SEMICLASSICAL CORRECTIONS TO A REGULARIZED SCHWARZSCHILD METRIC*

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We propose a regular version of the Schwarzschild metric to be valid in microphysics. The time–time metric coefficient is modified as [1] (see also [2])

$$-g_{tt} = 1/g_{rr} \equiv f(r) = 1 - \frac{2m}{r} e^{-\frac{k}{mr}}\,, \tag{1}$$

where m is the black hole mass, k is a positive dimensionless constant and the mass m has units of length in front of the exponential and 1/length at the exponent. We select $k = 2/e$, so that $f(r)$ becomes minimal at $r = k/m = 2/me$. For a horizon to exist, we found that the condition $m \geq m_{\rm P}$ should be obeyed [3].

An expansion of $f(r)$ for $r \gg r_0 = 2/em$ gives us

$$f(r) \approx 1 - \frac{2m}{r} + \frac{4l_{\rm P}^2}{er^2}\,, \tag{2}$$

where $l_{\rm P}$ is the Planck length. From (2), one obtains that $f(r)$ acquires its Schwarzschild value when $\hbar = 0$. Solution (1) is not a vacuum solution of Einstein's equations. The source stress tensor has $p_{\rm r} = -\rho$ and fluctuating transversal pressures, where ρ is the energy density and $p_{\rm r}$ is the radial pressure. The Komar energy associated to geometry (1), with $k = 2/e$, appears as

$$W = \left(mc^2 - \frac{2\hbar c}{er}\right) e^{-\frac{2\hbar}{emcr}} \tag{3}$$

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which tends to zero when $r \to 0$ and $W \to mc^2$ at infinity. The classical situation ($\hbar = 0$) leads to the standard result $W = mc^2$.

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