

Some pattern is emerging from the welter of data obtained, chiefly as a result of improved detection, electronics and on-line computing facilities. Dr P. J. Twin (University of Liverpool) showed examples of the combined power of the measurement of lifetimes, X-ray angular distributions and polarizations in elucidating the level schemes of these nuclei. The broad overview is that the nuclei around Mg are deformed and prolate with a change to oblate shape at around  $^{28}\text{Si}$ . So the systematics here reveal shape transition, a phenomenon which has motivated much work previously on heavy nuclei.

Dr P. G. Hansen (University of Aarhus and CERN) described some sophisticated experiments at CERN on nuclei well off the stability line. For example the isotope effect has been measured for several neutron-deficient mercury isotopes. This seems to follow the simple dependence on neutron number of a straightforward volume effect down to  $^{185}\text{Hg}$  where there is a distinct break. A sudden onset of nuclear deformation might explain this but it has not been confirmed by independent evidence. The Scandinavian workers have been speculating on the existence of the bubble nucleus. This would be spherical but would have a small hollow centre and it would favour high angular momentum states.

Professor J. de Boer (University of Munich) gave a handyman's guide to the principal features and parameters of heavy ion Coulomb excitation. This process affords direct measurement of nuclear electric multipole matrix elements. Current interest is in the measurement of static quadrupole and transition hexadecapole moments which are tell-tale signs of the nuclear charge distribution.

By virtue of parallel sessions it was possible for anybody to contribute. There was also time to hear Professor H. Frohlich (University of Liverpool) and Dr N. MacDonald (Glasgow) elevating biology by bringing to that field—with humour and effect—some methods of theoretical physics.

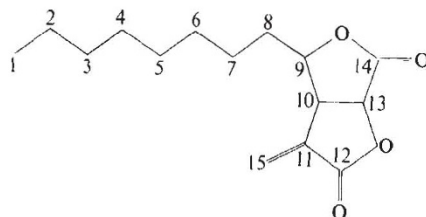
## NMR

### $^{13}\text{C}$ and Avenaciolide

from our Chemical Physics Correspondent

FOR many years isotopic labelling with radioactive  $^{14}\text{C}$  has been widely used in biosynthetic studies and it is not immediately obvious why anybody should prefer to use the stable isotope  $^{13}\text{C}$ . Yet this is precisely what Tanabe, Hamasaki, Suzuki and Johnson (*J. Chem. Soc. Chem. Commun.*, 212; 1973) have now done in their study of avenaciolide (see diagram). In its biosynthesis by the metabolite

*Aspergillus avenaceus* they have used in the feedstock  $^{13}\text{CH}_3\text{COONa}$  and, separately,  $\text{CH}_3^{13}\text{COONa}$ , and have confirmed that the  $\text{C}_8$  side chain and principal skeleton have the expected alternating origin for the carbon atoms; 1,3,5,7,9, and 13 are derived from the  $\text{CH}_3$  groups and 2,4,6,8,10, and 14 from the  $-\text{COO}^-$  groups. They have also confirmed that the adjacent atoms 11 and 15 may both come from the  $\text{CH}_3$  sites as would be expected if they were derived from the central atoms of a succinic acid intermediate.



Structure of avenaciolide.

The  $^{13}\text{C}$  atoms in the product are, nowadays, readily detected with a Fourier transform NMR spectrometer with proton decoupling facilities. This technique greatly improves the signal-to-noise ratio of the record, first because signals are detected from all the  $^{13}\text{C}$  nuclei throughout the measuring time instead of the resonances being recorded separately one after the other; the information is then unscrambled and presented in regular spectral form by a computer. Second, the improvement arises from the

collapse of a multiplicity of peaks into a single line of the same total strength, which occurs because all the influence of the carbon-proton spin-spin coupling is removed from the spectrum. Although the sensitivity is even then poorer than that of radioactive tracer work with  $^{14}\text{C}$ , it is quite sufficient provided that the biosynthetic growth process does not involve appreciable dilution of the feed material.

When the  $^{13}\text{C}$  technique is applicable it has several established or potential advantages. First, all labelled positions can be identified from the chemical shifts without the need for any chemical operations comparable to the selective degradations required to establish the site of  $^{14}\text{C}$ . Second, in principle the enrichment of each site can be determined from the signal strength. Third, the technique is non-destructive and so the product is available for further use. Fourth, for substitution at adjacent sites the carbon-carbon spin-spin coupling can be used to identify such double labelling. In other words, the technique can distinguish a mixture of the type  $^{12}\text{C}_a-^{12}\text{C}_b$  and  $^{13}\text{C}_a-^{13}\text{C}_b$  from a mixture of the types  $^{13}\text{C}_a-^{12}\text{C}_b$  and  $^{12}\text{C}_a-^{13}\text{C}_b$  and indeed could detect and quantify a mixture of the last three species. Fifth, in multiple labelling experiments it could distinguish  $^{13}\text{C}-\text{D}$  from  $^{13}\text{C}-\text{H}$  and also  $^{13}\text{C}-^{15}\text{N}$  from  $^{13}\text{C}-^{14}\text{N}$  groupings. With these attractive features it will be surprising if  $^{13}\text{C}$  labelling is not exploited to a great extent in future biosynthetic experiments.

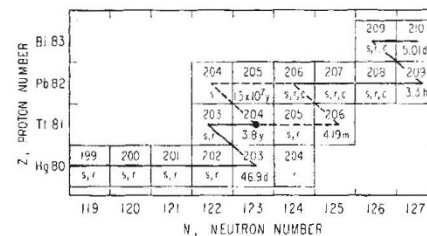
## Stellar Nucleosynthesis and the s-Process

THE importance of the short-lived s-process chronometer  $^{205}\text{Pb}$ , its relation to the mechanism of s-process nucleosynthesis and its implications for cosmochronology are discussed by Blake, Lee and Schramm in next Monday's *Nature Physical Science* (April 16). So far, the only reliable indicators of nucleosynthesis timescales are for the r-process, which proceeds rapidly by neutron capture and yields, ultimately, very heavy elements such as  $^{235}\text{U}$  and  $^{238}\text{U}$ . The s-process, of course, also proceeds by neutron capture, but slowly by comparison with the associated  $\beta$ -decay process, chiefly involving light elements initially and building up to, for example, Sr, Zr and Pb.

The importance of finding an s-process "chronometer" lies in the estimate it would provide of the time between the solidification of Solar System material and the end of the sequence of events which produced the element abundances observed in the Solar System.

One of the important links in the chain of element building occurs in the lead-thallium region (see diagram).

Here, there is a possible branching of the s-process at  $^{204}\text{Tl}$ ; this is shown by dashed lines in the figure, where r denotes r-process, s denotes s-process, and c indicates cosmogenic origin.



The most probable s-process site is in the interior of red giants. According to Blake *et al.*, the time scale for the s-process is comparable with that derived from the r-process, so that all Solar System material from all nucleosynthetic sources separated over the same time, between  $0.7$  and  $1.1 \times 10^8$  yr according to present estimates. With better measurements, this should provide an insight into the processes involved in the formation of the Solar System.