and 0.1 eV, the thermal-neutron range. X-ray scattering gives only an average picture of the structure; the neutrons can reveal the movement of the atoms about these average positions.

By means of phonon spectra, experimenters could look at complex solids, such as long-chain polymers, and determine the forces that hold the groups of chains together, the forces inside the chains and the existence of singularities or chain defects. Inelastic scattering can also be used for studying critical fluctuations, catalysis, and so on.

The core, moderator, hot and cold sources and spectrometry channels are contained in a pool of liquid water, with stainless-steel walls six meters in diameter and fifteen meters high. Experiments are carried out in a building about 60 meters in diameter that surrounds the reactor, with a separate building for experiments that use neutron guides. An assortment of spectrometers with changeable monochromators, collimators and so on will be made available, and between 20 and 40 experiments can be carried out at one time. The reactor is essentially a user's reactor, and 70% of the experiments will be performed by groups from outside the Institute. —MSR

Nuclear magnetic moments of picosecond states

Experimenters at Stanford and the Weizmann Institute are using very highly ionized atoms to study hyperfine interactions that produce magnetic fields of 50 to 100 megagauss at the nucleus. Their techniques are capable of studying fields as high as 10^{11} gauss (as strong as those to be expected in pulsars). With the methods one can measure the magnetic moments of very short-lived nuclear excited states—in the picosecond range.

The atomic electrons produce a magnetic field at the nucleus and by measuring the perturbation produced by that field on the nuclear magnetic moment, one can determine the magnetic moment. Recently experimenters have been able to produce very highly stripped atoms. Then the hyperfine interaction becomes very large because the unpaired electrons are in shells that are close to the nucleus. While producing very highly ionized atoms, you excite the nuclei into the nuclear states whose moments you would like to measure. One way is with Coulomb excitation. The nucleus can be excited and at the same time you can impart a very high velocity to the ion. When the ion leaves the target foil the electrons have been stripped off, and the ion travels through a vacuum chamber. Meanwhile the excited nucleus emits a gamma ray, which is measured.

During the nuclear excitation the spins become preferentially oriented in space. This orientation is usually destroyed by the hyperfine field and one observes an isotropic angular distribution. So one needs a way of restoring the alignment.

Two methods have been developed for restoring the alignment. One, which was used at Stanford by Stanley Hanna and his collaborators, is to apply a so-called "holding field;" this causes the atomic spin to decouple from the nuclear spin. By measuring the field strength needed to produce this decoupling one can in principle determine what the hyperfine field is.

The second method, developed by Gvirol Goldring and his collaborators at the Weizmann Institute in Rehovoth, Israel, has been used more in practice, according to Hanna. By allowing the ions to pass through a gas rather than a vacuum, they make many collisions, each of which violently perturbs the electron spins. If the collisions are made frequent enough, the spins flip so rapidly that the nucleus essentially doesn't feel the field, and its time average at the nucleus becomes very small. By increasing the gas pressure you can go from a state of complete perturbation (in vacuum) to a state of no perturbation, in which gas collisions are so frequent that there is no effective field. In this way one measures the product of the nuclear magnetic moment and the internal magnetic field, which is an average over many charge states and over atomic states.

To determine the value of the magnetic moment, one uses calibration nuclei whose moments are already known.

At Stanford, Hanna and his collaborators bombarded a silver target with a beam of chlorine ions. The silver nucleus was Coulomb excited, and the silver atoms were ionized and knocked out of the target. Typical fields at the nucleus were inferred to be 60 MG. The experimenters were able to measure the magnetic moments of nuclear states that last only about 10 picosec.

Earlier the Stanford group studied iron isotopes. Instead of measuring the perturbations by using perturbed angular correlation, they embedded the iron atoms into a medium and used the Mössbauer effect to measure the alignment of nuclei. In the vacuum the alignment was completely destroyed; then gas was introduced and the alignment was restored. In addition they used the holding field technique. Both kinds of measurements agreed well with each other, Hanna told us. Because the magnetic moment of the excited state of Fe^{57} was known from Mössbauer experiments, the Stanford group could measure the internal field directly. Depending on the velocity of the ion, values of 20–30 MG were obtained.

In work at the Weizmann Institute (where Hanna joined in the experiment), the measurements have been extended to light nuclei. Here with presently available accelerators one can strip away all or almost all electrons. Experiments have been done on oxygen, neon and magnesium. In many cases the observed hyperfine fields can be attributed to electrons in the 1S state. For a bare nucleus, the hyperfine field is of course zero. For two electrons, if the atom gets to its ground state right away, the two electron spins are paired off and no hyperfine field is produced. But for one-electron ions, if they immediately go into the ground state you would expect a magnetic field of about 85 MG for oxygen and 290 MG for magnesium.

In a collaboration between the Weizmann workers and a group from Oxford University, a magnetic spectrograph was used to measure ions with a particular ionic state. They find that for O^{8+} you get no perturbation, for O^{7+} you get a very strong perturbation (attributable to about 85 MG) and for O^{6+} you get only a small perturbation, thus confirming expectations.

Hanna points out that the method is capable of observing fields of 10^{11} gauss, a field to be expected for a single electron in the lowest state of atomic uranium. Such an experiment becomes feasible as accelerators yield heavier ions and higher charge states and one gets down to a few remaining electrons. Then one can produce these gigantic internal fields and measure magnetic moments in nuclei with very short-lived states.

The group at Stanford has also included Gene Sprouse, Peter Bond and Tom Miller. At Weizmann the group consists also of Z. Berant, M. B. Goldberg, H. M. Loebenstein, I. Plesser, M. Popp, J. S. Sokolowski, P. N. Tandon and Y. Wolfson. The Oxford experimenters are D. A. Hutcheon, W. L. Randolph and D. F. H. Start. —GBL

in brief

The Kitt Peak National Observatory is distributing a "User's Book" that contains brief descriptions of all instrumentation available to astronomers at KPNO. A similar book describing the facilities at Cerro Tololo Inter-American Observatory is being planned. Institutions that wish copies of the KPNO book should write to the Observatory Director, KPNO, P. O. Box 4130, 950 N. Cherry Ave, Tucson, Ariz. 85717. □