emitter or absorber. As the vibrational amplitudes of most atoms in molecular vibrations are of the same order of magnitude as the wavelength of γ-ray quanta with an energy of 10 keV to 1 MeV, the vibration of the nuclear emitter should cause a considerable frequency modulation of the γ radiation. In order to observe this effect the nuclear emission or absorption must be observed along the direction of propagation of the laser radiation. The nuclear absorption or emission line should be distorted by the interaction of the molecule with the intense laser radiation so that a dip is produced close to the centre frequency of the γ resonance, but shifted slightly from the centre by the effects of nuclear recoil and the particular velocity group chosen.

In addition to the dip, "sidebands" are produced at multiples m of the laser frequency, and these features should consist of emission peaks. The number of these "sideband" peaks depends on the amplitude of the nuclear vibration excited, and in the simplest example when $m=1$ there will be two peaks symmetrically placed about the dip. The widths of these resonances should be 10^{-2} to 10^{-4} of the Doppler width and they should be tunable by up to 10^{-5} of the γ frequency. Because only a small fraction of the molecules in the gas are in resonance with the coherent light wave, the amplitude of the resonances will lie in the region 10^{-1} to 10^{-3} of the total amplitude of the Doppler-broadened transition.

This picture is complicated by the effects of molecular rotation which will broaden the resonances considerably, although they will still be much narrower than the Doppler width. In order to minimize the effects of rotation it is suggested that it is better to choose molecules with the nucleus being studied on one of the principal rotation axes, or large molecules which have small rotational constants. As the resonant absorption coefficient for nuclear transitions in a gas at the low pressures needed for saturation is very small, it should be possible to observe the narrow resonances in absorption due to the γ fluorescence of the gas, or in the emission from a gas containing γ-active nuclei.

The use of this method for studying phonon absorption spectra of solids in the wing of a nuclear absorption line has also been suggested, allowing the measurement of the recoil energy of nuclei with an accuracy much greater than at present because the laser tuning can be measured very accurately. This method may allow the measurement of γ-quantum energy to an accuracy of 10^{-8} and a comparable accuracy in the connexion of the energy scales of the optical and γ ranges.

NUCLEAR PHYSICS

Complications Continue

from a Correspondent

At the International Conference on Nuclear Physics (successor to the 1969 Montreal conference) which was held in Munich from August 27 to September 1, it was clear that nuclear structure and reactions continue to turn up surprises and complications in abundance. Yet just two examples of developments in reaction theory indicate that phenomena which do not fall into one or other of the simpler extremes are no longer being ignored.

G. R. Satchler (Oak Ridge National Laboratory) spoke of the need to recognize multi-step processes in direct reactions and of the success of coupled channel calculations in accounting for them. Of course such processes, which are virtual transitions via intermediate stakes, must exist but, as Satchler showed with examples of (p, t) and charge exchange reactions, they may be comparable with or stronger than the one-step (DWBA) processes. J. M. Miller (Columbia University) discussed the theoretical efforts being made to understand pre-equilibrium processes — reactions which in time scale fall between the prompt (direct) and compound nucleus extremes, that is, the projectile suffers several but not a statistically huge number of interactions within the nucleus before the reaction products emerge. Examples were shown of efforts to reproduce the observed spectra of protons emerging from (p, np) reactions on heavy nuclei although it seems there is still much left to learn.

The increased availability of heavy ion beams and improvement in particle identification techniques has facilitated a vigorous effort in multinucleon transfer processes, reviewed by D. K. Scott (University of Oxford). The significant improvement in quality and quantity of data and the selectivity of the process in populating nuclear states has now established this field especially in the study of cluster structure in nuclei. D. Pelte (University of Heidelberg) spoke of the structures seen in excitation functions in systems like, for example, $^{12}C+^{12}C$, $^{12}C+^{16}O$, $^{24}Mg+^{24}Mg$, both above and below the Coulomb barrier. It is both interesting and puzzling that gross structures, which may correspond to quasimolecular resonances, are seen in some systems but not others. In the general area of resonant reactions there were several contributions reporting possible intermediate structure effects, but a convincing identification of these is not always easy and more objective statistical tests, such as those mentioned by Y. Baudinet-Robinet and C. Mahaux (University of Liége), might be used in data analysis.

H. J. Specht (Ludwig-Maximilians University, Munich) presented some of the systematics which have been gathered on fission isomers. The explanation of these in terms of a double-humped barrier seems now established and its verification has stimulated arguably some of the best recent experimental work. Indeed the physics of fission probably commands more attention now than for some time.

F. Stephens (University of California, Berkeley) presented evidence of decoupled bands in odd-A nuclei in the mass region of the deformed heavy nuclei. These bands may be formed by the weak coupling of an odd nucleon to the rotational (strong coupling) states of the neighbouring even nucleus and could arise, according to Stephens, from a cancellation in the Hamiltonian for a particular deformation. The oldest band in the business, the 0,2,4 . . . notational sequence, continues to attract interest, not only through the familiar "backbending" phenomenon, for which no explanation is yet generally accepted, but also in the more recently reported "forking". This is the splitting of the ground state band into two which has been observed at a spin value of 8 in two palladium isotopes.

Fields related to nuclear physics provided some interesting talks. J. N. Bahcall (Princeton University) spoke of the impasse in the solar neutrino problem. At present nobody can see any flaw in the nuclear physics and stellar evolution theory which together predict a certain minimum flux on Earth of solar neutrinos or in the one extraordinarily careful experiment which has so far failed to detect it. If nuclear physics is central to stellar physics it is evidently now more than touching archaeology, and I. Perlman (Jerusalem) showed how firm evidence concerning the origin of clay used in ancient pottery can be found by neutron activation analysis.

This correspondent feels bound to raise some questions concerning the scope of a conference of this nature and magnitude, notwithstanding its value to the very many participants. It seemed that a few of the talks did less than justice to the fields being reviewed. Perhaps it really is becoming too difficult —at least in less than an hour—both to review a branch of nuclear physics to the interested non-specialist and also to discuss current problems and new directions for the researcher more clearly involved. It will surely continue to be essential to have periodic meetings surveying the whole of nuclear physics. It may be, however, that these should be fractured into fewer pieces and have the primary aim of helping participants perceive the unifying threads of the subject.