Rh , ERL #311

INSTITUTE FOR PLASMA RESEARCH
STANFORD UNIVERSITY
VIA CRESPI, STANFORD, CALIFORNIA 94305

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

NATIONAL RADIO ASTRONOMY OBSERVATORY
1000 BULLOCK BOULEVARD, N.W. POST OFFICE BOX O SOCORRO, NEW MEXICO 87801
TELEPHONE 505 835 2924 TWX 910 988 1710 VLA SITE 505 772 4011

Friday, May 15.

Hi Dick —

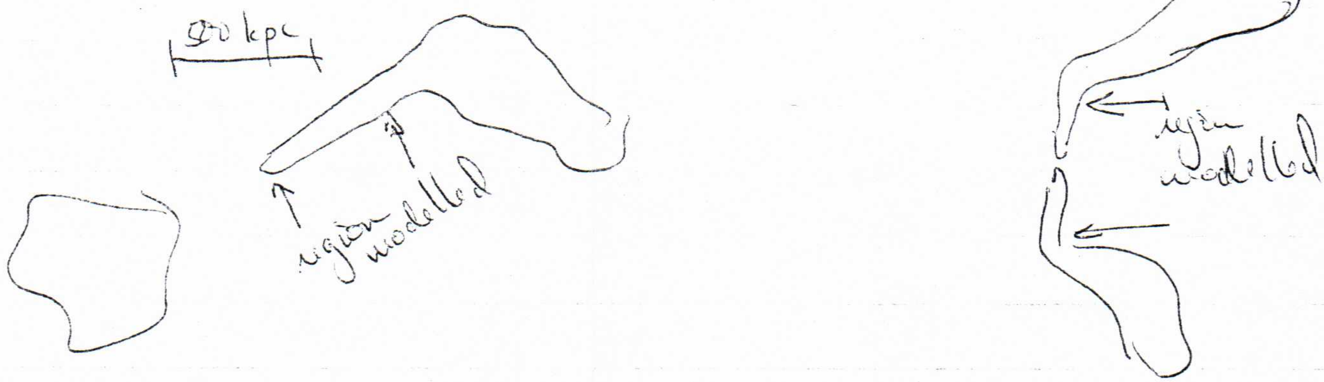
Boy, that is quite a paper. Very dense. But I've managed to get through it, and learned a lot in the process. I think the basic results are striking — as I have said. I don't have any major criticisms. I have found some points, ranging from minor to trivial, as ~~as~~ follows.

1. I still feel the Section IIa is overly long and detailed. All the def^n + 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 ~~the~~ does each become important?

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 vs (R) diagrams and trying to visualize the source. Partly my ~~…~~ 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 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. $p_s V_s = \frac{1}{\gamma} \rho_s V_s^3 = \frac{1}{\gamma} V_s^2 (A/R^2)$

(eq. 26)

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

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., $A \propto R^2$; $w(k) \propto \frac{1}{A}$; $B \propto wR = \frac{1}{R}$).

§V is not very clearly written.

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

INSTITUTE FOR PLASMA RESEARCH
STANFORD UNIVERSITY
VIA CRESPI, STANFORD, CALIFORNIA 94305

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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VIA CRESPI, STANFORD, CALIFORNIA 94305

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

Anyway, speed is of the essence. Kevin, 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 p29 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

INSTITUTE FOR PLASMA RESEARCH
STANFORD UNIVERSITY
VIA CRESPI, STANFORD, CALIFORNIA 94305

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

NATIONAL RADIO ASTRONOMY OBSERVATORY
P. O. BOX O
SOCORRO, NEW MEXICO 87801
TELEPHONE 505-835-2924
VLA SITE 505-772-4011
TWX 910-988-1710

POST OFFICE BOX 2
GREEN BANK, WEST VIRGINIA 24944
TELEPHONE 304-456-2011
TWX 710-938-1530

EDGEMONT ROAD
CHARLOTTESVILLE, VIRGINIA 22901
TELEPHONE 804-296-0211
TWX 510-587-5482

SUITE 100
2010 NORTH FORBES BLVD.
TUCSON, ARIZONA 85705
TELEPHONE 602-882-8250

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.

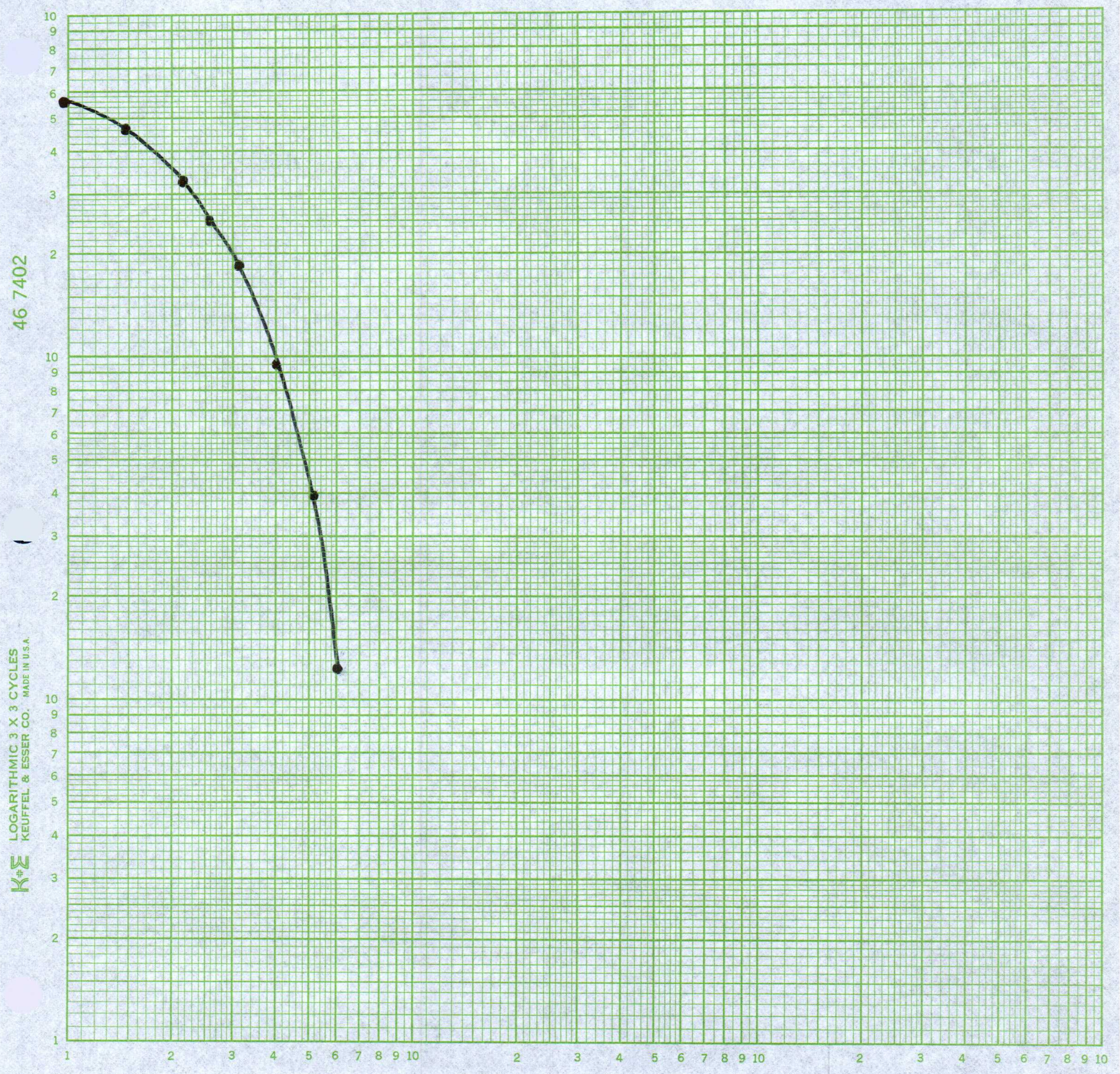
Cheers,

A.

12-March 1981

3C31 N jet new CH fit

Turbulence fit



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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
LONGITUDINAL ALFVENIC MACH NO.**-2              0.1000E-13

SPECIFICATION OF EXTERNAL PRESSURE LAWS:
HEIGHT WHERE TWO PRESSURE TERMS EQUAL              10.8000
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

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

Handwritten annotations: beside the longitudinal Alfvenic Mach numbers: "no magnetic eff."; beside the pressure law terms: "pressure law"; beside EPSILON-B: "no magnetic effects!"

IMPROVED FIT TO BRIGHTNESS DISTRIBUTION IN 3C31

ITER#	HEIGHT Z	RADIUS	W(Z)	W(R)	BPHI/BZ	FPINCH
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