## Evolution in the Expanding Universe

A LECTURE was delivered by the Abbé G. Lemaître, professor of mathematics in the University of Louvain, at Armstrong College, Newcastle-upon-Tyne, on the subject of "Evolution in the Expanding Universe" before a joint meeting of the Durham University Philosophical Society and the Newcastle Astronomical Society on February 12. Dr. R. A. Sampson, Astronomer Royal for Scotland, occupied the chair, and the speaker was welcomed by Sir William Marris.

The age of the universe, calculated from the observed recession of the nebulæ, is about $2 \cdot 4 \times 10^9$ years, whereas the ordinary theory of stellar evolution requires about $10^{13}$ years. If the matter in the universe were evenly distributed, the density would be $10^{-30}$ gm./cm.$^3$. The correction of Newton's law given by Einstein may be regarded as equivalent to a density, of negative sign, associated with space, and if accompanied with a positive pressure the system would be invariant in the Lorentz transformation. This density, a cosmical constant, works out at $-10^{-27}$ gm./cm.$^3$ and as this is greater than the average density of matter, the effect produced would be, in general, a repulsion.

Taking any point as centre, the motion for a nebula at distance $r$ is represented by

$$\left(\frac{dr}{dt}\right)^2 = -h + \frac{2Gm}{r} + \frac{\lambda}{3} c^2 r^2.$$

The density of a vacuum is $\rho^v = \lambda c^2/4\pi G$, where $G$ is the gravitational constant. Over large (spherical) areas this is to be regarded as a map in which distances normal to the radius vector are real, but those along it are in a scale $\sqrt{1 - h/c^2}$ where $h$ is the energy constant in the equation of motion. ($h$ varies as $r^2$, and $m$ as $r^3$.) For some value $h = c^2$, the scale becomes zero and the map ends, but actually antipodal points are the same, like the points at the sides of a map on Mercator's projection.

Suppose now that the universe once consisted of matter with an average density greater than the critical, but with an initial velocity sufficient to carry it over the critical radius, this gives the proper expansion. When $r$ is put equal to infinity in the above equation, only the last term is important, so that the velocity squared is equal to $\lambda/3\ c^2$, from which the cosmical constant may be obtained. Actually, there must have been fluctuating density in the initial state, and areas in which the separation of matter was less than the mean. In these, the matter would eventually fall back producing collapsing regions; more rarely, equilibrium areas would occur which would divide into collapsing regions. The first might produce nebulæ, the second, nebular clusters. If these areas coalesce, some loss of kinetic energy must take place due to encounters, and the original diffuse matter would agglomerate into stars.

A nebula has a mass of about $10^9$ suns; its radius at critical density would be $10^5$ light-years; the order of diameter is now about 1,000 light-years. The loss of kinetic energy will be

$$\frac{3}{2} G \frac{N^2 m^2}{R}$$

where $N$ is the number of stars, $m$ the average mass of each, $R$ the radius. The gravitation energy of a star is

$$\frac{3}{2} G \frac{m^2}{r}$$

where $r$ is the radius. Multiplying this by $N$ gives the total, and dividing, $Nr/R = 6 \times 10^{-2} = 6$ per cent of the gravitation energy of the stars. This energy becomes heat, and the heat content of stars is of this order.

Regarding clusters, here also the right order is obtained. They should have the same densities, and this should be about the critical density. If $N$ be the number of nebulæ in the cluster, $m$ the mass of each,

$$Nm = c \times D^3 d^3$$

where $D$ is diameter, and $d$ angular diameter in degrees, and $c = 0 \cdot 155 V^2$ where $V$ is the velocity of recession at 1 megaparsec. The observations of Hubble and Shapley give figures of the right order ($10^9$ suns).

## Salmon and Trout Disease

IN the year 1911, cases of a hitherto unrecognised disease, causing death of large numbers of fish of various kinds, were reported from six rivers in the south-west of England. This was the first official record in Great Britain of the occurrence of furunculosis, a bacterial disease that has spread to many rivers in England and Wales and is now prevalent throughout Scotland. Serious outbreaks occurred in the Conway and Coquet districts in 1926 when salmon and migratory trout were attacked, and in the Kennet in 1924 and 1925, when the valuable brown-trout fisheries suffered, and in recent years the disease has continued to spread. While in 1932 there was a considerable abatement in the number of serious outbreaks in English rivers, in Scotland conditions were nearly as bad as ever.

The monetary loss entailed by the spread of this disease must be large, since in one river over a period of six years the estimated loss was £1,400, and in another larger river it was £2,000 in three years. But apart from this loss, there must be a more serious loss in the depletion of the breeding stock. The alarming increase in the number of outbreaks led to the setting up of a Furunculosis Committee in 1929, a copy of the second interim report of which is now before us.* The report indicates the satisfactory progress of research into the problem, carried out by a number of workers chiefly at the Bacteriological Laboratory of the University of Edinburgh, among whom Mrs. Isobel Blake deserves special mention.

Furunculosis is a disease caused by a bacillus, *B. salmonicida*, which infests salmon, trout and coarse fish; in advanced stages of the disease there may be lesions in the muscles, but in many cases death occurs without any obvious external symptoms and

* Second Interim Report of the Furunculosis Committee. (Edinburgh and London: H.M. Stationery Office, 1933.) 2*s*. 6*d*. net.

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the cause can only be definitely proven by bacteriological examination.

Once established in any locality, the spread of the disease is practically uncontrollable. Experiments have shown that infection can be water-borne or carried in food, and that the presence of fish that have died from the disease may be a serious source of infection. The disease is not brought in from the sea, and migratory fish may be infected in the fresh water sooner or later after they have left the sea; the fish appear to be highly susceptible when they first enter fresh water.

The most dangerous source for the spread of the disease is the occurrence of 'carriers' in which the bacilli are present in small numbers only and are located in the kidneys. Such fish may live apparently unharmed for a considerable time but generally fall victims themselves in the end, not without, however, infecting other members of the community before their death. It has been found that wounds and scratches render fish especially liable to infection.

It is probable that the disease has been spread over so large an area by the practice of stocking rivers with eggs and fry from other localities and from fish farms. It has now been shown that the eggs can be sterilised with dilute solutions of acriflavine.

Experiments and observations in Nature show that the outbreaks of the disease are controlled by temperature conditions, a temperature within a range of about 55°–66° F. apparently being necessary for its spread and development when the fish are healthy: cases have been reported of the occurrence of the disease at lower temperatures among fish in poor condition after spawning. Overcrowding is a further predisposing cause for outbreaks, and it is noticeable that where barriers occur to cause the congregation of fish awaiting flood water the disease is prevalent; where possible, therefore, such difficulties in the paths of the fish on their upstream migrations should be removed. The reporting of suspected outbreaks as soon as possible is of the utmost importance, as is also the quick removal of all dead infected fish.

Of even greater importance at this stage is the necessity for the passing of legislation whereby action may be taken to reduce risk of further dissemination to a minimum. In December 1929 an interim report was submitted in which a system of control was urged so that importation of live fish might be controlled and notification of outbreaks of disease made compulsory, and that there might also be power of control both over fish farms and over open rivers declared to be infected. It is to be hoped that the necessity for such action in the near future will receive serious consideration before the plague has assumed such alarming proportions as has been allowed with the musk-rat. It is, however, evident that one of the main difficulties in controlling the disease is that the symptoms are not always obvious and that identification necessitates sending the corpses to bacteriological laboratories for examination, and furthermore, that they should arrive before decomposition has set in.

## A New Experimental Phonetics Laboratory

WITH the advent of the talking film, the recording of speech has recently received considerable attention, but, as at the time of the invention of the phonograph, more interest is shown in commercial circles in the entertainment possibilities of the new electrical methods of speech recording and reproduction. In experimental phonetics the older mechanical methods still predominate. At Armstrong College, Newcastle-upon-Tyne, with the support of Prof. W. E. Curtis and Prof. W. L. Renwick, an investigation was undertaken by Mr. R. O. L. Curry, Noble Memorial Scholar, of the available methods of speech-recording, with the object of seeing how far these were suitable for classifying speech sounds, particularly those of local dialects. The work of making and testing different types of apparatus has been so successful that the Council of the College, mindful of the importance of the investigation, has granted space in a newly-acquired building for a phonetics laboratory to house the apparatus, and in which records may be taken under conditions free from noise and vibration.

The laboratory looks out upon an empty court, and the windows on this side are sealed and provided with dark blinds. The floor is of concrete and the partition walls are 1 ft. thick, so that it was thought unnecessary to introduce sound-insulating material except on the door, which is faced on the inside with a layer of Newall's Asbestos Blanket. A ventilating shaft in the thickness of the wall leads out to the roof at a point sheltered from street noise. To make doubly sure that no 'ground noise' shall reach the recording apparatus, the microphones are placed in a double-walled insulated kiosk of the telephone-cabinet type. There is also provision for the development of photographic plates.

The recording devices which are at present available in the laboratory are as follows:

(1) A kymograph, namely, an instrument in which the pressure variations which occur in the mouth, nose and throat during speech can be severally communicated to membranes provided with styles which make traces on a revolving drum. Owing to the damping and distortion introduced by the recording mechanism, this instrument is useless for obtaining exact traces of speech sounds, but is fully satisfactory for recording the relative time intervals involved in speech sounds, and for determining the relative extent to which different parts of the vocal apparatus contribute to the sound, as, for example, in the nasalisation of a vowel or a consonant.

(2) An Einthoven string galvanometer, which while capable of giving accurate traces of vowel sounds, is too heavily damped with regard to frequencies above 6,000 cycles/sec. to record correctly the fricative high-pitched sounds associated with many of the continuant consonants. This is, in fact, the principle of the apparatus by which most talking-films are made.

(3) A cathode ray tube. This is the most effective instrument of all, and is capable of delineating the wave-form at all frequencies to which the microphones are able to respond. For visual examination of vowel sounds a 'sweep circuit' is used, which allows of a single wave-pattern being 'held' on the screen; otherwise a moving film camera is used, capable of taking photographic records of the to-and-fro motion of the spot on the fluorescent screen at 6 ft./sec., a rate which permits of the recording of the high frequency stopping and starting noises that are characteristic of the consonants.

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