Mass loading and knot formation in AGN jets by stellar winds

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Introduction

Powerful radio jets are often observed ejecting from Active Galactic Nuclei (AGN; Figs. 1, 3). The stellar density at the center of these galaxies is such that interactions between the jets and some stars are likely to occur. As a result, the jets will be mass-loaded, and perhaps temporarily truncated if high mass-loosing stars were present, by red giant (RG) stellar winds [1]. We are carrying out 3D AMR numerical simulations to follow jet mass loading by stellar winds for a range of both jet mechanical powers, L_j, and jet/wind crossing trajectories. **Open questions:** What are the observational consequences of the jet/wind interaction? Does the jet/wind interaction cause radio knots as in Cen A [2] (see Fig. 3)? How does the interaction depend on the jet/wind impact parameter? Do radio jet magnetic fields affect the interaction?

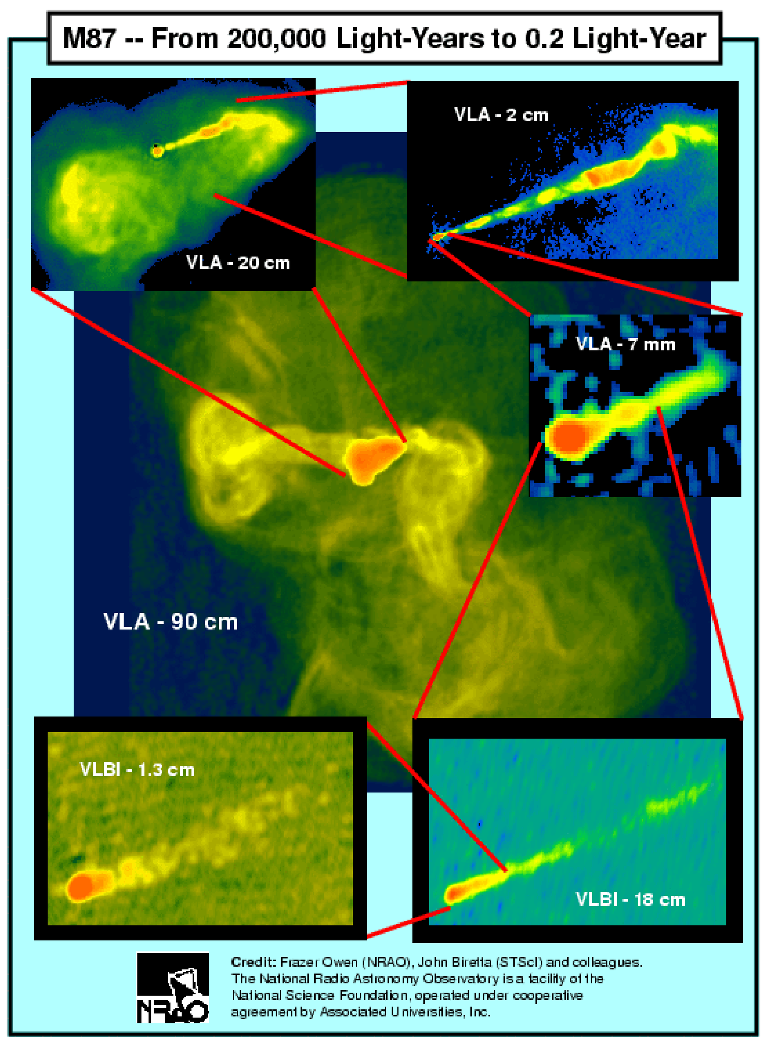

Fig. 1 Radio galaxy M 87.

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Models

We use the Adaptive Mesh Refinement (AMR) code *AstroBEAR2.0* [3] to solve the equations of hydrodynamics in 3D. The domain: $|x|, |y| \leq 2$ kpc and $0 \leq z \leq 6$ kpc, $40\times40\times120$ cells plus 3 AMR levels; resolution of 6.25 pc. The AMR follows the embedded boundary condition of the RG wind which moves vetically at 600 km s^{-1}.

Initial conditions:

	Dens par cm^{-3}	Tem 10^6K	vel km s^{-1}	$\dot{M}$ M$_\odot$yr^{-1}
Amb	1	3	0	0
Jet	.01,.0001	1300	1.5×10^8	3,.003
Wind	50	2.5	200	.0078

Simulations:

L_j 10^{45} erg s^{-1}	RG trajectory	Solver
1.5	jet axis	hydro & MHD
1.5	jet edge	hydro & MHD
0.024	jet axis	hydro & MHD
0.024	jet edge	hydro & MHD

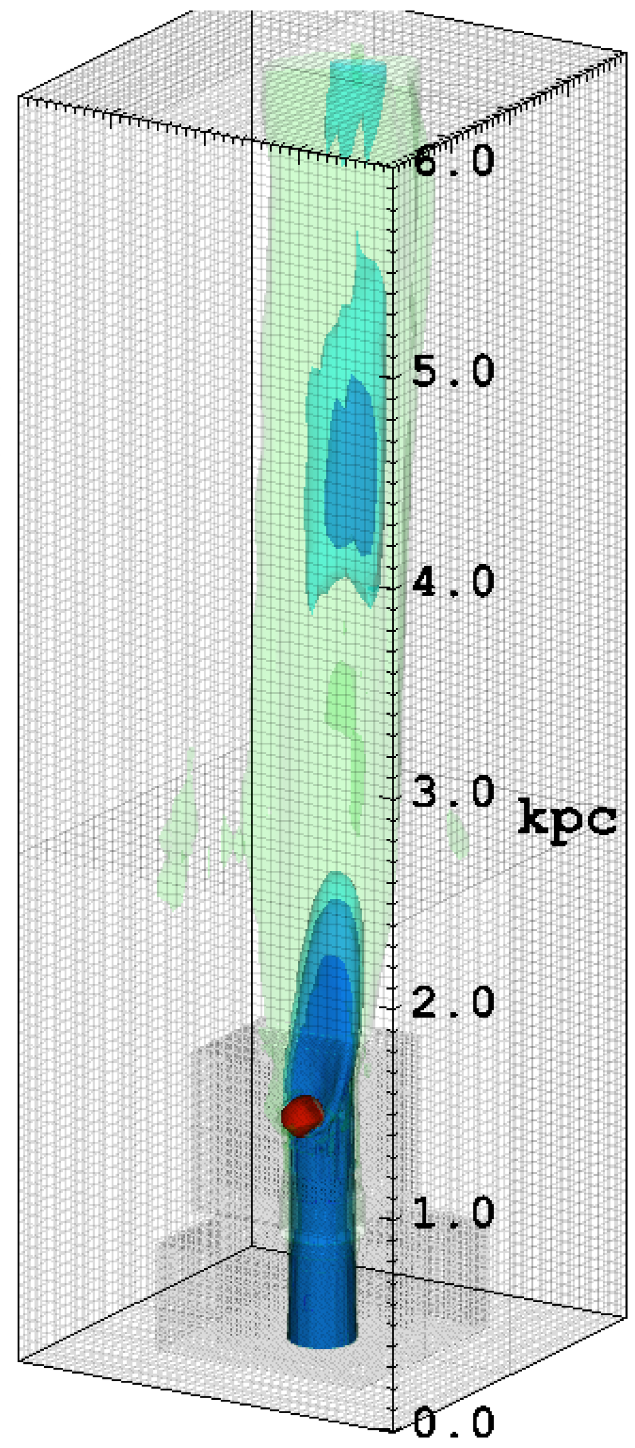

Fig. 2 *The RG (red) crosses the axis of a radio jet (blue) and yields mixed material down stream (light-blue & green).*

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Applications

The elliptical galaxy M87 has a well studied jet with luminosity LJ estimated to be between 10 42 and 10 43 erg/s (Biretta et al. (1991), Reynolds et al. (1996)) and a Îş of about 6 (Biretta et al. (1999)). It follows that MËŹ J > 3ÃŮ10 âĹŠ6MâŁŹ/yr. This value for MËŹ J is interesting as it can be attained and indeed surpassed by single stars and suggests that the jet is in our intermediate luminosity regime (see Sec. 3.4). The collimated jet has a length of 2 kpc (Perlman et al. (2001)), and is therefore truncated well within the coniňĄnes of M87. Stellar wind mass-loading is therefore a plausible cause of the jetâĂŹs truncation (implying the jet could be longer lived that its length alone would indicate). Faber et al. (1997) provide values for the luminosity density near the center of M87. The jet contains a total stellar luminosity of roughly 2ÃŮ10 7 LâŁŹ in the V-band and so, by Eq. (14), a stellar mass loss of MËŹ T âĹij 10 âĹŠ2MâŁŹ/yr. This iňĄts our estimate of the total mass-loss rate MËŹ T required to quench intermediate luminosity jets from Eq. (21), suggesting that âĂIJlow mixingâĂİ stars dominate the mass-loading process. Reynolds et al. (1996) iňĄnd evidence that the jet may be initially pair plasma dominated near the launch point, but this does not contradict a subsequent increase in baryon fraction due to mass-loading via stars on kpc scales. Reynolds et al. (1996) also estimate the mechanical luminosity of the M87 jet via its iňĆuence on the radio lobes. This estimate is independent of the jet composition. ——— Centaurus A []

Conclusions

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References

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Acknowledgements

Financial support for this project was provided by the Space Telescope Science Institute grants HST-AR-11251.01-A and HST-AR-12128.01-A; by the National Science Foundation under award AST-0807363; by the Department of Energy under award DE-SC0001063; and by Cornell University grant 41843-7012.