SHORT COMMUNICATIONS

DIVERGENCE FREE WEYL CONFORMAL TENSOR AND PERFECT FLUID DISTRIBUTIONS

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ASSUMING that the stream lines are normal to the surfaces $\rho=$ constant, Vaidya[1] obtained the non-static analogue of the Schwarzschild's interior solution. The purpose of this note is to give the geometric condition for which Vaidya's assumption holds and then study its consequences. First we give some necessary equations in usual notation.

Einstein's field equations for the perfect fluid distributions are

$$R^i_j-\tfrac{1}{2}Rg^i_j+\lambda g^i_j=-8\pi T^i_j \tag{1}$$

where

$$T^i_j=(\rho+p)u^iu_j-pg^i_j,\quad u^iu_i=1. \tag{2}$$

From (1), we have

$$-R+4\lambda=-8\pi T. \tag{3}$$

The contracted Bianchi identities give

$$R^h_{ijk;h}+R_{ik;j}-R_{ij;k}=0. \tag{4}$$

Also

$$(R^i_j-\tfrac{1}{2}Rg^i_j)_{;i}=0 \tag{5}$$

The equations $T^i_{i;j}=0$ for (2) imply the equation of continuity

$$\rho_{,i}u^i+(\rho+p)u^i_{;i}=0 \tag{6}$$

and the Euler equation

$$p_{,i}u^iu_j+(\rho+p)u_{j;i}u^i-p_{,j}=0. \tag{7}$$

The Weyl conformal tensor is given by

$$C^h_{ijk}=R^h_{ijk}-\tfrac{1}{2}(R_{ij}g^h_k+R^h_kg_{ij}-R^h_jg_{ik}-R_{ik}g^h_j)+\frac{R}{6}(g_{ij}g^h_k-g^h_jg_{ik}). \tag{8}$$

We now prove that if the Weyl conformal tensor is divergence-free then the stream lines in a perfect fluid are everywhere normal to the surfaces $\rho=$ constant.

If $C^h_{ijk;h}=0$ then from (8) with the help of (4) and (5), we can obtain

$$R^i_{j;k}-R^i_{k;j}+\tfrac{1}{6}(R_{,j}g^i_k-R_{,k}g^i_j)=0. \tag{9}$$

Using (1) and (3) this becomes

$$T^i_{k;j}-T^i_{j;k}+\tfrac{1}{3}(T_{,k}g^i_j-T_{,j}g^i_k)=0. \tag{10}$$

Take the inner product of (10) with u^ku_i and use (2) to get

$$(\tfrac{2}{3}\rho+p)_{,j}-(\tfrac{2}{3}\rho+p)_{,k}u^ku_j-(\rho+p)u_{j;k}u^k=0. \tag{11}$$

Using (7) in (11), we get

$$\rho_{,j}=\rho_{,k}u^ku_j \tag{12}$$

which proves the result.

The converse of the above result, in general, is not true. In a comoving co-ordinate system, (12) implies $C^h_{ijk;h}=0$ or equivalently (10) if $\rho=-p=$ constant or the Christoffel symbols Γ^1_{24}, Γ^1_{34}, Γ^2_{14}, Γ^2_{34}, Γ^3_{14}, Γ^3_{24} vanish and $\Gamma^1_{14}=\Gamma^2_{24}=\Gamma^3_{34}=\tfrac{1}{3}u_4u^i_{;i}$. One can verify that the converse is true for the Robertson–Walker metric but false for the metric

$$ds^2=-b^2t^{2\sqrt{1+a^2}}dx^2-(t/a)^2\times(dy^2+\sin^2y\,dz^2)+dt^2 \tag{13}$$

for which

$$8\pi p=\lambda-[(1+a^2)/t^2] \tag{14}$$

$$8\pi\rho=[(1+a^2+2(1+a^2)^{1/2})/t^2]-\lambda \tag{15}$$

where a and b are constants.

The angular velocity Ω^i of the flow vector u^i is given by

$$\Omega^i=(\epsilon^{ijkl}/\sqrt{-g})w_{jkl} \tag{16}$$

where ϵ^{ijkl} is the usual Levi-Civita symbol and

$$3!\ W_{jkl}=u_j(u_{k,l}-u_{l,k})+u_k(u_{l,j}-u_{j,l})+u_l(u_{j,k}-u_{k,j}). \tag{17}$$

For the flow vector given by (12) a straightforward calculation gives $W_{jkl}=0$. Hence $\Omega^i=(0,0,0,0)$. Its magnitude Ω is also zero. Thus the stream lines are twist-free. In fact we have proved that

$$C^h_{ijk;h} = 0 \Rightarrow \rho_{,i} = \rho_{,k}u^k u_i \Rightarrow \Omega = 0. \quad (18)$$

Since $u^4 \neq 0$, (12) implies that $\rho_{,4} \neq 0$ provided $\rho \neq$ constant. We note that Vaidya[1] has shown that if $\rho \neq$ constant then $p = p(\rho, d\rho/ds)$. Hence there is no static perfect fluid distribution with $\rho \neq$ constant for which $C^h_{ijk;h} = 0$. Lastly, since $C^h_{ijk} = 0 \Rightarrow 0 = C^h_{ijk;h} = 0$, all the above results are valid for conformally flat space times representing perfect fluid distributions.

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1. Vaidya, P. C., *Phys. Rev.*, 1968, **174**, 1615.

SLEEP MODE FOR TRANSISTOR RECEIVERS

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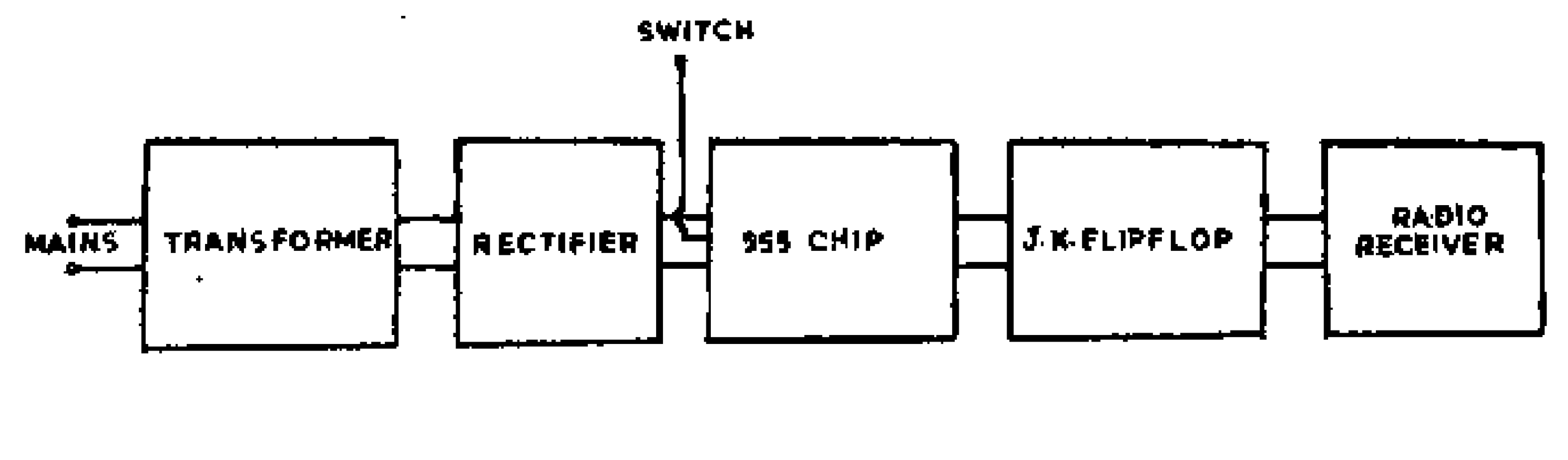
SLEEP mode is usually provided in two-in-ones. When the tape reaches one end the instrument switches off the receiver. The present gadget can switch off the receiver after a specified time. This can be incorporated into the existing radio receiver. See the diagram of the circuitary.

Usually a transformer and a rectifier are used as a battery eliminator. Addition of two chips—555 and J–K flipflop—would make the device a sleep mode gadget. The 555 chip provides the necessary delay time after which the receiver is switched off automatically. J–K flipflop reduces the load on 555 chip — once the switch is pressed down, 555 chip sends a pulse after a specified time, say 10 or 15 min. The J–K flipflop changes the state from high to low. This switches off the receiver automatically.



CIRCUIT DIAGRAM

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OCCULTATION OF SAO 185428 BY 336 LACADIERA

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THE predicted occultation of SAO 185428 by the asteroid 336 Lacadiera (Occultation Newsletter Vol. III, No. 14, p. 304, 1985) was recorded with the 50 cm telescope at the High Altitude Site Survey Observatory of the Department of Science and Technology in Leh (Long: 77° 34′ East, Lat: + 34° 09′) on 12 May 1986. However, the event occurred about 24 min prior to the predicted time.

The output from the unrefrigerated 1P21 photomultiplier was fed to a chart recorder after amplification through a DC amplifier. Figure 1 shows the portion of the record during the event.

The immersion occurred at $19^h\ 15^m\ 32^s$ and emersion at $19^h\ 15^m\ 57^s$ UT. Thus the duration of the event was 25 sec which turned out to be larger by 9 sec than the predicted duration. This longer duration suggests an elongated shape for the asteroid since the prediction was made assuming that the asteroid was spherical. Further the event appears to be a case of grazing occultation, because the observed drop in light level is about 0.9 mag, whereas a total occultation would have given a drop of ~ 4 mag. A continuous visual monitoring during the event through the 15 cm guide telescope showed flickering of the star light which could be a result of several disappearances and reappearances of the star behind the irregular limb of the asteroid.

A single observation like this can only set a lower limit to the size of the minor planet which may be obtained from a knowledge of the relative velocity of the object and the duration of the occultation event. Simultaneous observations from several sites within 10–50 km from the centre of the track will lead to a better estimate of the size and shape of the asteroid. However, on the basis of the present observation, it may still be inferred that the asteroid