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A NEW CLASS OF ELECTROMAGNETIC FIELDS

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RECENTLY, several authors[1-4] have derived theorems which may be used to generate electromagnetic solutions of the field equations from given vacuum solutions. These results are generalisations of an earlier work by Weyl[5] who investigated axially symmetric gravitational fields. Such electromagnetic fields are, therefore, known as Weyl class of electromagnetic fields. In this note we discuss a procedure by which one can generate a new class of electromagnetic fields, which are not of Weyl type, from a given axially symmetric, vacuum gravitational field.

Consider the following set of field equations:

$$R_{ij} - (1/2)\, g_{ij} R \equiv G_{ij} = -8\pi E_{ij}, \tag{1}$$

$$F^{ij}{}_{;j} = 0, \tag{2}$$

$$F_{[ij;k]} = 0, \tag{3}$$

where

$$E_{ij} = (1/4\pi)\,[g^{kl} F_{ik} F_{jl} - (1/4)\, g_{ij} F_{kl} F^{kl}]. \tag{4}$$

The symbols used here have their usual meaning. We choose the axially symmetric static metric in the form[6]

$$ds^2 = e^{2u}\, dt^2 - e^{2k-2u}\,[(dx^1)^2 + (dx^2)^2] - h^2 e^{-2u}\, d\phi^2, \tag{5}$$

where u, k and h are functions of x^1 and x^2 only. The vacuum field equations for the metric (5) are easily obtained as:

$$u_{,11} + u_{,22} + (1/h)\,(u_{,1} h_{,1} + u_{,2} h_{,2}) = 0, \tag{6}$$

$$2\,(u_{,2}^2 - u_{,1}^2) + (2/h)\,(k_{,1} h_{,1} - k_{,2} h_{,2}) + (1/h)\,(h_{,22} - h_{,11}) = 0, \tag{7}$$

$$2u_{,1} u_{,2} - (1/h)\,(k_{,2} h_{,1} + k_{,1} h_{,2}) + \frac{h_{,12}}{h} = 0, \tag{8}$$

$$h_{,11} + h_{,22} = 0. \tag{9}$$

However, if one takes the stress-tensor of an electromagnetic field as the source of the gravitational field equations, *i.e.*, Eqn. (1), one can obtain the field equations with the help of only two components of the four potential. If one introduces the potentials A and B in the following manner[3,7,8]

$$\left.\begin{aligned} F^{\alpha\beta} &= (-g)^{-1/2}\, \epsilon^{\alpha\beta\gamma} A_{,\gamma} \\ F_{0\alpha} &= B_{,\alpha} \end{aligned}\right\},\quad \alpha, \beta \ldots = (1,2,3) \tag{10}$$

where $A = A(x^1, x^2)$ and $B = B(x^1, x^2)$, one obtains the stress-tensor E_{ij} in a symmetrical form with respect to A and B. Further, there are only two non-trivial Maxwell equations amongst (2) and (3) which are identical with regard to A and B. This situation allows one to introduce a single potential C such that:

$$\left.\begin{aligned} A &= C \sin\alpha \\ B &= C \cos\alpha \end{aligned}\right\}, \tag{11}$$

where α is a constant. Equations (11) are equivalent to a 'duality rotation' of Misner and Wheeler.[9] These considerations lead to the following field equations:

$$u_{,11} + u_{,22} + (1/h)\,(u_{,1} h_{,1} + u_{,2} h_{,2}) = -e^{-2u}\,[C_{,1}^2 + C_{,2}^2], \tag{12}$$

$$u_{,2}^2 - u_{,1}^2 + (1/h)\,(k_{,1} h_{,1} - k_{,2} h_{,2}) + (1/2h)\,(h_{,22} - h_{,11}) = e^{-2u}\,[C_{,1}^2 - C_{,2}^2], \tag{13}$$

$$2u_{,1} u_{,2} - (1/h)\,(k_{,2} h_{,1} + k_{,1} h_{,2}) + (h_{,12}/h) = -2e^{-2u}\, C_{,1} C_{,2}. \tag{14}$$

Further, the only non-vanishing Maxwell equation is obtained as:

$$C_{,11} + C_{,22} + (1/h)\,(C_{,1} h_{,1} + C_{,2} h_{,2}) - 2\,(C_{,1} u_{,1} + C_{,2} u_{,2}) = 0. \tag{15}$$

Let us now introduce an auxiliary function M defined in terms of u by the relation:

$$e^u = \lambda h \sinh M \quad (16)$$

where $M = M(x^1, x^2)$ and λ is an arbitrary constant. When expressed in terms of M Eqns. (12) and (15) become:

$$\cosh M \sinh M [M_{,11} + M_{,22} + (1/h) \times (h_{,1} M_{,1} + h_{,2} M_{,2})] - (M_{,1}^2 + M_{,2}^2) = -(1/\lambda^2 h^2)(C_{,1}^2 + C_{,2}^2), \quad (17)$$

$$C_{,11} + C_{,22} - (1/h)(h_{,1} C_{,1} + h_{,2} C_{,2}) = 2 \coth M (C_{,1} M_{,1} + C_{,2} M_{,2}) \quad (18)$$

One may easily see by direct substitution that Eqn. (18) is identically satisfied if we choose the following relation between M and C.

$$C_{,1} = -\lambda h M_{,2},\ C_{,2} = \lambda h M_{,1} \quad (19)$$

Further, Eqn. (17) in view of (19) becomes,

$$M_{,11} + M_{,22} + (1/h)(M_{,1} h_{,1} + M_{,2} h_{,2}) = 0, \quad (20)$$

which is same as Eqn. (6) with u replaced by M. It may be noted that the integrability condition for C, *i.e.*, $C_{,12} = C_{,21}$ also leads to Eqn. (20).

Now, Eqns. (13) and (14), when expressed in terms of M become, in view of (19):

$$2(M_{,2}^2 - M_{,1}^2) + (2h_{,1}/h) \times [k_{,1} - \{\log(h \sinh^2 M)\}_{,1}] - (2h_{,2}/h)[k_{,2} - \{\log(h \sinh^2 M)\}_{,2}] - (1/h)(h_{,22} - h_{,11}) = 0, \quad (21)$$

$$2M_{,1} M_{,2} - (h_{,1}/h) \times [k_{,1} - \{\log(h \sinh^2 M)\}_{,1}] - (h_{,2}/h)[k_{,2} - \{\log(h \sinh^2 M)\}_{,2}] + h_{,12}/h = 0. \quad (22)$$

We can therefore write:

$$k = \bar{k} + \log(h \sinh^2 M)$$

where $\bar{k}$ is determined from:

$$2(M_{,2}^2 - M_{,1}^2) + (2/h)(\bar{k}_{,1} h_{,1} - \bar{k}_{,2} h_{,2}) + (1/h)(h_{,22} - h_{,11}) = 0, \quad (23)$$

$$2M_{,1} M_{,2} - (1/h)(\bar{k}_{,1} h_{,2} + \bar{k}_{,2} h_{,1}) + h_{,12}/h = 0. \quad (24)$$

One may notice that Eqns. (23) and (24) are the same equations as (7) and (8) with k replaced by $\bar{k}$. Thus, we have established the following theorem:

"For every static vacuum gravitational field with axial symmetry there corresponds a solution of the combined Maxwell-Einstein equations of the type discussed in this note which do not belong to Weyl class of electromagnetic solutions."

A special case of the investigations presented in this note was discussed earlier by Gautreau and Hoffman.[10]

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K-X RAY AND GAMMA-RAY ANGULAR CORRELATIONS IN THE DECAY OF ^{153}GD AND ^{186}RE, USING HIGH EFFICIENCY SUM-PEAK COINCIDENCE SCINTILLATION SPECTROMETER

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THERE has been a considerable interest in recent years on the angular correlations between X-rays emitted by isotopes in K-capture decay and the following gamma-rays. Dolginov[1] proposed a theory which denies any such correlation. However, Perepelkin[2] reported a finite correlation with a ^{54}Mn source in contradiction with the theory. Subsequent studies of Ramaswamy,[3,4] and Fechner *et al.*[5] did not find evidence for any such correlation. Since sum-coincidence techniques are very sensitive for the detection of small anisotropies, a systematic investigation is undertaken on K-X ray and gamma-ray directional correlations. Earlier studies[6] with an ^{114m}In source did not show any anisotropy. The studies are extended to include different nuclear environments and different types of K-capture.