Rh , ERL #311

INSTITUTE FOR PLASMA RESEARCH
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June 20 1.

Alan:

O.K., here is the latest version but for the reference list (which the typist still has). I hope we are by now down among the 'typos'. The present version seems much improved to me, but God there's a lot of work to be done! Science marches on I suppose ...

Anyhow let me have your remarks ASAP and I'll submit it. Don't tease me too long with the NGC6251 stuff, I'm dying to confront the challenge! Are there any other 'well-behaved' (e.g. NGC 315) jets ?

I'm thinking that there still might be quite a lot to squeeze out of the NGC 315 polarization data however! It's a kind of Rosetta stone in the sky.

Cheers

Dick

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Friday, May 15.

Hi Dick —

Boy, that is quite a paper. Very dense. But I've managed to get through it, and learned a lot in the process. I think the basic results are striking — as I have said. I don't have any major criticisms. I have found some points, ranging from minor to trivial, as follows.

1. I still feel the Section IIa is overly long and detailed. All the defn + discussion of l_T, l_K, etc. is very complicated for the average reader and hardly used in the paper at hand. All you use directly are (11) from (7), to get (14). And I am not convinced that "EH81" will justify this in every case — we may end up only finding boxes in parameter space that work. Altho' (14) is an interesting sum. But ignoring non-relativistic dissipation and not worrying about particle spectra, or about feedback on the Kolmogoroff waves, says to me that (14) comes from a good guess but doesn't have the detailed support that the length of (IIa) implies. My suggestion is to shorten it a lot, and say most of it in words. Save the details for EH81, when we will need them!

2. Two basic concepts/problems are brought up, methinks: full-blown turbulence, + entrainment. Just when does each become important?

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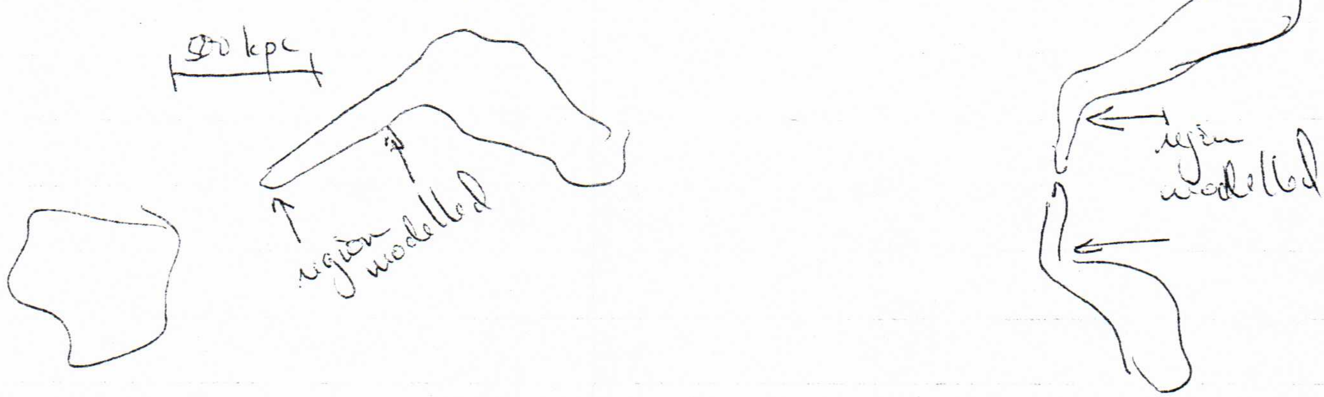
You say a little along these lines in the paper, but a more specific statement might be useful.

3. Re readability: I keep having trouble looking at $B_{axis}(R)$ diagrams and trying to visualize the source. Partly my ~~[illegible]~~ instinctive variable is z (jet length) and I keep trying to read the figure as B(z); and you do refer to "collimation plateaus" etc. I would find some pictures very useful, even though they have been published before. You know, things that look like:



4. In your fit of B(H) to B(R), you use the position of z_s as a sliding variable. My impression is ~~that~~ "S" is not a true sonic point (where $v = c_s$, and dv/dz stays non-singular), but just an ~~or~~ arbitrary choice of $v = c_s$, dv/dz = something where the external pressure has a scale height. If I'm not confused in this, then I wonder how unique the z_s-fit to the data is?

5. On the "convective smearing" at the $dR/dz = 0$ plateau: it sounds in the paper as though you're trying to claim $t_{sy} > t_{conv}$ in this plateau, to account for $B(\nu)$ staying nonzero and also have $t_{sy} \ll t_{conv}$ in the regions where the $B(\nu)$ fit works. Can you get away with this?

6. On the fit of "L_{jet}" to observations (pp. 25-26) — it seems like a circular argument. I think you are saying

a. $p_s v_s = \frac{1}{\gamma} \rho_s v_s^3 = \frac{1}{\gamma} v_s^2 (A/R^2)$

b. but (eq. 26) $A = \dfrac{4\pi B}{(v_z/R)^2 (dR/dz)^3}$

so $\dfrac{1}{\gamma} \dfrac{v_s^2 A}{R^2} = \dfrac{4\pi B}{\gamma} \left(\dfrac{v_s}{v_z}\right)^2 \left(\dfrac{dz}{dR}\right)^3$

c. Then $L_{jet} = p_s v_s \cdot \pi R_s^2 = \dfrac{4\pi}{\gamma} B \pi R_s^2 \left(\dfrac{v_s}{v_z}\right)^2 \left(\dfrac{dz}{dR}\right)^3$

which is an identity, since $\left(\dfrac{v_s}{v_z}\right)^2 \left(\dfrac{dz}{dR}\right)^2 \dfrac{4\pi}{\gamma} = O(1)$.

Or am I confused?

7. Finally — I tend to be conservative about referring to work in preparation, attributing glorious results to something we haven't started yet! Do you think some of the "EH" references are a bit optimistic?

REPORT OF REFEREE

Author, Title Henriksen et al: Synchrotron Brightness Distribution of Turbulent Radio Jets

The paper presents a very interesting contribution to our understanding of radio jets and their physics, and certainly deserves a place in The Astrophysical Journal. However, there are some sections in the paper which need to be changed. I mention the following points which should be addressed.

p.7 How can a turbulent external viscosity be non-dissipative, i.e., how can there be viscosity without momentum transport outward? Please explain?

Section IIa could be shortened by as much as 60%. Although the Lighthill mechanism may indeed be real, the section contains only plausibility arguments, and none of the formalism (except eq. 3, which is also ad hoc) is being used at later times. It would certainly deserve a place in the authors future paper on the particle-wave picture.

p.8/9 The "cone angle similarity" seems to suggest that viscosity determines the shape of the jets and not pressure gradients. Also on p. 32 entrainment seems to be the solution to the cascade problem. These concepts are not new in the literature, for instance I came across those in the Baan reference.

·.14 State that eq. 14 is an assumption.

p.18 The "jet radiation efficiency" is taken to be uniform all over the jet. It may in fact vary radially (a boundary layer; field variations) and in Z direction (field and mass entrainment). This could account for the discrepancies in the fits and should be stressed more, although it makes the present approach slightly less "authoritative".

p.22 A serious flaw in the assumption of eq. 3 is that the turbulence dies out at the collimation plateau. This is unrealistic. Either eq. 3 is not accurate or there is no collimation plateau.

p.26 The fits are rather suggestive, but cannot be called "excellent" as is claimed in the introduction. Probably other "mechanisms" can give equal quality fits.

p.29 The result that "$B(\nu) \sim$ const if $\rho \sim$ const" seems rather unlikely (i.e., $A \alpha R^2$; $w(k) \alpha \frac{1}{A}$; $B \alpha wR = \frac{1}{R}$).

§V is not very clearly written.

(Please type your report on this sheet...)

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ERL # 311
May 5/81

Dear Alan, Kwing,

Well I've finally managed to retrieve a legible copy from the typist! Not completely however.

Do not expect wonders in the details as there is still proof-reading to be done, but if it is correct I expect (and dearly hope) the bulk of the text and the science to be nearly right. If you too can return your comments to me ASAP, I'll prepare a final copy and submit it.

Please! Keep this dark at present! I don't want the ideas to become 'generally known' until we have a long head start on the next phase. Particularly, we should be trying this out on as many different sources as we can

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find data for. Perhaps we should recruit Perley and/or Wil van Breugel for this phase?

Anyway, speed is of the essence. Koenig, please check out the entrainment and cascade arguments carefully. Alan, adiabat is OK if $E_{part} \propto \underline{\underline{r}}^{-2/3}$. I'm bothered by not fitting the initial 'rise' in 3C 31 because of the nice correspondence between the optical and radio there. The statement on p 29 is based on my earlier fits and is an attempt to remove this difficulty. If you want to try for a better fit for fig 2, please feel free.

Note that the factor $\nu_{max}(10)^{p}$ occurring in the NGC 315 formulae is for $\gamma_{co} \sim 10^5$. If this is extended to 10^7 (optical) then p will be smaller. — Anyhow — out with this! Please return next week?

After ~2 months !!!

adieu
Dick

FRL #311

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Stanford March 24/81

Dear Alan,

I got various notes and interesting 'material' in the mail. All seems well but for the equation (15) point. It gives the maximum effect. There is no bending for a sphere. 'Infinite' just means bigger than the jet diameter. It is very like a reasonably flattened spheroid and physically could well correspond to a disc.

Really, you'll find it a very serviceable formula –

I've redone the 'Warps' business with all changes and corrections plus paragraph on use of (15) to avoid seeming foolish. It'll be ready to go soon.

I've solved 3C31 problem quite nicely I think. But question: Why does Fomalont et al. (1980) Brightness data go in to ~2"? I could use this initial rise and your figure doesn't show it. – also I detect some confusion on adiabatic variation at a fixed frequency I would guess

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12 March 1981

Dear Dick,

I have embedded our turbulence sum in my CH program here and reran the 3C31 Ap.J. fit and a new fit with a higher sonic point and no magnetic effects, just to see what would happen. The results are enclosed.

I think it is very important to show both the 3C31 data and the adiabat in our paper, as well as our predicted fit. Then at least it is clear that we do a factor of 10 better than the adiabat, and that the fit only really falls apart towards the very end. Our fits become steeper than the adiabat towards the end, which would not happen if we took convection into account. We really will have to work on a model that has both convection and turbulent input.

I enclose a listing of the CH program for your perusal.

I am now about to vanish into observing again - Coma A (the one in which we got an optical jet) and the core of 3C236 at super-high resolution (2cm and 1cm, about 0".1 HPBW) both in the coming week, as well as some meetings on VLA post-processing and optimisation of maps. We are contemplating putting on a Summer School for observers to teach them how to use the VLA effectively. Before we do that we have to decide whether we can agree amongst ourselves on some optimum procedures !

The progress of the Canadian VLBI deliberations is running true to form. The proposal for the design study is being funded to the tune of $300,000 from NSERC and NRC. About $100,000 comes from NRC, but the Ottawa gang is already saying that they have to have absolute control over that money, while the remainder is for both them and the University people to deal with. I will never cease to marvel at the attitude of the HIA group, and hope that silliness of this sort will not cripple the project. NRC itself has now rated the VLBA ahead of CHEER and TRIUMF (so I hear) in its priorities for future funding. So a good job is being done despite the attitudes of some of the people concerned. I hope it can be kept up.

Cheers,

A.

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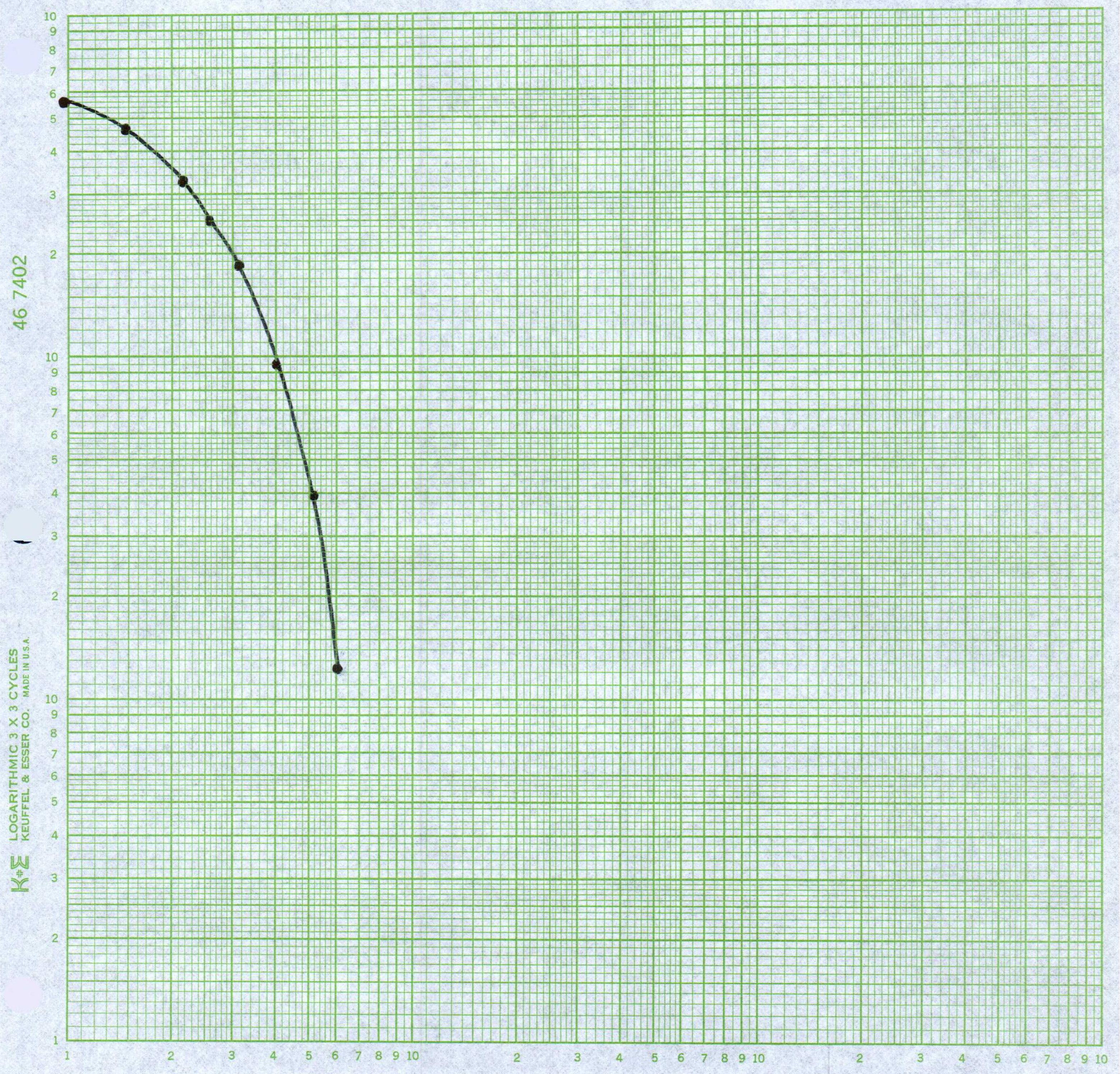
12-March 1981

3C31 N jet new CH fit

Turbulence fit



CH SUPERSONIC BEAM   AHB VERSION 4.2 (11-MAR-81)
==================
EXECUTION ON 12-Mar-81

SPECIFICATION OF SONIC POINT CONDITIONS:

BEAM RADIUS AT SONIC POINT	0.2100	⟵
HEIGHT OF SONIC POINT ABOVE CORE	2.3000	⟵
LONGITUDINAL ALFVENIC MACH NO.	0.1000E+08	} no magnetic eff.
LONGITUDINAL ALFVENIC MACH NO.**-2	0.1000E-13	

SPECIFICATION OF EXTERNAL PRESSURE LAWS:

HEIGHT WHERE TWO PRESSURE TERMS EQUAL	10.8000	} pressure law
SCALE HEIGHT FOR SECOND PRESSURE	20.0000	
POWER LAW OF FIRST PRESSURE	5.0000	
POWER LAW OF SECOND PRESSURE	3.0000	

SPECIFICATION OF MAGNETIC PARAMETERS:

BEAM RADIUS AT TRANSITION POINT	0.7000
BEAM RADIUS AT ALFVENIC POINT	0.0050

MODEL OUTPUT FILED IN DISKFILE 3c31b.DAT   DELETE WHEN PLOTTED

CONSTANTS:
GAMMA   = 1.3333
EPSILON-B = 0.340E-15 ⟵ no magnetic effects!

CJ =   0.7500E+00
CE =   0.7500E+00

[IMPROVED FIT TO BRIGHTNESS DISTRIBUTION IN 3C31]

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	EPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
1	2.3021	0.2100	1.0044	-0.7230E-04	-0.7898E+00	0.6266E-14
0	0.9979E+00	0.9941E+00	0.9956E+00	0.9985E+00	0.2000E-01	-0.8531E-11
3	2.3152	0.2100	1.0018	0.3809E-03	-0.7919E+00	0.6282E-14
0	0.9848E+00	0.9977E+00	0.9982E+00	0.9994E+00	0.8000E-01	0.1251E-08
4	2.3340	0.2100	1.0079	0.2680E-02	-0.7871E+00	0.6244E-14
0	0.9662E+00	0.9894E+00	0.9921E+00	0.9974E+00	0.8000E-01	0.4328E-06
5	2.3543	0.2101	1.0244	0.5425E-02	-0.7747E+00	0.6144E-14
0	0.9461E+00	0.9675E+00	0.9755E+00	0.9918E+00	0.8000E-01	0.3532E-05
6	2.3763	0.2102	1.0414	0.8296E-02	-0.7625E+00	0.6043E-14
0	0.9246E+00	0.9448E+00	0.9583E+00	0.9859E+00	0.8000E-01	0.1241E-04
7	2.4002	0.2104	1.0589	0.1141E-01	-0.7507E+00	0.5943E-14
0	0.9015E+00	0.9216E+00	0.9406E+00	0.9798E+00	0.8000E-01	0.3172E-04
8	2.4260	0.2107	1.0772	0.1488E-01	-0.7390E+00	0.5842E-14
0	0.8767E+00	0.8973E+00	0.9219E+00	0.9733E+00	0.8000E-01	0.6886E-04
9	2.4540	0.2111	1.0969	0.1874E-01	-0.7272E+00	0.5738E-14
0	0.8503E+00	0.8713E+00	0.9018E+00	0.9661E+00	0.8000E-01	0.1346E-03
10	2.4843	0.2117	1.1180	0.2303E-01	-0.7153E+00	0.5629E-14
0	0.8222E+00	0.8435E+00	0.8802E+00	0.9584E+00	0.8000E-01	0.2439E-03
11	2.5171	0.2124	1.1407	0.2777E-01	-0.7035E+00	0.5517E-14
0	0.7923E+00	0.8138E+00	0.8568E+00	0.9498E+00	0.8000E-01	0.4160E-03
12	2.5527	0.2133	1.1651	0.3295E-01	-0.6917E+00	0.5402E-14
0	0.7606E+00	0.7822E+00	0.8317E+00	0.9404E+00	0.8000E-01	0.6746E-03
13	2.5913	0.2145	1.1911	0.3857E-01	-0.6802E+00	0.5284E-14
0	0.7273E+00	0.7487E+00	0.8049E+00	0.9302E+00	0.8000E-01	0.1047E-02
14	2.6330	0.2159	1.2189	0.4463E-01	-0.6691E+00	0.5164E-14
0	0.6923E+00	0.7135E+00	0.7763E+00	0.9191E+00	0.8000E-01	0.1565E-02
15	2.6782	0.2176	1.2483	0.5114E-01	-0.6586E+00	0.5042E-14
0	0.6558E+00	0.6766E+00	0.7460E+00	0.9070E+00	0.8000E-01	0.2263E-02
16	2.7272	0.2197	1.2794	0.5812E-01	-0.6487E+00	0.4919E-14
0	0.6180E+00	0.6383E+00	0.7141E+00	0.8939E+00	0.8000E-01	0.3179E-02
17	2.7803	0.2222	1.3122	0.6559E-01	-0.6397E+00	0.4797E-14
0	0.5790E+00	0.5989E+00	0.6808E+00	0.8797E+00	0.8000E-01	0.4356E-02
18	2.8378	0.2252	1.3466	0.7360E-01	-0.6317E+00	0.4674E-14
0	0.5391E+00	0.5585E+00	0.6460E+00	0.8645E+00	0.8000E-01	0.5839E-02
19	2.9001	0.2287	1.3825	0.8216E-01	-0.6249E+00	0.4553E-14
0	0.4986E+00	0.5174E+00	0.6101E+00	0.8481E+00	0.8000E-01	0.7672E-02
20	2.9675	0.2328	1.4199	0.9132E-01	-0.6194E+00	0.4433E-14
0	0.4578E+00	0.4761E+00	0.5731E+00	0.8307E+00	0.8000E-01	0.9896E-02

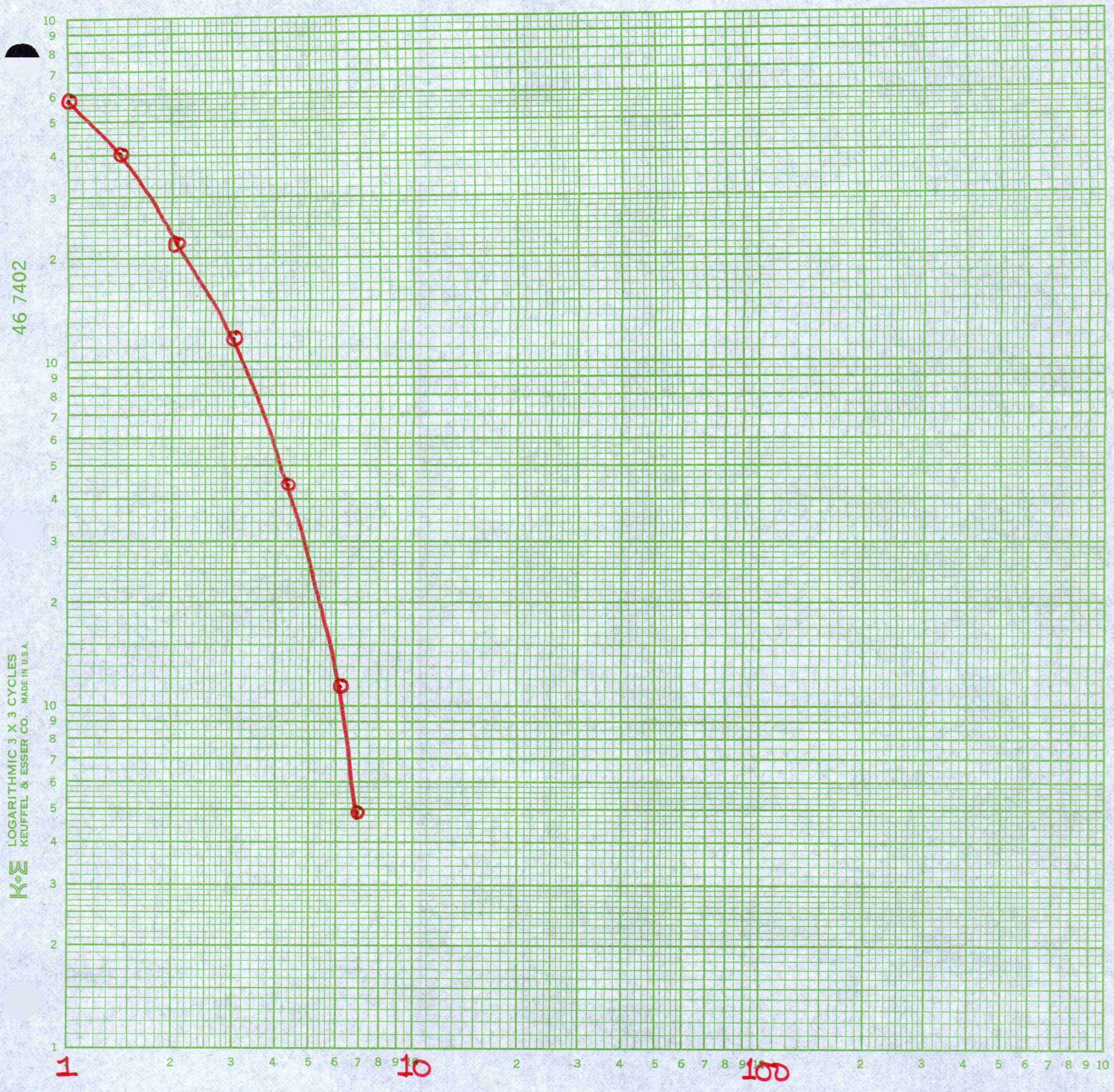
ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
21	3.0406	0.2376	1.4587	0.1011E+00	-0.6154E+00	0.4315E-14
0	0.4172E+00	0.4348E+00	0.5354E+00	0.8120E+00	0.8000E-01	0.1254E-01
22	3.1198	0.2433	1.4988	0.1115E+00	-0.6132E+00	0.4200E-14
0	0.3772E+00	0.3940E+00	0.4972E+00	0.7923E+00	0.8000E-01	0.1561E-01
23	3.2056	0.2498	1.5401	0.1224E+00	-0.6128E+00	0.4088E-14
0	0.3381E+00	0.3540E+00	0.4589E+00	0.7714E+00	0.8000E-01	0.1909E-01
24	3.2985	0.2574	1.5824	0.1340E+00	-0.6145E+00	0.3979E-14
0	0.3004E+00	0.3153E+00	0.4208E+00	0.7494E+00	0.8000E-01	0.2293E-01
25	3.3991	0.2661	1.6253	0.1460E+00	-0.6185E+00	0.3874E-14
0	0.2646E+00	0.2784E+00	0.3833E+00	0.7264E+00	0.8000E-01	0.2705E-01
26	3.5081	0.2761	1.6689	0.1586E+00	-0.6251E+00	0.3773E-14
0	0.2308E+00	0.2435E+00	0.3467E+00	0.7025E+00	0.8000E-01	0.3134E-01
27	3.6263	0.2876	1.7126	0.1716E+00	-0.6344E+00	0.3677E-14
0	0.1994E+00	0.2111E+00	0.3114E+00	0.6778E+00	0.8000E-01	0.3566E-01
28	3.7542	0.3006	1.7565	0.1850E+00	-0.6468E+00	0.3585E-14
0	0.1707E+00	0.1813E+00	0.2778E+00	0.6525E+00	0.8000E-01	0.3988E-01
29	3.8928	0.3155	1.8001	0.1988E+00	-0.6624E+00	0.3498E-14
0	0.1446E+00	0.1542E+00	0.2461E+00	0.6267E+00	0.8000E-01	0.4387E-01
30	4.0430	0.3325	1.8432	0.2131E+00	-0.6816E+00	0.3417E-14
0	0.1214E+00	0.1300E+00	0.2165E+00	0.6005E+00	0.8000E-01	0.4749E-01
31	4.2056	0.3516	1.8857	0.2277E+00	-0.7047E+00	0.3340E-14
0	0.1010E+00	0.1086E+00	0.1892E+00	0.5741E+00	0.8000E-01	0.5062E-01
32	4.3818	0.3733	1.9273	0.2426E+00	-0.7320E+00	0.3268E-14
0	0.8316E-01	0.8992E-01	0.1642E+00	0.5476E+00	0.8000E-01	0.5318E-01
33	4.5727	0.3978	1.9679	0.2579E+00	-0.7639E+00	0.3201E-14
0	0.6787E-01	0.7383E-01	0.1416E+00	0.5213E+00	0.8000E-01	0.5510E-01
34	4.7795	0.4254	2.0072	0.2735E+00	-0.8009E+00	0.3138E-14
0	0.5491E-01	0.6013E-01	0.1214E+00	0.4952E+00	0.8000E-01	0.5633E-01
35	5.0035	0.4565	2.0453	0.2894E+00	-0.8435E+00	0.3080E-14
0	0.4406E-01	0.4859E-01	0.1035E+00	0.4695E+00	0.8000E-01	0.5685E-01
36	5.2461	0.4914	2.0818	0.3054E+00	-0.8921E+00	0.3026E-14
0	0.3506E-01	0.3898E-01	0.8773E-01	0.4444E+00	0.8000E-01	0.5667E-01
37	5.5090	0.5306	2.1169	0.3216E+00	-0.9474E+00	0.2976E-14
0	0.2770E-01	0.3106E-01	0.7399E-01	0.4198E+00	0.8000E-01	0.5581E-01
38	5.7938	0.5746	2.1503	0.3379E+00	-0.1010E+01	0.2930E-14
0	0.2174E-01	0.2460E-01	0.6211E-01	0.3961E+00	0.8000E-01	0.5432E-01
39	6.1023	0.6239	2.1822	0.3541E+00	-0.1081E+01	0.2887E-14
0	0.1696E-01	0.1937E-01	0.5192E-01	0.3731E+00	0.8000E-01	0.5227E-01

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	EPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
40	6.4364	0.6790	2.2123	0.3701E+00	-0.1160E+01	0.2848E-14
0	0.1317E-01	0.1518E-01	0.4324E-01	0.3510E+00	0.8000E-01	0.4972E-01
41	6.7984	0.7405	2.2408	0.3859E+00	-0.1249E+01	0.2812E-14
0	0.1019E-01	0.1184E-01	0.3589E-01	0.3299E+00	0.8000E-01	0.4676E-01
42	7.1906	0.8090	2.2676	0.4011E+00	-0.1349E+01	0.2778E-14
0	0.7866E-02	0.9204E-02	0.2971E-01	0.3098E+00	0.8000E-01	0.4347E-01
43	7.6154	0.8852	2.2927	0.4155E+00	-0.1459E+01	0.2748E-14
0	0.6074E-02	0.7134E-02	0.2455E-01	0.2907E+00	0.8000E-01	0.3993E-01
44	8.0756	0.9697	2.3162	0.4289E+00	-0.1582E+01	0.2720E-14
0	0.4702E-02	0.5519E-02	0.2025E-01	0.2726E+00	0.8000E-01	0.3624E-01
45	8.5741	1.0631	2.3382	0.4410E+00	-0.1719E+01	0.2695E-14
0	0.3659E-02	0.4265E-02	0.1669E-01	0.2556E+00	0.8000E-01	0.3246E-01
46	9.1141	1.1660	2.3585	0.4514E+00	-0.1869E+01	0.2671E-14
0	0.2871E-02	0.3295E-02	0.1375E-01	0.2396E+00	0.8000E-01	0.2868E-01
47	9.6992	1.2789	2.3774	0.4597E+00	-0.2033E+01	0.2650E-14
0	0.2280E-02	0.2548E-02	0.1134E-01	0.2247E+00	0.8000E-01	0.2498E-01
48	10.3329	1.4022	2.3949	0.4654E+00	-0.2213E+01	0.2631E-14
0	0.1837E-02	0.1974E-02	0.9365E-02	0.2108E+00	0.8000E-01	0.2140E-01
49	11.0194	1.5362	2.4110	0.4681E+00	-0.2408E+01	0.2613E-14
0	0.1506E-02	0.1534E-02	0.7751E-02	0.1979E+00	0.8000E-01	0.1803E-01
50	11.7631	1.6807	2.4257	0.4673E+00	-0.2619E+01	0.2597E-14
0	0.1257E-02	0.1197E-02	0.6436E-02	0.1860E+00	0.8000E-01	0.1490E-01
51	12.5688	1.8355	2.4392	0.4627E+00	-0.2844E+01	0.2583E-14
0	0.1069E-02	0.9396E-03	0.5366E-02	0.1751E+00	0.8000E-01	0.1205E-01
52	13.4415	2.0001	2.4515	0.4538E+00	-0.3084E+01	0.2570E-14
0	0.9239E-03	0.7424E-03	0.4497E-02	0.1651E+00	0.8000E-01	0.9527E-02
53	14.3870	2.1732	2.4627	0.4403E+00	-0.3335E+01	0.2558E-14
0	0.8096E-03	0.5914E-03	0.3792E-02	0.1560E+00	0.8000E-01	0.7339E-02
54	15.4111	2.3534	2.4727	0.4222E+00	-0.3597E+01	0.2548E-14
0	0.7164E-03	0.4756E-03	0.3220E-02	0.1477E+00	0.8000E-01	0.5494E-02
55	16.5206	2.5387	2.4817	0.3995E+00	-0.3867E+01	0.2539E-14
0	0.6376E-03	0.3867E-03	0.2757E-02	0.1402E+00	0.8000E-01	0.3986E-02
56	17.7225	2.7267	2.4898	0.3726E+00	-0.4140E+01	0.2531E-14
0	0.5684E-03	0.3182E-03	0.2382E-02	0.1336E+00	0.8000E-01	0.2795E-02
57	19.0245	2.9146	2.4969	0.3421E+00	-0.4412E+01	0.2523E-14
0	0.5058E-03	0.2654E-03	0.2079E-02	0.1277E+00	0.8000E-01	0.1887E-02
58	20.4349	3.0994	2.5032	0.3088E+00	-0.4680E+01	0.2517E-14
0	0.4480E-03	0.2245E-03	0.1834E-02	0.1224E+00	0.8000E-01	0.1225E-02

ITER# / ERROR	HEIGHT Z / PE/PES	RADIUS / PJ/PJS	W(Z) / RHO	W(R) / TAU	BPHI/BZ / ITER STEP	FPINCH / TURBULENCE
59	21.9628	3.2778	2.5087	0.2739E+00	-0.4939E+01	0.2512E-14
0	0.3940E-03	0.1928E-03	0.1636E-02	0.1179E+00	0.8000E-01	0.7622E-03
60	23.6180	3.4471	2.5134	0.2385E+00	-0.5184E+01	0.2507E-14
0	0.3436E-03	0.1682E-03	0.1477E-02	0.1139E+00	0.8000E-01	0.4543E-03
61	25.4110	3.6047	2.5175	0.2041E+00	-0.5412E+01	0.2503E-14
0	0.2969E-03	0.1490E-03	0.1348E-02	0.1105E+00	0.8000E-01	0.2597E-03
62	27.3533	3.7489	2.5209	0.1718E+00	-0.5621E+01	0.2499E-14
0	0.2541E-03	0.1339E-03	0.1245E-02	0.1076E+00	0.8000E-01	0.1432E-03
63	29.4574	3.8788	2.5238	0.1430E+00	-0.5809E+01	0.2496E-14
0	0.2155E-03	0.1221E-03	0.1161E-02	0.1051E+00	0.8000E-01	0.7704E-04
64	31.7367	3.9946	2.5263	0.1187E+00	-0.5977E+01	0.2494E-14
0	0.1811E-03	0.1127E-03	0.1094E-02	0.1031E+00	0.8000E-01	0.4147E-04
65	34.2059	4.0982	2.5284	0.9964E-01	-0.6127E+01	0.2492E-14
0	0.1509E-03	0.1052E-03	0.1038E-02	0.1013E+00	0.8000E-01	0.2329E-04
66	36.8808	4.1927	2.5302	0.8643E-01	-0.6263E+01	0.2490E-14
0	0.1248E-03	0.9889E-04	0.9915E-03	0.9974E-01	0.8000E-01	0.1452E-04
67	39.7784	4.2829	2.5319	0.7935E-01	-0.6394E+01	0.2488E-14
0	0.1025E-03	0.9335E-04	0.9495E-03	0.9831E-01	0.8000E-01	0.1076E-04
68	42.9174	4.3753	2.5336	0.7844E-01	-0.6527E+01	0.2487E-14
0	0.8375E-04	0.8811E-04	0.9093E-03	0.9690E-01	0.8000E-01	0.9951E-05
69	46.3177	4.4779	2.5354	0.8346E-01	-0.6676E+01	0.2485E-14
0	0.6806E-04	0.8275E-04	0.8675E-03	0.9539E-01	0.8000E-01	0.1143E-04
70	50.0013	4.6003	2.5374	0.9392E-01	-0.6853E+01	0.2483E-14
0	0.5506E-04	0.7692E-04	0.8212E-03	0.9367E-01	0.8000E-01	0.1543E-04
71	53.9917	4.7535	2.5399	0.1091E+00	-0.7074E+01	0.2481E-14
0	0.4438E-04	0.7040E-04	0.7684E-03	0.9162E-01	0.8000E-01	0.2262E-04

⊙ Ap. J. fit to 3C31

Turbulence



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CH SUPERSONIC BEAM  AHB VERSION 4.2 (11-MAR-81)
===================
EXECUTION ON 11-Mar-81

SPECIFICATION OF SONIC POINT CONDITIONS:
BEAM RADIUS AT SONIC POINT                        0.1000
HEIGHT OF SONIC POINT ABOVE CORE                  1.4500
LONGITUDINAL ALFVENIC MACH NO.                0.1105E+01
LONGITUDINAL ALFVENIC MACH NO.**-2            0.8190E+00

SPECIFICATION OF EXTERNAL PRESSURE LAWS:
HEIGHT WHERE TWO PRESSURE TERMS EQUAL            12.0000
SCALE HEIGHT FOR SECOND PRESSURE                 25.0000
POWER LAW OF FIRST PRESSURE                       5.0000
POWER LAW OF SECOND PRESSURE                      3.0000

SPECIFICATION OF MAGNETIC PARAMETERS:
BEAM RADIUS AT TRANSITION POINT                   0.7000
BEAM RADIUS AT ALFVENIC POINT                     0.1000


MODEL OUTPUT FILED IN DISKFILE 3c31a.DAT   DELETE WHEN PLOTTED

CONSTANTS:
GAMMA     = 1.3333
EPSILON-B = 0.632E-02

CJ =      0.7500E+00
CE =      0.8214E+00
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3C31 Ap.J. fit
Curve (a)

[With turbulence calc

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
1	1.4510	0.1000	1.0044	-0.4407E-03	-0.4070E-04	0.1363E-08
0	0.9984E+00	0.9941E+00	0.9956E+00	0.9985E+00	0.2000E-01	-0.8522E-08
4	1.4662	0.1000	1.0210	0.3721E-02	-0.9566E-03	0.7648E-06
1	0.9744E+00	0.9720E+00	0.9789E+00	0.9929E+00	0.8000E-01	0.5045E-05
5	1.4759	0.1001	1.0361	-0.3053E-02	-0.2630E-02	0.5861E-05
0	0.9592E+00	0.9518E+00	0.9637E+00	0.9877E+00	0.8000E-01	-0.2741E-05
6	1.4834	0.1000	1.0176	0.8389E-02	-0.6802E-03	0.3855E-06
0	0.9474E+00	0.9766E+00	0.9824E+00	0.9941E+00	0.5832E-01	0.5799E-04
7	1.4914	0.1001	1.0404	0.1894E-01	-0.3215E-02	0.8789E-05
0	0.9349E+00	0.9461E+00	0.9593E+00	0.9863E+00	0.5832E-01	0.6517E-03
8	1.4999	0.1003	1.0720	0.1076E-01	-0.8804E-02	0.6764E-04
0	0.9218E+00	0.9042E+00	0.9272E+00	0.9751E+00	0.5832E-01	0.1156E-03
10	1.5185	0.1003	1.0759	-0.1718E-02	-0.9617E-02	0.8095E-04
0	0.8933E+00	0.8990E+00	0.9233E+00	0.9737E+00	0.5832E-01	-0.4682E-06
11	1.5286	0.1003	1.0706	0.1067E-01	-0.8517E-02	0.6323E-04
0	0.8780E+00	0.9061E+00	0.9287E+00	0.9756E+00	0.5832E-01	0.1129E-03
13	1.5507	0.1008	1.1141	0.2687E-01	-0.1851E-01	0.3078E-03
0	0.8449E+00	0.8487E+00	0.8842E+00	0.9598E+00	0.5832E-01	0.1715E-02
14	1.5627	0.1011	1.1361	0.1924E-01	-0.2417E-01	0.5322E-03
0	0.8272E+00	0.8199E+00	0.8616E+00	0.9516E+00	0.5832E-01	0.6132E-03
15	1.5755	0.1013	1.1475	0.1101E-01	-0.2722E-01	0.6792E-03
0	0.8086E+00	0.8050E+00	0.8498E+00	0.9472E+00	0.5832E-01	0.1136E-03
17	1.6034	0.1014	1.1569	0.1749E-01	-0.2979E-01	0.8172E-03
0	0.7688E+00	0.7927E+00	0.8401E+00	0.9436E+00	0.5832E-01	0.4495E-03
18	1.6186	0.1017	1.1700	0.3006E-01	-0.3336E-01	0.1031E-02
0	0.7477E+00	0.7759E+00	0.8267E+00	0.9385E+00	0.5832E-01	0.2246E-02
19	1.6348	0.1022	1.1925	0.3811E-01	-0.3963E-01	0.1470E-02
0	0.7257E+00	0.7470E+00	0.8035E+00	0.9297E+00	0.5832E-01	0.4449E-02
21	1.6700	0.1034	1.2390	0.3392E-01	-0.5280E-01	0.2648E-02
0	0.6792E+00	0.6882E+00	0.7556E+00	0.9108E+00	0.5832E-01	0.2949E-02
22	1.6892	0.1039	1.2558	0.2997E-01	-0.5756E-01	0.3159E-02
0	0.6548E+00	0.6673E+00	0.7383E+00	0.9038E+00	0.5832E-01	0.1988E-02
24	1.7312	0.1048	1.2847	0.3676E-01	-0.6573E-01	0.4139E-02
0	0.6038E+00	0.6320E+00	0.7088E+00	0.8916E+00	0.5832E-01	0.3520E-02
25	1.7541	0.1055	1.3034	0.4611E-01	-0.7103E-01	0.4842E-02
0	0.5774E+00	0.6093E+00	0.6897E+00	0.8835E+00	0.5832E-01	0.6760E-02
26	1.7783	0.1064	1.3269	0.5448E-01	-0.7765E-01	0.5788E-02
0	0.5504E+00	0.5814E+00	0.6658E+00	0.8732E+00	0.5832E-01	0.1077E-01

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
28	1.8313	0.1087	1.3796	0.6066E-01	-0.9237E-01	0.8152E-02
0	0.4954E+00	0.5206E+00	0.6129E+00	0.8495E+00	0.5832E-01	0.1368E-01
29	1.8602	0.1100	1.4047	0.6064E-01	-0.9935E-01	0.9380E-02
0	0.4675E+00	0.4927E+00	0.5880E+00	0.8378E+00	0.5832E-01	0.1312E-01
30	1.8909	0.1113	1.4285	0.6153E-01	-0.1059E+00	0.1059E-01
0	0.4395E+00	0.4668E+00	0.5648E+00	0.8266E+00	0.5832E-01	0.1316E-01
32	1.9578	0.1143	1.4759	0.7074E-01	-0.1191E+00	0.1314E-01
0	0.3839E+00	0.4171E+00	0.5190E+00	0.8036E+00	0.5832E-01	0.1837E-01
33	1.9943	0.1160	1.5018	0.7830E-01	-0.1263E+00	0.1458E-01
0	0.3566E+00	0.3910E+00	0.4945E+00	0.7908E+00	0.5832E-01	0.2374E-01
34	2.0330	0.1181	1.5296	0.8611E-01	-0.1342E+00	0.1616E-01
0	0.3297E+00	0.3640E+00	0.4686E+00	0.7767E+00	0.5832E-01	0.2992E-01
36	2.1175	0.1232	1.5890	0.9869E-01	-0.1512E+00	0.1961E-01
0	0.2781E+00	0.3095E+00	0.4149E+00	0.7459E+00	0.5832E-01	0.3988E-01
37	2.1636	0.1261	1.6191	0.1033E+00	-0.1601E+00	0.2138E-01
0	0.2536E+00	0.2836E+00	0.3886E+00	0.7298E+00	0.5832E-01	0.4288E-01
39	2.2642	0.1326	1.6786	0.1122E+00	-0.1783E+00	0.2485E-01
0	0.2078E+00	0.2361E+00	0.3387E+00	0.6971E+00	0.5832E-01	0.4780E-01
40	2.3191	0.1363	1.7081	0.1175E+00	-0.1878E+00	0.2655E-01
0	0.1867E+00	0.2144E+00	0.3150E+00	0.6805E+00	0.5832E-01	0.5109E-01
41	2.3773	0.1404	1.7375	0.1237E+00	-0.1977E+00	0.2822E-01
0	0.1669E+00	0.1938E+00	0.2921E+00	0.6635E+00	0.5832E-01	0.5532E-01
43	2.5044	0.1497	1.7970	0.1384E+00	-0.2190E+00	0.3148E-01
0	0.1314E+00	0.1560E+00	0.2482E+00	0.6285E+00	0.5832E-01	0.6584E-01
44	2.5737	0.1552	1.8270	0.1463E+00	-0.2306E+00	0.3305E-01
0	0.1157E+00	0.1388E+00	0.2274E+00	0.6104E+00	0.5832E-01	0.7126E-01
45	2.6472	0.1611	1.8570	0.1543E+00	-0.2429E+00	0.3457E-01
0	0.1013E+00	0.1228E+00	0.2074E+00	0.5920E+00	0.5832E-01	0.7617E-01
47	2.8077	0.1749	1.9164	0.1698E+00	-0.2699E+00	0.3738E-01
0	0.7655E-01	0.9459E-01	0.1705E+00	0.5546E+00	0.5832E-01	0.8343E-01
48	2.8952	0.1828	1.9455	0.1773E+00	-0.2847E+00	0.3865E-01
0	0.6605E-01	0.8245E-01	0.1539E+00	0.5359E+00	0.5832E-01	0.8569E-01
50	3.0864	0.2007	2.0019	0.1922E+00	-0.3170E+00	0.4091E-01
0	0.4846E-01	0.6188E-01	0.1241E+00	0.4988E+00	0.5832E-01	0.8803E-01
51	3.1907	0.2108	2.0291	0.1997E+00	-0.3347E+00	0.4189E-01
0	0.4121E-01	0.5330E-01	0.1109E+00	0.4805E+00	0.5832E-01	0.8839E-01
52	3.3012	0.2218	2.0556	0.2075E+00	-0.3536E+00	0.4278E-01
0	0.3489E-01	0.4573E-01	0.9889E-01	0.4625E+00	0.5832E-01	0.8835E-01

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
54	3.5426	0.2468	2.1064	0.2237E+00	-0.3953E+00	0.4428E-01
0	0.2466E-01	0.3330E-01	0.7796E-01	0.4272E+00	0.5832E-01	0.8722E-01
55	3.6743	0.2609	2.1307	0.2321E+00	-0.4185E+00	0.4489E-01
0	0.2060E-01	0.2827E-01	0.6893E-01	0.4101E+00	0.5832E-01	0.8616E-01
56	3.8139	0.2763	2.1543	0.2407E+00	-0.4434E+00	0.4543E-01
0	0.1714E-01	0.2391E-01	0.6080E-01	0.3933E+00	0.5832E-01	0.8475E-01
58	4.1187	0.3112	2.1990	0.2583E+00	-0.4989E+00	0.4628E-01
0	0.1171E-01	0.1694E-01	0.4694E-01	0.3608E+00	0.5832E-01	0.8090E-01
59	4.2850	0.3310	2.2202	0.2672E+00	-0.5299E+00	0.4661E-01
0	0.9628E-02	0.1419E-01	0.4111E-01	0.3452E+00	0.5832E-01	0.7846E-01
61	4.6481	0.3758	2.2603	0.2852E+00	-0.5993E+00	0.4708E-01
0	0.6436E-02	0.9877E-02	0.3133E-01	0.3153E+00	0.5832E-01	0.7271E-01
62	4.8461	0.4011	2.2791	0.2942E+00	-0.6381E+00	0.4724E-01
0	0.5235E-02	0.8211E-02	0.2727E-01	0.3011E+00	0.5832E-01	0.6947E-01
63	5.0561	0.4285	2.2971	0.3031E+00	-0.6799E+00	0.4736E-01
0	0.4245E-02	0.6812E-02	0.2371E-01	0.2873E+00	0.5832E-01	0.6604E-01
65	5.5146	0.4904	2.3307	0.3206E+00	-0.7734E+00	0.4749E-01
0	0.2768E-02	0.4663E-02	0.1784E-01	0.2613E+00	0.5832E-01	0.5883E-01
66	5.7647	0.5251	2.3464	0.3292E+00	-0.8257E+00	0.4751E-01
0	0.2227E-02	0.3850E-02	0.1546E-01	0.2491E+00	0.5832E-01	0.5512E-01
67	6.0298	0.5627	2.3614	0.3375E+00	-0.8819E+00	0.4751E-01
0	0.1788E-02	0.3175E-02	0.1338E-01	0.2374E+00	0.5832E-01	0.5142E-01
69	6.6088	0.6470	2.3891	0.3534E+00	-0.1007E+01	0.4744E-01
0	0.1147E-02	0.2155E-02	0.1000E-01	0.2155E+00	0.5832E-01	0.4412E-01
70	6.9246	0.6941	2.4019	0.3608E+00	-0.1077E+01	0.4738E-01
0	0.9177E-03	0.1774E-02	0.8642E-02	0.2052E+00	0.5832E-01	0.4060E-01
72	7.6142	0.7993	2.4255	0.3745E+00	-0.1233E+01	0.4724E-01
0	0.5881E-03	0.1202E-02	0.6453E-02	0.1862E+00	0.5832E-01	0.3390E-01
73	7.9904	0.8578	2.4364	0.3807E+00	-0.1319E+01	0.4716E-01
0	0.4719E-03	0.9895E-03	0.5578E-02	0.1774E+00	0.5832E-01	0.3077E-01
74	8.3892	0.9205	2.4467	0.3863E+00	-0.1411E+01	0.4707E-01
0	0.3797E-03	0.8152E-03	0.4824E-02	0.1690E+00	0.5832E-01	0.2780E-01
76	9.2601	1.0593	2.4657	0.3956E+00	-0.1614E+01	0.4689E-01
0	0.2495E-03	0.5548E-03	0.3614E-02	0.1535E+00	0.5832E-01	0.2237E-01
77	9.7351	1.1358	2.4744	0.3991E+00	-0.1726E+01	0.4680E-01
0	0.2043E-03	0.4585E-03	0.3133E-02	0.1463E+00	0.5832E-01	0.1991E-01
78	10.2386	1.2173	2.4825	0.4018E+00	-0.1845E+01	0.4671E-01
0	0.1687E-03	0.3795E-03	0.2718E-02	0.1396E+00	0.5832E-01	0.1764E-01

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
ERROR	PE/PES	PJ/PJS	RHO	TAU	ITER STEP	TURBULENCE
80	11.3383	1.3957	2.4975	0.4045E+00	-0.2105E+01	0.4653E-01
0	0.1190E-03	0.2614E-03	0.2055E-02	0.1272E+00	0.5832E-01	0.1361E-01
81	11.9381	1.4929	2.5043	0.4043E+00	-0.2246E+01	0.4644E-01
0	0.1018E-03	0.2176E-03	0.1792E-02	0.1215E+00	0.5832E-01	0.1184E-01
82	12.5740	1.5954	2.5107	0.4030E+00	-0.2396E+01	0.4636E-01
0	0.8824E-04	0.1817E-03	0.1565E-02	0.1161E+00	0.5832E-01	0.1024E-01
84	13.9626	1.8167	2.5224	0.3968E+00	-0.2717E+01	0.4620E-01
0	0.6896E-04	0.1277E-03	0.1201E-02	0.1063E+00	0.5832E-01	0.7505E-02
85	14.7200	1.9352	2.5277	0.3917E+00	-0.2889E+01	0.4612E-01
0	0.6206E-04	0.1076E-03	0.1056E-02	0.1019E+00	0.5832E-01	0.6349E-02
87	16.3741	2.1871	2.5373	0.3774E+00	-0.3253E+01	0.4598E-01
0	0.5166E-04	0.7726E-04	0.8240E-03	0.9377E-01	0.5832E-01	0.4428E-02
88	17.2763	2.3198	2.5416	0.3681E+00	-0.3446E+01	0.4592E-01
0	0.4760E-04	0.6588E-04	0.7311E-03	0.9011E-01	0.5832E-01	0.3645E-02
89	18.2328	2.4565	2.5457	0.3573E+00	-0.3643E+01	0.4586E-01
0	0.4403E-04	0.5643E-04	0.6510E-03	0.8669E-01	0.5832E-01	0.2970E-02
91	20.3214	2.7396	2.5529	0.3316E+00	-0.4052E+01	0.4575E-01
0	0.3783E-04	0.4203E-04	0.5219E-03	0.8053E-01	0.5832E-01	0.1903E-02
92	21.4607	2.8845	2.5561	0.3168E+00	-0.4262E+01	0.4570E-01
0	0.3503E-04	0.3657E-04	0.4702E-03	0.7778E-01	0.5832E-01	0.1495E-02
93	22.6685	3.0307	2.5591	0.3008E+00	-0.4473E+01	0.4565E-01
0	0.3234E-04	0.3200E-04	0.4254E-03	0.7523E-01	0.5832E-01	0.1158E-02
95	25.3059	3.3230	2.5644	0.2658E+00	-0.4895E+01	0.4557E-01
0	0.2724E-04	0.2497E-04	0.3531E-03	0.7070E-01	0.5832E-01	0.6632E-03
96	26.7445	3.4671	2.5668	0.2472E+00	-0.5103E+01	0.4553E-01
0	0.2482E-04	0.2227E-04	0.3241E-03	0.6871E-01	0.5832E-01	0.4895E-03
98	29.8862	3.7461	2.5708	0.2086E+00	-0.5505E+01	0.4547E-01
0	0.2025E-04	0.1808E-04	0.2772E-03	0.6522E-01	0.5832E-01	0.2518E-03
99	31.5999	3.8787	2.5726	0.1891E+00	-0.5696E+01	0.4544E-01
0	0.1813E-04	0.1646E-04	0.2584E-03	0.6371E-01	0.5832E-01	0.1747E-03
100	33.4166	4.0055	2.5742	0.1697E+00	-0.5879E+01	0.4542E-01
0	0.1614E-04	0.1510E-04	0.2421E-03	0.6235E-01	0.5832E-01	0.1183E-03
102	37.3837	4.2370	2.5769	0.1317E+00	-0.6212E+01	0.4537E-01
0	0.1258E-04	0.1298E-04	0.2162E-03	0.6003E-01	0.5832E-01	0.4943E-04
103	39.5476	4.3399	2.5780	0.1135E+00	-0.6361E+01	0.4535E-01
0	0.1102E-04	0.1217E-04	0.2060E-03	0.5907E-01	0.5832E-01	0.3015E-04
104	41.8416	4.4329	2.5790	0.9600E-01	-0.6495E+01	0.4534E-01
0	0.9608E-05	0.1149E-04	0.1973E-03	0.5823E-01	0.5832E-01	0.1746E-04

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10 March 1981

Dear Dick,

Here are some second thoughts on the first three Sections of our paper, plus the first redraft of Section IV. I've dropped the detailed numerical stuff from it because I felt it gave the impression we might take the stuff more seriously than we do. The major results come quite quickly from the algebra itself (I tuink).

I also think you dropped a factor of R from your algebra on p.20 of this draft. Check it there.

Rather than just send point-form conclusions as we said on the phone I allowed myself to ramble at the typewriter. Don't take Section V any more seriously than point form, but use the less bumpy bits of wording to add to your own gems !

I also enclose the 4885 MHz numbers for 3C31 in what I hope is the most useful form. I'll do some NGC315-style sums using these and send you the results as soon as possible.

I think we need to bolster up the stuff on p.11 (to make it more intelligible) and the stuff on 3C31 (to make it more right !).

I await your redraft with breath a-bated.

This is fun.

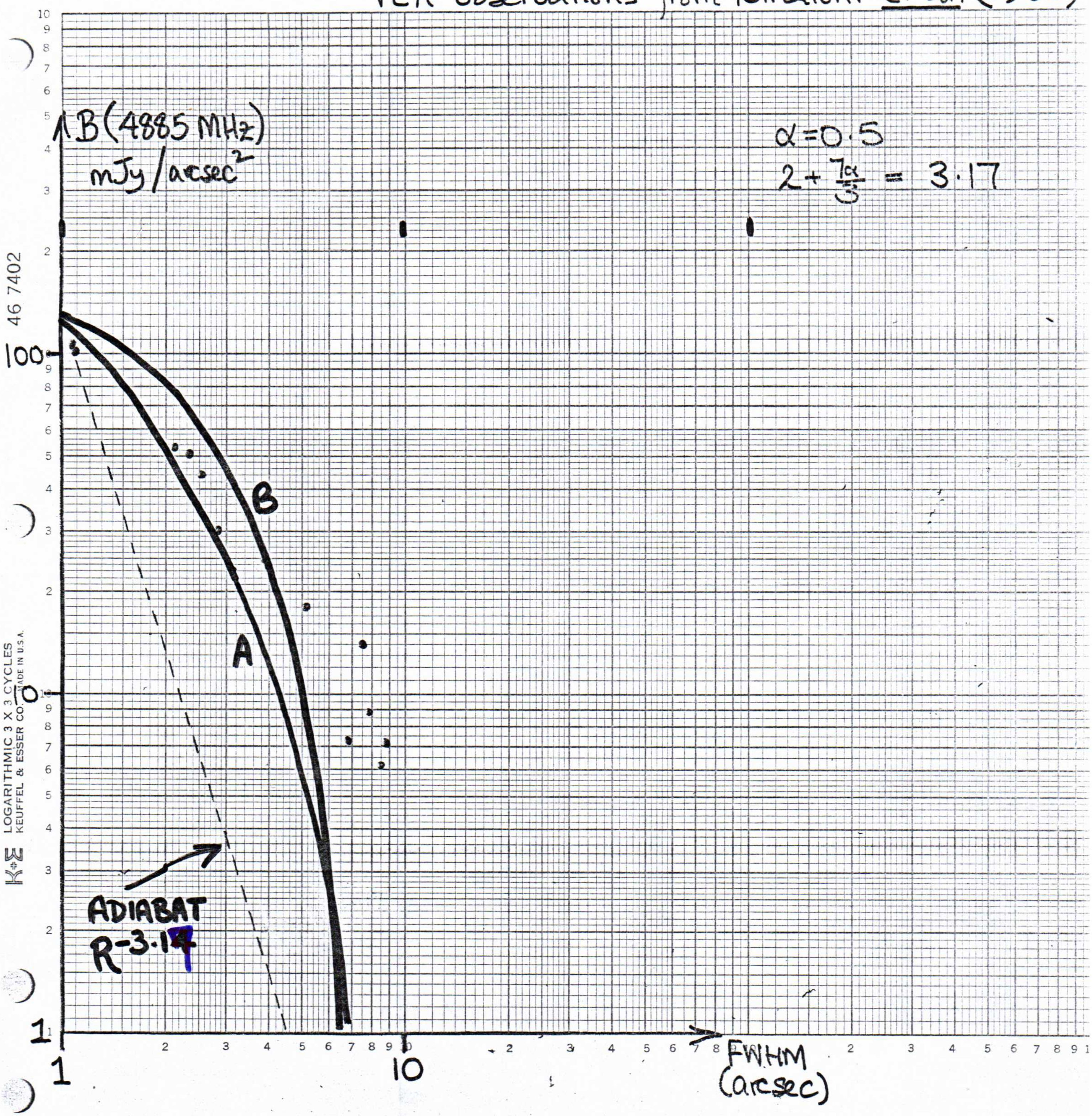
Cheers,

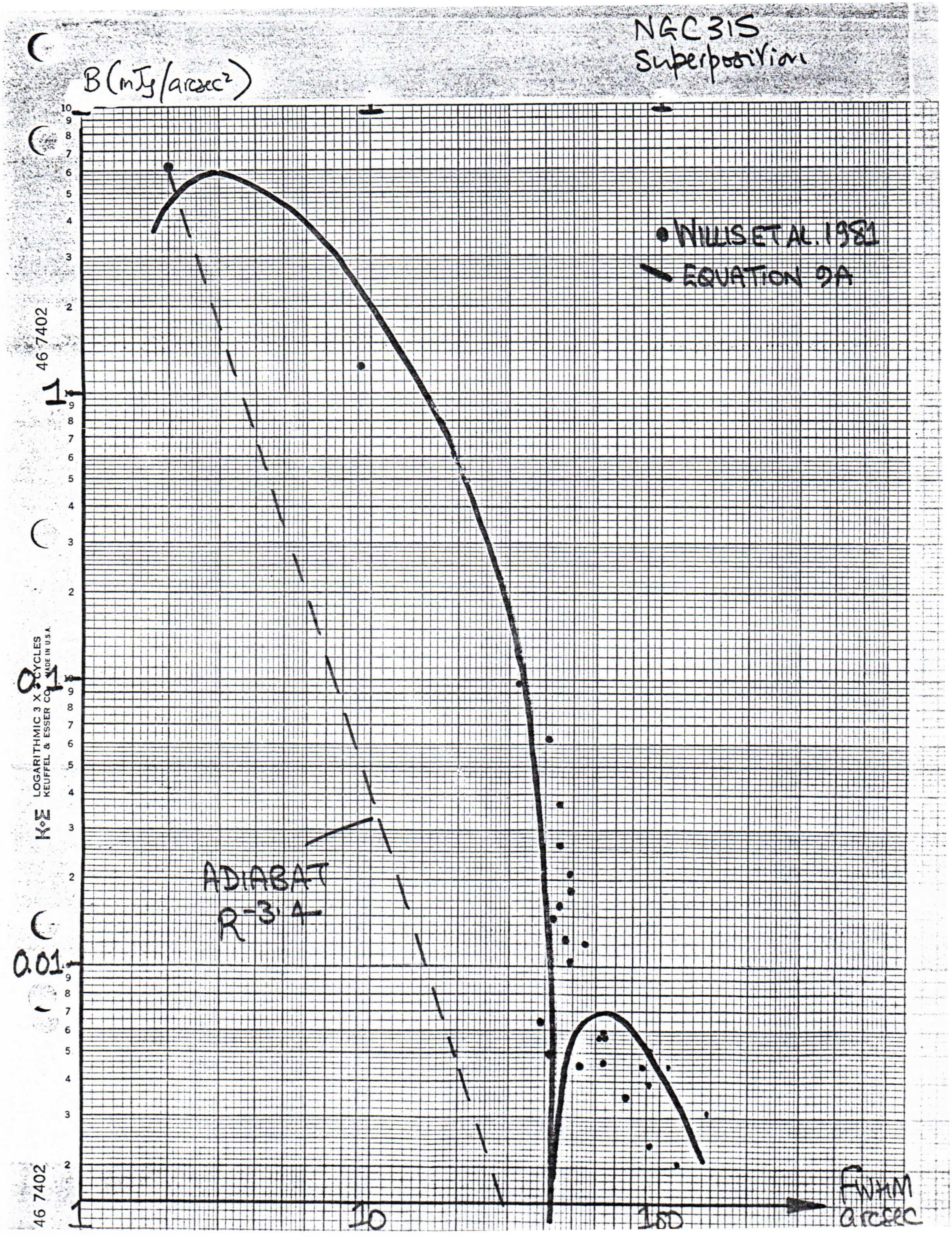
A.

10 March 1981

3C31 N jet Brightness vs. FWHM

VLA observations from Fomalont *et al.* (1980)





NGC 315
Superposition
B (mJy/arcsec²)
WILLIS ET AL. 1981
EQUATION 9A
ADIABAT
R-3.4
FWHM
arcsec
1
0.1
0.01
10
100
LOGARITHMIC 3 X 3 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 7402

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Stanford
Feb 11, 1981

Dear Alan;

Well I sweated blood over this. As you can see it has grown a little beyond the letter size! Please read it carefully and do your usual clarifications and improvements. I feel that it is potentially very important and we should pull out all the stops to get it out. Clearly there is a tactical problem. There are probably enough new ideas here for several letters, but unfortunately it stands or falls mostly on the fit to the observations (Quite a startling conversion for me, wouldn't you say?). I think we might well submit this as a paper and then generate a series of letters discussing other suitable sources. This can be proceeding while some more advanced theoretical work (perhaps with Kwing, I'm sending him a copy of this too, but to no-one else at present) or perhaps with Jean Eilek (she's coming here in March). What do you think? Please let me know soon.

I got your letter and I gathered that it crossed in the mail with mine. I waited until this week to send Warps off, which I have now done. It's not perfect, but events were overtaking it I feel. Begelman and Blandford (and Rees) are doing (yet another) 'jet review' paper. They now have a copy of Warps, BCH; and I hope this present thing ~~[illegible]~~ will be ready in time to be included.

By the way, Begelman is looking for a job. If he doesn't get one at Stanford he'll probably go back to Cambridge, but it might be worth trying to entice him to Queen's?

I have not tried to distinguish 'jet' from 'beam' in the current manuscript as they are invariably referred to as jets in the hydrodynamic, turbulence, literature. It becomes difficult to be consistent with all the conventions!

Anyhow good luck! I have some more thoughts on interpreting those oscillations in NGC 315. It may support the turbulence idea if $\lambda \sim 6R$. I will send John some thoughts on characterizing a turbulent magnetic field (but with a helical mean) that might be useful for your polarization stuff.

I hope the 'winter' continues benignly there. Here they are all moaning about the 'winter' term and student depression — and I can not believe it! They haven't the foggiest notion ---

Hello to Mary

Cheers

Dick

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Feb 23, 1981
Stanford

Dear Alan;

Well you had me worried! There is no doubt that the fit is only to the curve delineated by the large scale structure. In fact you can see this in the paper if you read it carefully. Poor old Jacques was trying to tell us this when he considered the small scale structure irrelevant! — and 3C76.1 very similar in the large scale to 3C293. But that's not right either. What is really true is that we simply have not given a reason in the paper for including the small scale structure! It is really another Fornax A! We have in fact fitted neither of these, but the discussion I propose to give is enclosed herewith. It is based on

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the formulae (14) of the paper plus your equi-partition numbers. I suspect a very similar result would hold for Fornax A !! I think this can be included in a few lines, which I will write and circulate to those who received the preprint, if you wish. Otherwise, as this is a prepublication version, we can include it in the next version.

The existing numbers are not so bad for the large scale when you recall an 'motherhood' statement on p13. ---

As for the Turbulent Brightness Distribution, I enclose the references. But I really think the best plan is the one I suggested in my letter to you. Namely, to make this a paper, suitably smoothed and edited, and to follow up

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with applications, e.g. to NGC 6251, M84 (?) et. cet.

Whatever, this is far too hot to hold! If we can't get this submitted within a month much will be lost.

Please remember that this was a new idea when we announced it, but it won't take long for it to become 'generally known'. I propose:

(i) Smooth this into a paper, but roughly as presently conceived

* (ii) Cut out most theory and go with bare statement of result and general idea (we lose considerable substance but gain impact) – What of M84 data?

best bet

(iii) Let me stick my neck out with theory and present applications, and follow up with subsequent catalogue of jets and their interpretation — This only if you have no time to finish this on one month time scale. – I'd rather have your steadying hand on Obs. papers!

OVER →

~~You~~

I'll call you or you call me on Monday next. Kwing and I and Jean Eilek and I will be turning to detailed theory in the next few weeks. The greatest deficiency at present lies in being not able to deal with spectral distribution of the energy, but we're working on it!

Anyway, fight on. I too have many things going, and this is the reason for some lapses — But I have <u>not</u> compromised the science at any stage. It is carefully done. The present discussion of 3C293 could have been done <u>months</u> ago in this crude form. It always seems to me that such equations as (4) contain their own implications after all. My concentration was simply elsewhere as I left the numbers up to you and Jacques — admittedly Jacques mainly — mostly laziness on my part. —

By the way, how do you want to pursue NGC315 (wiggles)? Any results on 3C219? Life is very busy! Maybe you should come here for a <u>working</u> holiday? Mary will not be pleased at that!

Cheers
Dick

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P. S.

The ideal would be really to treat NGC 315, NGC 6251, 3C31, 3C449 and possibly M84 as an ensemble to check the limits of application of the turbulent formula. At least one another sparkling success would be nice! NGC 6251 really has very similar collimation structure to NGC 315. Is it really so difficult to do this one? You must have the CH fit stuff handy so all we really need ~~are~~ the peak fluxes? — Anyhow — I really don't want to delay this one. If all else fails I will go it alone, But it will be a better paper with broader observational input. — Maybe Robert Laing would help out on M84?

Cheers
Dick

$$E = n_{er} m_e c^2 \left(\frac{K_1(1/\theta)}{K_2(1/\theta)} + 3\theta \right)$$

$$p_{er} = n_{er} kT$$

$$\theta = kT / m_e c^2 = 1/x$$

MIDAS

$2.72\,K \equiv 3.23 \times 10^{-6}$ gauss

1415-MHz

Lifetimes in NGC315 at equipartition [Willis et al. fields]

$1'' = 236$ pc

Dist from nucleus (arcsec)	(kpc)	B_{min}	$t_{1/2}$ syn	$t_{1/2}$ syn + C^{-1}
12	2.83	3.1×10^{-5}	5.2×10^{6} yrs.	5.1×10^{6}
24	5.66	1.3×10^{-5}	1.9×10^{7}	1.8×10^{7}
73	17.23	5.7×10^{-6}	6.5×10^{7}	5.3×10^{7}
132	31.15	3.0×10^{-6}	1.7×10^{8}	9.6×10^{7}
342	80.70	2.3×10^{-6}	2.6×10^{8}	1.1×10^{8}
450	106	1.6×10^{-6}	4.4×10^{8}	1.3×10^{8}
749	176	9.4×10^{-7}	9.8×10^{8}	1.4×10^{8}
1037	244	1.7×10^{-6}	4.0×10^{8}	1.3×10^{8}
		4×10^{-6}		7.6×10^{7}

Dear Alan:

Thanks for sending me the ~~preprint~~ preprint on ~~[illegible]~~ NGC 315. I have received Dick's manuscript on turbulent radio jets. I like the local "everywhere" acceleration mechanism very much. I've ~~[illegible]~~ just send him back my comments and some notes about my way of ~~looking at~~ approaching this problem. I am going to summarize my present-day view on this problem here.

About the acceleration mechanism, I glanced at Bell, Blandford --- etc. and notice that all of them really do not accelerate the jet particles, they can only get cosmic ray particles which has a much steeper energy spectrum and this mechanism has been investigated in considerable detail by Colgate quite a while ago. Some kind of mechanical energy cascade – wave – particle interaction mechanism like what Dick is proposing is certainly an attractive approach. However, I ~~fe~~ feel that the physics of this mechanism (as expounded in the manuscript) may ~~of~~ need to be worked out in greater detail ~~to attract~~ before attention ~~[illegible]~~ can be aroused

~~On~~ About the hydrodynamics – turbulence part of the theory with which I am more familair, I can offer my difference in opinion on a few points:

(i) The basic formula Eq.(9) predicts that $I \propto V_{to}^3/R^2$ which implies that I drops at least as fast as R^{-2} (V_{to} usually does not increase in a large region). This cannot explain the very flat distribution of I as observed in NGC 315 and 3C31 (see enclosed Fig. 1 based on rough measurement of the figures in Fomalont et. al. 1980; a "break" seems to occur in $d\log I / d\log R$ — is it genuine? — this is my question addressed to you!).

(ii) By setting I directly 'equal' to the energy injection rate due to ~~turble~~ turbulence, one assumes instantaneous release of ~~a~~ "excess" energy. The energy buget of the particles (e) is not followed, there may be inconsistency with certain J–e relationships (e.g. $J \propto R\, e^{7/4}$ for equipartition distibution).

(iii) The turbulence energy cascade rate V^3/R is valid for isotropic ~~turb~~ turbulence, it is not certain how good it is for the high Mach number compressible jets.

(iv) By equating the turbulence velocity V to be the lateral velocity V_∞, one ~~o~~ contradicts the fundamental assumption of CH and BCH which interpret V_∞ to be controlled by pressure balance. If V_∞ is ~~really~~ taken to be the turbulence velocity, then one needs an equation to describe its evolution to complete a deductive theory. V_∞ should not stay as a phenomenological quantity.

Let me explain a little bit about my approach. ~~S~~ Starting with the basic stationary conservation equations, one can relate the mechanical energy dissipation ~~to th~~ rate to the mass entrainment rate. Then the problem is reduced to two step for modelling: (i) How to model the entrainment rate? (ii) How to model the efficiency of converting the mechanical energy to relativistic particle energy? For step (i), I take the entrainment rate to be proportional to the material sweeped in from the external medium. ~~by some tools~~ For step (ii), I take the efficiency factor to be a constant at the moment, but it is very likely that it depends on the acceleration mechanism. This way, the ~~enerjected into~~ energy injection rate directly depend on the density profile of the external medium. I then study the behaviour of the energy density of the radiating particles which gives the observed intensity J. With a galactic structure not drastically different from that employed by CH / BCH, one can produce the "hot spot" at the base of the jet and the slow drop of I by pumping energy into the beam so that the total relativistic energy is actually increasing! ~~It also is~~ It is also easy to explain the fast drop off of J if ~~[illegible]~~ the external density drops faster than Z^{-2} outside.

I ~~ko~~ am now waiting for Dick's decision on how he handles the manuscript. Let's keep in contact and please send me the numbers for J, R, ..etc. if available.

Best wishes!

Kwing

March 5, 81