A COSMOLOGICAL MODEL WITHOUT SINGULARITY

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Abstract. Based on the assumption, that potential energy of matter in a mass filled space contributes a negative term to the energy tensor, solutions of the Einstein field equations are possible that exhibit no singularities, since the action of gravity changes sign when the density of potential energy exceeds the density of mass-energy. The solution, in which potential energy and mass-energy are in balance, is identical with Einstein’s static universe. It is shown that all the observational facts, that are usually considered as confirming the “big bang” model, as the cosmological red shift, the abundances of light elements and the existence of the microwave background radiation, can be understood also in a static world model, when it is taken into account that due to the finite velocity of gravitational interaction all moving quanta lose momentum to the gravitational tensor potential. As in the static cosmological model the overwhelming fraction of the total mass exists in form of a hot intergalactic plasma. The model gives a simple explanation for the diffuse x-ray background and a solution to the missing mass problem without invoking any kind of new physics or of yet undiscovered particles. Also the causality problem and the curvature problem posed by the energy density of the quantum mechanical vacuum fields find a natural solution.

1. Introduction

Today there is a strong belief in the physics community that the universe has started from a singular state about 10 to 20 billion years ago and is expanding since then. There are strong indications which support this view: the observed red shift of radiation emitted by distant galaxies may be explained by a recession caused by the expansion of space, the microwave background radiation, when explained as a residue of the radiation field, that filled the hot young universe, gives the correct spectral distribution and intensity of the radiation. Also the observed abundance of the light elements can be understood from the assumption that they have been synthesized in the hot “big bang”.

But there are a number of observed facts that are not understood or even contradict the big bang model.

1. Some stars in globular clusters in our galaxy seem to be older than the entire age of the universe, especially if we assume that the matter density is close to the critical density necessary to close the universe.

2. The microwave background radiation is isotropic to such a degree that it is difficult to explain how the observed distribution of galaxies and galaxy clusters should develop from such a homogeneous starting state.

3. The microwave background fits so well to a black body spectrum that there must be a thermalizing process at work still today. If the radiation field had been uncoupled from matter at the time when the ionized plasma cooled into neutral gas (at a red shift of about 1000), we should still see the red
shifted residuals of the hydrogen resonant lines, as in these spectral regions the radiation field would have been uncoupled from matter at a much later time and thus exhibit another radiation temperature than in those spectral regions, where only free-bound and free-free transitions contribute to the radiation balance.

4. The element abundances as calculated from big bang models are in agreement with observational facts only, if the density of baryonic matter is far below the critical density. On the other hand inflation theory (Guth, 1981), which has been developed to give an explanation for the large scale isotropy of space, requires a density very close to the critical density. But other than baryonic matter, what could solve the missing mass problem has not yet been discovered.

In addition there is an unresolved problem in the present view of the universe, that comes in from quantum mechanics. Quantum field theory requires a non-zero energy density of the vacuum due to quantum fluctuations which cause temporal formation of particle-antiparticle pairs. If both theories, quantum field theory and the presently favoured form of gravitation theory were correct, vacuum fluctuations should lead to a curvature of space that is 120 orders of magnitude above the limits posed by observations (Weinberg, 1989).

So there is a strong need for an improved model of the global structure and development of the universe, a model that combines the successes of the big bang model with a solution of the problems listed above.

2. The Theory of General Relativity and the Energy Tensor

Our present view of the development of the universe is based on Einstein’s theory of general relativity (GRT), which relates the geometry of space-time to the distribution of energy or matter fields and describes the dynamics of matter under the influence of gravitation as geodesic motion in a non-Euclidean space. The deformation of space-time by the matter fields is given by the well known Einstein field equations (Einstein, 1922)

$$R_{ij} - \frac{1}{2} R \times g_{ij} = -\kappa T_{ij} + \Lambda \times g_{ij}$$

where $R_{ij}$ is the Ricci tensor of curvature, $g_{ij}$ is the fundamental tensor, and $T_{ij}$ the energy tensor. The constant $\kappa$ is related to the gravitational constant $\gamma$ by $\kappa = 8\pi \gamma / c^4$. The last term is the so called “cosmological term”, added by Einstein to allow a stationary metric of the universe as a solution of the field equations. The second term of the left hand side has been added to the Ricci-tensor to assure that the covariant derivative of the left side is zero, with the argument that the total energy is a conserved quantity, so that the covariant derivative of the right hand side is zero by definition.