

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 $\approx 5^\circ$ (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 (γ_0) would be large enough to widen the beam and thereby reduce the particle density and effective luminosity in the beam (Fig.1).

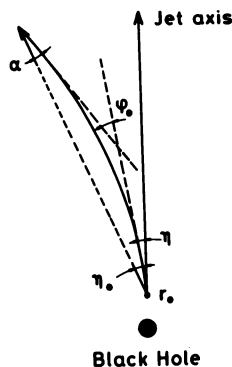


Fig. 1. Schematic Illustration of particle trajectory starting from $r=r_0$ near the black hole.

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 ($\eta = 1^\circ-5^\circ$) and for mean radii (r_0) varying from 2 to 8 times the Schwarzschild radius where jet material might be accelerated. We describe the degree of collimation

and attenuation of density by a quantity $\epsilon = (\sin \eta / \sin \eta_0) (d\eta/d\eta_0)$ where η_0 is the new value of the opening angle: $\eta_0 = \eta_0 + \eta^{-1} (\alpha \rightarrow 0 \text{ as } r \rightarrow \infty)$ and η_0 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).

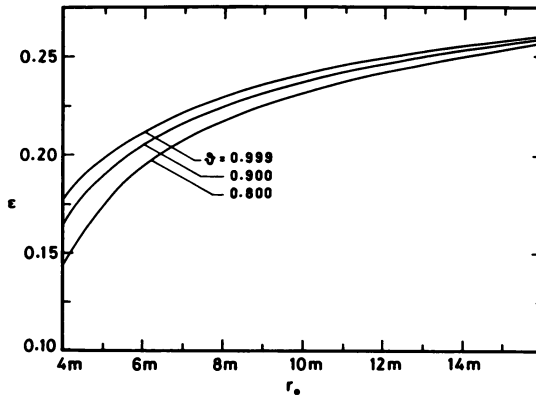


Fig.2. Attenuation factor for various values of r_0 and β .

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} (~ 10) times larger than the values implied by beam models provided $r_0 \lesssim 20m$; for $r_0 > 20m$, 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

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