the phonons again after they had travelled several mm through the liquid with a superconducting tunnel junction, a device which is sensitive only to phonons of energy greater than 2Δ. Thus, the decay of an injected phonon would have yielded two phonons each of whose individual energies would have been too small to be seen by the detector, so that the observed attenuation of the phonon pulse could be regarded as a direct measure of the extent to which 3-phonon decays had occurred during the transit.

The main experimental finding was that the number of phonons reaching the detector depended strongly on pressure for pressures from 0 to 13.5 bar, but was almost pressure independent from 13.5 bar right up to the solidification pressure of 25 bar. The effect could not be due to changes in the number of high energy phonons generated in the fluorescer, since the performance of these devices is independent of pressure. There appeared to be two possible explanations: (1) some sort of dissipative effect occurring in the bulk of the liquid, attenuating all phonons; or (2) because of positive dispersion, the injected phonons might have been able to decay by 3-phonon processes, resulting in phonons of insufficient energy to stimulate the detector.

The first hypothesis was rapidly disposed of by altering the separation of the source and detector. The pressure dependence of the detector signal was quite independent of the separation, thus ruling out possible bulk attenuation effects.

The authors therefore conclude that the second hypothesis is the correct explanation. They suggest that there is a critical phonon energy ε_c below which a phonon decays rapidly, but above which a phonon will be stable and therefore able to travel long distances through the liquid. If ε_c decreases with increasing pressure, and if at 13.5 bar ε_c is equal to the minimum injected phonon energy of 2Δ, then the experimental data can all be understood. At higher pressures ε_c would become smaller than the lowest energy phonon from the fluorescer and the injected phonons would therefore all reach the detector without decaying, thus accounting for the observed pressure independence of the signal above 13.5 bar.

The scenario proposed by the authors is therefore as follows. When a pulse of phonons with an initially wide range of energies is injected into the superfluid, those phonons with energies less than ε_c decay almost immediately owing to the existence of positive dispersion, whereas those with higher energies, in the negative dispersion regime, propagate freely. Thus the liquid acts as a high pass filter, passing only phonons of energy above ε_c. Because ε_c can be changed by altering the pressure, the filter is tunable and clearly has possible applications in the growing field of phonon spectroscopy.

This rather novel picture of liquid helium is certainly consistent with existing experimental information, but it is to be hoped that the authors will now carry out further checks on its veracity, in particular by repeating the experiments using detectors sensitive to a number of different phonon energies.

Structure and dynamics of spiral galaxies

from Vincent Icke and James Pringle

On Thursday, January 9, an informal discussion day at the Institute of Astronomy, Cambridge, brought together some 50 astronomers from various parts of the UK, to exchange news and views on the structure and dynamics of spiral galaxies.

BARRY MADORE (IOA, Cambridge) reviewed the situation nearest home, showing how the spiral structure of our Galaxy in the neighbourhood of the Sun can be determined by 'spiral tracers'. These are young, massive bright stars which, since star formation takes place predominantly in spiral arms, serve as 'standard candles' to delineate spiral structure out to distances of about 15,000 light years. Observing at Cerro Tololo, Madore has concentrated on the Northern Hemisphere which thus far has received only thin coverage. His results on the distances of classical Cepheids has extended the known nearby spiral pattern, but more observations are still required.

Passing to external galaxies, Greg Davidson (Jodrell Bank) and Darrell Emerson (Mullard Radio Astronomy Observatory, Cambridge) presented observations of the rotation speed and the neutral hydrogen distribution of the Andromeda Nebula M31. The dependence of the rotation speed on radial distance indicates the mass distribution in a galaxy. Davidson found that in the outer regions of M31, the rotation curve is flat, indicating a very large amount of mass in the 'halo' of this galaxy. The results, however, are not yet clear cut because the low resolution of the Jodrell Bank Mk I telescope tends to smear out and flatten the rotation curve. Emerson's observations of the disk showed ridges of condensed gas around the centre of M31, forming rings or spiral arms (this galaxy is seen too edge on to enable one to say which of these two alternatives is the better). The velocity field, mapped by observing the Doppler shifts of the 21 cm hydrogen line, shows distinct non-circular motions, perhaps indicative of the motions which theorists predict for the gas condensations as spiralling density waves propagating through the disk. But here too the galactic inclination makes it impossible to distinguish between spiral and ring-like structure.

An alternative to density waves as the cause of spiral structure is the possibility that spiral arms are formed by galactic 'tides', generated by a previous close encounter of two galaxies. Observational evidence for such encounters was given by Anthony Winter and Geoffrey Cottrell (MRAO, Cambridge) who have respectively studied the pairs NGC9631–9656 and M81–NGC3077. An extensive neutral hydrogen complex is found to surround the spiral galaxies NGC9631–9656. From the velocity structure of the complex it is apparent that the gas actually links the two galaxies; the velocities in the gas match those of the galaxies and show a systematic trend from one to the other, thus linking them in 'velocity space'. Although the observations clearly show that the encounter profoundly disturbs each member of the pair, the influence on spiral structure is unknown because both galaxies are seen edge on. The pair M81–NGC3077 is more promising in this respect: M81 is one of the most beautiful two-armed spiral galaxies known. In this case, however, the evidence for tidal interaction is less strong. NGC3077 possesses a comma-shaped hydrogen extension, pointing towards M81, and this 'tail' may be a remnant of a hyperbolic encounter about 10^9 yr ago.

A hundred years ago

IN reference to the proposed Channel Tunnel between France and England, we may refer our readers to NATURE, vol. i., pp. 160, 303, 631, and vol. x., p. 181, where the scientific bearings of the subject are pretty fully discussed. While on this matter we may state, on the authority of *La Nature*, that there has been in existence for some time in Spain an Inter-continental Railway Company, whose object is to connect Europe and Africa by a tunnel underneath the Straits of Gibraltar, the maximum depth of which is 819 metres.
from *Nature*, **11**, 273; February 4, 1875