LETTERS TO THE EDITOR

A UNIVERSE FILLED WITH MAGNETOFLUID

THE field equations for relativistic magnetohydrodynamics proposed by Lichnerowicz (1967) are as follows:

$$T_{\alpha\beta} = (\rho_0 \nu + \mu \mid h \mid^2) u_\alpha u_\beta - \left(\frac{p}{c^2} + \frac{1}{2}\mu \mid h \mid^2\right) g_{\alpha\beta} - \mu h_\alpha h_\beta, \quad (1)$$

$$(u_\beta h^\alpha - u^\alpha h_\beta);\ \alpha = 0, \quad (2)$$

$$TdS = d\epsilon + pd\left(\frac{1}{\rho_0}\right), \quad (3)$$

where

$$\nu = 1 + \frac{\epsilon}{c^2} + \frac{p}{\rho_0 c^2}, \quad (4)$$

$$u^\alpha h_\alpha = 0, \quad h^\alpha h_\alpha = -\mid h \mid^2 \quad (5)$$

u^α is flow vector, h^α is magnetic field vector, μ is the constant magnetic permeability, p is the pressure, ρ_0 is the matter density, ϵ is the internal energy of the fluid, T is the proper temperature and S is the specific entropy.

A solution of the field equations with the energy momentum tensor (1) has been obtained as

$$ds^2 = dt^2 - \frac{R^2}{c^2}\left(1 + \frac{n^2}{4r^2 R^2}\right)^2 \times (dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta d\phi^2), \quad (6)$$

where R is an arbitrary function of t only and n is an arbitrary constant.

The magnetic field gives rise to supplementary pressure, energy density and internal energy density. Therefore, the total pressure p^*, the total density ρ^* and total internal energy density ϵ^* (*see* Lichnerowicz, 1967) for the solution (6) are given by

$$8\pi G\rho^* = \frac{3\dot{R}^2}{R^2} + \frac{c^2 n^2}{r^4} e^{-2b},$$

$$\frac{8\pi G}{c^2} p^* = -\frac{\dot{R}^2}{R^2} - \frac{2\ddot{R}}{R} + \frac{n^2}{r^4} e^{-2b},$$

$$\frac{8\pi G}{c^2} \epsilon^* = \frac{1}{\rho_0}\left\{\frac{3\dot{R}^2}{R^2} + \frac{c^2 n^2}{r^4} e^{-2b}\right\} - 8\pi G, \quad (7)$$

where

$$e^b = R^2\left\{1 + \frac{n^2}{4r^2 R^2}\right\}^2$$

An overhead dot denotes differentiation with respect to t.

The expansion θ^*, the acceleration $\dot{u}^\alpha$ the rotation $\omega_{\alpha\beta}$ and shear $\sigma_{\alpha\beta}$ for the solution (6) are

$$\theta^* = \frac{3\dot{R}}{2R}, \quad \dot{u}^\alpha = \omega_{\alpha\beta} = \sigma_{\alpha\beta} = 0. \quad (8)$$

Thus the solution corresponds to an expanding non-uniform model universe (McVittie, 1965) filled with a non-accelerating irrotational and thermodynamical perfect fluid with an infinite conductivity and constant magnetic permeability. The constant n can be interpreted as magnetic polestrength of a point source situated at the centre of a spherically symmetric space-time filled with a magnetofluid. Even if the existence of isolated magnetic monopole is not known, the situation described here may be present in astronomical systems like magnetic stars, galaxies and pulsars where the magnetic field is strong (Yodzis, 1971). If the magnetic field is absent ($n = 0$) the solution (6) reduces to well-known deSitter's non-static universe.

The unknown function R for incompressible fluid ($\epsilon = 0$, $n = 0$, $\rho_0 =$ const.) is given by

$$R(t) = R_0 \exp.\{\surd(8\pi G\rho_0/3)\ t\}, \quad (9)$$

where R_0 is a constant. For the degenerate gas (Taub, 1956) characterized by the caloric equation

$$\frac{\epsilon}{c^2} = \frac{3p}{\rho_0 c^2} - 1, \quad (10)$$

we have

$$R(t) = A\sqrt{t + B}, \quad (11)$$

where A and B are constants.

The relation between relative mass M and proper mass M_0 (Narlikar, 1968) of a test particle in the field characterised by (6) is given by

$$M^2 = M_0^2\left\{1 + \frac{F(r)}{R^2(t)}\right\}\left(1 + \frac{n^2}{4r^2 R^2}\right)^{-2} \quad (12)$$

where F (r) is an arbitrary function of r only. We find that the relative mass m varies with r and t. When $r = r_0$ and $t \to \infty$ for incompressible fluid as well as for degenerate gas the relative mass approaches to proper mass.

The author is grateful to Professor V. V. Narlikar for discussion and Dr. L. Radhakrishna for valuable suggestions.

Shivaji University, T. H. DATE.
Kolhapur-4, *December* 20, 1972.

1. Lichnerowicz, A., *Relativistic Hydrodynamics and Magnetohydrodynamics*, Benjamin, Inc., N.Y., 1967, p. 94.
2. McVittie, G. C., *General Relativity and Cosmology*, Chapman and Hall Ltd., London, 1965, p. 140.
3. Yodzis, P., *Phys. Rev. D.*, 1971, 3 (12), 2941.
4. Taub, A. H. *Phys. Rev.*, 1956, 103, 454.
5. Narlikar, V. V., *Curr. Sci.*, 1968, 37 (10), 281.

ON THE LEVELS OF ^{192}Pt AND ^{192}Os

THE study of the energy levels of ^{192}Pt and ^{192}Os has attracted the attention of several investigators[1-6]. Among all the earlier investigations[1-5] there has always been inconsistencies in the number of existing levels and the gamma transitions in both the ^{192}Pt and ^{192}Os. We have studied the decay of ^{192}Ir using a high resolution Ge (Li) gamma ray spectrometer in order to remove such inconsistencies, and the efforts have been made to look critically the weak gamma ray transitions which might have not been resolved in earlier investigations.

The ^{192}Ir radioactive source was used in the form of sodium chloro iridate in HCl solution, which was obtained from the BARC, Trombay (India). The lithium drifted germanium detector having a resolution of about 3 keV was used for the detection of gamma rays. The gamma ray spectra were recorded in the 4096 channel analyzer. ^{152}Eu was used as the calibration source for determining the energies of the gamma ray peaks.

The ^{192}Ir isotope decays through all the three beta processes and populates the levels of ^{192}Os through electron capture and β^+-emission, and the levels of ^{192}Pt through β^--emission. Twenty-eight gamma transitions have been observed in the decay of ^{192}Ir. Out of them, ten gamma rays depopulate the levels of ^{192}Os and the rest are observed to depopulate the levels of ^{192}Pt. The gamma rays of our interest in the gamma ray spectra obtained from 4096 channel analyzer are shown in Figs. 1 and 2. The energies of the prominent gamma rays obtained from our data fit well with the level scheme shown in Fig. 3.

In addition to the well-established gamma rays, four new weak but clear gamma ray peaks of energies 628·5, 785, 912·1 and 921 keV are also observed in our spectrum (Figs. 1 and 2).

We find a weak but clear evidence for the existence of 478 and 1090 keV gamma rays. These gamma rays fit well in the level scheme of ^{192}Pt by ascribing a level at 1090 keV. The 1090 keV gamma ray is a cross-over transition and the 478 keV gamma ray seems to exist between the 1090 and 612·5 keV states. So far, only Schellenberg[2], on the basis of his internal conversion studies, has reported the existence of these gamma rays by ascribing a level at 1090 keV in ^{192}Pt.

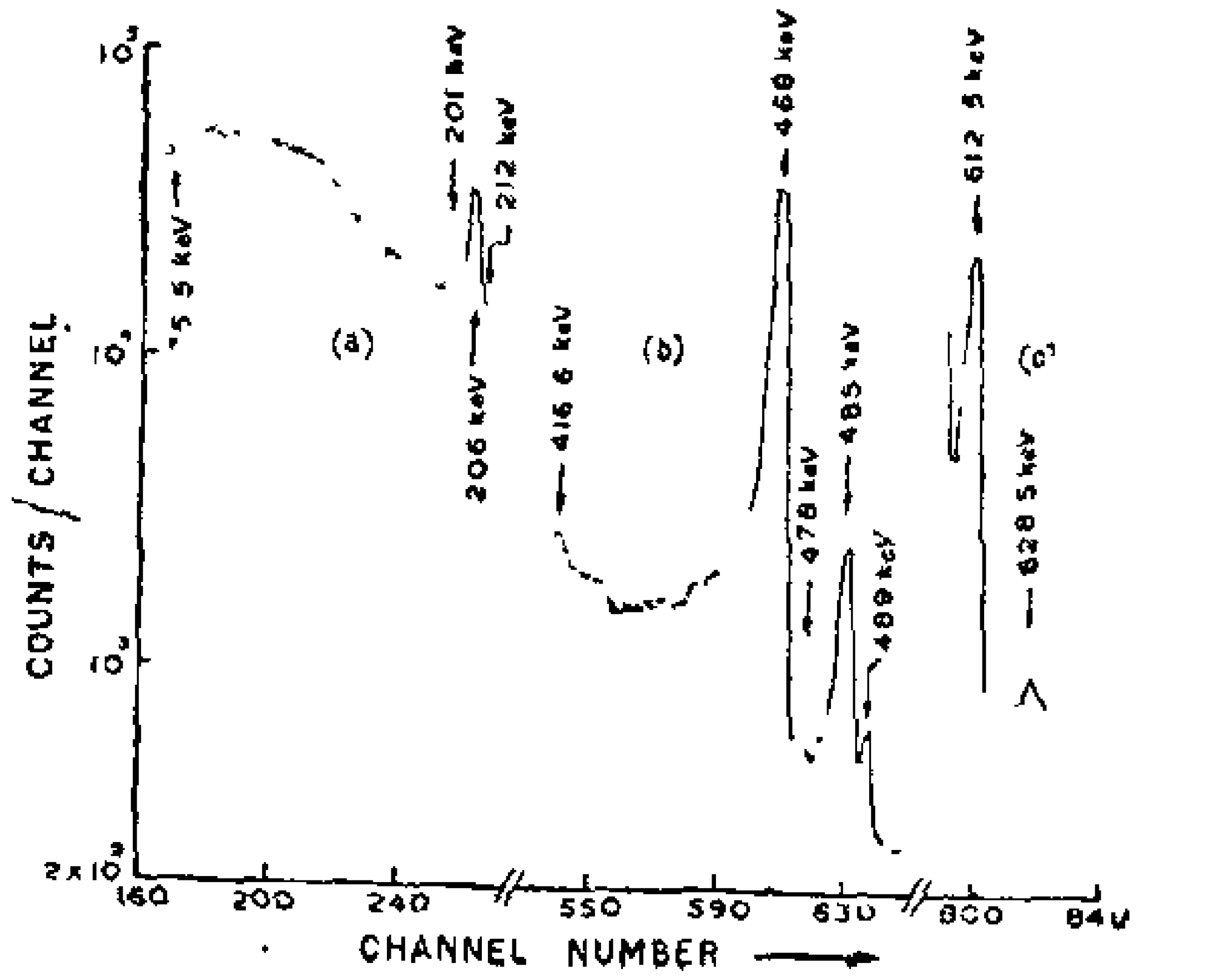

FIG. 1

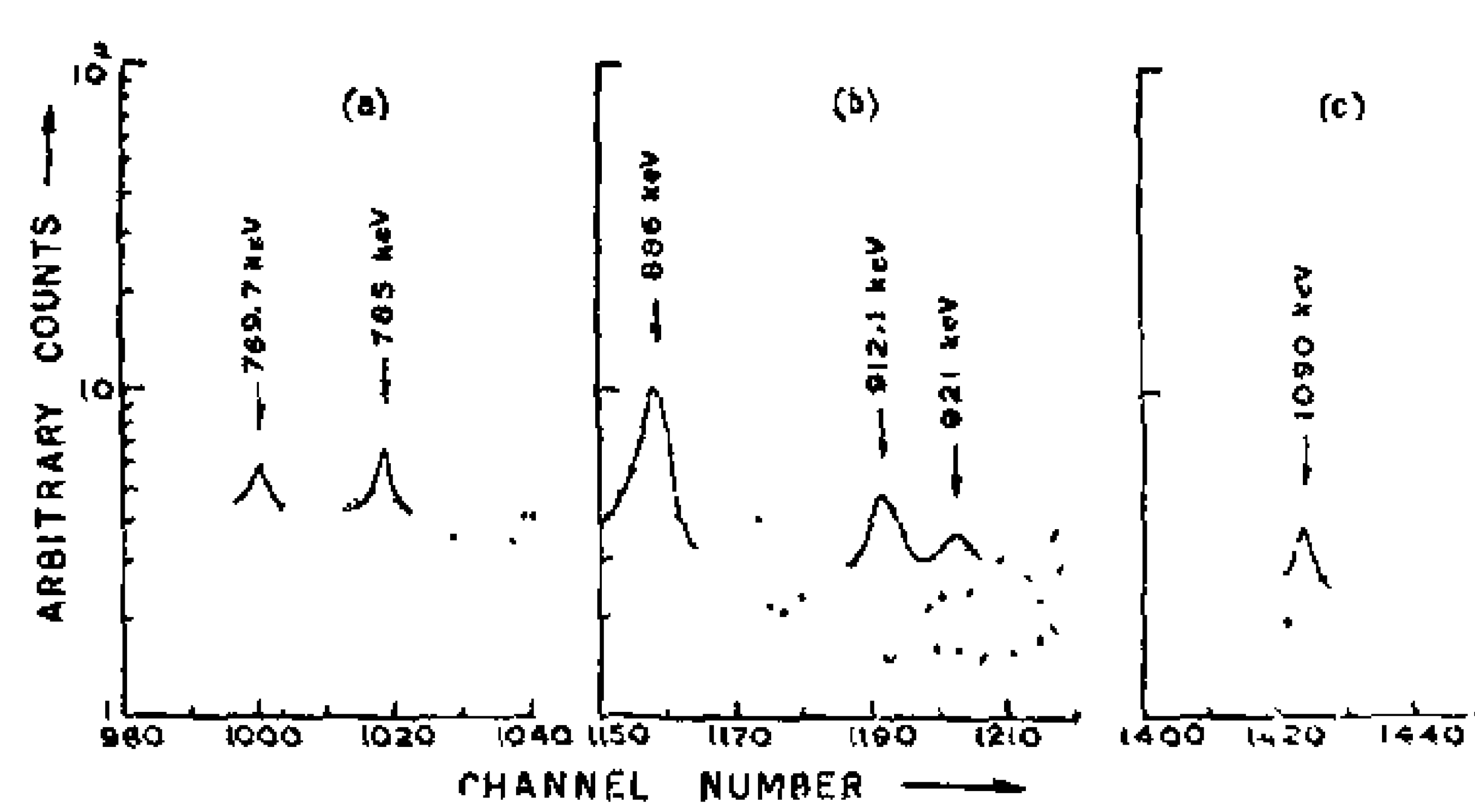

FIG. 2

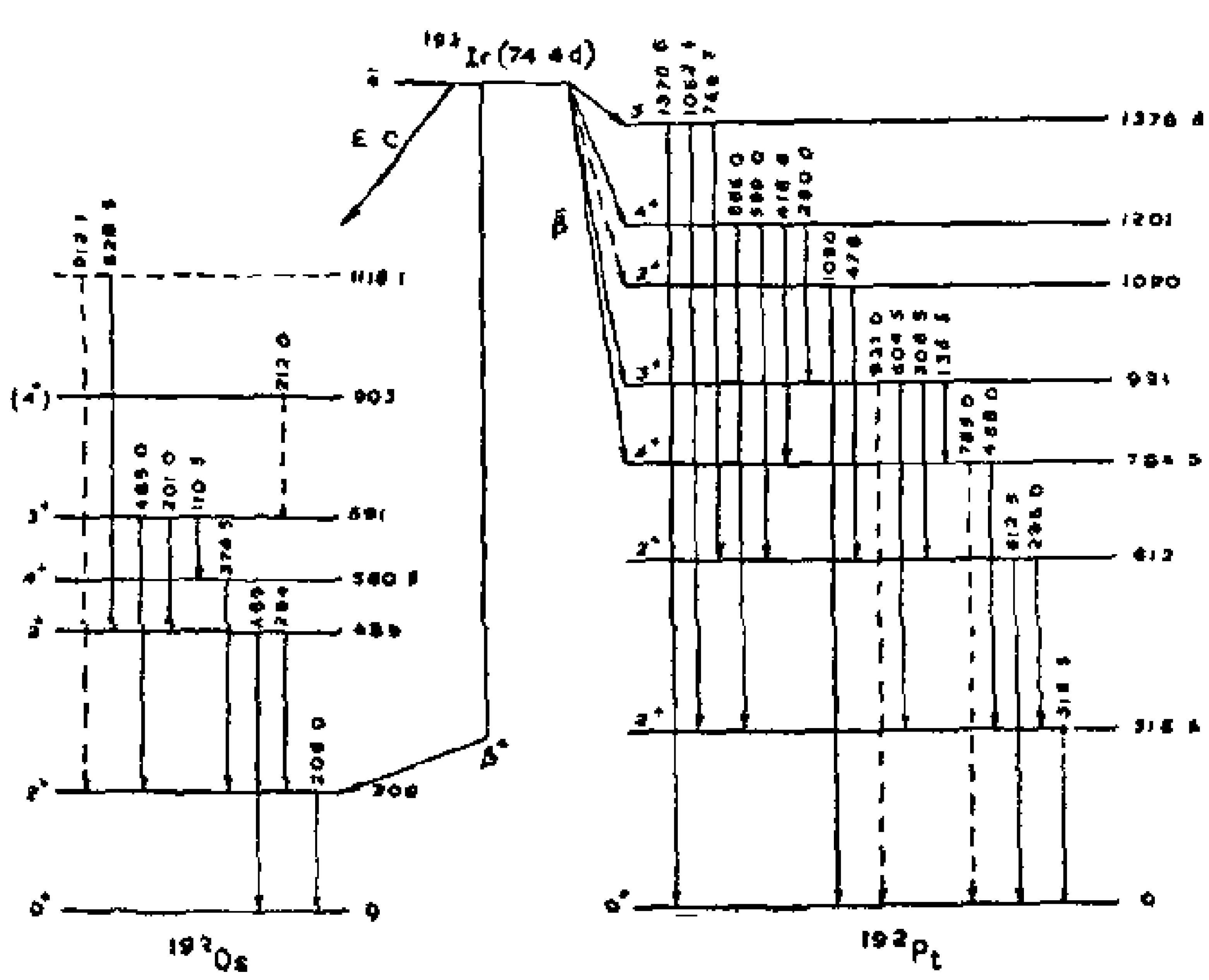

FIG. 3