Zeitschrift: Helvetica Physica Acta

Band: 29 (1956)

Heft: [4]: Supplementum 4. Fünfzig Jahre Relativitätstheorie = Cinquantenaire de la Théorie de la Relativité = Jubilee of Relativity Theory

Artikel: On the Eddington relations and their possible bearing on an early state of the system of galaxies

Autor: Klein, O.

DOI: https://doi.org/10.5169/seals-112734

On the Eddington Relations and their Possible Bearing on an Early State of the System of Galaxies

by O. KLEIN (Stockholm)

Although astrophysical observations may require new laws of nature for their interpretation the arguments for such laws sought in the so called cosmological postulate and similar considerations seem to me very little convincing and more in line with aristotelian physics than with the general trend of science. Although arguments of beauty or simplicity are certainly of great importance in the search for new elementary laws, where the need of such laws is apparent, as in meson and nuclear physics, they are hardly at their place when we are concerned with a particular state of a large system. The following is an attempt to make use of EDDINGTON'S numerical relations, which have given rise to so much speculation of the kind just mentionned, as a starting point for a further inquiry with the history of the system of galaxies using only the well known laws of nature. This attempt is made on the following hypothetical assumptions about an early state of the system before the HUBBLE expansion had begun:

1. The system consisted of a thin, enormous hydrogen gas cloud, finite and limited in the ordinary sense of the word, in a quasistationary state under the influence of radiation pressure (exerted by means of THOMSON scattering of radiation of comparatively high frequency by the hydrogen atoms) and gravitation. The system of galaxies according to these assumptions is thus regarded just as one big stellar system, not as the entire world.

2. The system approached the highest degree of expansion compatible with the quasistationary state, namly that the mean free path of a proton was approaching its linear dimensions. This leads to the relation

$$\frac{\varrho_0}{m_p} \times \frac{8\pi}{3} d^2 R_0 \gtrsim 1 \,.$$

Here R_0 is the radius of the cloud, ϱ_0 its average density, m_p the proton mass and $d = e^2/m_e c^2$ the radius of the electron, m_e being the electron mass and e the elementary charge.

3. The system approached the highest mass compatible with its dimensions on general relativity theory. By means of the well-known SCHWARZSCHILD solution this implies

$$\frac{2\gamma M_0}{c^2 R_0} \gtrsim 1 ,$$

where M_0 is the mass of the cloud, γ the gravitational constant and c the vacuum velocity of light.

From the two inequalities which we shall give the form

$$\frac{8\pi}{3} \times \frac{8\varrho_0 R_0^2}{c^2} = \lambda , \qquad \frac{8\pi}{3} d^2 \frac{\varrho_0}{m_p} R_0 = \frac{1}{\mu} \tag{1}$$

where λ and μ are two positive fractions, we get

$$R_0 = \lambda\,\mu \frac{e^2}{\gamma m_e m_p} d = \lambda\,\mu \times 6{\cdot}3 \times 10^{26}\ \mathrm{cm}$$

$$\varrho_0 = \frac{1}{\lambda\mu^2} \times \frac{3}{8\pi} \times \left(\frac{e^2}{\gamma m_e m_p}\right)^{-1} \times \frac{m_p}{d^3} = \frac{1}{\lambda\mu^2} \times 4 \times 10^{-27}\ \mathrm{g/cm^3} \tag{2}$$

$$M_0 = \frac{\lambda^2\mu}{2}\left(\frac{e^2}{\gamma m_e m_p}\right)^{-1} = \lambda^2\,\mu \times 4 \times 10^{54}\, g = \lambda^2\,\mu \times 2 \times 10^{11}\, M_s .$$

Here M_s is the mass of the sun. Rewriting (2) in the form

$$\left(\frac{4\pi}{3} \times \frac{\varrho_0 R_0^3}{m_p}\right)^{1/2} = \frac{1}{\lambda\mu}\frac{R_0}{d} = \sqrt{\frac{\lambda^2\mu}{2}} \times \frac{e^2}{\gamma m_e m_p} \tag{3}$$

and assuming that the factors containing λ and μ do not deviate by any order of magnitude from unity we have the EDDINGTON relations with the difference that in them the quantities refer to the present condition of the world. The value (2) of ϱ_0, however, agrees better with an earlier, more condensed state of the system of galaxies than with the present state.

There is one more relation, which in this connection is often taken as the definition of the world radius, namely that it should correspond to the value c for the redshift velocity. Combined with the first relation (1) and with ϱ and R referring to the present state of the system of galaxies this gives

$$\frac{8\pi}{3}\gamma\,\varrho\, T^2 \approx 1 , \tag{4}$$

where T is the reciprocal HUBBLE constant. Taking BAADE's new value $T = 5{,}4 \times 10^9$ years, (4) gives

$$\varrho \approx 6{\cdot}7 \times 10^{-29}\ \mathrm{g/cm^3},$$

which agrees well with Hoyle's new value. Now, as is well known, (4) expresses approximately the condition for curvature 0, which for a finite, approximately Newtonian system means that it is just about able to expand to infinity. For this we may find an interpretation by means of the hypothesis that the gas cloud is a stage in the condensation of cold, extremely thin hydrogen gas through the action of gravity, the radiation present in the cloud considered above being due to ionisation by collisions followed by radiative recapture of electrons.