THE STATISTICS OF BENT JETS +

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I present some results of a study of the statistics of bent jets. The general conclusion is that non relativistic jets appear less bent than they really are, while relativistic jets appear more bent.

The study of radio sources which do not have a perfectly linear structure is greatly complicated by projection effects which can make a relatively simple source appear quite complex. Attempts have been made to model particular sources with precessing jets (Gower et al. 1982) however, this procedure requires very good data to produce meaningful results. I have approached a somewhat simpler problem from the opposite viewpoint, i.e. given a random sample of bent jets, how will an average jet appear to an observer. The bent jet is represented by the idealization of two straight lines with an angle α between them. The bisector of the angle α defines the x axis of a coordinate system and the lines making the angle α lie in the x-y plane. If this angle is viewed from a position with angular coordinates (θ, ϕ) then the apparent angle of the bend α' is given by

$$\cos \alpha' = \frac{\cos\alpha - \sin^2\theta \cos(\phi+\frac{\alpha}{2}) \cos(\phi-\frac{\alpha}{2})}{\sqrt{(1-\sin^2\theta \cos^2(\phi+\frac{\alpha}{2}))\,(1-\sin^2\theta \cos^2(\phi-\frac{\alpha}{2}))}}.$$

Using this expression one can calculate the probability of seeing an angle α' for a given intrinsic bend angle α. The details of the calculation will be given elsewhere (Allan, in preparation) however a simple way of visualizing the result is to draw lines of constant α and α' on the surface of a sphere. The probability of seeing an angle in the range α' to $\alpha' + d\alpha'$ is proportional to the area between the lines (α, α') and $(\alpha, \alpha' + d\alpha')$. The main result of this is that if an obtuse angle α is observed from many random directions then it will appear to be bent less than α (i.e. $\alpha' > \alpha$) more often than it will appear to be bent more than α (see Figure 1). If α is an acute angle the reverse is true, but presumeably this is less significant for real bent jets.

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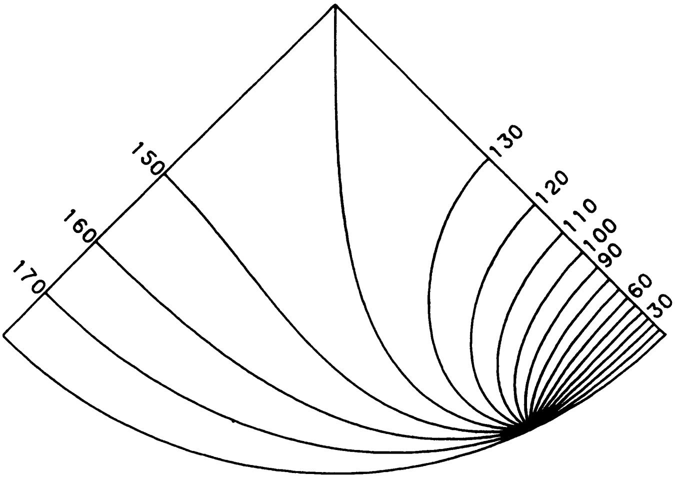
Figure 1. Lines of constant (α, α') drawn on a projection onto a plane of the octant $0 < \theta < \pi/2$, $0 < \phi < \pi/2$ for the case $\alpha = 140°$. θ increases downwards and ϕ increases anticlockwise. The numbers indicate the value of α'.



So far I have not mentioned the velocity of the jet and I have implicitly assumed that the jet is non relativistic. If a bent relativistic jet is observed with a limited dynamic range, then the bend will not be visible from certain directions as the Doppler beaming may make one side of the bend much brighter than the other side, thus when actually observed, only one side is seen and the source is not described as being bent at all. The directions where one side of the jet is lost are predominantly those directions from which the jet appears straighter than it really is (i.e. small ϕ), and so the effect is that on the average, bent relativistic jets will appear more bent than they really are. This effect has been appreciated for a while in that VLBI jets often appear very bent (Readhead et al. 1978). What has not been fully realized is that it can be impossible to 'straighten' the jet since when it is observed from a direction where it appears straight, half of the jet is lost in the noise.

When applied to a large complete sample of bent jets, these techniques should be capable of giving the distribution of intrinsic bend angles. They can also be applied to the large scale double sources where the central galaxy does not lie on the line joining the radio lobes (Ingham and Morrison 1975).

References

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