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ORIGINAL ARTICLE

# Kaluza-Klein radiating model in a general scalar-tensor theory

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**Abstract** A five dimensional Kaluza-Klein space-time is considered in the presence of prefect fluid source in the general scalar-tensor theory of gravitation proposed by Nordtvedt (Astrophys. J. 161:1069, 1970) with the help of special law of variation for Hubble's parameter given by Bermann (Nuovo Cimento 74B:182, 1983). A cosmological model with a negative constant deceleration parameter is obtained in this theory. Some physical properties of the model are also discussed.

**Keywords** Kaluza-Klein model · General scalar-tensor theory · Radiating model

## 1 Introduction

Several theories have been proposed as alternatives to Einstein's theory. Brans and Dicke (1961) formulated a scalar-tensor theory of gravitation which is supposed to be the best alternative to Einstein's theory. This theory includes a long range scalar field interacting equally with all forms of matter (with the exception of electromagnetism). Brans-Dicke field equations for combined scalar and tensor fields are

$$G_{ij} = -8\pi\phi^{-1}T_{ij} - \omega\phi^{-2}\left(\phi_{,i}\phi_{,j} - \frac{1}{2}g_{ij}\phi_{,}\phi^{,k}\right) - \phi^{-1}(\phi_{i;j} - g_{ij}\Box\phi) \tag{1}$$

$$\Box\phi = \phi^{;k}_{;k} = 8\pi\phi^{-1}T(3+2\omega)^{-1} \quad \text{and} \tag{2}$$

$$T^{ij}_{;j} = 0 \tag{3}$$

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where $G_{ij} = R_{ij} + \frac{1}{2}g_{ij}R$ is the Einstein tensor, $T_{ij}$ is stress energy tensor of matter, $\omega$ is a dimensionless coupling constant and comma and semicolon denote partial and covariant differentiation respectively.

In view of the recent experimental evidence it is argued that if Brans-Dicke theory of gravitation is to be a correct theory, the value of the coupling parameter $\omega$ in this theory has to be as large as, or even greater than 500. With such a large value for $\omega$ it is difficult to distinguish between Brans-Dicke theory and general theory of relativity, at least from their consequences. However, since there is no 'a priori' reason to exclude the introduction of any long-range scalar field in the evolution of the universe, which might be quite important at some epoch, one may explore the possibility of a general scalar-tensor theory with $\omega$ as time dependent function.

Within the framework of the general scalar-tensor theory of gravitation proposed by Nordtvedt (1970) the parameter $\omega$ of Brans-Dicke theory is allowed to be an arbitrary function of the scalar field $\phi$.

The field equations of this scalar-tensor theory are

$$G_{ij} = -8\pi\phi^{-1}T_{ij} - \omega\phi^{-2}\left(\phi_{,i}\phi_{,j} - \frac{1}{2}g_{ij}\phi_{,k}\phi^{,k}\right) - \phi^{-1}(\phi_{i;j} - g_{ij}\phi^{;k}_{;k}) \tag{4}$$

$$\phi^{;k}_{;k} = \frac{8\pi T}{3+2\omega} - \frac{\phi_{,k}\phi^{,k}}{3+2\omega}\frac{d\omega}{d\phi} \tag{5}$$

where the symbols have their usual meaning as in Brans-Dicke theory. Equation (3) is valid in this theory also. This general class of scalar-tensor theories includes the Jordan (1955) and Brans-Dicke (1961) theories as special cases.

Barker (1978), Ruban and Finkelstein (1972), Banerjee and Santos (1981a, 1981b), Shanthi (1989) and Shanthi and