Vidyodaya J. Arts., Sci., Lett., Vol. 6 *No.* 2 *pp.* 70-71, 1978

Strong Interaction and Mini Black Holes

K. TENNAKONE

Department of Physics, Vidyodaya Campus

Several authors have discussed the possible existence of quantum black holes and their implications on problems ranging from cosmology to elementary particle physics. Hawking[1] has suggested that a major part of the matter in the universe may be in the form of mini black holes having masses 10^{5}gm and upwards. Sarfatt[2] attempts to identify the quantum black hole with the quark. Motz[3] argues that Weyl principle of gauge invariance leads to mass quantization in units of about 10^{5} gm. According to above discussions the mass of the quantum black hole is the minimum mass that a black hole can have, the argument is as follows: In order to create a black hole of mass m, the mass has to be confined to a radius of the order Gm/c^2, but a requirement of quantum mechanics is that a particle of mass m can be localized only to a distance greater than its Compton wavelength h/mc giving

$$Gm/c^2 \geq \hbar/mc \text{ or } m > (hc/G)^{1/2} \backsim 10^{5} \text{ gm}, \qquad (1)$$

and the Schwarzchild radius corresponding to the mass limit (1) is of the order 10^{33} cm. The abovementioned discussions about quantum black holes ignore the effect of strong interaction which becomes important at distances very much larger than the Schwarzchild radius of the quantum black hole. In this note we investigate the effect of strong interaction on formation of black holes and conclude that the strong interaction effects also limit the mass of a black hole to a value of the order 10^{5} gm.

When the pi-meson field is treated as a classical field given by the Yukawa potential

$$\phi(r) = ge^{\mu r}/r, \qquad (2)$$

(where $g^2/hc \sim 14$ is the pion-nucleon coupling constant and u P mrc/h) it has been shown that the gravitational field due to a mass m is described by the metric[4-5]

$$ds^2 = Ac^2dt^2 - Bdr^2 - r^2de^2 - r^2\mathrm{Sin}^2e\,d\phi^2 \quad , \qquad (3)$$

$$\text{where } A = 1 - 2Gm/c^2r + Gg^2e^{-2\mu r}/2c4r2, \qquad (4)$$

$$B^{-1} = 1 - 2Gm/c^2r + \mu Gg^2e^{-2\mu r}/c^4r + Gg^2e^{-2\mu r/c^4r^2} \qquad (5)$$

In the immediate neighbourhood of a particle collapsed to a radius less than the Compton wave length of the pion we can set $e^{-2\mu r} \sim 1$, so that

$$A \simeq 1 \mathrm{P}\, 2Gm/c^2r + Gg^2/2c^4r^2 \ , \qquad (6)$$

$$\begin{aligned} B^{-1} &\simeq 1 - 2Gm/c^2r + \mu Gg^2/c^4r + Gg^2/c^4r^2 \\ &\simeq 1 - 2Gm/c^2r - Gg^2/c^4r^2 \quad (m \gg m_\pi) \ , \qquad (7) \end{aligned}$$

which is similar to the Nordstrom-Reissner metric with g taking the place of the electric charge. A black hole is produced only if B-1 vanishes for real r, the condition for which is

$$m \gtrsim (g^2/G)^{1/2} (14)^{1/2} (hc/G)\ 1/2. \qquad (8)$$

Hence the lower limit (8) for the mass of a black hole given by the consideration of strong interaction effects is also of the same order of magnitude as the lower limit (1) resulting from quantum mechanical effects. This suggests that the lower limit for the mass of a black hole is governed by both strong interaction and quantum mechanical effects and the value of the lower limit is of the order of 10-5 gm.

REFERENCES

1. S. Hawking, Mon. Not. R. Astr. Soc. **152**,75 (1971).
2. J. Sarfatt, Nature Physical Science **240**, 101 (1972); ICTP preprint IC/74/30.
3. L. Motz, Nuovo Cimento **12B**, 239 (1972).
4. D. K. Ross, Nuovo Cimento **8A**, 603 (1972).
5. C. Sivaram and K. P. Singha, Lett. Nuovo Cimento **8, 324** (1973).