THE SPACETIME SURROUNDING SUPERCONDUCTING COSMIC STRINGS

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In 1981, A. Vilenkin derived the stress tensor for a straight nonconducting cosmic string of linear mass density μ oriented in the z-direction;[1] it is given by $T_\mu{}^\nu = \mu \mathrm{diag}(1,0,0,1)\delta(x)\delta(y)$. He also showed that in linear approximation the resulting exterior spacetime is flat but conical, with deficit angle $8\pi G\mu$.[1] Subsequently it was shown that even the exact spacetime is flat but conical.[2,3] Recently E. Copeland, M. Hindmarsh, and N. Turok have derived the stress tensor

$$T_\mu{}^\nu = \mu \mathrm{diag}(1+j^2,0,0,1-j^2)\delta(x)\delta(y)$$

for a straight current-carrying string, where j is proportional to the current.[4] We have used this stress tensor, together with the stress tensor of the external electromagnetic field caused by the current, to find the external spacetime of a conducting string in linear approximation. In cylindrical coordinates, the metric may be written

$$ds^2 = (1 + h_{00})dt^2 - (1 - h_{33})dz^2 - dr^2 - a^2r^2d\phi^2$$

where $h_{00} = 4GI^2\ell n^2 r/r_0 + 8G\mu j^2 \ell n r/r_0 = h_{33} + 8GI^2 \ell n r/r_0$, and $a = 1-4G\mu-2GI^2$. Here r_0 is the string radius and I is the electric current, related to j as described in reference 4. The linear approximation is valid as long as h_{00} and h_{33} are small compared with unity, which restricts the range of r. The (r,ϕ) subspace is flat but conical, with deficit angle $8\pi G(\mu + I^2/2)$. The spacetime reduces to that found by Vilenkin if j and I go to zero. Efforts are currently underway to find an exact exterior solution, which would apply for arbitrary values of r.

[1] A. Vilenkin, Phys. Rev. D 23, 852 (1981).
[2] J.R. Gott III, Astrophys. J. 288, 422 (1985).
[3] W.A. Hiscock, Phys. Rev. D 31, 3288 (1985).
[4] E. Copeland, M. Hindmarsh, and N. Turok, Phys.Rev.Letters 58, 1910 (1987).

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