Evidence of Doppler Beaming in Variable Radio Sources +

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Total flux observations of variable sources (Andrew et al. 1978) have been re-examined to test their consistency, or lack of it, with the Doppler beaming hypothesis of Scheuer and Readhead (1979).

Probably the most significant finding is that bursts from different variable sources, though differing in time scale, have profiles of the same shape. Fig. 1 shows burst profiles at λ=2.8 cm from six sources in which individual bursts are isolated from surrounding events. The data

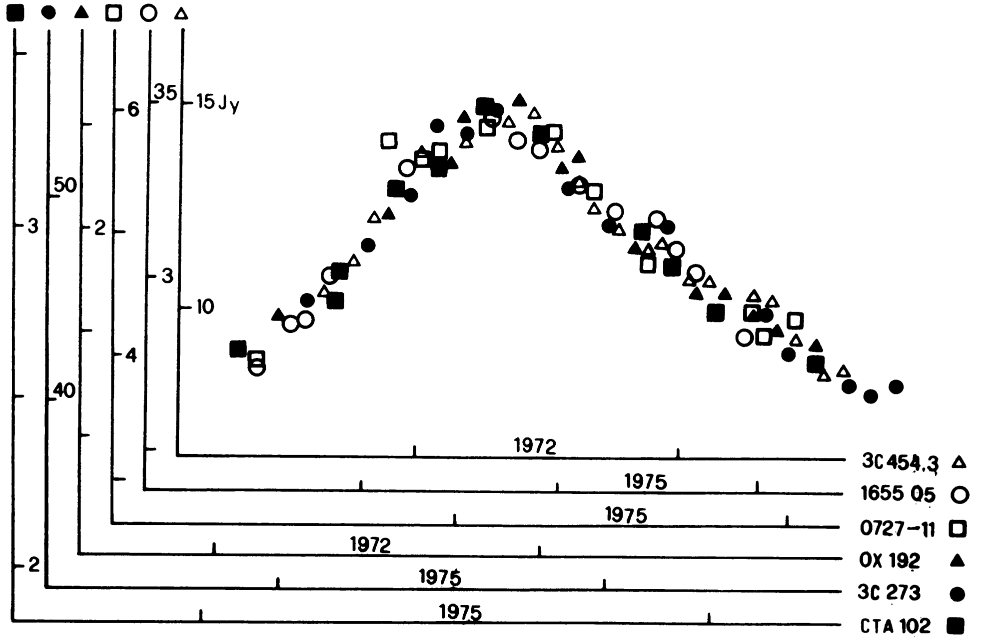

Fig. 1 - Burst profiles from six variable sources.

+ Discussion on page 440

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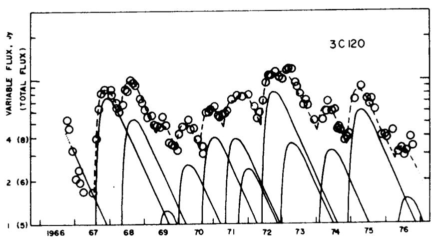

Fig. 2

are evidently consistent with various amounts of time-compression, such as would be imposed by Doppler beaming. The data also suggest a common physical mechanism in these sources.

The profiles of Fig. 1 are

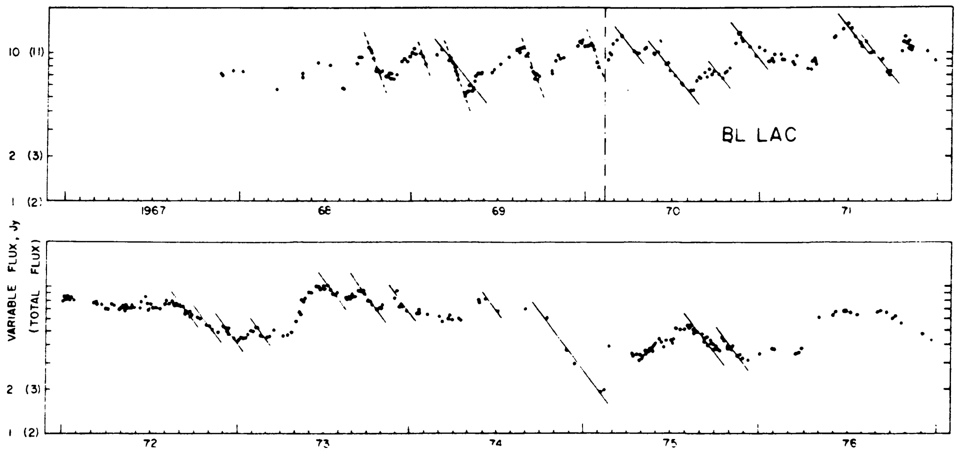

Fig. 3

fitted reasonably well with a function of the form: $t^n e^{-t/\tau}$, with $n \gtrsim 3$. The most distinctive feature of the profiles is an exponential decay. This is evident when the 'light-curve' is plotted on a logarithmic scale of flux, as for the 3C120 data shown in Fig. 2. Here, an attempt has been made to fit the observed data with burst profiles of various amplitude, but the same shape, superimposed upon a quiescent component of flux. For 3C120, burst of the same shape (and in particular the same exponential decay) are found to fit best for an assumed quiescent component of about 4 Jy.

An exponential decay is also evident in the light curve of Bl Lac (Fig. 3). Here, however, there is an interesting change in 1970, February, when the rate of decay of the bursts decreases suddenly and unmistakably, by a factor of about two. Though admittedly, the number of bursts observed in other sources is not large, Bl Lac is the only source to show this behavior. A plausible explanation might be that, because Bl Lac varies so rapidly, the angle of its axis to the line-of-sight would (on the Doppler beaming hypothesis) be small. Bl Lac would therefore be effected more noticeably by a change in this angle than would other sources.

It has been previously questioned (e.g. Andrew et al. 1978) whether rapid variability, such as in Bl Lac, is associated with bursts of large amplitude. Such a relationship would be expected with Doppler beaming and its existence was investigated by estimating the 'half-life' (i.e. the time for the flux of a burst to drop by a factor of two in the exponential part of the profile) of 24 variable sources. These constituted all of the sources with a measured redshift for which such an estimate could be made.

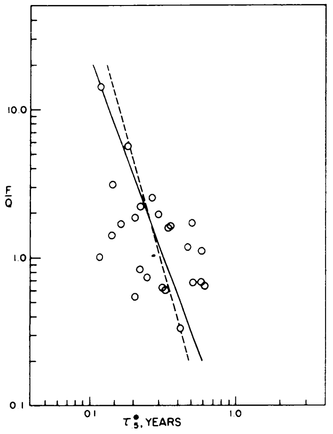

Fig. 4

A weak anti-correlation was found between a corrected half-life, $t^*_{0.5}$ (half-life $x(1+Z)^{-1}$), and the peak variable part of the luminosity of the 24 sources. The correlation is slightly better, though still not strong, between $t^*_{0.5}$ and the ratio of (peak) variable flux, F, to quiescent flux, Q. The data are shown in Fig. 4.

Despite the large scatter (part of which is due to poor statistical sampling of the variable flux), the slope of the least-squares regression line (solid) is close to the value 3.0 (indicated with a dashed line) that would be expected on the basis of Doppler beaming and the assumption that the sources have the same intrinsic ratio of variable to quiescent flux.

REFERENCES

Andrew, B.H., MacLeod, J.M., Harvey, G.A., and Medd, W.J., 1978, A.J., 83, 863

Scheuer, P.A.G., and Readhead, A.C.S., 1979, Nature, 277, 182