

THE ASTROPHYSICAL JOURNAL

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August 31, 1981

Dr. Jacques P. Vallée
Institut Herzberg
100 Sussex Drive
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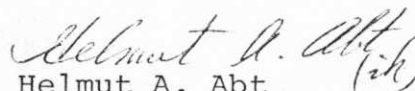
Dear Dr. Vallée:

X-RAY EMISSION FROM CLUSTERS OF GALAXIES
CONTAINING "CLASSICAL" DOUBLE RADIO SOURCES
by J. P. Vallée and A. H. Bridle

We are pleased to report that the above paper has been accepted for publication in The Astrophysical Journal. It is scheduled for the February 15 issue. You will receive the edited manuscript by October 8. Please return it to our production office in Chicago within forty-eight hours. Galley proofs will be sent to you by November 19. These also must be returned to our production office within forty-eight hours. If you will not be at the present address during these periods, please provide Mr. Bilsens with a forwarding address or arrange for a review of the manuscript and galleys during your absence. Your cooperation will expedite the publication of your paper in the scheduled issue of the Journal.

Please sign the enclosed Publication Agreement pertaining to copyright assignment, and return it as addressed.

Sincerely,


Helmut A. Abt
Managing Editor

HAA:ih

Enc.

cc: Mr. Elmars Bilsens
Production Manager



NATIONAL RADIO ASTRONOMY OBSERVATORY

1000 BULLOCK BOULEVARD, N.W. POST OFFICE BOX 0 SOCORRO, NEW MEXICO 87801
TELEPHONE 505 835 2924 TWX 910 988 1710 VLA SITE 505 772 4011

24 August 1981

Dear Jacques,

Your letter with the referee's report on the Einsteini paper arrived here today. This is my last day at the VLA before I begin driving home. When I get back I will be moving house and getting teaching ~~prepared~~ ^{prepared} for a while, so you should draft a response and send the draft to me at Queen's. I will be coming to the CLBA meetings on Sept 24/25; we might get things settled then.

Comment (1) OK

Comment (2) We're not writing a review. I don't think we have to oblige the referee by writing one.

Comment (3) This seems fair. We could quote a dispersion based on the dispersion in core radii.

Comment (4) Is this correct? If so, we should say a little about it.

Comment (5) I have wondered about this diagram myself. Is it worth including?

Comment (6) I already sent you my typo list(s).

Best wishes

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June 23, 1981

Dr. Jacques P. Vallee
Institut Herzberg
Conseil national de Recherches
100 Sussex Drive
Ottawa, Ont. K1A 0R6
Canada

Dear Dr. Vallee:

I am returning your paper, X-RAY EMISSION FROM CLUSTERS OF GALAXIES CONTAINING "CLASSICAL" DOUBLE RADIO SOURCES, with a copy of the referee's comments. I am willing to consider a revised version for publication in Part I of the *Astrophysical Journal*.

Yours sincerely,



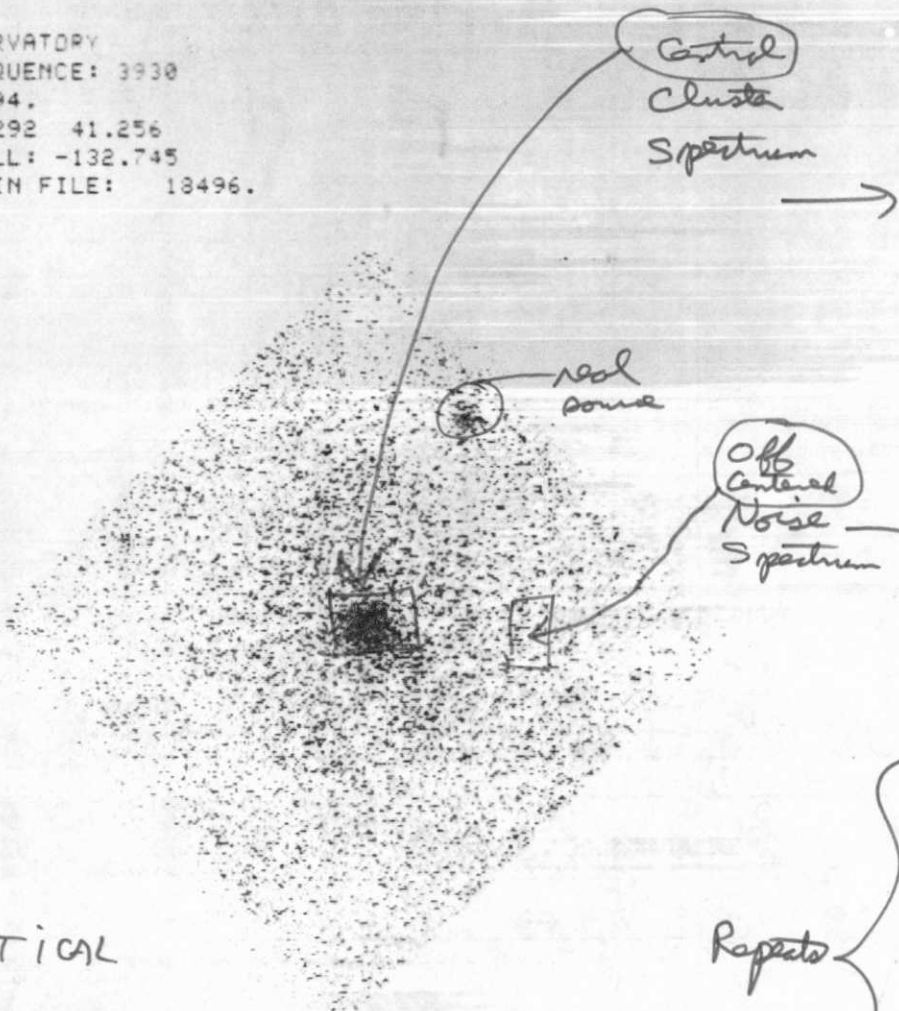
A. Dalgarno
Letters Editor

AD:mb
Enclosures

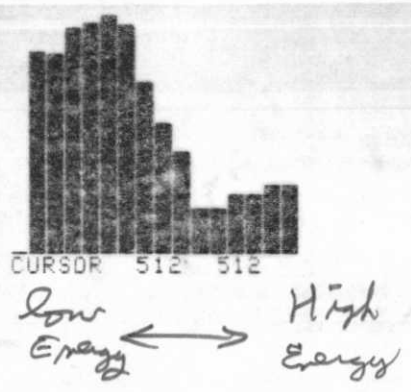
1. I would recommend publication of these results in the main Journal rather than the Letters after consideration of the following points.
2. The authors present their X-ray results on non-deformed radio sources without giving any background on the X-ray properties of clusters which contain deformed sources. There is very little published on the combined interpretation of radio and X-ray measurements in this area. However, the authors have not included references to at least two previous papers on tail sources: Burns et al. 1979, Ap.J. 84, 1683 and Burns and Ulmer, Ap.J. 85, 773. I would suggest that the paper be expanded to give a coherent picture of both deformed and non-deformed radio sources in clusters of galaxies.
3. The upper limit computations for Abell 643 and 1562 require an assumption about X-ray core radius. The authors have picked an average value but have not discussed the possible impact of the factor of 20 variations found in actual X-ray measurements for a large sample of clusters.
4. Because of the uncertainties in a_c and T , for the undetected clusters, it seems possible that the density may be large enough to exert significant thermal and ram pressures. Presumably, the authors would then argue that the ram pressure is low due to a low velocity for these galaxies also. Can a statistical argument be made about the fraction of clusters in which one would expect the radio galaxy to have such a low velocity?
5. The contours in Figure 1 are misleading. The cluster emission appears to extend out 10'-15' from the cluster center. However the King model predicts only 1% of the intensity at a radius of 10', and the minimum contour is 11%. Are these contours artifacts? The reader needs some guidance as to what to believe when confronted with this type of plot.
6. Various typographical errors: pg. 2, 4, 5.

(Please type your report on this sheet. Use other side if necessary.)

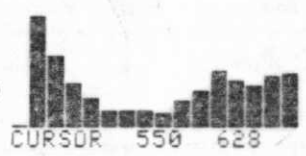
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 RA, DEC: 203.292 41.256
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 OBSERVER: _____



Control
 Cluster
 Spectrum



Off
 Centered
 Noise
 Spectrum



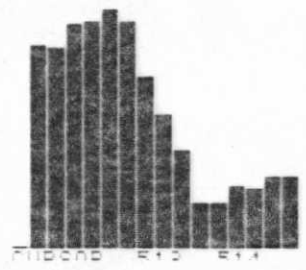
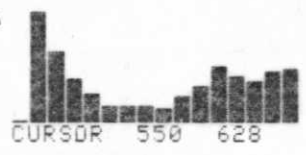
ABEL 1763

$\alpha = 13^h 33.1^m$
 $\delta = +41^{\circ} 14'$

OPTICAL

Abell Richness = 3
 Cluster Redshift = 0.189

Repeats



Radio Map in: AJ, 82, 1-20

Radio LAS $\approx 20''$

alleged Separation (Radio Gal. vs Opt. Cluster Center) = 420 Kpc

RADIO

$L_{X-RAY} \approx 10^{45}$ erg/sec

0.5keV-5keV
 (INCLUDES ANY EMISSION FROM RADIO GAL.)

X-RAY

Implication: Central Cluster Spectrum
 - has lots of low Energy Photons
 - hasn't high Energy Photons

VLA Site -

23 June 1981

Dear Jacques,

Your note about the Einstein paper is to hand. Unless we do a major rewrite in the light of referees' comments, I feel that we should either

(a) not shorten the paper but ask that it go in Part 1

or

(b) do most of the shortening by compressing the rather lengthy Tables, which contain some redundant data.

Send me the ref's report when we get it. I'll be here until mid-August, then return to Queen's until mid-January 1982.

Your comments re BFC were reviewed by BFC. We do not agree with most of them. The paper has been accepted for the September A.J. essentially as submitted (minor modification of the last Figure).

I expect I shall see you in Ottawa at CLBA meetings towards the end of the year, if not before.

A handwritten signature, possibly 'A.', consisting of a large, stylized letter 'A' with a dot to its right.

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617-495-4479

May 26, 1981

Dr. Jacques P. Vallee
Institut Herzberg
Conseil national de Recherches
100 Sussex Drive
Ottawa, Ontario K1A 0R6
Canada

File / Dossier	27800-2
Encl. / Pch	
Dir. to / Trans. à	
Indexed by / Class. par	#2
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Dear Dr. Vallee:

We have received your paper, X-RAY EMISSION FROM CLUSTERS OF GALAXIES CONTAINING "CLASSICAL" DOUBLE RADIO SOURCES, and have sent it to a referee. It will be necessary for you to prepare a shorter version consistent with our page limit of four journal pages, but you may want to wait for the referee's comments before preparing this revised version. We estimate that the present length of your paper is 4 1/2 journal pages and will need to be shortened by at least 1 1/2 typewritten pages.

For copyediting purposes, you will also need to double space Table 1.

Yours sincerely,

A. Dalgarno

AD:mb

THE ASTROPHYSICAL JOURNAL

60 Garden Street • Cambridge, Massachusetts 02138
Center for Astrophysics

This will acknowledge receipt of a manuscript entitled... X-RAY...
EMISSION FROM CLUSTERS OF GALAXIES CONTAINING...
by Vallee & Bridle...
together with...¹... figures. The paper will receive prompt attention, and I shall notify you if there are any questions regarding publication. **Mean-time may I draw your attention to the fact that there is a page charge for papers published in the *Astrophysical Journal*. Unless I hear from you to the contrary, I shall assume that your Department, University, Observatory is willing to pay the charges.**

A. DALGARNO, *Letters Editor*
5/26/81

DATE.....

3 June 81

Further adjustments for XEFCO&CCDRS

① Ap.J. requires entire title page typed double-spaced and footnotes to be called for with Arabic numerals.

② Ap.J. requires postal addresses for the authors in alphabetical order on a separate sheet at the end of the manuscript.

For A.H.B. the address should be

National Radio Astronomy Observatory VLA Program,

P.O. Box 0, Socorro, NM 87801

↑ N.B. Capital letter O, not numeral 0.

A.



NATIONAL RADIO ASTRONOMY OBSERVATORY

1000 BULLOCK BOULEVARD, N.W. POST OFFICE BOX 0 SOCORRO, NEW MEXICO 87801
TELEPHONE 505 835 2924 TWX 910 988 1710 VLA SITE 505 772 4011

2 June 1981

Dear Jacques,

I have alerted NRAO to the existence of the Einstein paper (copy enclosed).

After it is accepted, you will receive a page charge authorization, and reprint order form (separate). Take copies of the blank forms before filling them in. Send a copy to the Librarian, NRAO, Edgemont Road, Charlottesville, VA 22901.

Authorize your payment on the original form, and note on it that the remaining 50% will be paid by NRAO. Send a copy of your completed form to NRAO for their information. Order however many reprints HIA will need, and note on your order that a further 250 without covers will be ordered by NRAO. Send a copy of your completed order to NRAO for their information.

Alan

National Radio Astronomy Observatory

Very Large Array

To: Librarian, Charlottesville

From: A.H. Brade, VLA.

Subject: Paper by Vallée and Brade - "X-ray emission from clusters. . . ."

I enclose three copies of a paper which has just been submitted to the Ap. J. — two of these are for the CV and GB libraries. I have given a copy directly to the VLA library.

I presume that the page charge distribution for this will be 50% NRAO, 50% Herzberg Institute.

A. H. Brade

2 June 81

P.S. Dr. Vallée at the Herzberg Institute of Astrophysics will be processing their page charge authorization and reprint order. I have alerted him to the procedures for this and he will forward copies of the Ap. J. forms directly to you for processing. His telephone number is 613-593-6060

XEFCOGCCDRS

Corrections, typos etc. To JPV 1 June 81

Title page P.O. Box $\text{\textcircled{O}}$, not P.O. Box $\text{\textcircled{O}}$,
Queen's University at Kingston, Ontario...

p. 7 para. 2, l. 1 $\approx 1500 \text{ km.s}^{-1}$

p. 4 line 3 from end v should be script v

Table 1, ~~com~~ pressure line v should be script v
and it should be v^2

Table 2, ~~footnote~~ footnote (i) H_0 , not H_0 .
Gas temperature 6×10^7 K, not 6×10^7 °K



National Research Council
Canada

Conseil national de recherches
Canada

Herzberg Institute
of Astrophysics

Institut Herzberg
d'astrophysique

Dr. A. Dalgarno
Letters Editor,
Center for Astrophysics,
60 Garden St.,
Cambridge, MA 02138
U.S.A.

File Référence
Ottawa, 20 May 1981

re: Submission of a paper for publication

Dear Dr. Dalgarno,

You will find enclosed three copies of a manuscript entitled:
"X-RAY EMISSION FROM CLUSTERS OF GALAXIES CONTAINING "CLASSICAL" DOUBLE RADIO SOURCES",
by J.P. Vallée and A.H. Bridle, for eventual publication in the Astrophysical Journal,
Part Two, which you are editing.

Please address all Proofs and Correspondence to me at the address
given below.

Please accept, dear Dr. Dalgarno, the expression of my best
sentiments.

Yours truly,

Dr. Jacques P. Vallée,
Institut Herzberg,
Conseil national de Recherches
100 Sussex Drive,
Ottawa, Ont. K1A 0R6,
Canada.

N.B.:
 deadline of
 title in St-Foy
 is: 1 may 1981

ÉMISSION DE RAYONS-X EN PROVENANCE DU GAZ THERMIQUE DISTRIBUÉ HORS DES GALAXIES MAIS À L'INTÉRIEUR DES AMAS DE GALAXIES, par J.P.Vallée (Institut Herzberg d'astrophysique à Ottawa, Queen's University at Kingston, et Observateur Invité au Center for Astrophysics at Cambridge) et A.H.Bridle (National Radio Astronomy Observatory - VLA Program, University of New Mexico - Albuquerque, et Queen's University at Kingston).

Trois amas de galaxies ont été observés aux rayons-X entre $\lambda 3 \text{ \AA}$ et $\lambda 83 \text{ \AA}$.

En un premier temps, nous étudions l'interaction entre i) le gaz thermique hors des galaxies dans un amas de galaxies, et ii) les radio sources ayant une configuration classique jumelle (i.e., ayant un pic radio de part et d'autre d'une galaxie optique). Pour les amas Abell 643 et Abell 1562, nous trouvons une absence marquée de gaz thermique, et donc les radio sources ayant une configuration classique jumelle ne sont pas déformées par la pression du mouvement (ram-pressure). Pour l'amas Abell 1763, nous trouvons une absence marquée de vitesse relative entre le gaz thermique et la radio source de configuration classique jumelle, et donc une absence marquée de pression de mouvement (ram-pressure) pouvant déformer la radio source.

En un deuxième temps, nous étudions la densité de ce gaz thermique en fonction de la distance radiale à partir du centre de l'amas (dépassant un Mégaparsec). Pour l'amas Abell 1763, la densité du gaz thermique décroît un peu plus lentement que le prédit le modèle de la distribution de King. D'autres propriétés physiques de l'amas sont aussi déduites et présentées.

OK Jacques.
 More people would comprehend
 it if it were written and given
 in English. Final comments on
 the manuscript will follow
 J.

National Radio Astronomy Observatory

Very Large Array

23 March 1981

To: Jacques

From: Alan

Subject: EINSTEIN paper

I enclose what I hope may be the final draft of the paper. As the draft you sent me was still too long for Ap.J.Letters, which is clearly the most suitable journal for the work, I have made an intensive effort to shorten the paper by leaving out mainly duplications, inefficiencies and peripheral remarks which are not important to its main points.

To assist you in sending it off speedily in your spare time, I have retyped the body of the text in the double-spacing format that is required by all journals. I leave the reformatting of the references to you.

I would be surprised if Pilkington (1964) actually measured a redshift as he was a radio astronomer (actually a colleague of mine at Trinity College, Cambridge). I do not have the reference here to check however as the VLA library only has M.N. back to 1966. I suggest you check the Pilkington 1964 paper in the NRC library, which doubtless takes M.N. back to primeval times, and see (a) if a redshift was actually measured, or just guessed, there and (b) if the Pilkington paper itself referred to another paper for the redshift measurement.

I have deleted a number of the more trivial equations from the paper in the interest of shortening it.

I hope that this is now almost ready to be sent off to Ap.J.Letters and look forward to receiving the copy of the final version from you.

Good luck with your presentation to CASCA. Let me again urge you to make your presentation in the language which most CASCA members comprehend, rather than making a politically relevant but scientifically unintelligible statement.

Best wishes,

P.S. please note that the velocity of separation of the lobes is not the same as a jet velocity in beam models of extragalactic sources. The ram pressure must confine the internal pressure of the hot spot and the momentum flux imparted by the jet; for light relativistic jets the lobe separation velocity will be $\ll v_{jet}$.

→ Comments on 1st Draft of Classical Doubles (X-RAY)
→ ALREADY INCLUDED IN 2ND DRAFT (ENCLOSED)



THE UNIVERSITY OF NEW MEXICO

ALBUQUERQUE, NEW MEXICO 87131

September 29, 1980

Dr. Jacques Vallée
Physics Department
Queen's University
Kingston
Ont. K7L 3N6, Canada

Dear Jacques:

I wanted to thank you for sending me the papers on 1200+519 and the X-ray observations of the classical doubles. I want to make a variety of comments on each draft.

First, I believe that your model calculations on 1200+519 are a good start to a paper. However, the VLA data is far from being in a publishable form. Alan and I have a great deal of work to do on the maps at different tapers and frequencies. Among the more important tasks will be a careful modelling and subtraction of a nuclear point source. There are obvious problems in the preliminary maps including a deep negative hole where the nuclear source was improperly subtracted. Furthermore, the dynamic range on the preliminary maps are not good enough to see very low level surface brightness regions in the tail; we cannot easily see the hook at the end of the tail as in the Miley & Harris map. Self-calibration should greatly improve these data. When the Stokes I and polarization maps are complete, there are a number of additional questions concerning the source morphology that we should address. For example, how does the westward diffuse "lobe" of 1200+519 fit into a general picture of this tailed galaxy? Why is the source so asymmetrical? Why is the eastward jet and tail bent by 90° but the western jet plus lobe lie on nearly a straight line with the galaxy nucleus? What has happened to the "twists" which I saw with the Green Bank interferometer? Are the jets similar in structure and magnetic field orientation to jets in more linear sources? From depolarization data, can we estimate source densities? How about the spectral index of the Western lobe? As you can see, a great deal of work is still needed before a paper is ready for submission. Please be patient, Jacques, as Alan and I will work on this source when time permits.

→ Second, I was pleased to see your draft on the Einstein Observatory observations of the classical doubles in the directions of Abell clusters. If you will permit me, I have several observations and comments on the paper and these data.

- (1) You did not mention anywhere in the paper that these radio galaxies might not be cluster members. No published red shift data exists on these galaxies at the present time. It is possible that all or some are powerful, distant radio galaxies which could be isolated or in

poor clusters. You might not detect X-rays both because the objects are distant and because there is little or no ICM around the galaxies.

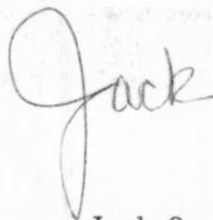
A1562

Frazer Owen managed to get a quick estimate of the red shift of 1232+414 using the MMT in Arizona. The galaxy has strong emission lines and a $Z \sim 0.19$. This is close to the predicted redshift of the cluster, but we do not know what the distances of the other galaxies are as yet. Frazer, Richard White, and I have requested Kitt Peak 4-m time in the winter to determine the red shifts of galaxies in the 0816+526 and 1232+414 fields as well as 3 other Abell cluster fields which were recently determined to have classical doubles.

- (2) On the subject of detectability, it appears to me that a few thousand seconds of observation with the IPC would be inadequate to detect clusters with luminosities similar to nearby rich clusters (e.g., Jones et al. 1979) if they are at a red shift of ~ 0.2 . Only the very brightest X-ray clusters could be seen in this short time. It might be useful to the reader if you make simple calculations to see if you should expect to detect a typical cluster source at these distances. Also, you may want to request additional IPC time on a few fields, say, $1-2 \times 10^4$ sec on each.
- (3) It seems to me that in the case of A1763, you have a unique opportunity to estimate the flow velocity of the radio plasma from the galaxy nucleus. You have rightly shown that the source cannot be thermally confined. Therefore, the lobes are probably ram-pressure confined. Since you have a reasonable estimate of P_{ICM} from L_X , then you can estimate V_{plasma} by equating the internal particle plus field pressure to the external ram pressure. This number, even with the uncertainties involved, should still be better than previous statistical approximations for V_{plasma} .

As soon as we have further red shift data on these classical doubles, I will send these numbers to you. Hope things are going well for you at Queen's. When is your next trip to New Mexico?

Best wishes,



Jack O. Burns

JOB/dls



DEPARTMENT OF PHYSICS
STIRLING HALL
Physics
Engineering Physics
Astronomy

Queen's University
Kingston, Canada
K7L 3N6

Dr. Christine Jones,
Harvard-Smithsonian Center for Astrophysics,
60 Garden St.,
Cambridge, MA 02138
U.S.A.

Kingston 20 November 1980

Dear Christine,

Enclosed you will find a copy of a paper on X-ray emission from three clusters of galaxies, a result of my trip in May '80 at Cambridge for the IPC Guest Observer HB-154 project.

Would you by any chance have any preprint on the cluster Abell 1314 (we killed the HRI Guest Observer project on the galaxy IC708 in Abell 1314) ?

Finally, regarding your Figure 3 in your paper in *Astrophys.J.*, 234, L21, giving the surface brightness distribution as a function of radial distance to 1 Mpc, I wonder if you could send me such curves (radial brightness distribution) out to 20 arc min instead, for the three clusters Abell 2256, Abell 2319, and Abell 1314 ?

Please accept, dear Christine, the expression of my best sentiments.

Yours truly,

J.P. Vallée,
Physics Dept.,
Queen's University,
Kingston, Ont. K7L 3N6
Canada.

Dear Jacques

3 Dec. 1980

I enclose some things relating to the X-ray paper.

1. The list of discrepancies between Kriss et al. and other X-ray formulae. You may want to rewrite the discussion of the formulae we are using in light of this. There is the factor of 4π , the allowance for abundances, and various estimates of the Gaunt factor.

2. Various dependencies on H_0 [my marginal note in paper was remembered incorrectly]

3. The Ap.J. subject heading list.

A.

Al763 most resembles clusters showing smooth and broadly distributed emission encompassing many of the bright galaxies, as in A2256 and A2319 (17% of the clusters in Jones et al., 1979).

Radio observations with higher angular resolutions than presently available will be required to find if such confined sources as in Al763 have ~~the~~ distributions of spectral index ^{ices} ~~values~~, magnetic field intensities, etc. that differ from ^{those of} classical doubles in the outskirts of clusters, ~~of galaxies~~. For Al763, the integrated values at radio wavelengths from Rudnick and Owen (1977) may suggest an overall size of 20 arcsec (i.e., 75 kpc, smaller than the 'typical' value of 200 kpc), and an overall spectral index of $\alpha = -1.0$ (steeper than the 'typical' value of -0.7), ~~as expected for strong confinement by an external medium of hot gas.~~ ^{and consistent with ageing of He particles during}

what is 'typical' α in an exponential distribution?

Of course, the confinement of the relativistic particles in the two radio components in Al763 by the thermal gas outside of the radio components is a rough balance only. We expect that along the major axis of the radio double, the radio component may advance into the gaseous atmosphere ^(density ρ_s) (due to a continuous supply of relativistic particles from the nucleus of the galaxy) ^{at a velocity v_H} . This advance of a 'hot spot' gives rise to a small amount of ram pressure: $P_{HOTSPOT} = \rho_{GAS} \cdot v_{HOTSPOT}^2$

If this $P_{HOTSPOT}$ is set equal to the relativistic electron pressures ^{OUTSIDE} (Table 1c) for Al763, this equation yields: $v_{HOTSPOT} \sim 1400$ km/s (similar to values found in radio jets). ^{If expanding into} ~~moving through~~ the hot gas at this constant speed, this radio source would ^{have} ~~takes about~~ 40 million years to reach its present linear extent.

by whom? α kpc?

But are there real hot spots reproduced in this value? This is dodgy with the law and def. Wait for VLA data?

6. METHOD TO OBTAIN THE RADIAL THERMAL DENSITY DISTRIBUTION

The profile of the X-ray distribution ^{is} shown in Figure 2a, ^{as} seen with the IPC. We develop in this section a method to convert this intensity profile into a thermal density profile (radial distribution).

Jacqueline. If this were put in another paper, what remains is just A.P.J. Letter length. I suggest you separate this off, as I have had no part in it.

a) Conversion of Counts to Radiation Intensity (ergs/sec/cm²/Hz/sterad)

The total luminosity L_x (ergs/sec) is related to the radiation intensity I_v (ergs/sec/cm²/Hz/sterad) via the equation:

$$L_x = 4\pi D^2 \int_{\nu_1}^{\nu_2} \int_{\Omega_s} I_v d\Omega \cdot d\nu \quad (8)$$

For a radially symmetric function I_v , with a thermal spectrum, one has:

$$I_v = c_o \cdot e^{-hv/kT} \cdot f(x) \quad (9)$$

where $f(x)$ is the radially symmetric function shown in Figure 2a (ordinate value minus the background level, in counts/sq. arcmin), x is the abscissa in radian, and c_o is the normalisation factor given by:

$$c_o = hL_x / [8\pi^2 D^2 kT (e^{-E_1/kT} - e^{-E_2/kT}) (\int_0^{x_{\max}} f(x) x dx)] \quad (10)$$

Thus for Al763, $c_o = 1.34 \times 10^{-25}$ (counts/sq. arcmin)⁻¹ ergs/sec/cm²/Hz/sterad.

b) Conversion of Radiation Intensity to Emission Measure (cm⁻⁶ . pc)

The solution of the equation for radiation transfer is given by:

$$I_v = B_v [1 - e^{-\tau_v}] \quad (11)$$

$$B_v \equiv \epsilon_v / k_\nu = 2hv^3 c^{-2} [e^{hv/kT} - 1]^{-1} \quad (12)$$

in dynamical equilibrium, with emissivity coefficient ϵ_v given by:

$$\epsilon_v = 7.6 \times 10^{-39} T^{-1/2} g e^{-hv/kT} N^2 \text{ ergs/cm}^3/\text{sec/Hz/ster} \quad (13)$$

and:

elsewhere

$$\tau_{\nu} \equiv \int_{\text{line of sight}} K_{\nu} \cdot dl \quad (14)$$

In the optically thin case, relevant to Al763 with $h\nu = 2 \text{ keV}$, one gets:

$$\tau_{\nu} = 5.8 \times 10^{-31} E_M(x) \quad (15)$$

$$I_{\nu} = 2.0 \times 10^{-24} E_M(x) \text{ ergs/sec/cm}^2/\text{Hz/ster} \quad (16)$$

where

$$E_M(x) = \int_{\text{line of sight}} \left(\frac{N}{\text{cm}^{-3}} \right)^2 \left(\frac{dl}{\text{pc}} \right) \quad (17)$$

is the emission measure ($\text{cm}^{-6} \cdot \text{pc}$). The integrals are evaluated along the line of sight in each of (14) and (17).

c) Conversion of Emission Measure to Thermal Electron Density (cm^{-3})

For a spherical geometry of the thermal gas, one can write:

$$E_M(x) = \int_x^R [N(r^2)]^2 [r^2 - x^2]^{-1/2} d(r^2) \quad (18)$$

where r is the radial variable (centre at $r = 0$, radius = R). Salem's transformation (Salem, 1974) yields

$$[N(r^2)]^2 = \frac{1}{\pi} \int_0^{E_M(r)} [x^2 - r^2]^{-1/2} dE_M \text{ cm}^{-6}$$

and is rewritten as:

$$N(r^2) = \left[\frac{1}{D\sqrt{\pi}} \int_0^{E_M(r)} [\Omega(E_M) - \Omega(E_M(r))]^{-1/2} dE_M \right]^{1/2} \text{ cm}^{-3} \quad (19)$$

where:

$$\Omega(E_M(q)) = \pi q^2 / D^2 \quad (20)$$

is the solid angle within which the radiation has an emission measure greater than or equal to E_M .

Table 3 shows for A1763 the various radial dependencies involved, while Figure 2b shows the radial dependence of the electron density as computed with Equation (19).

d) Comparison of the Actual Density Distribution with the King Approximation

The King approximation to the radial dependence of the electron distribution (Equation 2) is often fitted to the profile of the radial intensity distribution (Figure 2a). The ^{isothermal} intensity profile (surface brightness) is ^{proportional to} the projected value of density squared; so for a King density profile:

$$I_{\text{KING}}(x) = I_{\text{CENTRE}} \left[1 + \left(\frac{x}{R_c} \right)^2 \right]^{-5/2} \quad (21)$$

In this case ~~and so~~ I_{KING} decreases to 50% of its central value at

$$x_{1/2} = 0.565 R_c \quad (22)$$

From Figure 2a, $x_{1/2} \approx 290$ kpc so $R_c \approx 515$ kpc.

Fits of X-ray intensity profiles often leave a sizeable residual in the core of clusters of galaxies (Kriss et al., 1980). This residual in the core is often comparable in intensity to the central intensity predicted by fitting the outer profile (outside the core) only.

The King approximation to the central density N_0 has been computed under various assumptions for the point source component at the centre (Table 2). The resulting values of the central density N_0 in the King model for A1763 have an estimated r.m.s. error of $8 \times 10^{-4} \text{ cm}^{-3}$ from Equation 1 (exclusive of the bias of the point core contribution), while the estimated r.m.s. error of the actual central density from Equation 19 is about $4 \times 10^{-4} \text{ cm}^{-3}$. Thus the combined r.m.s. error (quadratic sum) is about $9 \times 10^{-4} \text{ cm}^{-3}$, sufficient to show an agreement between N_0 and the actual central density for a point core contribution of about 10% (or more).

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Herzberg Institute
of Astrophysics

Institut Herzberg
d'astrophysique

Ottawa, 18 August 1981

File Référence

Dr. A. Dalgarno, Editor,
Center for Astrophysics,
60 Garden St.,
Cambridge, MA 02138
U.S.A.

Dear Dr. Dalgarno,

Thank you for your letters of 26 May (with the Acknowledgement of Receipt) and of 23 June (with the Referee's Report), concerning the paper entitled: "X-RAY EMISSION FROM CLUSTERS OF GALAXIES CONTAINING "CLASSICAL" DOUBLE RADIO SOURCES", by J.P.Vallée and A.H.Bridle, for eventual publication in the Astrophysical Journal.

The title page and Table 1 have now been retyped with double spacings, as requested in your first letter. In your second letter, you mentioned that you would be willing to consider a revised version (for Part I, normally edited by H.A.Abt). Therefore, please find enclosed three copies of the revised version of the above paper, submitted to you for Part I.

Briefly, these revisions take account of all the points raised by the Referee. His/her acceptance of this paper (point no.1) is welcomed. His/her point no.2 (expansion of the paper to review deformed sources) has been dealt with in the Introduction (top paragraph). His/her point no.3 (deviation of core radius from accepted mean) and point no.4 (consequence of that deviation for the density) have been discussed in Sections III (end of first paragraph) and IV (end of first paragraph). His/her point no.5 (Figure 1) has been incorporated in the Figure caption (last sentence). All the typographical errors mentioned have been corrected (point no. 6). I trust that the Referee will like these revisions.

Please continue to address correspondence and Proofs to me at the address given below. Please accept, dear Dr. Dalgarno, the expression of my best and sincere sentiments.

Yours,

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