A PRECESSING JET IN L1551

J. F. Lightfoot
Department of Physics and Astronomy
University College London
Gower Street
London WC1E 6BT

ABSTRACT. An analysis of published observations of the L1551 optical jet leads to the conclusion that the driving region is very small, possibly little larger than the star itself. Further the data suggest that the jet is precessing.

## 1. THE OPTICAL JET

The jet from L1551 IRS5 is composed of largely neutral gas travelling at about 300kms$^{-1}$ (Snell et al., 1985). It is highly collimated within 100AU of IRS5 (Mundt & Fried, 1983) and is twisted, as if the source is precessing. The absence of shock emission along the leading edge of the twist implies that the jet is moving through very rarefied material.

The jet radius is too small to be observed directly, but the regular spacing of the emission knots along it may provide an indirect measure if this spacing reflects the responsivity of the jet while seeking equilibrium. Thus, if the knots are internal shocks caused by changes in the external pressure (Sanders, 1983), their spacing would be $\sim$Mxr, where M is the Mach number of the jet and r its radius. For a cool, neutral jet (M$\sim$50) this implies a radius of 1.5x10$^{14}$ cm. Alternatively, if the jet is magnetically collimated, the characteristic wavelength of internal oscillations is $\sim 3M_A$xr, where $M_A$ is the Alfven Mach number of the jet (Chan & Henriksen, 1980). Since the jet is probably highly super-Alfvenic, this would again imply a radius of a few x 10$^{14}$ cm.

Since all the jet driving mechanisms proposed so far, be they magnetic (e.g. Blandford & Payne, 1982) or thermal (Torbett, 1986), involve a large sideways expansion by a factor of 10-100 before the (magnetic?) collimating force becomes effective, the width of the visible jet is almost certainly much greater than that of its place of origin. This suggests that the driving region has a radius of several x10$^{12}$ cm, little larger than the young star itself.

## 2. THE HERBIG-HARO OBJECTS

Once the jet has cooled and faded, it will speed onward through the ISM



*I. Appenzeller and C. Jordan (eds.), Circumstellar Matter, 75–76.*

as a dark filament, only becoming visible again when it hits dense gas. HH29 appears to be the brightest section of a large helical emission structure and we suggest that this is the bow-shock formed along the length of the cold jet as it advances through chaotic gas remnants inside the L1551 molecular shell. The shape of the kinked optical jet near IRS5 and the helix at HH29 can both be quite well explained if the jet axis has been precessing with opening angle 8° and period 100yr around an axis which itself precesses with opening angle 40° and period 2000yr (figure 1).

If this is correct, then the L1551 jet is behaving very like that of SS433, save with precession periods longer by a factor 4000. SS433 is itself poorly understood, but in one model (Katz et al., 1982) the precessional motion results from the gravitational torque exerted by a binary companion on the accretion disc around the compact object driving the jet. If it is valid to extend this model to L1551, it would imply that IRS5 is a binary composed of $1M_{\odot}$ stars separated by $10^{15}$ cm. Radio observations resolve IRS5 into two point sources at just this spacing (Bieging & Cohen, 1985).

Any model of this type again requires that the jet originate in the central part of the accretion disc, or at the young star itself.

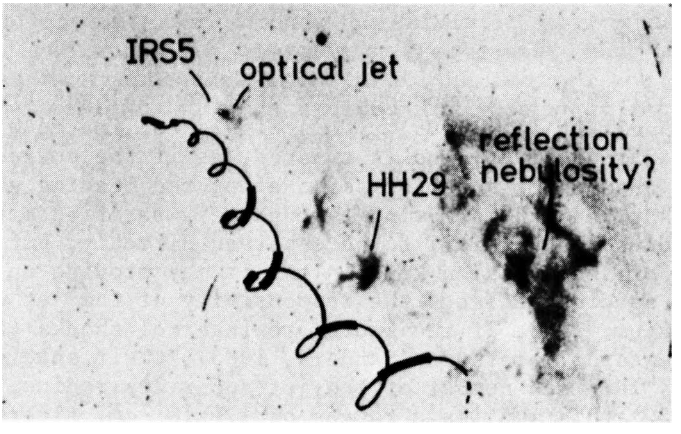


Figure 1. This is an Hα image of L1551 obtained by Snell et al. (1985). The precessing jet discussed in the text is superimposed as a solid line, displaced eastward for clarity.

REFERENCES

Bieging, J.H. & Cohen, M. 1985, Astrophys.J.Lett., 289, L5
Blandford, R.D. & Payne, D.G. 1982, Mon.Not.R.Astron.Soc., 199, 833
Chan, K.L. & Henriksen, R.N. 1980, Astrophys.J., 241, 534
Katz, J.I. et al. 1982, Astrophys.J., 260, 780
Mundt, R. & Fried, J.W. 1983, Astrophys.J.Lett., 274, L83
Sanders, R.H. 1983, Astrophys.J., 266, 73
Snell, R.L. et al. 1985, Astrophys.J., 290, 587
Torbett, M.V. 1986, Can.J.Phys., 64, 514

https://doi.org/10.1017/S0074180900155986 Published online by Cambridge University Press