1953AJ.....58R..39G

Gamow, G. Origin of protogalaxies.

According to the general theory of relativity, expansion of a homogeneous isotropic universe is governed by the formula:

$$\frac{1}{l}\frac{dl}{dt} = \sqrt{\frac{8\pi G}{3}\rho + \text{const.}},$$

where l is the distance between two arbitrary material points, G the gravitational constant, and ρ the total mean density. Using for $l^{-1}dl/dt$ the present value of Hubble's constant, and for ρ the usually accepted value 10^{-30} g/cm³, we find that the first term under the radical is much smaller than the second. Thus the expansion proceeds now, and has been proceeding for a long time in the past, according to a simple linear law. Measuring time from the stage of maximum contraction, and expressing it in seconds, we obtain $\rho = 10^{21}\,t^{-3}$ g/cm³. This formula is approximately correct for $t > 10^{15}$ sec $= 3 \times 10^7$ years, whereas for earlier epochs the first term under the radical causes the deviation from linearity.

It is important to remember that total density is composed of matter density proper, and the mass density of thermal radiation, $\rho = \rho_{\text{mat}} + aT^4/c^2$. At the present epoch radiation density is negligibly small as compared with matter density, but it was not so in the past since in adiabatic expansion of radiation its density drops as the inverse 4th power of linear dimensions. Thus during early stages of expansion, it was governed entirely by radiation density. Noticing that $l^{-1}\,dl/dt = T^{-1}\,dT/dt$ (Wien's law), and neglecting matter density for small t's, we can integrate the expansion equation obtaining

$$T = \sqrt[4]{\frac{3c^2}{32\pi Ga}} \times t^{-\frac{1}{2}} = 1.5 \times 10^{10} t^{-\frac{1}{2}}\,{}^\circ\text{K},$$

and $aT^4/c^2 = 4.5 \times 10^5\ t^{-2}$g/cm³. Comparing this expression for mass density of radiation with the above derived expression for matter density, we find that the two curves intersect at $t_0 = 2.2 \times 10^{15}$ sec $= 7 \times 10^7$ years. At that epoch, when the mass density of thermal radiation sank below the density of matter, the temperature of the space was about 320°K, and the total mean density about 2×10^{-25} g/cm³.

It is reasonable to assume that the gravitational breakup of the originally homogeneous gas masses took place immediately after the matter threw off the yoke of radiation, i.e., at $t = 7 \times 10^7$ years. Using Jeans's formula of gravitational instability, we find that the minimum mass of original gaseous protogalaxies must have been 5×10^6 sun masses. This is about ten times smaller than the lower limit of galactic masses as estimated by Holmberg. To obtain a better agreement, we must assume that primordial gas was in a state of supersonic turbulence. Using Chandrasekhar's formula for that case, we find that in order to obtain a correct lower mass limit, one should assume that the mean Mach-number of primordial turbulence was somewhere between 3 and 5.

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Gasteyer, Charles. The quadruple system ζ Cancri.

The purpose of the present study was to investigate the orbital motion in the quadruple system ζ Cancri and to find the masses of the individual components. Three of the components are visible through the telescope. The photovisual magnitude of the brightest star A is 5.6. Star A is 0.3 magnitudes brighter than star B, and star B is 0.2 magnitudes brighter than star C, as determined in the present study from photovisual plates. The spectral type of A–B is F7 and of star C is G2. The fourth component, D, is invisible.

Stars A and B form a close visual pair whose motion about their common center of gravity, G, was determined from visual observations (1831–1951). The motion of star C and its invisible companion star D about their center of gravity, G′, as well as the motion of G′ about G were determined from visual observations (1821–1951) and from modern multiple-exposure photographic observations (1914–1952) by successive approximations. The period (P), eccentricity (e). periastron time (T), semi-major axis (a), and inclination (i) of the final orbits are as follows:

	B about A	G′ about G	C about G′
P	59.7 years	1150 years	17.8 years
e	0.32	0.26	0.11
T	1930.0	1820 ?	1944.4
a	0″.88	7″.5	0″.20
i	±172°	±156°	±142°

All orbital motions are retrograde.

The proper motion and parallax of the system were computed from measures made on photographic plates taken at the Yerkes Observatory on 49 nights, 1915–1951. The proper motion for equinox 1900 is $\mu_x = +0''.084$, $\mu_y = -0''.110$, where a mass ratio $(m_C + m_D)/(m_A + m_B + m_C + m_D) = 0.39$, derived from the above orbits, is assumed. The absolute parallax found from the

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