The Expansion of the Universe in Relation to the Observed Red-Shifts, and ~~the~~ Distribution in Space, of Nebulae

~~The Expansion of the Universe in Relation to the Observed Red-Shifts and Distribution in Space of Nebulae in Space.~~

To

The Editor of Nature

Dear Sir,

Hubble in his well-known book The Observational Approach to Cosmology has discussed in detail the available observational data concerning the nebular red-shifts, and the distribution of nebulae in space, in relation to plausible models of the Universe, both static and expanding. Since the estimate of the distance of a nebula from us is based on its apparent luminosity, this estimate will differ according as the nebula is regarded as stationary — in which case the origin of the red-shift remains unexplained — or as receding from us, with the velocity corresponding to the observed red-shift. In other words the ~~time~~ distance-scales on the two models will be different. On the static model, Hubble finds (1) that the dependence of the red-shift of a nebula on its distance from us conforms closely to the linear law

$$\Delta\lambda/\lambda = kr, \qquad ----(1)$$

where $k = 5.37 \times 10^{-10}$ (light - year)$^{-1}$ and r is the distance expressed in light-years; (2) that ~~On the static model again~~, the distribution of nebulae in space, as given by the available surveys, is ~~found to be~~ practically homogeneous.

On the other hand when the red-shift is attributed to the recession of the nebula, the scale of distances is altered; the estimated distance of a nebula of a given apparent luminosity becomes now shorter by a factor $1 + v/c$, or $1 + \Delta\lambda/\lambda$, which ~~(practically equal to that in~~ ~~throughout~~ ~~the observed region to (or $1 + \Delta\lambda/\lambda$), which~~ Hubble calls the recession factor, in which v is the velocity of recession of the nebula, and c is the velocity of light. Using these distances r, Hubble finds that the red-shift can be represented by the expression

$$\Delta\lambda/\lambda = kr + lr^2 + \cdots \qquad \cdots (2)$$

where k has the same value as before, and $l = 2.54 \times 10^{-19}$ (light-year)$^{-2}$. Though Hubble uses two different numerical constants k and l in expression (2) it will be clear from the preceding ~~argument~~ statements that they are related; l must be approximately equal to k^2, which from the numerical values given above will be seen to be actually the case.

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The homogeneity of distribution of the nebulae found on the static model is now disturbed, and in order to restore the homogeneity Hubble has to postulate a curvature for the Universe. The radius of curvature required for this purpose, besides being small absolutely — it is not ~~very~~ very much greater than the range accessible to the 100 inch reflector — corresponds, according to Hubble, to a density of matter in the Universe, a thousand times greater than can be accounted for by the nebulae that we observe.

The distances r appearing in (2) which are also the distances with reference to which the nebular distribution in space just ~~just now~~ mentioned ~~above~~ is ~~calculated~~ expressed, are the distances at which the nebulae were at the times when the light signals which give us information now, left the nebulae; these times are natually different for different nebulae.

Besides drawing attention to

~~Besides noticing~~ the relationship between the two constants k and l appearing in (2), which is the main ~~The~~ purpose of this note, ~~is to draw attention to the~~ I may ~~be permitted to~~ mention incidentally the following simple results that follow therefrom, if we assume uniform velocities for the nebulae (i.e. velocities independent of time, the velocities being of course different for different nebulae and corresponding to their respective observed red-shifts) and if we substitute for the distances r in (2) the distances R at which the nebulae will actually be now, R being given by

$$R = r + \frac{r}{c}\cdot v = r\left(1 + \frac{v}{c}\right). \quad --- (3)$$

The results referred to are

1) the linear relation between the red shift and the distance is restored:

$$\Delta\lambda / \lambda = k R,$$

where k has the same numerical value as before:

2) to the same approximation, the distribution of the nebulae in space becomes homogenous, in the Milne sense, without our having to invoke any curvature for the Universe; and the ~~i.e. any larger curvature than would be given by the known density of mass in the Universe; the~~ homogeneity will ~~of course~~ remain undisturbed by the expansion.

Yours truly,

K S Krishnan

(K. S. KRISHNAN)

Oxford
July 2, 1946.

1) It may ~~of~~ be of interest to some of the educationists in India ~~to know~~ that this relationship was noticed while writing on this topic in one of the Indian languages.

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(Besides noticing the relationship between ~~k and l~~ the constants k and l appearing in (2), The purpose of this note is to draw attention to the following simple results that follow therefrom, if we assume uniform velocities for the nebulae, (i.e. velocities independent of time, the velocities being of course different for different nebulae and corresponding to their respective observed red-shifts,) and if we substitute for the distances r in (2) the distances R at which the nebulae will actually be now, R being given by

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