news and views

Physics of pulsars

from F. G. Smith

LESS than a year after their discovery it was widely accepted that pulsars are rotating neutron stars, with high magnetic fields and consequently with a very energetic co-rotating magnetosphere. Progress beyond this basic interpretation has been slow, not through a lack of experimental data but through the sheer unfamiliarity of the physics involved in these strange objects. The solid state physics has to deal with densities approaching $10^{15} g\ cm^{-3}$, with a composition varying from a neutron superfluid to a crystalline crust mainly composed of iron nuclei. The very strong magnetic field is sustained by the superconductivity of the neutron star, and itself modifies the crystalline structure of the crust. Conditions in the magnetosphere are even more bizarre, with complete charge separation and vacuum spark gaps as possible features.

The difficulty in interpreting the radio pulses, which provide our only observational material on nearly all of the pulsars, is that they originate in only a local region of the magnetosphere, and their radiation processes are limited indicators of the behaviour of the rest of the neutron star. Furthermore, they have very complex structures, which we cannot easily interpret without knowing more about the radiation process and the precise location of the emitter in the magnetosphere.

Recent work on pulsars at Jodrell Bank has used the timing of the radio pulses to investigate the slow-down of rotation of the neutron star. The slow-down is a consequence of radiation from the rotating dipole magnetic field, so that this investigation was using the radio pulses as an indicator of conditions within the star. Surprisingly it led to the suggestion that the magnetic field decays with a time constant of a few million years, which is in conflict with present theories of the superconducting interior of neutron stars.

Another investigation, also related to the age and evolution of pulsars, but which refers to the magnetosphere rather than the star itself, is reported in this issue of *Nature*. Ritchings and Lyne (page 293) have found a new orderliness in the apparent disorder of the structure within radio pulses. Some pulsars, and particularly the older ones as shown by the previous investigation, have "drifting subpulses". An individual radio pulse in these pulsars consists of one or two narrow sub-pulses, which can be seen in several consecutive pulses but at slowly varying times within the pulses. The "drift" in time can be either earlier or later, although until recently it was thought that all drifts were earlier. The remarkable observation now reported is that these two categories are simply divided between those pulsars with slowly lengthening periods, which drift earlier, and those with rapidly lengthening periods, which drift later.

The most important conclusion must be that there is after all some simple classification and evolution in the pulsars, whose behaviour may perhaps be regulated mainly by the strength of their magnetic fields. We do not know at all how the drifting itself occurs, although there have been some interesting suggestions about the drifting of discharge paths across a spark gap near a magnetic pole. But we can at any rate rule out those theories which allow only one direction of drift, or those in which the direction was regulated by the aspect of the rotating star as seen by the observer.

The physics of the emission process is not revealed by the drifting phenomenon, since this may occur in a region remote from the emitter. For example, drifting in a spark gap at the poles provides a lateral movement in a stream of particles, which then sweep across an emitting region which might be close to the velocity of light circle. There is some evidence in favour of this location for the emitter from the work on pulsar slowdown rates, which indicate that the pulsars stop emitting when the magnetic field in that region falls below a critical value. On present evidence, the behaviour of pulsars seems to be completely dominated by the strength of the magnetic field.

Do seamounts form near ridges?

from Peter J. Smith

SEAMOUNTS are active or extinct conical or flat-topped ocean floor volcanoes with elevations of at least 1,000 m, the majority not rising above sea level. They occur throughout the world's oceans but are particularly associated with the Pacific where, according to Menard (*Experientia*, **15**, 205; 1959), there are some 10,000. Several hundred of the Pacific volcanoes form linear chains (the best-known of which is the Emperor–Hawaiian chain) which are widely believed to result from the motion of the Pacific plate above hot spots with roots in the mantle. Most seamounts, however, are apparently individual bodies located at random on the ocean floor, although they tend to lie in clusters or bands.

As long as the oceans were thought to be permanent, the points of origin of seamounts posed no particular problem; volcanoes erupted on the ocean floor and thereafter remained fixed in position. But moving sea floors have introduced an ambiguity. Leaving aside the small proportion of seamounts aligned in chains, did the rest originate at random locations by some intraplate volcanic process or did they erupt near oceanic ridges and spread away to cover the ocean floor? As the number of seamounts per unit area of ocean floor does not seem to increase away from spreading ridges (which means that the density of seamounts is no greater in older than in younger sea floor), the random hypothesis seems the less likely; but this can hardly be said to be definitive evidence.

An obvious way of settling the matter would be to date both seamounts and the surrounding ocean floor; a seamount embedded in ocean floor of comparable age would then imply ridge formation whereas discrepant ages would imply random volcanism. Unfortunately, experiments along these lines have provided conflicting evidence. Fisher *et al.* (*Science*, **160**, 1106; 1968), for example, found that three seamounts near the East Pacific rise were apparently up to 40 Myr younger than the underlying crust. The age of the