

## Circular orbits of an electron around a proton in Schwarzschild geometry

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**Abstract.** The energy of an electron in circular orbits around a proton in Schwarzschild geometry has been investigated and is found to be red shifted. The electrical dipole moment of such a system is also estimated.

**Keywords.** Charged particle orbits; general relativity; Schwarzschild geometry.

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### 1. Introduction

Charged particle orbits in the field of a static charge near a Schwarzschild black hole have been recently discussed by Sonar *et al* (1985) and Chellathurai *et al* (1986). They found that the charged particles can execute circular orbits around the axis joining the static charge and the black hole. In this paper we apply the same formalism to a system of a static proton and an electron-executing circular orbits in the gravitational field described by Schwarzschild metric.

### 2. Calculation

The background geometry is given by

$$ds^2 = \left(1 - \frac{2m}{r}\right) c^2 dt^2 - \left(1 - \frac{2m}{r}\right)^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2 \theta d\phi^2, \quad (1)$$

wherein  $m = MG/c^2$ ,  $M$  being the mass of the black hole and other symbols having usual meaning. The electric field of the proton stationary at  $r = b$ ,  $\theta = 0$  can be obtained from the four-potential

$$A_i = (A_r, 0, 0, 0), \quad (2)$$

where

$$A_r = \frac{e[(r-m)(b-m) - m^2 \cos \theta]}{br[(r-m)^2 + (b-m)^2 - m^2 - 2(r-m)(b-m) \cos \theta + m^2 \cos^2 \theta]^{1/2}} + \frac{em}{br}, \quad (3)$$

where  $e$  is the charge of the proton.