BIPARTITION OF THE UNIVERSE

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ABSTRACT : The three-dimensional distribution of quasars known to date shows an empty zone about 300 Mpc wide, almost planar, and covering about half the sky.

We discuss the possibility of bias or artefact and suggest a cosmological interpretation which involves a Friedman-Lemaître model of positive curvature, with $\Omega_0 = 0{,}06$, $q_0 = -1{,}11$.

Key Words : Cosmology, quasars, absorption lines, antimmatter, γ-rays.

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I. A SINGULAR ZONE

Absorption line observed in the spectra of quasars (Q.S.O) are generally narrow. There are, however, several quasars with broad absorption lines, in particular the following:

α	(12h46mn, -5°42')	$z_{abs} = 2.050$	[1246 - 057]
β	(13h31mn, +17°04')	$z_{abs} = 1.782$	[1331 + 170]
γ	(13h34mn, +28°35')	$z_{abs} = 1.873$	[1334 + 285, or RS23]
δ	(22h25mn, -5°34')	$z_{abs} = 1.880$	[2225 - 055, or PHL5200]

Assuming that these lines are a manifestation of intervening gaseous clouds, and applying Hubble's law, we can situate them in space. We notice then that the four clouds are almost exactly coplanar ; more precisely α, β, γ, δ determine a sphere (S) of very large radius ($\sim 6\ c/H_o$). We are in the interior of (S) (Fig.1) ; the direction of its center is :

$$(5h45mn, +6°30'). \qquad (1)$$

Let us study the distribution of quasars in the neighbourhood of this sphere : we shall make a diagram by plotting, for each quasar Q and for the Earth T, the distance QC as abscissa, and the angle $\widehat{TCQ}$ as ordinate. We see

clearly an empty vertical band (Fig.2) containing the four clouds (Fig.3).

If this fact is significant (see §III), it shows a singular region (S) of the Universe where matter appears not in condensed form (quasars) but rather in diffuse form (clouds).

The thickness of this zone is not negligible on a cosmological scale ($\sim 0.08\ c/H_o \sim 300$ Mpc) ; this is sufficient to explain, by multiple absorptions, the widths of the observed lines. Furthermore, the four quasars showing the broad absorption lines α, β, γ, δ, also display standard absorption lines, with red-shifts indicating 4 other clouds that are all situated in (S) (Fig.4).

II. UTILIZATION OF RELATIVISTIC COSMOLOGY

In fact, Figs. 2, 3, 4 have been drawn with a small correction in the position of the centre C of the sphere, so as to optimize the width of the band (S). The corrected direction of C is :

$$(5h44mn, 5°55') \qquad (2)$$

(cf. (1)), i.e. a point in the constellation of Orion, at 2°6 from Betelgeuse. The radius of the sphere is

$$5.5 \ c/H_o \qquad (3)$$

Despite this correction, we notice of Figs. 2, 3, 4 that the band (S) has a pronounced curvature to the right. It is hard to interpret this in the context of the naïve Hubble model : the empty zone would be a neighbourhood of a non spherical surface of revolution, the axis of which would go through the Earth. It is thus necessary to use the more refined Friedman-Lemaître models of the Universe.

These models contain two dimensionless parameters: the density parameter Ω and the reduced curvature k (one can also use the reduced cosmological constant $\lambda = 1 + k - \Omega$ or the deacceleration parameter $q_o = -1 - k + 3/2\,\Omega$). If $k \neq 0$, the geometry of space is non-euclidean ; a non euclidean plane seems curved to a distant observer using Hubble's law; curving away from the observer if $k < 0$, towards him if $k > 0$.

It may be that it is this effect that produces the curved appearance of (S) ; we can thus assume that the singular region is (physically) a plane, if the curvature k of space is positive. The value of the radius of curvature found above (3) gives directly an estimate $k \sim 1/5$.

We can adjuste the second parameter Ω in such a way that the empty band in Figs. 2, 3, 4 loses its residual curvature. After maximization of the width of this band, we obtain the corrected diagram of Fig.5, which appears satisfactory. This optimization gives the values

$$k = 0.20 \pm 0.01 \quad , \quad \Omega = 0.06 \pm 0.01. \qquad (4)$$

It is remarkable that this value of the density parameter Ω is not only positive, but also in agreement with the value obtained from a direct study of galaxies, namely $\Omega = 0.06 \pm 0.02$ (Gunn et al. ; 1975).

On the other hand the cosmological model so defined (with $\lambda = 1.14$ and $q_o = -1.11$) is in agreement with the following observational tests :

a) Redshift-luminosity relation for galaxies (Gunn et al., 1975) and,

b) for quasars (Fliche and Souriau, 1979) ;

c) redshift-angular diameter relation for radio-sources (Fliche et Souriau; 1979 , Lequeux ; 1978) ; and finally,

d) age of the Universe, which is in this model 22×10^9 years (with the value $H_o = 85$km/s/Mpc as measured by de Vaucouleurs).

III. DISCUSSION

It remains to be seen whether the structure displayed here may be an artefact or due to a bias. We shall now discuss the various possibilities.

a) Selection Effects in Observation.

The empty band (S) is particularly clear in Fig.5 ; the neighbouring bands of the same width contain respectively 20 and 22 objects. Fig. 6 is a Mercator view of the Sky, with the galactic plane marked. Quasars of our sample are denoted by points, except for the 20+22 objects bordering (S). (○ : in front, + back of (S)). The objects denoted by ○ or + are uniformly distributed over a half of the Sky, around the center denoted by ✳ (in Ophiuchus). There is no obvious selection effect by direction.

-It is known that the technical possibilities of observing a Q.S.O depend strongly of the value of its redshift z ; this could, "a priori", produce a selection effect. However, the effect described here consists of the absence of objects in a relatively narrow range Δz of redshifts ($\Delta z/z \sim 0.07$), the center of which depends strongly on the direction of observation, going from $z \sim 0.9$ in the central region Ophiuchus to $z \sim 3.5$ in the direction perpendicular to it (see Table 1).

TABLE 1

Forbidden zone for redshifts versus angular distance to

✳ (17h44mn, -5°55')

0°	.86	.92
5°	.86	.93
10°	.87	.94
15°	.88	.95
20°	.90	.97
25°	.93	1.00
30°	.97	1.04
35°	1.01	1.09
40°	1.06	1.15
45°	1.13	1.22
50°	1.22	1.31
55°	1.32	1.42
60°	1.45	1.56
65°	1.61	1.73
70°	1.82	1.95
75°	2.08	2.23
80°	2.42	2.60
85°	2.86	3.08
90°	3.43	3.72

It is clear that no selection by redshift can produce such an effect.

b) Precision of Data.

Measurements of redshifts of quasars are often given with an accuracy of 1/1000 ; a comparison of data published by different authors on the same object shows that the mean accuracy is close to 1/100. The band to be observed has a width Δz that varies from 0.06 to 0.25, depending on the direction of observation ; it can be thus detected with confidence. Besides one notices, that if one introduces artificially a gaussian error of the order of 1/100 in the data the empty band persists, even though it becomes less wide. Using the optimization procedure described above one can estimate the variation of parameters so produced. A repetition of this procedure gives an estimate of the precision of the value of the parameters : 1/100 for the cosmological parameters k and Ω (see (4)) and 1/500 for the direction orthogonal to the plane of symmetry of (S) :

$$(5h44mn \pm 30s \; , \; 5°55' \pm 10') \qquad (5)$$

and for our distance to this plane :

$$[0.941 \pm 0.002] \; c/H_o \qquad (6)$$

c) Significance Test.

The variable we maximize is either the width of the empty band, or the number of objects in adjacent bands of same width, or else a combination of the two above variables, always with comparable results (see Triay ; 1980).

These optimizations allowed us to determine 5 parameters (two cosmological parameters, the direction and distance of the empty zone).

In order to verify whether this result is significant, we have used the following procedure :

Our sample was divided at random in two equal parts, one of which was used for optimization of the parameters and the other as a significance test : if the observed effect were an artefact, the two samples would be independent. Consequently, the probability of observing an empty band in the second sample would be given by the law of Poisson, i.e. by e^{-n} , where n is the mean number of objects in zones of the same width.

The average value of n, obtained from several random partitions, is equal to 8.8, giving a probability < 0.00015 that the effect is an artefact. This number becomes even smaller if we take into account independent facts such as the existence of gaseous clouds of which 8 indications have been found precisely in this zone.

Consequently it seems difficult to interpret our data except by assuming that a physical phenomenon takes place in this zone.

d) Sources.

It is clear that the precision of redshift measurements plays a crucial role in this work : the result can be compromised by a single erroneous object (e.g. if the lines used to determine z have not been well identified).

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In order to have as reliable a sample as possible, we have selected the catalogs 1 to 39, and have taken into account all 811 objects that the authors consider as unambiguous (Sample I). Incidentally, this sample has not modified the characteristics of the zone that we obtained in March 1979 from the catalog (1) only (see Souriau ; 1979).

As of now (March 1980) there are other available catalogs (40, 41) which define a complementary sample of redshifts given as probable (Sample II) ; however, these prism objective data are less reliable for various reasons (technique used, estimation of the authors, etc.). In Sample II there are published objects, the redshifts of which place them in the "forbidden" zone (S) (Table 2). We thus suspect that these redshifts are mistaken or not sufficiently accurate ; and their verification is evidently a crucial test for the present work.

- TABLE II -

REFER.	NAME	R.A. , DEC. (1950)		REDSHIFT	FORBID.ZONE	COMMENTS
FIRST SERIES : DOUBTFUL REDSHIFTS						
40	2226-401	22 26 43.6	-40 09 31	2.01	[1.89,2.03]	A
40	2227-395	22 27 31.1	-39 34 06	2.00	[1.89,2.03]	A
40	2228-393	22 28 44.0	-39 20 06	1.95	[1.90,2.04]	A
40	2225-414	22 25 28.2	-41 27 25	1.93	[1.89,2.03]	A
40	2226-393	22 26 33.0	-39 20 37	1.92	[1.88,2.02]	A
40	2224-408	22 24 32.7	-40 49 05	1.91	[1.87,2.01]	A
41	2159-186U	21 59 19.7	-18 38 16	1.65	[1.55,1.67]	B
41	2200-182U1	22 00 14.8	-18 14 30	1.59	[1.56,1.68]	B
41	2211-196U	22 11 23.8	-19 39 24	1.68	[1.66,1.78]	B
SECOND SERIES : BOUNDARY OBJECTS , NEEDING ACCURATE MEASUREMENTS OF REDSHIFT.						
35,7	1337-013	13 37 30.4	-12 23 38	1.619	[1.50,1.61]	C
30	1631+627KP	16 31 42.0	+62 44 49	1.96	[1.81,1.95]	
7,40	2225-4040	22 25 30.8	-40 25 20	2.02	[1.88,2.02]	
40	2229-397	22 29 00.1	-39 42 13	2.05	[1.91,2.05]	
40	2224-403	22 24 56.1	-40 40 56	1.87	[1.87,2.01]	
41,7	2214-208U	22 14 06.4	-20 48 01	1.684	[1.68,1.81]	
30	1244+347KP	12 44 57.3	+34 43 54	2.49	[2.49,2.69]	
30	1228+077KP	12 28 47.9	+ 7 23 31	2.39	[2.40,2.58]	
7	1426+295	14 26 31.8	+29 32 22	1.421	[1.42,1.53]	D
7,30	1334+285	13 34 36.0	+28 34 22	1.908	[1.77,1.91]	

A) OBTAINED FROM OBJECTIVE PRISM, IN A SEARCH FOR FAINT EMISSION LINES.
A COINCIDENCE : NEARLY SAME REDSHIFTS FOR NEARBY OBJECTS.
B) FIRST ANALYSIS FROM OBJECTIVE PRISM. NO COMMENTS ABOUT LINES OBSERVED
C) (7) GIVES A REDSHIFT Z=1.607, AND RECENT ANALYSIS (35) Z=1.619
D) OQ 244 (7) DOES'NT CONFIRME THE REDSHIFT.

IV. INTERPRETATION AND CONCLUSIONS

a) Global Map of the Universe.

In the case of a Friedman model with positive curvature, the Universe contains a finite amount of matter uniformly distributed on a three-dimensional space in expansion which is, geometrically, the hyper-sphere S_3. Any (non-euclidean) plane in S_3 -and in particular the singular zone (S) - is in fact an equator of S_3, associated to the two poles P, P'.

We can represent globally the Universe through the following mathematical procedure : we embedd the hyper-sphere S_3 in a numerical space R^4 and project orthogonally S_3 on an equatorial 2-plane. This construction has the useful property of preserving homogeneity ; points that are uniformly distributed in the Universe will be represented by a uniform distribution in a disk.

We have used the model defined by (4) and the procedure just given to represent all the quasars of Sample I on Fig.7, by projection on the 2-plane defined by the Earth T and the two poles P , P' associated to (S). We see

i) The observed quasars fill approximately half of the Universe ;

ii) The zone (S) is visible as a lack of objects on the diameter orthogonal to P, P' ; its visibility is enhanced on an affine figure above ;

iii) The "cosmic latitude" of the Earth (relative to the equator (S)) is approximatively 24°, which does not put us in any distinguished position ;

iv) The selection by redshift is clearly visible since points of equal redshift are situated on a chord perpendicular to the diameter T T'.

b) A Cosmological Scenario.

The bi-partition of the Universe on each side of (S), visible on Fig.7, requires a physical and cosmological explanation. We can propose the following one : in the big-bang neither particles nor symmetry preexisted ; they both appeared as evolutionary effects.

Under this assumption matter appeared by creation of pairs, i.e. in equal global quantity for matter and antimatter. The subsequent evolution has to preserve the initial electrical neutrality at all scales, because of the long-range nature of electromagnetic interactions. On the other hand, the short-range force between particles allow the existence of separate regions filled by matter and antimatter respectively, and evolving according to laws that have been studied in detail (Omnes, 1971).

The onset of density homogeneity in the Universe is a necessary consequence of the expansion in the framework of the laws of gravitation : the perfectly homogeneous Friedman model is stable (Lifshitz et al., 1963 ; Fliche, to appear);

density fluctuations around this model decrease in time, and the Universe becomes homogeneous and isotropic (SO(4) symmetry for density) : the theoretical model appears as an asymptotic state for the real Universe.

If matter and antimatter do not disappear entirely through recombination reactions (the survival ratio has been estimate to 10^{-10}), the most stable final configuration is evidently a bi-partition on each side of an equator (a non-euclidean plane, i.e. a minimal surface of zero curvature).

This dipolar asymmetry is the only possible remnant of the initial anisotropy.

Gravitational forces, which require a spatially constant density, bring about a contact between matter and antimatter along this equator. This contact should permanently give rise to annihilation reactions, at a low rate (compared to the case of a curved surface of contact). If these reactions prevent the formation of condensed matter (quasars), matter and antimatter have to exist in diffuse form with the same average density (clouds).

This scenario provides thus an explanation of the genesis of the singular zone (S) which we believe to have seen. The recombination reactions which it implies could produce the background γ-ray radiation that has been observed by SAS 2 in the

energy range around 100 MeV (after substraction of the galactic component) ; background which is apparently the end-result of $p\,\bar{p}$ reactions (see Fichtel et al., 1978).

We can notice that this scenario eliminates all difficulties encountered by symmetric cosmology in the case of negative or null curvature k (production of matter-antimatter emulsion leading to an unacceptable high rate of γ-ray production ; see (Steigman, 1976).

c) Stratification

On Fig.5 we can notice the existence of others vertical empty bands, finer and therefore less well defined than the zone (S). We have plotted on Fig.8 the clouds that correspond to all the absorption lines of the 4 quasars considered in §I; they seem to appear preferentially in these empty bands. This suggests the possibility of a general stratification of the Universe by zones parallel to (S) ; (in fact, by spheres around the poles P and P') which could explain the frequent occurence of absorption lines in quasar spectra. This search is delicate, in particular because of the high precision it requires in redshift determinations ; a preliminary study has been published (Souriau, 1980).

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TABLE III

CATALOGS REFERENCES !

001)BOKSENBERG,A.,CARSWELL,R.F.,SMITH,M.G.,WHELAN,J.A.J.! 1978,
MONTHLY NOTICES ROY.ASTRON.SOC.,184,773
002)BOKSENBERG,A.,SARGENT,W.L.W.! 1978,ASTROPHYS.J.,220,42
003)BOOTH,R.S.,SPENCER,R.E.,STANNARD,D.,BAATH,L.B.! 1979,
MONTHLY NOTICES ROY.ASTRON.SOC.,188,159
004)BOROSON,T.,SARGENT,W.L.W.,BOKSENBERG,A.,CARSWELL,R.F.! 1978,
ASTROPHYS.J.,220,772
005)BROWN,R.L.,SPENCER,R.E.! 1979,ASTROPHYS.J.,230,L1
006)BURBIDGE,E.M.! 1970,ASTROPHYS.J.,169,L33
007)BURBIDGE,G.R.,CROWNE,A.H.,SMITH,H.E.! 1977,ASTROPHYS.J.SUPPL.,
33,113
008)CLOWES,R.G.,SMITH,M.G.,SAVAGE,A.,CANNON,R.D.,BOKSENBERG,A.,WALL,J.V.!
1979,MONTHLY NOTICES ROY.ASTRON.SOC.,189,175
009)DAVIS,M.M.,MAY,L.S.! 1978,ASTROPHYS.J.,219,1
010)ELLIS,R.,PHILLIPS,S.! 1978,MONTHLY NOTICES ROY.ASTRON.SOC.,183,217
011)GRANDI,S.A.! 1979,ATROPHYS.J.,233,5
012)HUDSTEAD,R.W.,MURDOCH,H.S.,SHOBBROK,R.R.! 1978,
MONTHLY NOTICES ROY.ASTRON.SOC.,185,149
013)JAUNCEY,D.L.,WRIGHT,A.E.,PETERSON,B.A.,CONDON,J.J.! 1978,
ATROPHYS.J.,219,L1
014)JAUNCEY,D.L.,WRIGHT,A.E.,PETERSON,B.A.,CONDON,J.J.! 1978,
ASTROPHYS.J.,221,L109
015)JAUNCEY,D.L.,WRIGHT,A.E.,PETERSON,B.A.,CONDON,J.J.! 1978,
ASTROPHYS.J.,223,L1
016)JAUNCEY,D.L.,WRIGHT,A.E.,PETERSON,B.A.,CONDON,J.J.! 1979,
ASTROPHYS.J.,229,73
017)JAUNCEY,D.L.,WRIGHT,A.E.,PETERSON,B.A.,CONDON,J.J.! 1979,
ATROPHYS.J.,232,400
018)KUNTH,D.,SARGENT,W.L.W.! 1980, PRIVATE COMMUNICATION
019)MITTON,S.,HAZARD,C.,WHELAN,J.A.J.! 1977,MONTHLY NOTICES ROY.
ASTRON.SOC.,179,569
020)OSMER,P.S.! 1979,ASTROPHYS.J.,227,18
021)OWEN,F.N.,WILLS,B.J.,WILLS,D.! 1980,ASTROPHYS.J.,235,L57
022)PERRY,J.J.,BURBIDGE,E.M.,BURBIDGE,G.R.! 1978,PUBL.ASTRON.SOC.PAC.,
90,337
023)PERRENOD,S.C.,CHAISSON,E.J.! 1979,ASTROPHYS.J.,232,49
024)SARGENT,W.L.W.,YOUNG,P.J.,BOKSENBERG,A.,CARSWELL,R.F.,WHELAN,J.A.J.!
1979,ASTROPHYS.J.,230,49
025)SAVAGE,A.,BOLTON,J.G.,TRITTON,K.P.,PETERSON,B.A.! 1978,
MONTHLY NOTICES ROY.ASTRON.SOC.,183,473
026)SAVAGE,A.,BROWNE,I.W.A.! 1977,MONTHLY NOTICES ROY.ASTRON.SOC.,
179,65P
027)STANNARD,D.,NEAL,D.S.! 1977,MONTHLY NOTICES ROY.ASTRON.SOC.,
179,719
028)SMITH,H.E.,JURA,M.,MARCOM,B.! 1979,ASTROPHYS.J.,228,369
029)SPINRAD,H.,MCKEE,C.F.! 1979,ASTROPHYS.J.,232,54
030)SRAMEK,R.A.,WEEDMAN,D.W.! 1978,ASTROPHYS.J.,221,468
031)TURNSHEK,D.A.,WEYMANN,R.J.,WILLIAMS,R.J.! 1979,ASTROPHYS.J.,230,330
032)WALSH,D.,WILLS,B.J.,WILLS,D.! 1979,MONTHLY NOTICES ROY.ASTRON.SOC.,
189,667
033)WEHINGER,P.A.,WYCKOFF,S.! 1978,MONTHLY NOTICES ROY.ASTRON.SOC.,
184,335
034)WILLS,D.! 1979,ASTROPHYS.J.SUPPL.,39,291
035)WILLS,D.,LYNDS,R.! 1978,ASTROPHYS.J.SUPPL.,36,317
036)WILLS,D.,WILLS,B.J.! 1976,ASTROPHYS.J.SUPPL.,31,143
037)WRIGHT,A.E.,MORTON,D.C.,PETERSON,B.A.,JAUNCEY,D.L.! 1979,
MONTHLY NOTICES ROY.ASTRON.SOC.,189,611
038)WRIGHT,A.E.,PETERSON,B.A.,JAUNCEY,D.L.! 1979,MONTHLY NOTICES ROY.
ASTRON.SOC.,188,711
039)YOUNG,P.J.,SARGENT,W.L.W.,BOKSENBERG,A.,CARSWELL,R.F.,WHELAN,J.A.J.! 1979,
ASTROPHYS.J.,229,891
040)HOAG,A.A.,SMITH,M.G.! 1977,ASTROPHYS.J.,217,362
041)SAVAGE,A.,BOLTON,J.G.! 1979,MONTHLY NOTICES ROY.ASTRON.SOC.,188,[illegible]

R E F E R E N C E S

FICHTEL, C.E., SIMPSON, G.A., THOMPSON, D.J., 1978, Astrophys. J. 222, 833.

FLICHE, H.H., These (To appear).

FLICHE, H.H., SOURIAU, J.M., 1979, Astron. Astrophys. 78, 87.

GUNN, J.E., TINSLEY, B.M., 1975, Nature 257, 454.

LEQUEUX, J., 1978, La Recherche 85, 37.

LIFSHITZ, E.M., KHALATNIKOV, I.M., 1963, Advances in Physics, (G.B. Transl.) 46, 85.

OMNES, R., 1971, Astron. Astrophys. 11, 450.

SOURIAU, J.M., 1980, Symposium Einstein C.N.R.S. (To appear). Preprint 79/P.1151 C.P.T./C.N.R.S. Marseille.

STEIGMAN, G., 1976, Ann. Rev. Astron. Astrophys. 14, 339.

TRIAY, R., These 3e Cycle, C.P.T./C.N.R.S. Marseille (To appear).

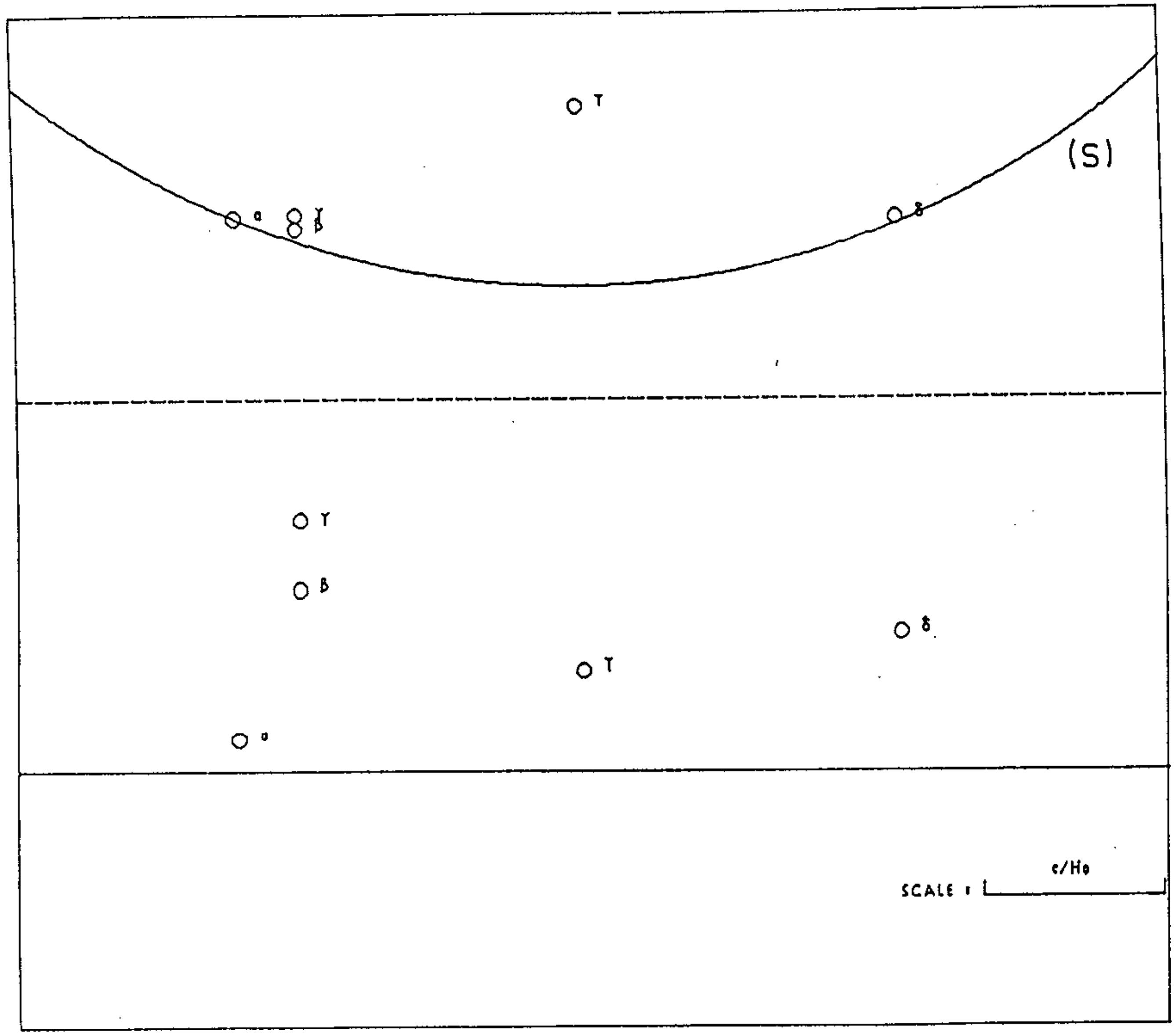


FIGURE 1

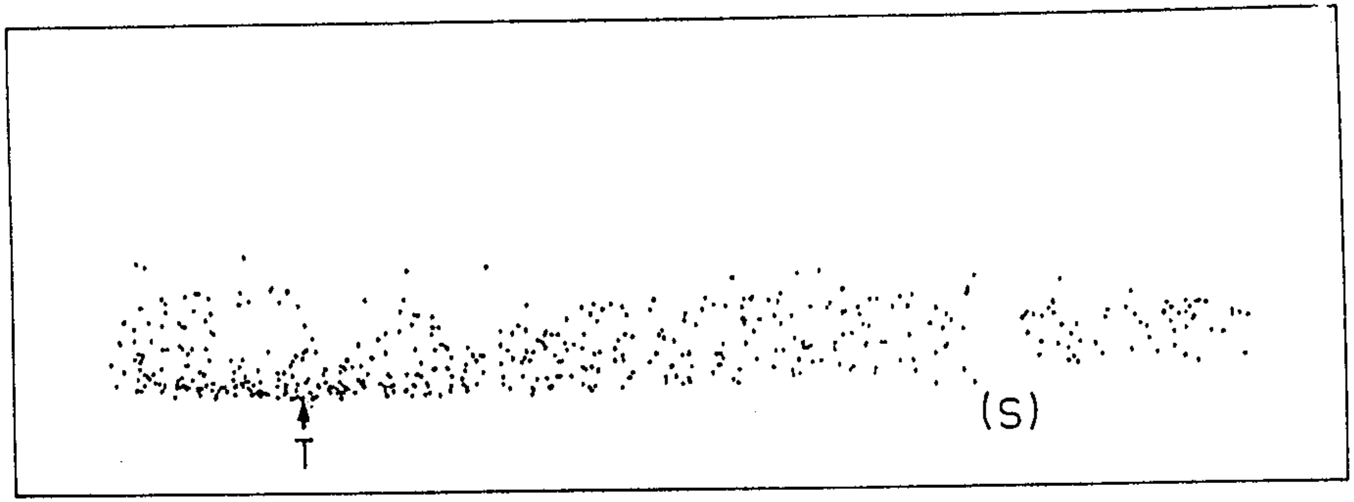
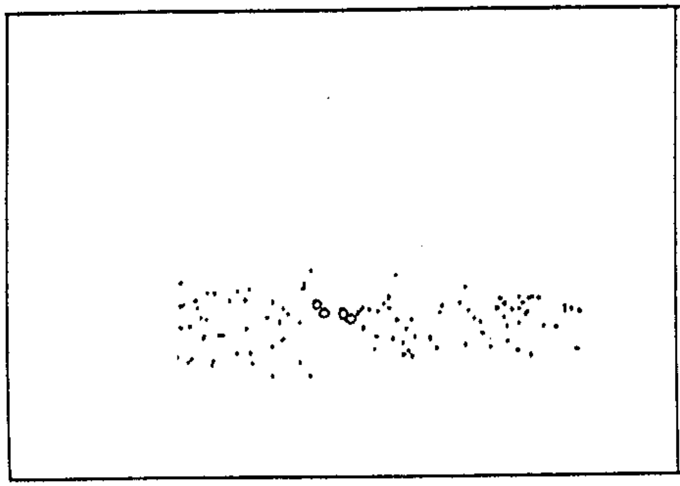


FIGURE 2



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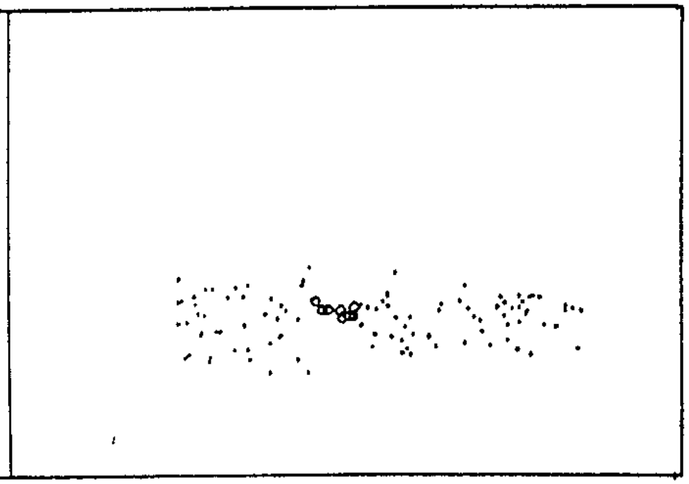

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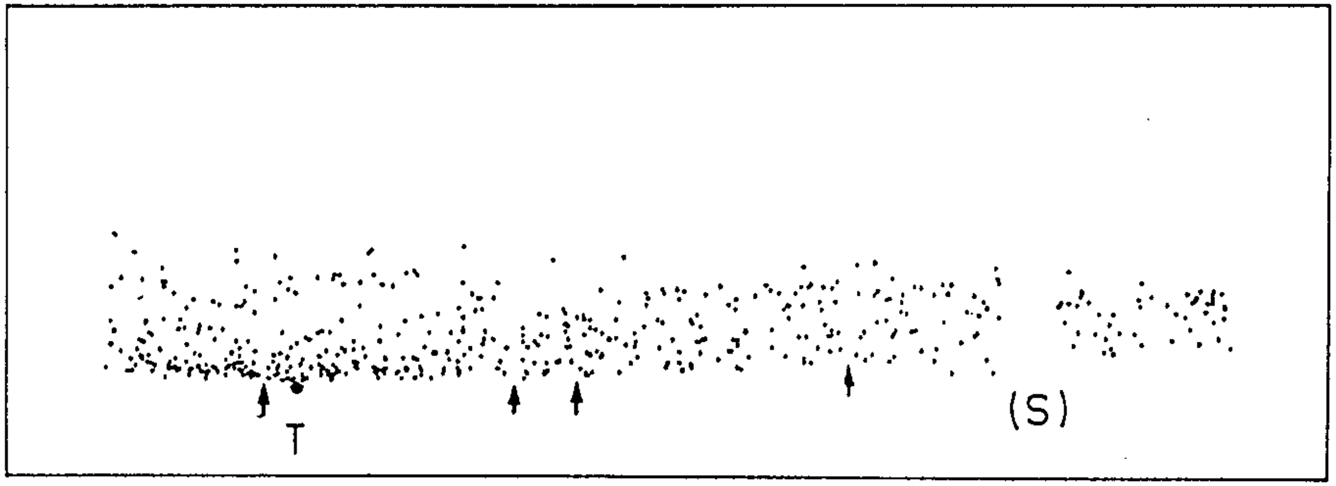

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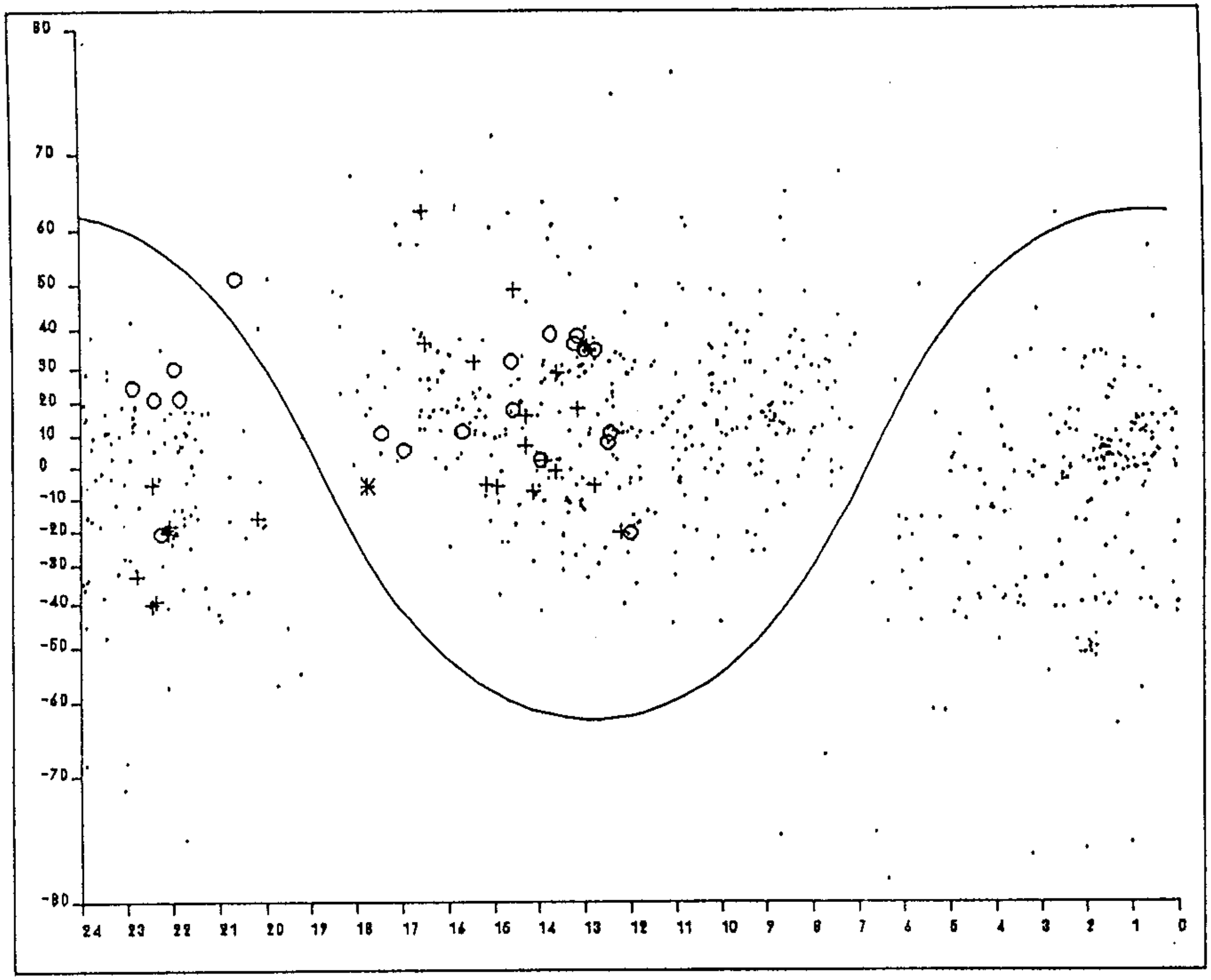
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FIGURE 6

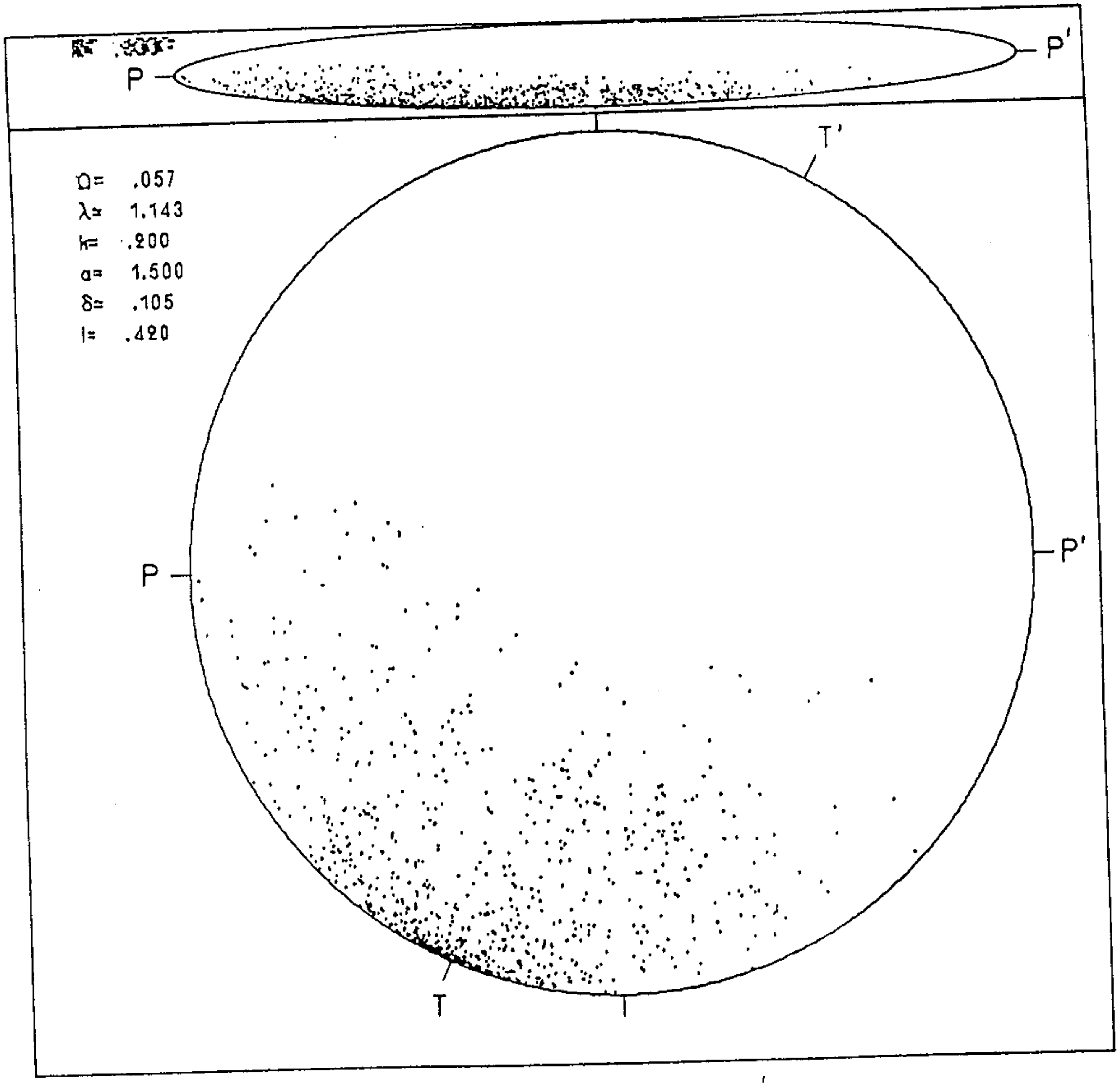

FIGURE 7

FIGURE 8