

## ALIGNING ATOMIC NUCLEI

**T**HE alignment of atomic nuclei is of great importance in many areas of research in nuclear physics. Nuclei have only very small magnetic moments, however, and it at first appeared that extremely high magnetic fields or extremely low temperatures would be required to produce any appreciable nuclear orientation.

A means of escape from this situation was indicated by Overhauser who showed in 1953 that under certain conditions electronic paramagnetic resonance absorption can be employed to enhance the degree of nuclear polarization. George Feher of Bell Telephone Laboratories has recently made another significant advance in this field of research by his development of a powerful new technique which employs both electronic and nuclear paramagnetic resonance absorption.

Interaction of the electronic and nuclear magnetic moments in an atom leads to splitting of its electronic energy levels. The resulting hyperfine levels are further split by an external magnetic field, but this field splitting is not the same for two adjacent hyperfine levels, and this is fundamental to Feher's novel process of nuclear alignment.

Because of the unequal field splitting, nuclear transitions in only one of the two resulting sets of hyperfine levels can be produced by absorption of selected radio frequency quanta. Such transitions involve a change of nuclear spins, or a spatial reorientation of nuclear magnetic moments, and this leads to nuclear alignment.

The new scheme of nuclear polarization is unique in that it places no requirements on the relaxation mechanism for either nuclei or electrons except that the relaxation times be quite long. It is only necessary to sweep through a fraction of the applied magnetic field in a time short compared to either relaxation time. The

combined action of this swept field and a microwave magnetic field induces allowed electronic spin resonance transitions between the two sets of hyperfine levels. These transitions produce changes in level population such that each set of hyperfine levels exhibits a nuclear polarization. However, the alignment in one set is opposite to that in the second, so that the sample as a whole is not yet polarized.

With the sample in this state, the nuclear polarization of just one of these sets is reversed by nuclear resonance absorption in a radio frequency magnetic field of the proper frequency. This results in nuclear alignment which is the same in both sets, so that nuclei in the sample as a whole are similarly polarised and the specimen possesses a microscopic nuclear magnetic moment.

Under certain conditions the changes in population of hyperfine levels produced by this nuclear resonance absorption result in pronounced changes in the electron resonance absorption intensities. Observation of the electron spin resonance line thus provides a very sensitive means of studying nuclear resonance phenomena.

This new double frequency resonance technique not only facilitates study of nuclear transitions but also permits determination of hyperfine interaction constants and nuclear gyromagnetic ratios. It is applicable in those cases where the hyperfine interaction is small compared to the electron line width so that hyperfine structure cannot be resolved by the usual single frequency spin resonance technique. Through its use new information is being obtained on impurities in semiconductors, on F centres in alkali halides, and on values of the electron wave function at various lattice points in solids.

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## JENA REVIEW

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The Review, the first number of which is in our hands, contains articles from heads of sections dealing with the scientific and technical problems occurring during the use of their in-

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The Review is excellently got up and we heartily welcome the publication which will serve as a guide to all the users of Zeiss instruments in the world.

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