DECOLLIMATION OF A JET DUE TO SPACETIME CURVATURE

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Central cores of compact radio sources are believed to contain super-massive black holes accreting material from their vicinity which produce fast moving plasma in the form of directed beams (jets), with apparent opening angles $\gtrsim 5°$ (Rees et al. 1981). In case, the jets are produced and their collimation is established on scales few times the Schwarzschild radius ($2m$; $m=GM/c^2$) of the central engine, deflection in particle trajectories in the curved spacetime (ψ_o) would be large enough to widen the beam and thereby reduce the particle density and effective luminosity in the beam (Fig.1).

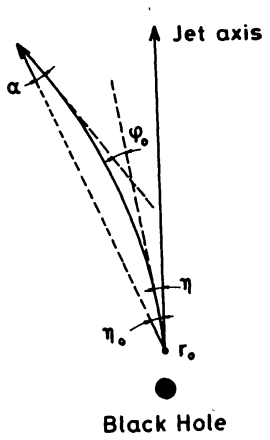

Fig. 1. Schematic Illustration of particle trajectory starting from $r=r_o$ near the black hole.

We have made a numerical study of particle motion in a Schwarzschild background to estimate the general relativistic contribution to the beaming process for various values of initial bulk velocities (v= 0.8-0.999c), for different opening angles (η=1°-5°) and for mean radii (r_o) varying from 2 to 8 time the Schwarzschild radius where jet material might be accelerated. We describe the degree of collimation

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and attenuation of density by a quantity $\epsilon = (\sin\eta/\sin\eta_o)(d\eta/d\eta_o)$ where η_o is the new value of the opening angle: $\eta_o = \psi_o + \eta - \pi$ ($\alpha \to 0$ as $r \to \infty$) and ψ_o is determined from a knowledge of particle trajectories in the Schwarzschild spacetime; ϵ is found to be larger for smaller values of the initial bulk velocities and the mean radius considered (see Fig.2).

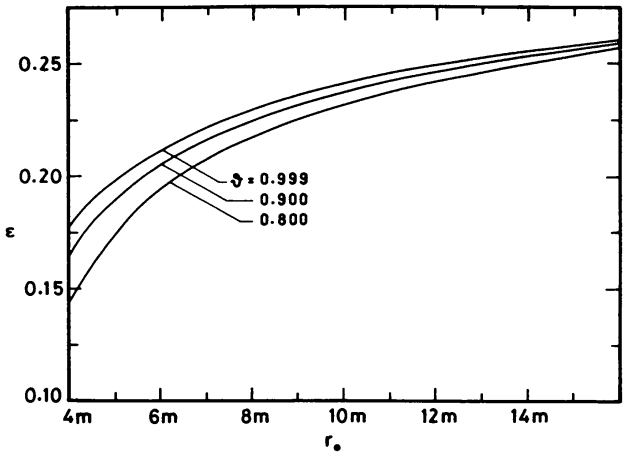

Fig.2. Attenuation factor for various values of r_o and v.

The general conclusion that can be drawn from the calculations is that in the local rest frame the beam starts out with an opening angle less than half and a particle density as well as an effective luminosity in the beam ϵ^{-1} ($\sim$10) times larger than the values implied by beam models provided $r_o \lesssim$ 20m; for $r_o >$ 20m, the effect becomes comparatively less in magnitude (c.f. Abramowicz and Piran 1980; Sikora and Wilson 1981). Details of this work will be published elsewhere (Kapoor 1986).

References

Abramowicz, M.A., Piran,T. 1980 Ap.J. 241, L7
Kapoor, R.C., 1986 to be published.
Rees, M.J., Begelman, M.C. Blandford, R.D. 1981 Ann.N.Y.Acad. Sci. 10th Texas Symp. Relativistic Astrophysics p.254.
Sikora. M, Wilson, D.B., 1981, M N R A S, 197, 529