated by controlling the current to the parabolic coil. The technique, he points out, is not related to zeugmatography.

Damadian and his collaborators have described nmr measurements on living human subjects employing the point-by-point scanning method. They built their own 53-inch superconducting magnet to obtain a two-dimensional image of a cross section through the thorax last July.[2]

At Philips Research Laboratories in Eindhoven, the Netherlands, P. Robert Locher and his collaborators are doing image reconstruction from signals and gradients. Larry Crooks, Leon Kaufman (University of California at San Francisco Medical School) and J. Singer (University of California at Berkeley) are using nmr to image blood-flow channels and determine blood-flow velocities. In 1959 Singer and Melvin Calvin published their earliest work on blood-flow measurements in living animals—mice and rats. Recently the California group began observations in humans. J. M. S. Hutchison and his collaborators at the University of Aberdeen in Scotland are building a whole-body imaging device, using an extension of the selective-excitation method. The two independent groups at Nottingham are also tooling up for human size; Mansfield's group already has a large electromagnet for whole-body imaging. EMI in Hayes, UK, the company that introduced the x-ray scanner for computer tomography, is said to be trying to develop a commercial prototype for doing nmr imaging.

Lauterbur notes that nmr imaging involves no ionizing radiation, instead involving static (typically about 1 kG) and pulsed (about 1 G) magnetic fields and low-frequency radio waves, which he feels are probably less hazardous to health than x rays. However, "it remains to be seen if one can detect with zeugmatography things that are difficult to see with x rays." Almost all of the work, he went on, has been measurements of relaxation times on tissue samples. It is not clear to what extent this research will be applicable to living organisms. The costs of an nmr imaging device will probably be comparable to that of an x-ray computer tomography instrument, he feels.

Cartilage, bone, organs and so on, show up differently because water and fat concentrations in different tissues vary—water concentration is lower in bone and lung, for example. Proton nmr signals, other things being equal, will have intensities proportional to the local concentrations of hydrogen.

Another contribution to contrast in an image is the difference in relaxation time. One can do experiments in which the signal intensity depends on the spin-lattice relaxation time and the spin-spin relaxation time. So, even if the proton concentration is the same, if the relaxation times are different, one can obtain intensity contrast.

Lauterbur and his collaborators have been selectively imaging regions where flow is occurring, so far in mock-ups only. He feels that the approach might be useful for studying cardiovascular flow. Nuclear-magnetic resonance studies of flow without imaging have been done in a number of places, including the National Heart, Lung and Blood Institute, the Medical College of Wisconsin in Milwaukee and at the Leningrad Institute of Railroad Transport. —GBL

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Small-angle neutron-scattering facility

A user-oriented facility for small-angle neutron scattering is to be built at Oak Ridge National Laboratory at a cost of $1.4 million spread over three years. Funds come from NSF under an inter-agency agreement with the Department of Energy.

The National Small-Angle Neutron-Scattering Facility, scheduled for operation in late 1979, will be located at the High-Flux Isotope Reactor, at present the most intense source of thermal neutrons in the US. One of four existing neutron beams from the 100-MW research reactor will be extended to provide a new 30-meter flight path into a computer-controlled, two-dimensional, position-sensitive detector.

NSF will also support about 30% of the operation of the Oak Ridge 10-meter small-angle x-ray scattering camera. This instrument has the same type of advanced position-sensitive detector and data-acquisition system as the new neutron-scattering facility. Until the latter is completed, NSF is also supporting up to 30% of the beam time of an existing small-angle neutron-scattering camera, also equipped with an area detector.

The new neutron detector will be mounted on a motorized dolly that will travel on rails within the evacuated flight path. The detector is an outgrowth of work by Casimir J. Borkowski and Manfred J. Kopp of Oak Ridge.

Equipment at the center will be used to study proteins and other macromolecules in solution, oriented biological systems, the conformation and structure of solid-state polymers, phase transformation in alloys, long-range magnetic-moment correlations, defect structures, surface properties of catalysts, and fluxoid lattices in superconductors.

Proposals for research are being solicited from potential users in both academia and industry. Beam time will be allocated by a review committee. The director of the new facility is Wallace C. Koehler; Robert W. Hendricks is associate director.

in brief

Responsibility for developing a five-year plan for the recently signed US–Saudi Arabia solar-energy agreement has been assigned to the Solar Energy Research Institute of Golden, Colo. □