by quantum mechanical tunnelling, as for superconducting tunnel junctions. In either case, a current flows which consists of an a.c. component of frequency $2eV/h$ where e is the electronic charge, V the voltage and h is Planck's constant; and, under appropriate conditions, a d.c. component is also present. The device therefore generates electromagnetic radiation, whose frequency $2eV/h$ depends on the applied voltage, known as Josephson radiation.

The superconducting microbridges developed by the Copenhagen group are in the form of very thin metal films prepared by an ingenious technique on glass microscope slides. The slide is first scratched very lightly with a razor blade, and then etched briefly in dilute hydrofluoric acid, producing a uniform groove 5×10^{-7} m wide and of semicircular cross section. A layer of tin or indium about 10^{-7} m thick is then deposited on the slide in an evaporator, and this film is divided into two parts by a second razor blade cut, at right angles to the groove. The metal deposited at the bottom of the groove, however, is protected from the final cut and so forms a bridge between the two halves of the divided film. Such microbridges can be made, typically, 5×10^{-7} m wide and 2×10^{-7} m long, which is considerably smaller than has been achieved by other workers using more conventional techniques.

Plots of current i against V for these devices showed, among other interesting effects, a series of very slight kinks when eV was less than the energy gap, 2Δ, which separated the superconducting and normal electrons. By measuring dV/di rather than i, a series of sharp peaks was obtained; each peak occurred when V was approximately $2\Delta/Ne$, where N is an integer. Because a peak in dV/di corresponded to a reduction in i, it was necessary to explain why the current should be suppressed at these particular values of V.

Gregers-Hansen *et al.* suggest that the phenomena were caused by the Josephson radiation, given out by the bridge, acting on itself. They point out that, in metal microbridges, harmonics of the radiation, at frequencies $2NeV/h$, are always also present. Whenever V is such that the energy $2NeV$ of a photon is equal to 2Δ, there will be a probability of that photon being absorbed in exciting a pair of superconducting electrons across the energy gap into normal states. Thus, whenever $2NeV=2\Delta$, some further suppression of the superconductivity of the bridge, and a corresponding drop in the current, are to be expected, in agreement with the experiments.

This elegant explanation of the phenomena runs into one apparent snag: the peaks in dV/di do not, in fact, occur in quite the right places. Gregers-Hansen *et al.* evade this difficulty, however, by noting an earlier theoretical prediction by Eliashberg (*J.E.T.P. Lett.*, **11**, 114; 1970) that Δ should be increased by the application of a microwave field. They suggest that the energy gap in the bridge is being changed by its own Josephson radiation and, acting on this assumption, have analysed their data to determine Δ as a function of V.

As a check on this interpretation of the measurements, they repeated the experiment in an externally applied 9 GHz microwave field. One effect was that each dV/di peak acquired sidebands, exactly as would be expected if the Josephson radiation were mixing with the external microwave field to give the sum and difference frequencies: this is convincing evidence in support of their ideas.

Similar subharmonic structure has frequently been observed in tunnel junctions, and several very elaborate and apparently successful theories have been devised to account for it. It now seems clear from the Copenhagen results that these phenomena arise, in reality, from small metallic short circuits in imperfect junctions.

NUCLEAR STRUCTURE

Heavy Ions

from a Correspondent

THE increasing interest in the use of accelerated beams of heavy ions was highlighted at a nuclear structure conference sponsored by the Institute of Physics and held at the University of Manchester from September 5 to 7.

The contribution made to the understanding of the structure of the nucleus through the study of single nucleon transfer reactions induced by light ions has been considerable. Now with the increasing availability of heavy ion beams of good energy resolution and with advances in experimental techniques and improvements in the understanding of the reaction mechanism, the study of transfer reactions induced by heavy ions promises to extend the usefulness of this spectroscopic tool. G. C. Morrison (University of Birmingham) reviewed the progress which has been made in this exciting field during the past few years. From studies of single nucleon transfer much has been learned about the mechanism of the heavy ion-induced transfer reaction and the importance of angular momentum selection rules. It is, however, in the study of multinucleon transfer reactions that valuable new spectroscopic information is to be expected and several examples of such reaction studies were reported at the meeting.

M. A. Grace (University of Oxford) described the very elegant experiments being carried out at Oxford to measure the g factors of excited nuclear states. The technique involves measurements of the Larmor precession of the nuclear moment in the hyperfine field of a hydrogen-like ion. For example, the $H(^{19}F, \alpha)^{16}O^*$ reaction has been used at a fluorine bombarding energy of 48 MeV to measure the g factor of the 3^- state of ^{16}O. As a result of this heavy ion-induced reaction the oxygen ion recoils into vacuum with a simple electronic configuration, namely one electron in the 1s shell. In these circumstances the magnetic field acting on the nuclear moment is calculable (86 Mgauss) and thus a direct measurement of the frequency of Larmor precession yields the magnetic moment of the state.

The anomalous behaviour of high angular momentum states of rotational bands in the rare earth region, predicted in 1960 by Mottelson and Valatin and first observed experimentally as recently as 1971, continues to be the subject of much experimental and theoretical interest. Thus in a review of recent theoretical developments in the study of heavy nuclei K. Kumar (Vanderbilt University, Nashville, and Research Institute for Physics, Stockholm) described the successes of the pairing plus quadrupole model and in particular demonstrated that the observed features of the anomalous behaviour of the energy levels at high angular momentum could be understood within the context of this model.

I. S. Grant (University of Manchester) discussed the important parts played in the fission process by pairing and shell effects. The recent identification of a rotational band in the second potential minimum and the observation of γ-ray decay from the second well to the first have provided new information on the shape of the nuclear energy surface at large deformation. Theoretical attempts to explain the deformation of the second potential minimum have, encouragingly, been rather successful. The use of heavy ion projectiles also allows the role of angular momentum to be investigated in the formation of a compound nucleus and in the fission process. One interesting new advance here is the evidence for the enormous importance of viscosity in the fusion of very heavy ions and nuclei.

Other invited talks were given by T. S. Green (Culham Laboratory, Abingdon) who discussed plasma sources for heavy ion production, G. Astner (Research Institute for Physics, Stockholm) who reviewed the present state of understanding of effective electric quadrupole charges, and R. Huby (University of Liverpool) who described the impressive theoretical advances which have been made in the description of stripping to unbound states.