Dismantling Hubble's Legacy?

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http://www.giss.nasa.gov/staff/mway/hubble-legacy.pdf

Hubble's Legacy?

1 Confirming the island universe theory of Swedenborg, Wright, Kant, etc.

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2 The Classification of Galaxies

Hubble's Legacy?

1 Confirming the island universe theory of Swedenborg, Wright, Kant, etc.

2 The Classification of Galaxies

3 The Expanding Universe

None of these was discovered in a vacuum

The Island Universe Theory

The Island Universe Theory

- Leavitt (1912) HarCi 173, 1
  - First published period-luminosity relation for Cepheids
  - Shapley (1917) Mt. W. Contr. No. 151. [makes it useful]
- Curtis (1917) PASP 29, 206

Novae in Spiral Nebulae and the Island Universe Theory

- "a difference of 10 magnitudes between galactic novae and spiral novae. If we assume equality of absolute magnitude for galactic and spiral novae then the latter being apparently 10 mags fainter are of the order **100 times as far away**. That is spirals containing the novae are far outside our stellar system.
- Effects of any existing **absorbing materials** in the spirals upon the novae is to reduce their apparent brightness and thus to make them seem farther from our system than they are.

The Island Universe Theory

- Shapley (1917) PASP 29, 213

Notes on the magnitudes of novae in Spiral Nebulae

  - Differences between **Novae** in Andromeda & Milky Way give a distance "**at least 50 times as great** ... as for the average novae of the galactic system"
  - **Using brightest stars the minimum distance of the Andromeda is of the order of 1 million light years**
  - At that distance the **diameter of Andromeda is about 50,000 light years** – a value that now appears most probable as a min for our galactic system.
  - Mentions problem of reconciling with van Maanen's measures of internal proper motion

The Island Universe Theory

- Lundmark (1919) AN 209, 369
  - Large numbers of citations: Slipher, Shapely, Curtis, Wirtz
- Luplau-Janssen & Haarh (1922/03) AN 215, 285
  - Few references (Lundmark 1919)
- But S Andromeda (Supernova) had put into doubt all the novae derived distances to M31
- Opik (1922/06) ApJ 55, 406
  - Assumed mass and luminosity comparable to MW and rotational velocity from literature to calculate Distance
  - **Distance compatible with those above "450,000 pc" or 1.5 million light years**.

The Island Universe Theory

- Hubble (1925/01) PASP 33, 252

  Cepheids in Spiral Nebulae

  – "The corresponding distance (to M31/33) is about **285,000 parsecs" (~930,000 light years)**

  – No mention of other methods supporting this conclusion

- Hubble (1925/12) ApJ 62, 409

  NGC 6822, A Remote Stellar System

  - "The first object **definitely** assigned to a region outside the galactic system"
  - M–m=21.65, π=0.00000468, **214000pc, 700000ly**
  - References Shapley (1918) for Cepheid curves

The Island Universe Theory

- Lundmark (1927) “Studies of Anagalactic Nebulae”
  - “Hubble (1925) has shown a very nice agreement between the distances derived from the Cepheids and from the Novae”
  - Novae obviously refers to Curtis, Shapley, Luplau-Janssen & Haarh, Lundmark.

The Classification of Galaxies

The Classification of Galaxies

- Reynolds (1920) MNRAS 80, 746

  Photometric Measures of the Nuclei of some Typical Spiral Nebulae

  – A Spiral Classification

I. Spirals consisting entirely of amorphous nebulosity : examples of this are not numerous, but *N.G.C.* 205 (one of the two nebulæ near the Andromeda Nebula) and *N.G.C.* 3623 may be cited.

II. Spirals showing incipient condensation in the outer whorls only, the greater part of the nebula consisting of amorphous nebulosity. The Andromeda Nebula itself is a good example of this, the outer regions being broken up into comparatively bright and disconnected nodules on a hazy background.

III. In this class the condensation in the outer regions has advanced considerably towards the nucleus. This is the stage reached by *N.G.C.* 3031 (Ursa Major), where the outer half is of the condensed type, including what appear to be actually star discs, while the nuclear region is of the amorphous type and has a light distribution similar to the Andromeda Nebula. Another example is *N.G.C.* 2841 (Ursa Major).

IV. Includes the great majority of spirals. The nebular condensations appear in all regions except the nucleus itself, but a hazy background is still more or less conspicuous.

V. An advanced stage of Class IV. : the whole nebula is of the condensed type, the nucleus often having a definite boundary like a planetary nebula. The hazy background has practically disappeared in all regions. Example *N.G.C.* 5457 (Ursa Major. M. 101).

VI. In certain of the spirals another mode of condensation seems to be taking place. In these examples the nebular condensations appear in the intermediate regions between the nucleus and the outer whorls, usually along an area of which the nuclear point is the centre. These condensations are themselves the starting-points of numbers of spiral arms consisting of faint amorphous nebulosity which extends to a considerable distance. A good example of this is *N.G.C.* 4736 (Canum Ven. M. 94).

VII. There are others which do not seem to have followed symmetrical lines of development at all. Such are spirals of the coarse granular type which have apparently no definite nucleus at all, such as *N.G.C.* 253 (Sculptor), and spirals of irregular brightness and form like *N.G.C.* 4900.

The Classification of Galaxies

- Lundmark (1926/01) AMAF 19B, 8 [summary]

  Studies of Anagalactic Nebulae – First Paper (1927)

  - Reynolds, Slipher, Hubble, Wolf etc. cited several times
  - "Classifications of nebulae based on photographic material have been made by Bailey, Curtis, Mrs. Isaac Roberts, Wolf, Hubble and others. The schemes of the first three authors do not have many subgroups and serve more the purpose of a first brief subdivision." (pg 23)
  - "The classification suggested by me does not perhaps give very much more than the one by Wolf, but includes some forms which have no room in his scheme"

The Classification of Galaxies

- Lundmark (1926/01) AMAF 19B, 8
  - Gives Hubble credit for term “galactic nebulae”
  - “Among the anagalactic nebulae 3 main subdivisions”

1 Globular, elliptical, ovate of lenticular nebulae where no spiral structure can be traced

2 Spiral nebulae or spindle types where spiral arms can be traced (multitude of subtypes)

3 Irregular chaotic forms, akin to the Magellanic clouds.

The Classification of Galaxies

- Hubble (1926/12) ApJ 64, 321
  - Spiral classification very similar to Reynolds (1920)
  - No reference to work of Reynolds (1920)
    - Correspondence between them found by Block & Freeman
  - Reference to work of Lundmark (1926) hints at plagerism

Meanwhile K. Lundmark, who was present at the Cambridge meeting and has since been appointed a member of the Commission, has recently published (*Arkiv för Matematik, Astronomi och Fysik, Band 19B*, No. 8, 1926) a classification, which, except for nomenclature, is practically identical with that submitted by me. Dr. Lundmark makes no acknowledgments or references to the discussions of the Commission other than those for the use of the term "galactic."

The Classification of Galaxies

- Lundmark (1927) “Studies of Anagalactic Nebulae”
  - Replies to Hubble’s comment:

“In his paper Hubble (1926) makes an attack on me which is written in such a tone that I hesitate to give any answer at all. Still, I may take the occasion to state a few facts”:

1. I was present at the Cambridge meeting of the Astronomical Union.
2. I was not then a member of the Commission of Nebulae.
3. I did not have any, access whatsoever to the memorandum or to other writings of E. P. Hubble, neither did I have access to the report of nebulae (which does not give details of Hubble's classification) until at the end of the meeting,
4. Neither did I recognize until I obtained a letter from Hubble at the end of 1926 that he had made another classification of nebulae than the one published in his paper, A general study of the Diffuse Galactic Nebulae, Mt Wils. Contr. No. 24-1, 1922.

The Classification of Galaxies

- Lundmark (1927) “Studies of Anagalactic Nebulae”

5. Hubble's statement that my classification except for nomenclature is practically identical with the one submitted by him is not correct. Hubble classifies his subgroups according to eccentricity or form of the spirals or degree of development while I use the degree of concentration towards the centre.
6. As to the three main groups, elliptical, spiral and Magellanic nebulae it may be of interest to note that the two first are slightly older than Hubble and myself. The term elliptical nebulae thus is used by Alexander in 1852 and the term spiral by Rosse in 1845; The importance of the Magellanic group has been pointed out by myself (Observatory 47, 277, 1924) earlier than by Hubble.
7. **As to Hubble's way of acknowledging his predecessors I have no reason to enter upon this question here.**

Lundmark's Classification

	Symbol.	Example	Corresponding type in Wolfs system
I. Galactic nebulæ	**G**		
1. *Quasi-planetary nebulæ*	*Gp*		a, b, c
a. No central star	Gp0	N.G.C. 6537	a, b
b. Heliocoidal forms	Gph	N.G.C. 6543	a
c. Central star and different gradations in the ratio total light of nebula to light of central star	Gp1—Gp10	N.G.C. 40	c
2. *Irregular nebulæ*	*Gi*		
a. Irregular bright nebulæ	Gib		
b. Irregular dark nebulæ	Gid		
II. Anagalactic nebulæ	**A**		
1. *Anomalous nebulæ*	*Aa*	N.G.C. 2537 N.G.C. 5144	
2. *Globular, elliptical, elongated, ovate or lenticular nebulæ*	*Ae*		
a. Very little compressed towards centre	Ae0	N.G.C. 4302	d, h_0
b. Slightly » » »	Ae1	I.C. 2233	e
c. Somewhat » » »	Ae2	N.G.C. 1600	e
d. Rather » » »	Ae3	N.G.C. 4382	f, g, h
e. Much » » »	Ae4	N.G.C. 4278	f, g, h
f. Very much » » »	Ae5	N.G.C. 4486	i, k,
The letter a is added if absorption is present e. g.	Ae3a		
3. *Magellanic nebulæ*	*Am*		
a. Very little if at all compressed towards the centre	Am0		p? q?
b. Different degrees of compressibility	Am1—Am5	N.G.C. 4449	

Lundmark's **Spiral** Classification, cont'

	Symbol.	Example	Corresponding type in Wolfs system
4. *Spiral nebulæ*	*As*		
a. Spiral structure barely seen . . .	As0	N.G.C. 4594	o
b. Different degrees of compressibility towards centre	As1—As5		
Spiral arms continuous	As1c—As5c	N.G.C. 3031	s, v
Spiral arms broken up into patches or separate points	As1b—As5b	N.G.C. 598	r, u, w.
c. One-branched spirals	As0	N.G.C. 5278	
d. Spiral arms form a bright ring . .	Asr	N.G.C. 4736	t
e. Doubtful connection of ring with the centre (Saturn-shaped)	Ass	N.G.C. 936	
f. Ring or arms connected with centre through a bar (pin-wheels or Curtis φ-type)	Asp	N.G.C. 1326.	
g. Spiral arms have an appendix nebula	Asa	N.G.C. 5194—95	

Hubble's

CLASSIFICATION OF NEBULAE

	Symbol	Example
I. Galactic nebulae:		
A. Planetaries	P	N.G.C. 7662
B. Diffuse	D	.....
1. Predominantly luminous	DL	N.G.C. 6618
2. Predominantly obscure	DO	Barnard 92
3. Conspicuously mixed	DLO	N.G.C. 7023
II. Extra-galactic nebulae:		
A. Regular:		
1. Elliptical	E*n*	N.G.C. 3379 E0 221 E2 4621 E5 2117 E7
(*n* = 1, 2, ... , 7 indicates the ellipticity of the image without the decimal point)		
2. Spirals:	Symbol	Example
a) Normal spirals	S	.....
(1) Early	Sa	N.G.C. 4594
(2) Intermediate	Sb	2841
(3) Late	Sc	5457
b) Barred spirals	SB	.....
(1) Early	SBa	N.G.C. 2859
(2) Intermediate	SBb	3351
(3) Late	SBc	7479
B. Irregular	Irr	N.G.C. 4449

The Classification of Galaxies

Notes found in the margin of Reynold's MNRAS article at Mt. Wilson Observatory Library (Block & Freeman pg 202)

The following is a classification made up on these lines, the so-called "spindle" nebulæ, which are undoubtedly spirals seen edgewise, not being included:—

I. Spirals consisting entirely of amorphous nebulosity: examples of this are not numerous, but *N.G.C.* 205 (one of the two nebulæ near the Andromeda Nebula) and *N.G.C.* 3623 may be cited.

Sa II. Spirals showing incipient condensation in the outer whorls only, the greater part of the nebula consisting of amorphous nebulosity. The Andromeda Nebula itself is a good example of this, the outer regions being broken up into comparatively bright and disconnected nodules on a hazy background.

Sb III. In this class the condensation in the outer regions has advanced considerably towards the nucleus. This is the stage reached by *N.G.C.* 3031 (Ursa Major), where the outer half is of the condensed type, including what appear to be actually star discs, while the nuclear region is of the amorphous type and has a light distribution similar to the Andromeda Nebula. Another example is *N.G.C.* 2841 (Ursa Major).

Sc IV. Includes the great majority of spirals. The nebular condensations appear in all regions except the nucleus itself, but a hazy background is still more or less conspicuous.

V. An advanced stage of Class IV.: the whole nebula is of the condensed type, the nucleus often having a definite boundary

The Classification of Galaxies

- Jeans 1929 “Astronomy & Cosmogony“
  - Tuning fork idea actually from this book

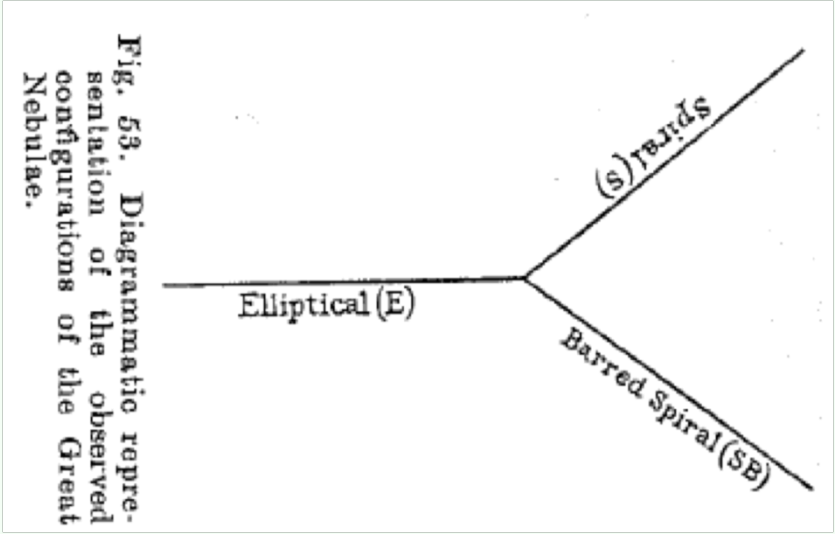


Fig. 53. Diagrammatic representation of the observed configurations of the Great Nebulae.

- Hubble (1936) “Realm of Nebulae” populates tuning fork.

The Classification of Galaxies

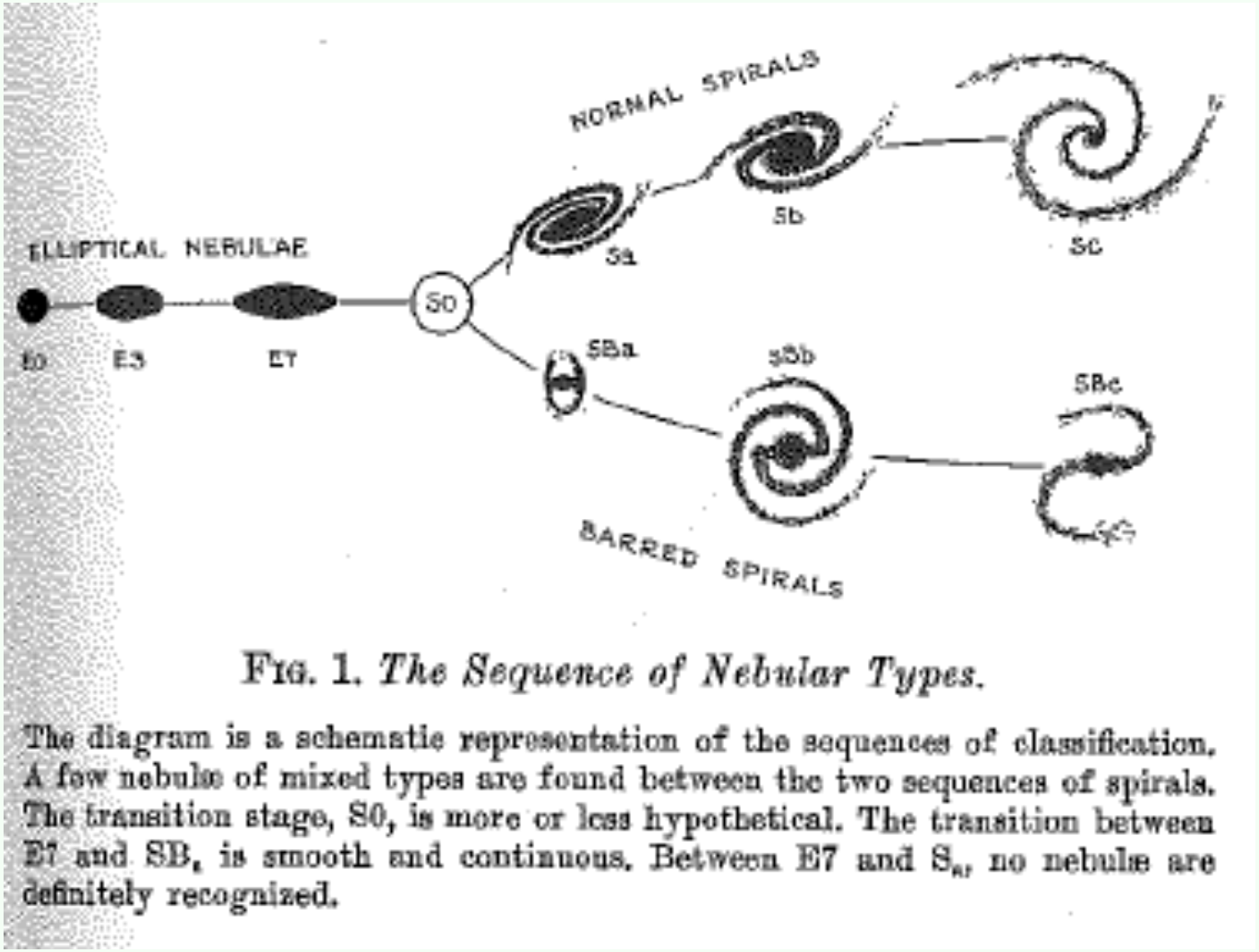


FIG. 1. *The Sequence of Nebular Types.*

The diagram is a schematic representation of the sequences of classification. A few nebulæ of mixed types are found between the two sequences of spirals. The transition stage, S0, is more or less hypothetical. The transition between E7 and SB_a is smooth and continuous. Between E7 and S_a, no nebulæ are definitely recognized.

Hubble (1936) "Realm of Nebulae"

The Expanding Universe

The Expanding Universe

- Slipher (1912) ApJ 64, 321
  - First measured Doppler shift of a spiral nebulae
- Leavitt (1912) HarCi 173, 1
  - First published period-luminosity relation for Cepheids
- Einstein (1915-17) and de Sitter
  - General Relativity and solutions
- Slipher (1917) Obs 40, 304
  - 30 radial velocities mentioned
- Shapley (1917) Mt. W. Contr. No. 151. (Cepheids)
- Wirtz (1921) AN 215, 349

The Expanding Universe

- Friedman (1922) ZD f. Phys 10, 377
  - Ad-hoc assumptions give an age of 10^{10} years.
- Lundmark (1924) MNRAS 84, 747
  - First published radial-velocity vs. distance diagram
  - If fit would have given $H_o \sim$ 44-100 km/sec/Mpc
    - See Duerbeck & Seitter (2001)
  - Thanks "Dr. Slipher"
- Wirtz (1924) AN 222, 21
  - log-diameter versus velocity relation (cites Slipher)
- Strömberg (1925) ApJ 61, 353
  - Cites Slipher, but no relationship is found for de Sitter.

The Expanding Universe

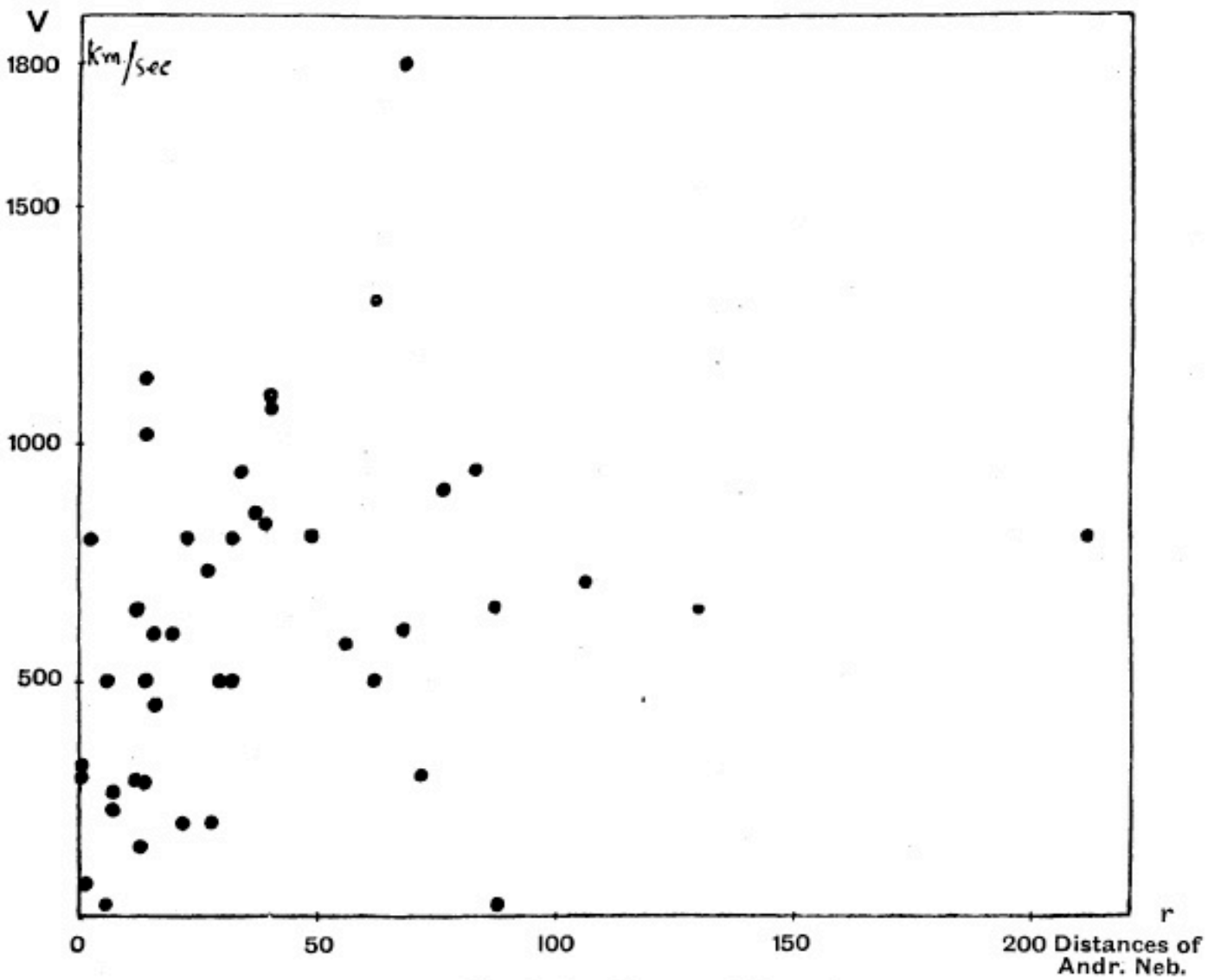


FIG. 5.—Relation between the relative distances (the unit is the distance of the Andromeda nebula) and the measured radial velocities of spiral nebulæ.

- Lemaitre (1927) ASSB 47, 49
  - Independently derives Friedman's non-static solutions
  - The velocity of recession is *"the apparent Doppler effect due to the variation of the radius of the universe"*
  - Derives distance vs. radial-velocity relationship for spiral nebulae using data from Strömberg (Slipher) & Hubble
  - Using 42 galaxies found values of **625** & **575** km/s/Mpc
  - Mentions previous attempts by Lundmark & Stromberg
  - Paper is (almost) lost to the world until republished in 1931 in MNRAS, but w/o the H_o numbers!
  - **De Sitter (1930) BAN 3, 211 & BAN 5, 157 mentions Lemaitre's non-static solution (read the original ASSB)**
  - Deep suspicion in recent years (Block 2011), but was recently cleared up by Mario Livio (2011) Nat 479, 171

0,95 million de parsecs et une vitesse radiale de 600 km/sec, soit 625 km/sec à 10^6 parsecs[a].

Nous adapterons donc

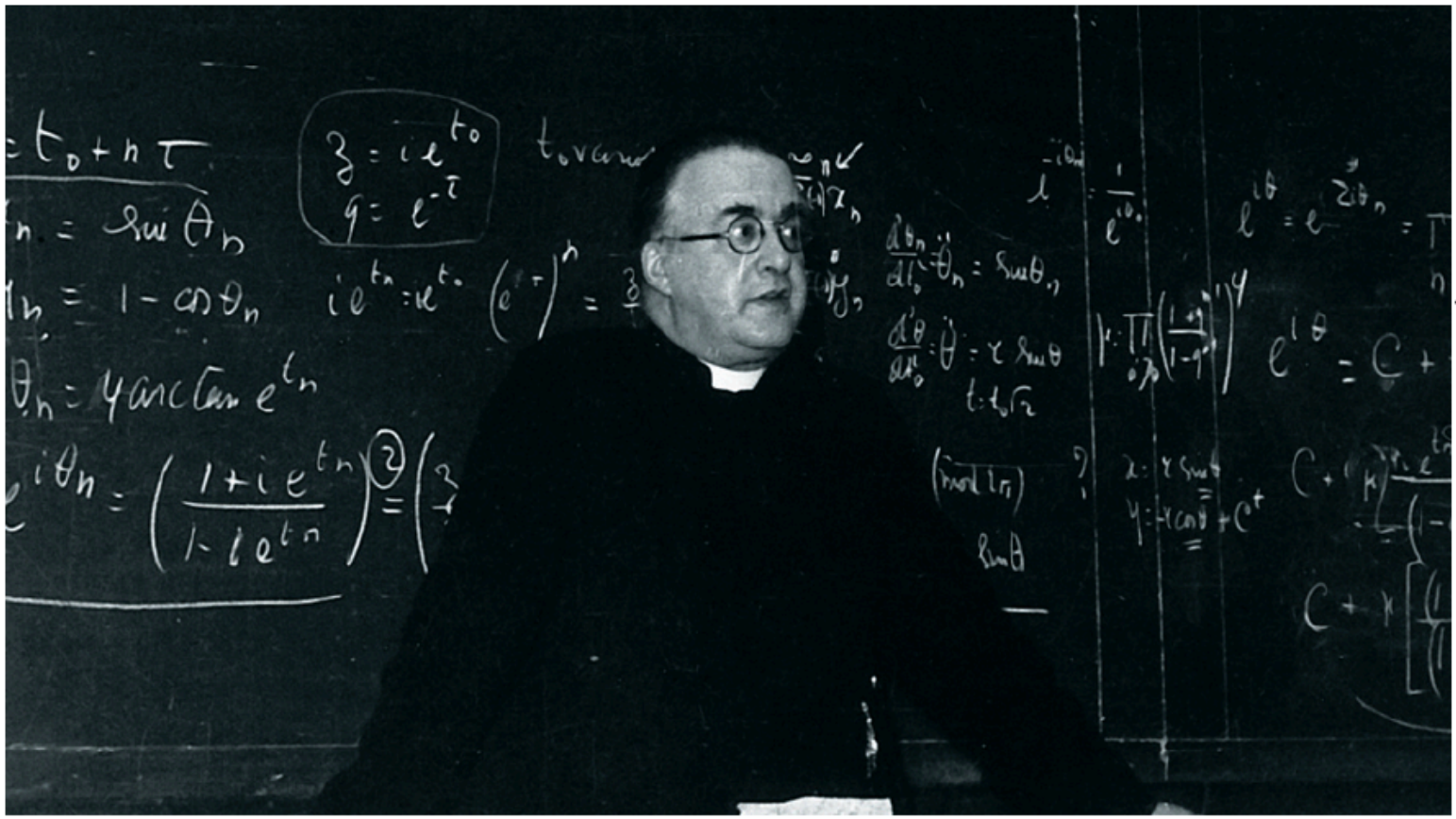
$$(24) \qquad \frac{R'}{R} = \frac{v}{rc} = \frac{625 \times 10^5}{10^6 \times 3{,}08 \times 10^{18} \times 3 \times 10^{10}} = 0{,}68 \times 10^{-27}\ \mathrm{cm}^{-1}.$$

a En ne donnant pas de poids aux observations, on trouverait 670 km/sec à $1{,}16 \times 10^6$ parsecs, 575 km/sec à 10^6 parsecs. Certains auteurs ont cherché à mettre en évidence la relation entre v et r et n'ont obtenu qu'une très faible corrélation entre ces deux grandeurs. L'erreur dans la détermination des distances individuelles est du même ordre de grandeur que l'intervalle que couvrent les observations et la vitesse propre des nébuleuses (en toute direction) est grande (300 km/sec d'après Strömberg), il semble donc que ces résultats négatifs ne sont ni pour ni contre l'interprétation relativistique de l'effet Doppler. Tout ce que l'imprécision des observations permet de faire est de supposer v proportionnel à r et d'essayer d'éviter une erreur systématique dans la détermination du rapport v/r. Cf. Lundmark, « The determination of Curvature of Space Time in De Sitter's World », *M.N.*, vol. 84, 1924, p. 747, et Strömberg, art. cité.

"A Hubble Eclipse: Lemaître and Censorship"

David L. Block, School of Computational & Applied Mathematics, University of the Witwatersrand, Johannesburg, South Africa.

Abstract. One of the greatest discoveries of modern times is that of the expanding Universe, almost invariably attributed to Hubble (1929). What is not widely known is that the original treatise by Lemaître (1927) contained a rich fusion of both theory and of observation. The French paper was meticulously censored when printed in English - all discussions of radial velocities and distances (and the very first empirical determination of "H") were omitted. Fascinating insights are gleaned from a letter recently found in the Lemaître archives. An appeal is made for a Lemaître Telescope, to honour the discoverer of the expanding universe.



ARCHIVES GEORGES LEMAÎTRE/CATHOLIC UNIV. LOUVAIN/TECLIM

Georges Lemaître giving a lecture at the Catholic University of Louvain in Belgium.

Mystery of the missing text solved

A discovered letter explains the loss of key paragraphs during the translation of one of Georges Lemaître's papers about the expanding Universe, shows **Mario Livio**.

- Hubble (1929) PNAS 168, 73
  - Using 24 galaxies to find **465** & **513** km/s/Mpc
  - Mentions previous attempt by Lundmark
  - No citation for Slipher, only Humason!
- de Sitter (1930) BAN 5, 157
  - Similar result to Hubble (1929) with additional data
  - But understands GR context like Lemaitre (1927)
- Hubble (1931) ApJ 74, 43
  - Much discussion about magnitudes and distances
  - "Velocities previously available, owing very largely to the great pioneer work of V.M. Slipher at Lowell Observatory…" **but no actual citation to his work!**
  - Age of Earth becomes problem (1921, 1929, 1930…)

Kragh & Smith (2003) on Expanding Universe Discoverer

Friedman: "Since he gave no reasons why the universe should be expanding, he cannot reasonably be said to have discovered the phenomenon."

Lemaitre: "In so far as Lemaitre did not establish observationally that the universe is in fact expanding, he did not make a discovery; but in so far as he gave theoretical as well as observational reasons for it, he did discover the expansion of the universe."

Hubble: "Hubble must therefore be considered the discoverer of this empirical law. But the law of receding galaxies is not the same as the expanding universe, a notion that Hubble did not suggest in 1929."

Making of a Hero(es)?

- Thomas Kuhn: “There is a persistent tendency to make the history of science look linear or cumulative, a tendency that even affects scientists looking back at their own research”.
- Campbell’s “monomyth” (Hero of a Thousand Faces)
- Have we been presented evidence of the “Inevitability of the conqueror” (Alexander, Genghis Khan, etc)??
- Why not more FLRW

1 Confirming the island universe theory of Swedenborg, Wright, Kant, etc.

- Recently in Marcia Bartusiak's book "The Day we Found the Universe"

2 The Classification of Galaxies

- Block & Freeman's book "Shrouds of the Night"

3 The Expanding Universe

- Smith (1979) JHA 10, 133
- Duerbeck & Seitter (2001)
- Kragh & Smith (2003) HistSc 41, 141
- "The Expanding Universe: Astronomy's 'Great Debate' , 1900-1931" by R. Smith (1982)
- "Discovering the Expanding Universe" by Nussbaumer & Bieri (2009)

http://www.youtube.com/watch?v=3Pa34orcwwA