NATIONAL RADIO ASTRONOMY OBSERVATORY
Edgemont Road, Charlottesville, Virginia 22903-2475

Dr. Alan H. Bridle, Tel. 804-296-0375, FTS 940-7375

October 20, 1986

Prof. P. P. Kronberg
Department of Astronomy, Univ. of Toronto
60 St. George Street
Toronto, Ont. M5S 1A7 CANADA

Dear Phil:

Enclosed is a 6250 BPI FITS tape containing u,v data on 3C353 and image data at 3 arcsec resolution on 3C219, with a detailed tape index.

I talked with Jack Burns about the 3C219 data and he was indeed concerned that the full data set be available to his student David Clarke in the first instance, as Rick and I had agreed to provide this as part of a collaboration that will yield four-frequency rotation measures and spectral data. However, I do not think I should restrict the image data to this context, hence the enclosed full suite of 3 arc sec resolution images. I am sending I, Q and U maps as well as some derived polarization images so that your student could decide on his own cutoff levels, etc. for evaluating spectral indices and rotation measures. We will publish results on the large-scale structure based on our own interpretation of these images, but your student is welcome to use them for the purposes of his thesis. The tapering used to obtain these images was 75 kilowavelengths in the AIPS tasks MX and APCLN.

There are interesting spectral gradients and some RM structure shown by these images. The spectral data in particular suggest outflow from both recessed hot spots toward the eastern sides of the lobes. There is also a distinct spectral gradient across the ring-like hot spot in the north lobe. We confirm the large-scale gradients across the lobes that were mapped by Burch.

Best wishes.

AB

UNM
The
University of New Mexico
INSTITUTE FOR ASTROPHYSICS
DEPARTMENT OF PHYSICS AND ASTRONOMY
Albuquerque, NM 87131
Telephone 505: 277-2616

February 14, 1986

Dear Dr. Bridle

Jack asked me to send you a copy of our VLA proposal and related matter regarding 3C219. As you can see by the referees' reports, time allotment is presumably imminent and we expect to hear about time scheduling within the month. Also enclosed is a copy of a letter that I sent to Dr Barry Clark several months ago. Jack was concerned that there were some rumblings about the necessity of any further 3C219 observations and so I tried to convey to Dr. Clark how important we felt these new observations to be.

I hope this clarifies for you our current status on the project. Please let me know if you have any other questions.

Yours very truly

David Clarke

VLA OBSERVING APPLICATION

A

received:

SEND TO: Director NRAO Edgemont Rd. Charlottesville, Va. 22901

DEADLINES: 15th of Mar., June, Sept., Dec. for Q 3, 4, 1, 2 respectively

(1) Date: September 3, 1985

(2) Title of Proposal: A Search for Active Magnetic Field Effects in Extragalactic Radio Sources

(3) Authors	Institution	Who will observe?	For Grad Students Only: Observations for PhD Thesis?	For Grad Students Only: Anticipated PhD Year
D. A. Clarke	University of New Mexico (UNM)	X	Yes	1987
J. O. Burns	UNM	X		
M. L. Norman	Los Alamos National Labs and UNM	X		
W. A. Christiansen	University of North Carolina			

(4) Related previous VLA proposal number:

(5) Contact author for scheduling: D. A. Clarke

Address: Department of Physics and Astronomy
University of New Mexico
Albuquerque, N.M., 87131

(6) Telephone: (505) 277-1527
TWX:

(7) Scientific category: ☐ planetary, ☐ solar, ☐ stellar, ☐ galactic, ☒ extragalactic

(8) Configuration(s) (A, B, C, D, A/B, B/C, C/D, Any)	A	B	C		
(9) Wavelength (90 20 18 6 2 1.3 cm)	20, 6	20, 6	6		
(10) Time requested (hours or days)	24 hrs.	23 hrs.	6 hrs.		

(11) Type of observation: ☒ mapping, ☐ point source, ☐ monitoring, ☒ continuum, ☒ lin poln, ☐ circ poln, ☐ spectral line, ☐ solar, ☐ VLBI, ☐ phased array, ☐ other ______

(12) ABSTRACT (do not write outside this space): The purpose of this investigation is to determine if there are any observational signatures of active magnetic fields in extragalactic jets and cocoons. We propose to make multifrequency, high resolution observations of 3C219 and 3C388 to produce detailed polarization and rotation measure maps. We have developed several analytical tests to identify the presence of active magnetic fields, and will apply these to our observations. Further, we shall be producing detailed numerical MHD models of axisymmetric jets during the next year. By comparing the MHD models (with varying B-field intensities) with the observations, our goal is to distinguish jet features that are produced hydrodynamically, from those that are produced electromagnetically.

NRAO use only

(13) Observing style: ☐ Will be present ☐ Will prepare files & return to reduce ☒ Will use modem ☐ Absentee (NRAO prepares OBSERV file & sends calibrated data)

(14) Reduction: Number of maps many Maximum size of maps 1024 Self-cal maps yes Private disk pack ____

(15) Off-site reduction: ☐ none, ☐ post map, ☒ post calibration, ☐ everything.

(16) Help required: ☒ none, ☐ consultation, ☐ friend (extensive help), ☐ staff collaborator.

(17) Spectral line only:

	line 1	line 2	line 3		line 1	line 2	line 3
transitions to be observed				number of channels (N)			
channel bandwidth (KHz) (Δ)				number of antennas			
observing frequency (±NΔ/2)				rms noise after 1 hour (mJy)			

(18) Number of sources 2 (If more than 10 sources please attach list. If more than 30 give only selection criteria and LST range(s).)

Name	Epoch 1950☒ 2000☐ RA hh mm	Dec ±xx°x	Config.	Band (cm)	Band width (MHz)	Total Flux line (Jy)	Total Flux cont. (Jy)	Largest ang. size	Weakest signal (mJy/beam)	Required dynamic range	Possible LST range hh - hh	Time requested
3C219	9 18	45°9	A	20	25		5	3'	0.05	5000	3 - 16	8 hrs.
			B	20, 6	25		5	3'	.05, .03	6000	3 - 16	14 hrs.
3C388	18 43	45°5	A	20, 6	25		1	1'	.06, .025	>1000	12 - 25	16 hrs.
			B	20	25		1	1'	0.06	>1000	12 - 25	9 hrs.
			C	6	25		1	1'	0.03	>1000	12 - 25	6 hrs.

(19) Special hardware, software, or operating requirements: none

(20) Preferred range of dates for scheduling: Jan., 1986 - Dec., 1986

(21) Dates which are not acceptable: none

(22) Please attach a self-contained Scientific Justification not in excess of 1000 words.

When your proposal is scheduled, the contents of this cover sheet become public information. (Any supporting documents are for refereeing only)

Scientific Justification

I Background

To model structures seen in extragalactic jets, astrophysicists generally invoke ordinary hydrodynamics. Magnetic fields are introduced in a passive manner only, and are frozen in the fluid. This is reasonable provided the flow is dominated by hydrodynamical pressure gradients (i.e., $\beta \gg 1$, where β is the ratio of thermal to magnetic pressures). However, when $\beta \leqslant 1$, this assumption breaks down.

Many of the features seen in jets are ambiguous in their origin. Both hydrodynamical (HD) and magnetohydrodynamical (MHD) explanations often apply. It is the purpose of this investigation to determine if there are any observables in extragalactic jets that are characteristic of active magnetic fields and cannot be explained using ordinary HD. Analytically, we have determined several properties of magnetically dominated jets, which could be observed with the VLA. These are discussed below. Further, as part of his Ph.D. dissertation, D. Clarke will be working with M. Norman (starting this fall) to develop a fully MHD 2-D code for axisymmetric jets. The numerical calculations will be more illuminating than the analytical models since β's of order unity can be considered, and the nonlinear regime of the flow can be explored.

The following properties of magnetically dominated jets may be observable:

1. If the jet is magnetically confined, the jet should appear overpressured. That is, the minimum internal pressure of the jet is greater than the external thermal pressure (computed from X-ray data).

2. A poloidal field confining a jet in the plane of the sky would be pointing toward the observer on one side of the jet, and away from the observer on the other. Hence, the rotation measure (RM), which is proportional to the **B**-field, would have opposite signs on the two sides of the jet. Thus, an RM gradient would be observed across the jet.

3. In the limit where $\beta \ll 1$, the jet's **B**-field could be arranged in a force-free configuration (defined by $\nabla\times\mathbf{B}=\mu\mathbf{B}$). Such jets would exhibit several characteristic features that would distinguish them from jets where $\beta \gg 1$ (Konigl and Choudhuri, 1985). In particular, the total intensity distribution should show side to side oscillations with a wavelength of about 5R (R = radius of the jet). The oscillations are not fluid wiggles, but arise because the regions of intense magnetic fields alternate from side to side along the jet. This model also predicts that the maximum fractional polarization is anticorrelated with the maximum total intensity. These predictions seem applicable to the inner portion of the jet in NGC 6251, and may also apply to the sources that are the subject of this proposal.

4. Another prediction from the force free model is that jets which impinge on a conducting barrier (a hot IGM for example), form a spheromak configuration at their head. The situation is shown in figure 1, and should be compared with laboratory steady state spheromaks (see Jarboe, 1982). Thus, at the head of a magnetically dominated jet, poloidal **B**-fields would produce a gradient in the RM across the lobe, in a direction perpendicular to the jet axis. This is unlike the lobe produced by a $\beta \gg 1$ jet, where a strong poloidal field, and hence an RM gradient, is not expected.

We emphasize that identification of active magnetic fields will come only when several or all of the features discussed above are seen simultaneously. Further confirmation will follow once the numerical MHD and HD models have been compared with the observations.

II Proposed Observations

For a proper comparison between theoretical models and observations, we need to observe sources that are highly luminous, overpressured, nearby, and have jets embedded in extensive cocoons, where confining poloidal **B**-fields would be located. (Here, we define a cocoon as an extended region of backflowing jet material coming from the head of the jet.) The highly luminous jets associated with QSO's are clear candidates for magnetic confinement, but are too distant to be well resolved by the VLA. Of the nearby jets, only a few are clearly overpressured and possess substantial cocoons. Our choice of promising candidates is therefore limited.

We have chosen two sources which provide the best hope of detecting active magnetic fields. The jets in 3C219 (figure 2) and 3C388 (figure 3) are relatively nearby, appear overpressured and are embedded in extensive cocoons (Perley et al, 1980, Burns et al. 1982). Figures 2 and 3 were produced with the incomplete VLA, whose uv coverage best resembles that of the present day B configuration. If the cocoons contain confining poloidal **B**-fields, the VLA can resolve these sources sufficiently so that polarization data can map them. The VLA also provides the proper combination of frequency coverage and resolution to measure any RM gradients across the jet and the hotspot in the radio lobe.

Both Perley and Bridle have indicated that their VLA data on 3C219 would be available for this project. This includes: 9 hours at 6 cm in the A configuration, 3 hours at one frequency in the L band in each of the A and B configurations and 6 hours at 6 cm in the C configuration. To determine if there is a gradient in the RM across the jet, we will require two more frequencies in the L band (A configuration) with four hours of integration at each frequency (theoretical RMS=.05 mJy). Six hours of 6 cm B configuration will complete the frequency coverage. The badly needed shorter baselines will be provided by the 20 cm B configuration observations that are being requested and Perley and Bridle's 6 cm C configuration data.

Using a confining azimuthal **B**-field of 44 μG (determined by equating the magnetic stress exerted by such a field to the internal pressure quoted in Perley et al, 1980), a jet diameter of 2 kpc and an electron number density of 10^{-4} cm^{-3}, we expect to see an RM of 7 rads/m². This will result in a 30 degree difference in the 20 cm polarization position angle on opposite sides of the jet. It is emphasized that these values are estimates only. Random components to the **B**-field, an angle of inclination of the source in the sky, a non-confining azimuthal field and a smaller cocoon density will reduce the RM gradient. Hence, it is necessary to have high sensitivity and accurate position angles of the polarization **E**-vectors in order to detect subtle RM gradients. On the other hand, higher cocoon densities will increase the RM gradient, so it is necessary to have observations at several frequencies to detect any $n\pi$ ambiguities.

In order to compare observed **B**-field structures with the theoretical models, it will be necessary to obtain high sensitivity and high resolution polarization data. Because 3C219 is so bright and highly polarized, it is the ideal source for this type of mapping. Hence, we propose to combine Perley and Bridle's 6 cm A and C configuration data with the B configuration data proposed here (yielding a theoretical RMS of .015 mJy). Of particular interest is how far the poloidal field penetrates into the cocoon, and how it diminishes with distance from the jet axis. Does the poloidal field drop off as 1/r, characteristic of a current induced field?

We already have some VLA data for 3C388 (6 cm, incomplete B-array). To determine if there is a gradient in the RM (which we expect to be 7.5 rads/m²), we will require 3 hours in each of three frequencies in the L band in the A configuration. This will yield a theoretical RMS of .06 mJy which will be sufficient for our purposes. The shorter baselines will be provided by the 20 cm B configuration and the 6 cm C configuration observations that are being requested.

For a high resolution map of the polarization **E**-vectors in 3C388, we will require 7 hours in the A configuration at 6 cm. Combined with our present data and the proposed C-configuration data, the expected RMS of the 6 cm map will be 0.015 mJy, which should be sufficient to map much of the **B**-field structure in the jet and the cocoon.

References

Burns, J.O., Christiansen, W.A., Hough, D.H., 1982, Ap. J., 257, 538

Jarboe, T.R., 1982, Fifth Symposium on Physics and Technology of Compact Toroids in the Magnetic Fusion Energy Program

Konigl, A., Choudhuri, A.R., 1985, Ap. J.

Perley, R.A., Bridle, A.H., Willis, A.G., Fomalont, E.B., 1980, A. J., 85, 499

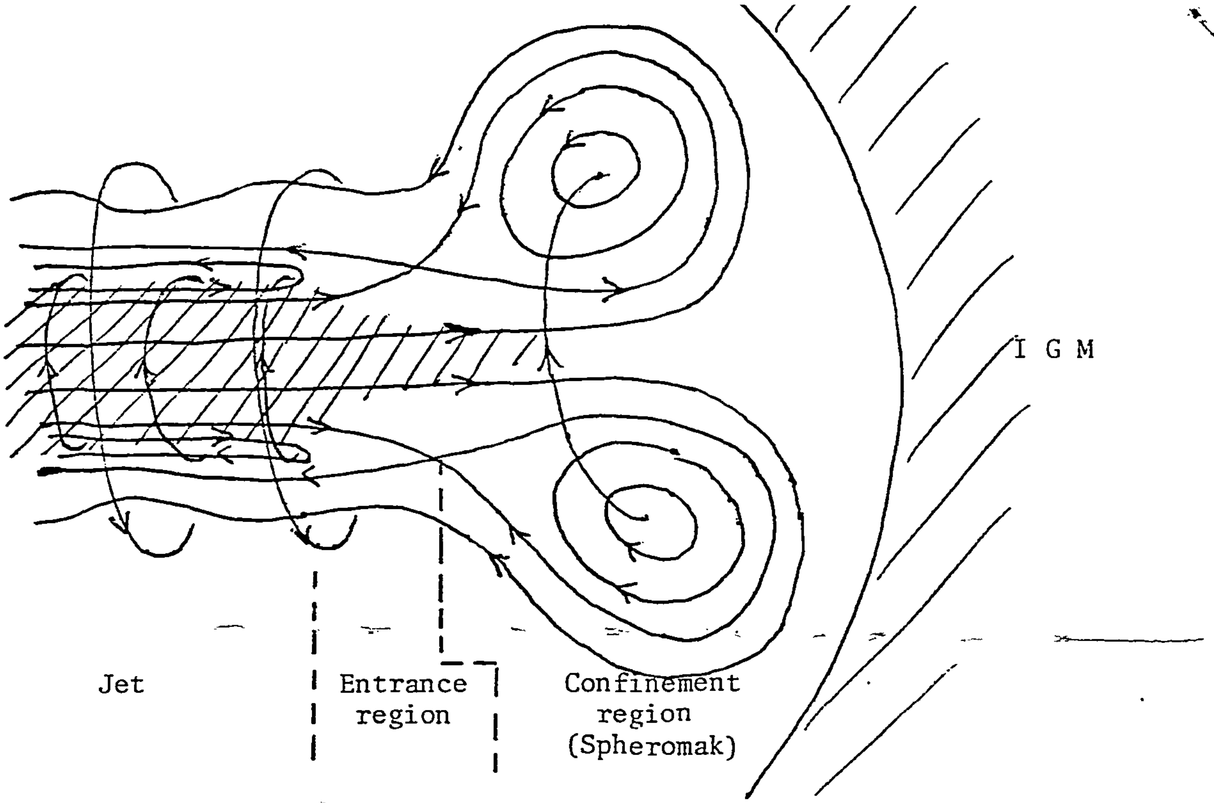

Figure 1 - The spheromak, as applied to the head of an astrophysical jet.

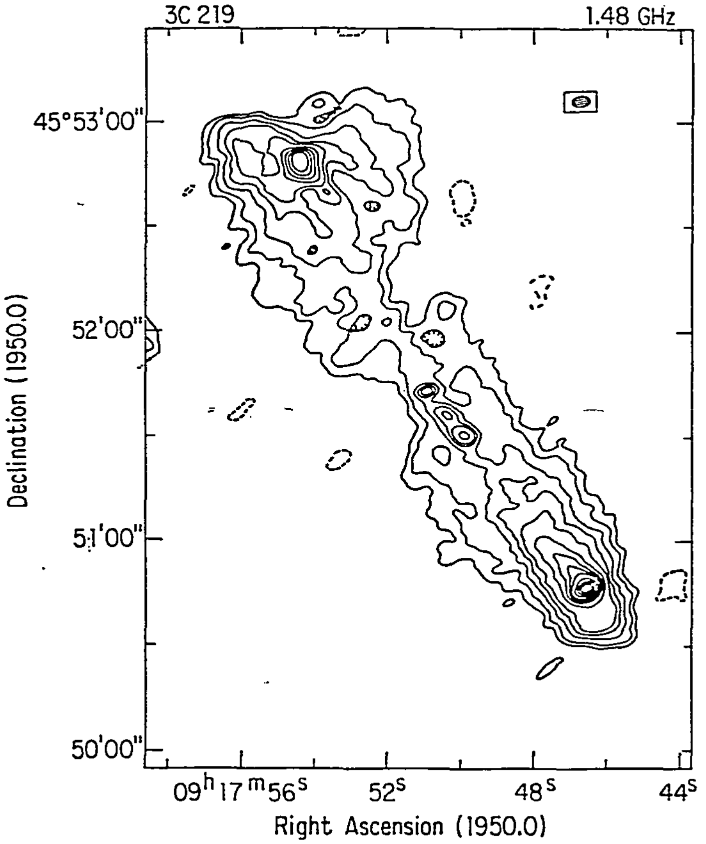

Figure 2 - 20 cm B configuration data of 3C219 (Perley et al, 1980). Contour levels are at -5,5,10,20,30,40,60,80, 100,120,160,200 and 240 mJy per beam.

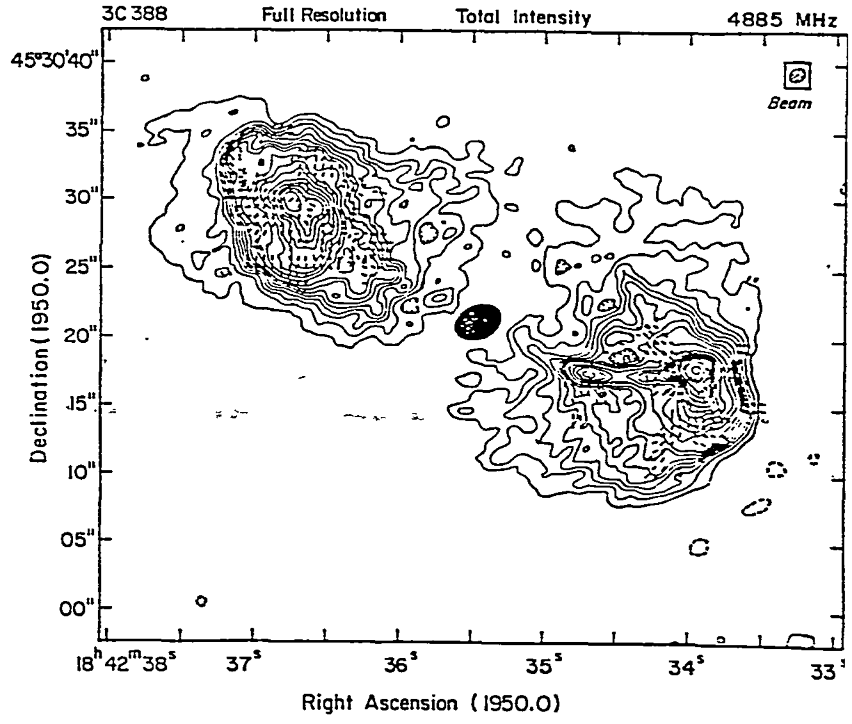

Figure 3 - 6 cm incomplete VLA B configuration data of 3C388 (Burns et al, 1982). Contour levels are at -1,1,2,3,4,5,6,7,8,10,12,15,16, 18,20,22,25,30,40,60,80 and 100% of peak (61.7 mJy per beam). Dashed lines are polarization E-vectors.

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November 26, 1985

Dr. Barry Clark
NRAO
P.O. Box 0
Socorro, NM 87801

re: project number AC149

Dear Dr. Clark;

Jack Burns has briefed me on his telephone conversation with you today and has suggested that I write to you and explain further why we feel that 3C219 is so crucial to our project.

First, let me say that we do not agree at all with REF& who stated that rotation measure gradients across jets have been unsuccessfully sought in other sources. Although this very type of measurement is frequently suggested at conferences (Taos, for example) as a measurement that ought to be done, we are not aware of any such endeavours in the literature. Rick Perley has stated to me that he is certain that such an experiment has not been done, and is long overdue. We therefore see no reason, based on alleged previous efforts, that a gradient in the rotation measure should not exist across the jet of 3C219.

During numerous conversations with Drs. Rick Perley, Alan Bridle and Frazer Owen, 3C219 was consistently mentioned as the primary source for this type of study. Drs. Perley and Bridle already have a substantial data base on 3C219 and have generously offered it for our use in this project. However, their frequency coverage is insufficient to definitively measure any rotation measures. In particular, subtle gradients in the rotation measure would be lost in the present data base. Data that Dr. Perley has already reduced shows a great deal of polarization in an extended cocoon region. It also suggests that the jet may not be thermally confined. Further, although 3C219 is rather distant (z=.17), its great linear size allows the jet and cocoon features to be resolved significantly. 3C219 is, therefore, an ideal source for the study of magnetic jets, according to the tests described in our proposal. Although we feel that 3C388 is also an excellent source for this project, we think that 3C219 is perhaps even more promising. Here, we are in disagreement with REF& again.

Naturally, we are not proposing to redo Perley et al's observations. Rather, we wish to complete the frequency coverage with comparable sensitivity. Without complete frequency coverage, the present data, as good as it may be, is insufficient for the measurements that we wish to make. Hence, we are asking for VLA time to observe 3C219 at two more frequencies in the L band (four hours each, for a total of eight hours) in the A configuration and six hours at 6 cm in the B configuration. Perley and Bridle have some 6cm, B configuration data, but this consists of several short scans, taken several months apart. The remaining proposed observing time on this source is to provide the shorter baselines at 20 cm to raise the level of the extended emission regions on the map. The short baselines at 6 cm will be provided by some C configuration data that Perley and Bridle have.

I should point out that the observations of Zukowski earlier this year are not sufficient for our purposes. As he told me on the telephone, he observed 3C219 for no more than 30 minutes at any one frequency.

I cannot emphasize enough the importance we place on the 3C219 observations. Although it is perhaps naive to expect to see the simple-minded effects we described in our proposal, we still feel that 3C219 has all the tell-tale signs of an active magnetic field. In particular, good observations of this source will be their most useful when the numerical models of magnetic jets, which are to be done at Los Alamos, have been completed.

Yours very truly;

David Clarke

From: VAX3::RICK 25-APR-1984 18:58
To: CVAX::BRIDLE
Subj: Gas in lobes.

I don't think we are quite eye-to-eye on this question. Is it your intention to say that if the jet is confined we require either:
1) The lobes to be evacuated of external gas, and far out of equipartition,
2) The lobes full of external gas, similar to, or somewhat greater than, the presumed X-ray cluster pressure,
or 3) magnetic collimation, for which we see no evidence (yet).
A fourth possibility might be that the lobes did sweep out the external gas as they were forming, but the jet refilled them back so to produce the needed pressure.

I think this is how I see it. I see no reason why the lobes must have evacuated the external medium, although it is my distince impression that this has been assumed in all models.

Later: why not have thermal support throughout the lobes, with mixed thermal/nonthermal pressures?

We are obviously not eye to eye (maybe we're eyeball to eyeball).

Running down your alternatives, let me suppose that we think jets are confined (from the evidence of the collimation data that we have provided the world with so much of). Then either:

(a) they are in contact with hot dense gas, which must therefore be adjacent to them, or

(b) they are not in contact with hot dense gas, and must be confined by some other pressure.

Let us take (a) first. This is the case we have been calculating when we try to do thermal bremsstrahlung checks. It is inconsistent with the first part of your option (1). If the lobes are evacuated, the gas ain't there. The second part of your option (1) then becomes moot. It is consistent with your option (2), though I don't think we need the "greater than" part of (2). It pre-empts your option (3). Your option (4) points to two sub-options of (a):

(a1) the hot dense gas came into the lobes from outside by some inhalation/ingestion process ferrying gas across the stand-off shock, or

(a2) the hot dense gas was pumped out along the jet, and is being recirculated back to the galaxy where it refuels the monster, getting repumped out the jet, etc. etc.

The difference between (a1) and (a2) is: does the radio galaxy recycle its own gas (a2), or keep ingesting gas from the outside (a1) ? The choice between them does not impact the confinement problem directly, or bear directly on the question of equipartition in the lobes. It is obvious;y an important ingredient of source evolution, however, and we have to try to make the choice somehow, some day, (far far away for most sources but maybe not for things like 3C449 and Cyg A).

My problem is that the lobes are seen to be full of synchrotron which, if it is in equipartition, is at a much lower pressure than the jets. What I am debating with myself (and you) is: what is the pressure balance between this stuff and the hot gas which coexists with it, according to (a - a1 or a2). Are we simply looking at a synchrotron emitting plasma that is uniformly mixed with the dense hot gas and is thus able to exist throughout it at a lower partial pressure, or should the dense hot gas be packing the synchrotron stuff into smaller volumes ("crushing it"). Or is the synchrotron stuff way out of equipartition (this one started out as your idea, not mine, remember !). [I don't attach the non-equipartition to option (1), as you do, but to option (2).]

Now what of option (b) ? We are forced to it if the thermal bremsstrahlung calculations come out wildly wrong, as I believe they do for Cyg A and for the big bright QSRs. Under it, your option (1) just postpones the problem - the out-of-equipartition lobe might confine the jet in the absence of dense hot gas in the lobe, but then what confines the lobe ? So I don't like (1) in the context of (b), either. Obviously (3) rears its head in the context of (b).

A further issue is -- if (3) is ever correct, then magnetic pressures may play a role in all jets, even if there is thermal gas out there as well. I recall that in the BCH paper in JRASC the jets most like what we saw in 3C219 in fact had BOTH thermal and magnetic pressures acting on them. Magnetic collimation itself tended to produce wild oscillations, but the magnetic/thermal partnership damped these oscillations down to an acceptable level.

On the evacuation question, most people assumed that the standoff shock was impregnable, for simplicity. It can also go unstable and let the stuff be ingested, although nobody to my knowledge has done anything predictive. The key question will be - how much gas is involved in the jet confinement ? If the mass required is small, then the recycling approach may work. If it is large, then it won't. Ingesting the gas rather than shocking it and pushing it back has the minor advantage that it cuts down on the total energy required to pump the source up. I think we should compute gas masses in the models when we talk of confinement (I did this for 3C293 and NGC6251) - let's work it out also for 3C219 and Cyg A and see where that gets us.

From: VAX3::RICK 25-APR-1984 17:36
To: CVAX::BRIDLE
Subj: 219

I looked thru the new version (unfortunately, I don't know how to print it out down here). Some comments I have are as follows.
We have separated the 'extended' from the 'point' X-ray emission by using the mean relation in Fabbiano. I note in that paper that their best estimate of the size is a whopping <10.7'. That's pretty poor for an instrument with a 0.9' beam. Why is this so poor? They had rather little data on source, but on the other hand, the source is relatively strong.
I am a little worried that those who read the paper carelessly will quickly home in on the part on the top of page 8 which says that we can barely make thermal confinement work, without reading the preceding paragraphs carefully where we display the assumptions made about separating core from halo. I suggest we add, or repeat, the statement that we are presuming half the Fabbiano X-ray flux is from the nucleus.

You have added the discussion on the lack of Faraday rotation around the jet. Do you want to add that we have data on this, and will be 'reportin this in a later paper', or should we totally leave this out, as you now have. Certainly, between 6 and 20cm, there is no measureable RM gradient around the jet (Hmmm, this might be used to constrain the X-ray halo -- maybe all of it is nuclear. The 3C449 RM gradients are easily explained in terms of the X-ray emission seen surrounding the galaxy).

More in a few minutes.

From: VAX3::RICK 25-APR-1984 16:57
To: CVAX::BRIDLE
Subj: Comments on 219.

O.K. Get ready. Here comes.

First off, I have not yet gotten the ratio of A array data to short array data - PRTUV only outputs to the 'line printer', and down here in Socorro, we ain't got none. Will do tomorrow.

I have derived the dependencies on h, and agree with you on all of them.

To continue our discussion about lobe/cocoon/thermal gas pressure, doesn't the problem arise because we have assumed that the lobes have pushed aside the cluster/halo thermal gas, and the minimum pressures of the halo are greatly less than those presumed in the external medium? If this is so, it seems certain that the halo pressure should 'crush' the lobe. Since this doesn't seem to be happening, the pressure in the lobes must be much greater than that given by equipartition. Either equipartition is way out (meaning the total energy rises greatly), or another pressure component is present. My hypothesis was that perhaps the same gas giving the X-rays is present in the lobes as well. This leads to plenty of predictable results, including depolarization (which may be occuring in Cyg A), and no notable X-ray images of radio lobes. The problem is how the gas gets in there. On MOnday, I mumbled something about processing it thru shocks, as the coccoo expands sideways (I mean the lobes) supersonically. This could result in significant heating, but only if the shock is strong. Let's suppose it is a weak shock - then the pressure/temperatur jump could be made small enough. On the other hand, maybe the internal pressure is a lot higher, due to a fairly strong shock - then we could really get rid of the confinement problem. Having an overpressured lobe is certainly no sin - we're sure it's expanding anyway. Another way to get gas in the lobes could be through turbulence - but I'm not too keen about this, the radio maps don't seem to lend much support to this (the radio contours are too smooth, all the way around).

This, I hope, explains what I got in my mind.

I am still working thru your new idea on expansion combined with sidedness. I think I see a flaw - but I haven't read carefully your note entitled 'the catch'. Will send stuff within a half hour,

From: VAX3::RICK 24-APR-1984 12:22
To: CVAX::BRIDLE
Subj: RE: 3C219 pol'n.

If the two of them occupied the same volume, this crushing would not occur. Suppose the lobes were due to shocks which propagated outwards from the 'jet' (or whatever), then the intergalactic material would be processed thru the shock. The shock would accelerate particles which should then find themselves in the thermal gas. The idea is that rather then pushing the IGM aside as the radio source expands, the expanding source uses the material along the way. This idea is closely related to those ideas we were tossing around last Wednesday nite - about infalling gas entering the lobe. I think we should have to take these ideas seriously (meaning external gas being present in the lobes) if the high gas density inside Cygnus A's lobes is confirmed by the new data.

Interoffice

National Radio Astronomy Observatory

Very Large Array
15 May 1981

To: RAP, RNH

From: AHB

Subject: 20cm maps of 3C 219

Here is the first set of untapered A configuration maps from our 20cm observations in January.

All have been CLEANed and restored with a 1".2 circular beam. The dynamic range is not wonderful and I think we may have some problems with aliasing. I propose to make and CLEAN 2048 x 2048 in the VAX with the sinc x exp convolving function to see if we can improve things. These maps were made in the usual fashion with pillbox convolution in the 11/70, using the maximum mapsize of 1024 x 1024.

Maps 1 and 2 - full field total intensity (IPOL) and polarized intensity (PPOL). Note the north-following blob in the jet is also detected here - also the considerable misalignment with the "shell" in the north-following lobe.

Map 3 - the "shell" with some surrounding lobe emission (IPOL). Maps 4,5,6 - on the same scale, IPOL, PPOL and IPOL with vectors proportional to PPOL and in PPOL's position angle. The radial E vectors and variation of degree of polarization reported in the pub-ished paper are nicely reproduced here.

Maps 7,8,9 - the same three displays as 4,5,6 but over the jet, core, "counter-jet" region. The core is less than 2% polarized. Note that we don't see rotation of the last vector at the end of the jet at 20cm, whereas we clearly did at 6cm. Possibly we will find evidence for some excess Faraday rotation at the end of the jet when we compare with 6cm at the same resolution ?

Maps 10,11,12 - the same three displays over most of the south-preceding lobe. Note the pattern in the E vectors over the extended emission relative to that over the warm spot. Also the regions of beam depolarization.

Maps 13,14,15 - the warm spot close-up.

%polarization maps will follow, when I have the VAX reductions done.