R^2 GRAVITY AND THE STRUCTURE OF THE UNIVERSE

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The "standard" hot big bang model accounts for the expansion of the Universe, the existence of the microwave background radiation, and the mass fraction of the light elements up to ^{4}He. It does not account for the high degree of isotropy and homogeneity of the Universe in the large, nor of the existence of structure (galaxies, clusters) on smaller scales. Other problems, such as the lepton to baryon ratio, the preponderance of matter over antimatter, and the "coincidences" of dimensionless ratios of several fundamental physical and cosmological "constants" also lie outside of the "standard" model at present.

A solution of the large scale homogeneity and isotropy problems, as well as the so-called "flatness" problem, has been proposed recently involving extreme supercooling during a phase transition associated with spontaneous symmetry breaking in Grand Unified Theories (Guth, 1981). This and related solutions are based on a direct application of the Einstein field equations for General Relativity $G_{\mu\nu} = -8\pi G T_{\mu\nu} - \Lambda g_{\mu\nu}$. The new feature of such theories is due to the introduction of a cosmological constant Λ at high densities due to the GUTs. Such theories do not, however, alleviate the problem of the origin of galaxies.

We propose a solution to both the large and small scale structure problems based on a modification of the left hand side of the field equations (Frenkel and Brecher, 1982). By starting with a gravitational field Lagrangian $R + AR^2$ (where A is a new dimensional constant), we derive a new set of field equations, consistent with all current weak field gravitational tests, which modify the cosmological solutions to General Relativity at early times when the high order terms predominate. Such solutions are without a particle horizon (with scale factor $a(t) \propto t$ as $t \to 0$). Furthermore, perturbations in both the density and metric tend to grow much more rapidly than in unmodified General Relativity.

REFERENCES

Frenkel, A. and Brecher, K.: 1982, Phys. Rev. D 26, pp. 368 - 372.
Guth, A.H.: 1981, Phys. Rev. D 23, pp. 347 - 356.

G. O. Abell and G. Chincarini (eds.), Early Evolution of the Universe and Its Present Structure, 483–484.

Discussion

Trimble: Presumably, you chose to add the particular term AR^2 to your Lagrangian because it was the simplest. Is there any more rhyme or reason to it than that?

Brecher: Reason, yes. In order to remove singularities in physical theories, adding a term with higher derivatives often does the trick. Rhyme? Yes, too. I present it below, in hopes that it will inspire Furgeson

UNIFIED FIELD THEORY

By Tim Joseph

In the beginning there was Aristotle,
And objects at rest tended to remain at rest,
And objects in motion tended to come to rest,
And soon everything was at rest,
And God saw that it was boring.

Then God created Newton,
And objects at rest tended to remain at rest,
But objects in motion tended to remain in motion,
And energy was conserved and momentum was conserved and matter was conserved,
And God saw that it was conservative.

Then God created Einstein,
And everything was relative,
And fast things became short,
And straight things became curved,
And the universe was filled with inertial frames,
And God saw that it was relatively general, but some of it was especially relative.

Then God created Bohr,
And there was the principle,
And the principle was quantum,
And all things were quantified,
But some things were still relative,
And God saw that it was confusing.

Then God was going to create Furgeson,
And Furgeson would have unified,
And he would have fielded a theory,
And all would have been one,
But it was the seventh day,
And God rested,
And objects at rest tended to remain at rest.

Tim Joseph works for a nutrition program affiliated with Cornell University. He also writes science fiction.

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