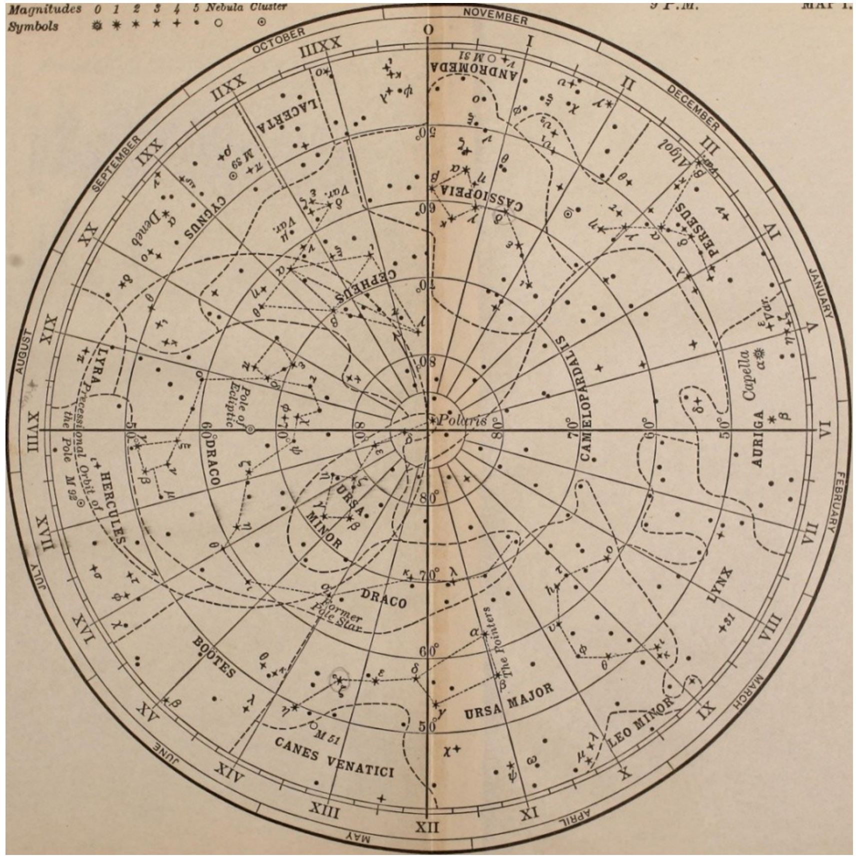
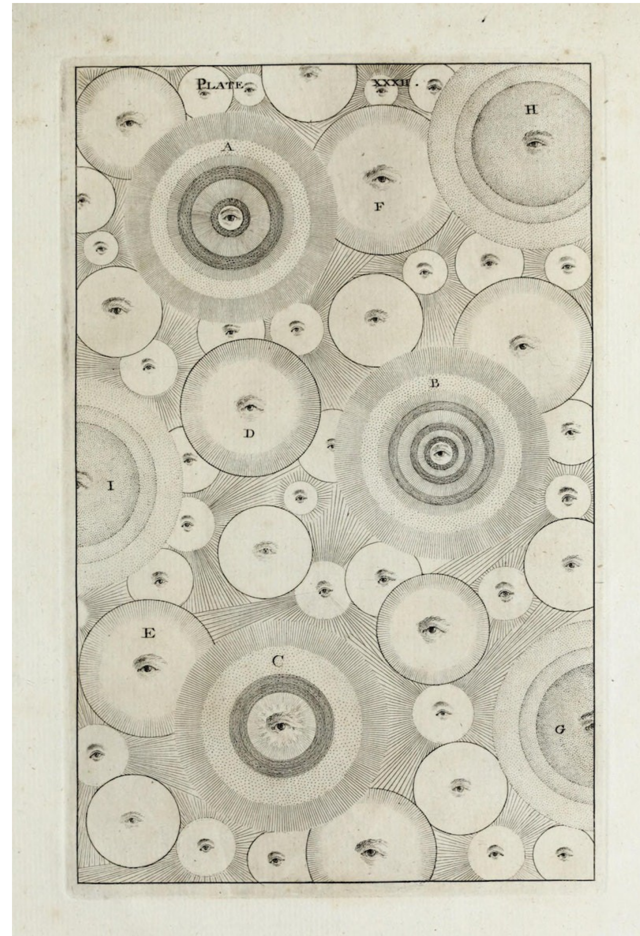
Historie astronomie X.



Vladimír Štefl
Ústav teoretické fyziky a astrofyziky

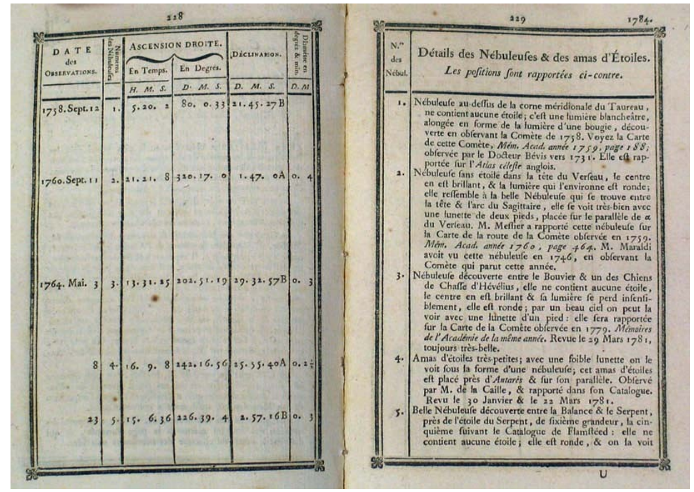
Vznik a rozvoj stelární astronomie

- Emanuel Swedenborg 1688-1772, rozložení hvězd
- Thomas Wright 1711-1786, ***Originální teorie neboli nová hypotéza o vesmíru, r. 1750*** hvězdná soustava složená z vrstvy jednotlivých hvězd, obíhajících kolem středu stejně jako Slunce, patrně existují i jiné Mléčné dráhy ve velkých vzdálenostech, proč mají oka uprostřed?



Charles Messier 1730 - 1817

francouzský astronom, pozorovatel, tvůrce katalogu, objevitel komet



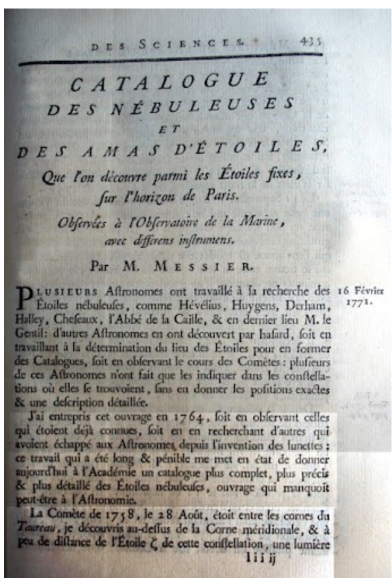
228

DATE des OBSERVATIONS.	Numeros des Nébuleuses	ASCENSION DROITE. En Temps.	ASCENSION DROITE. En Degrés.	DÉCLINAISON.	Diamètre en degrés & min.
		H. M. S.	D. M. S.	D. M. S.	D. M
1758. Sept. 12	1.	5. 20. 2	80. 0. 33	21. 45. 27 B	
1760. Sept. 11	2.	21. 21. 8	320. 17. 0	1. 47. 0 A	0. 4
1764. Mai. 3	3.	13. 31. 25	202. 51. 19	29. 32. 57 B	0. 3
8	4.	16. 9. 8	242. 16. 56	25. 55. 40 A	0. 2½
23	5.	15. 6. 36	226. 39. 4	2. 57. 16 B	0. 3

229 1784.

N.os des Nébul.	Détails des Nébuleuses & des amas d'Étoiles. *Les positions sont rapportées ci-contre.*
1.	Nébuleuse au-dessus de la corne méridionale du Taureau, ne contient aucune étoile; c'est une lumière blancheâtre, alongée en forme de la lumière d'une bougie, découverte en observant la Comète de 1758. Voyez la Carte de cette Comète, *Mém. Acad. année 1759, page 188;* observée par le Docteur Bévis vers 1731. Elle est rapportée sur l'*Atlas céleste* anglois.
2.	Nébuleuse sans étoile dans la tête du Verseau, le centre en est brillant, & la lumière qui l'environne est ronde; elle ressemble à la belle Nébuleuse qui se trouve entre la tête & l'arc du Sagittaire, elle se voit très-bien avec une lunette de deux pieds, placée sur le parallèle de α du Verseau. M. Messier a rapporté cette nébuleuse sur la Carte de la route de la Comète observée en 1759. *Mém. Acad. année 1760, page 464.* M. Maraldi avoit vu cette nébuleuse en 1746, en observant la Comète qui parut cette année.
3.	Nébuleuse découverte entre le Bouvier & un des Chiens de Chasse d'Hévélius, elle ne contient aucune étoile, le centre en est brillant & sa lumière se perd insensiblement, elle est ronde; par un beau ciel on peut la voir avec une lunette d'un pied: elle sera rapportée sur la Carte de la Comète observée en 1779. *Mémoires de l'Académie de la même année.* Revue le 29 Mars 1781, toujours très-belle.
4.	Amas d'étoiles très-petites; avec une foible lunette on le voit sous la forme d'une nébuleuse; cet amas d'étoiles est placé près d'*Antarès* & sur son parallèle. Observé par M. de la Caille, & rapporté dans son Catalogue. Revu le 30 Janvier & le 22 Mars 1781.
5.	Belle Nébuleuse découverte entre la Balance & le Serpent, près de l'étoile du Serpent, de sixième grandeur, la cinquième suivant le Catalogue de Flamstéed: elle ne contient aucune étoile; elle est ronde, & on la voit

U



DES SCIENCES. 435

CATALOGUE DES NÉBULEUSES ET DES AMAS D'ÉTOILES,

Que l'on découvre parmi les Étoiles fixes, sur l'horizon de Paris.

Observées à l'Observatoire de la Marine, avec differens instrumens.

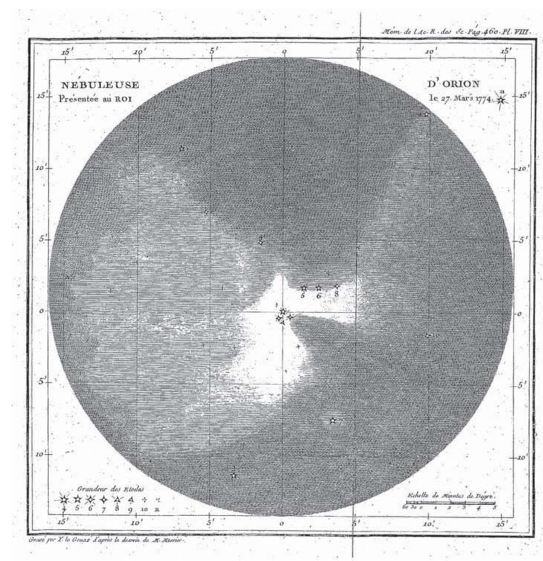
Par M. MESSIER.

PLUSIEURS Astronomes ont travaillé à la recherche des Étoiles nébuleuses, comme Hévélius, Huygens, Derham, Halley, Cheseaux, l'Abbé de la Caille, & en dernier lieu M. le Gentil: d'autres Astronomes en ont découvert par hasard, soit en travaillant à la détermination du lieu des Étoiles pour en former des Catalogues, soit en observant le cours des Comètes: plusieurs de ces Astronomes n'ont fait que les indiquer dans les constellations où elles se trouvoient, sans en donner les positions exactes & une description détaillée. 16 Février 1771.

J'ai entrepris cet ouvrage en 1764, soit en observant celles qui étoient déjà connues, soit en en recherchant d'autres qui avoient échappé aux Astronomes depuis l'invention des lunettes: ce travail qui a été long & pénible me met en état de donner aujourd'hui à l'Académie un catalogue plus complet, plus précis & plus détaillé des Étoiles nébuleuses, ouvrage qui manquoit peut-être à l'Astronomie.

La Comète de 1758, le 28 Août, étoit entre les cornes du *Taureau*, je découvris au-dessus de la Corne méridionale, & à peu de distance de l'Étoile ζ de cette constellation, une lumière

I i i i ij



Charles Messier

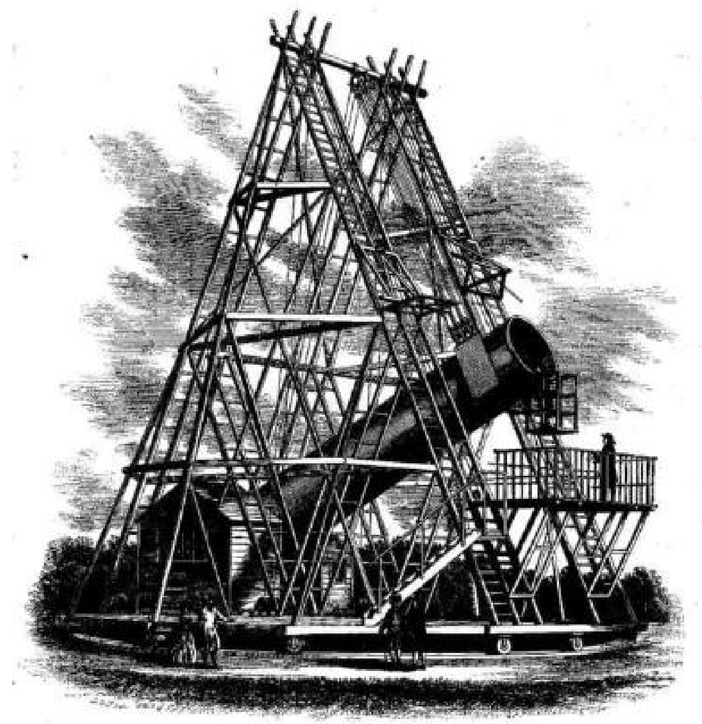
návrat Halleovy komety

Jako první pozoroval ve Francii návrat Halleyovy komety v lednu roku 1759 **Charles Messier (1730 – 1817)**. Jeho zásluhou byly komety od druhé poloviny 18. století systematicky pozorovány. Messier popisoval a zakresloval rozměry, změny jasností, jádra a hlavy komety. Zachycoval polohu komet na obloze do hvězdných map, odkud další astronomové propočítávali dráhové elementy. Zkušený pozorovatel Messier, nazývaný ve své době lovec komet, v letech 1763 – 1802 pomocí dalekohledu objevil 14 komet.

Pro usnadnění hledání komet Messier roku 1781 vydal první *katalog mlhovin a hvězdokup*, který obsahoval 103 objektů, z nichž více než 60 bylo objeveno samotným Messierem. Z těchto 103 objektů bylo 33 galaxií, především spirálních, 27 kulových a 30 otevřených hvězdokup a 11 plynných mlhovin. Pouze u dvou z těchto objektů Messier chybně považoval za mlhovinu dvě hvězdy – dvojhvězdu s malou jasností – M 40 a neznámý objekt – M 102. Později byl katalog doplněn o 7 dalších objektů. V Messierově katalogu M 1 označuje Krabí mlhovinu, M 31 mlhovinu v Andromedě a M 42 mlhovinu v Orionu.

Základy stelární astronomie

anglický astronom **William Herschel 1738 - 1822**, rod pocházel z Heršpic u Slavkova, zakladatel stelární astronomie, sestrojil desítky zrcadlových dalekohledů, r. 1789 největší s průměrem 122 cm, nejčastěji pozoroval s dalekohledem o průměru 30 cm, s ohniskovou vzdáleností 6 m, systematickou prohlídku oblohy započal roku 1774.



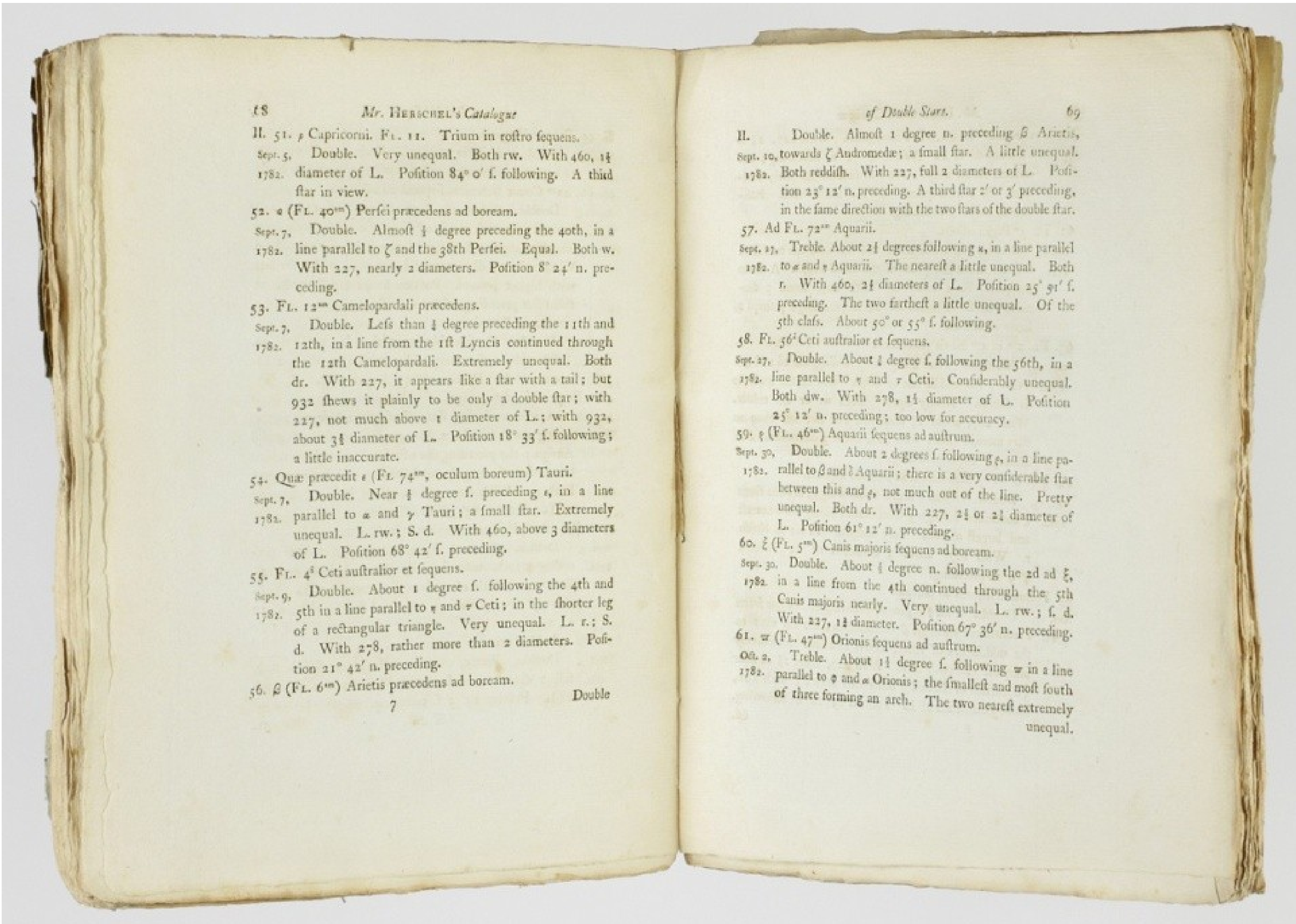
William Herschel

13. března r. 1781 objevil v souhvězdí blíženců těleso - Uran, v deníku uvedl: *,,Zpráva o kometě. V úterý 13. března 1781 mezi desátou a jedenáctou večer, když jsme zkoumal slabé hvězdy v sousedství κ Geminorum jsem zpozoroval jednu, která se zdála být větší než ostatní. Zaražen jejím nezvyklým vzhledem a velikostí, srovnával jsem ji s κ Geminorum….Shledav, že obě předčí jasností, domníval jsme se, že je to kometa.“* vlastní pohyb 2,5“ /hod podél zvířetníku, název dal J. E. Bode., Pokoušel se o změření paralaxy Galileovou metodou, z posuvů poloh hvězd různé jasnosti nacházejících se v blízkosti u sebe, slabší - patrně i vzdálenější složka by se vzhledem k obloze neměla téměř pohybovat, sloužila jako vztažný bod pro měření paralaktického posuvu hvězdy bližší - jasnější, tedy hledal paralaktickou elipsu-– posuv hvězd vzniklý důsledkem pohybu Země kolem Slunce,

objevil dvojhvězdy, r. 1782 uveřejnil první katalog 269 dvojhvězd, r. 1785 již 434 dvojhvězd, 1803 pochopil fyzickou souvislost složek, zjistil potočení spojnice obou složek u padesáti dvojhvězd, důsledek působení gravitace a oběhu kolem společného hmotného středu,

William Herschel

katalog dvojhvězd



18 *Mr.* HERSCHEL's *Catalogue*

II. 51. ρ Capricorni. FL. 11. Trium in roſtro ſequens.
Sept. 5, 1782. Double. Very unequal. Both rw. With 460, 1¼ diameter of L. Poſition 84° 0′ ſ. following. A third ſtar in view.

52. ε (FL. 40^m) Perſei præcedens ad boream.
Sept. 7, 1782. Double. Almoſt ½ degree preceding the 40th, in a line parallel to ζ and the 38th Perſei. Equal. Both w. With 227, nearly 2 diameters. Poſition 8° 24′ n. preceding.

53. FL. 12^m Camelopardali præcedens.
Sept. 7, 1782. Double. Leſs than ½ degree preceding the 11th and 12th, in a line from the 1ſt Lyncis continued through the 12th Camelopardali. Extremely unequal. Both dr. With 227, it appears like a ſtar with a tail; but 932 ſhews it plainly to be only a double ſtar; with 227, not much above 1 diameter of L.; with 932, about 3½ diameter of L. Poſition 18° 33′ ſ. following; a little inaccurate.

54. Quæ præcedit ε (FL. 74^m, oculum boreum) Tauri.
Sept. 7, 1782. Double. Near ½ degree ſ. preceding ε, in a line parallel to α and γ Tauri; a ſmall ſtar. Extremely unequal. L. rw.; S. d. With 460, above 3 diameters of L. Poſition 68° 42′ ſ. preceding.

55. FL. 4^5 Ceti auſtralior et ſequens.
Sept. 9, 1782. Double. About 1 degree ſ. following the 4th and 5th in a line parallel to η and τ Ceti; in the ſhorter leg of a rectangular triangle. Very unequal. L. r.; S. d. With 278, rather more than 2 diameters. Poſition 21° 42′ n. preceding.

56. β (FL. 6^m) Arietis præcedens ad boream.

Double

7

of Double Stars. 69

II. Double. Almoſt 1 degree n. preceding β Arietis,
Sept. 10, 1782. towards ζ Andromedæ; a ſmall ſtar. A little unequal. Both reddiſh. With 227, full 2 diameters of L. Poſition 23° 12′ n. preceding. A third ſtar 2′ or 3′ preceding, in the ſame direction with the two ſtars of the double ſtar.

57. Ad FL. 72^m Aquarii.
Sept. 27, 1782. Treble. About 2½ degrees following α, in a line parallel to α and η Aquarii. The neareſt a little unequal. Both r. With 460, 2½ diameters of L. Poſition 25° 51′ ſ. preceding. The two fartheſt a little unequal. Of the 5th claſs. About 50° or 55° ſ. following.

58. FL. 56^2 Ceti auſtralior et ſequens.
Sept. 27, 1782. Double. About ½ degree ſ. following the 56th, in a line parallel to η and τ Ceti. Conſiderably unequal. Both dw. With 278, 1½ diameter of L. Poſition 25° 12′ n. preceding; too low for accuracy.

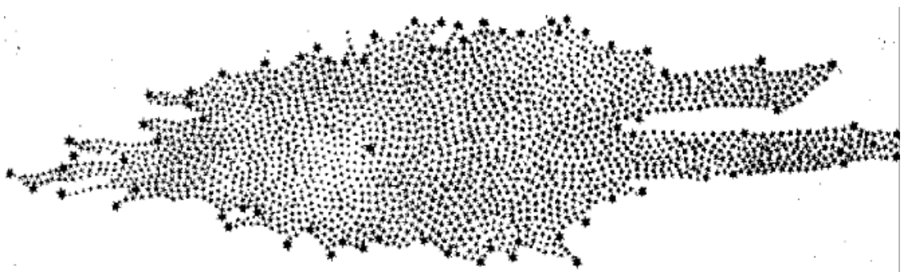
59. ε (FL. 46^m) Aquarii ſequens ad auſtrum.
Sept. 30, 1782. Double. About 2 degrees ſ. following ε, in a line parallel to β and δ Aquarii; there is a very conſiderable ſtar between this and ε, not much out of the line. Pretty unequal. Both dr. With 227, 2½ or 2¼ diameter of L. Poſition 61° 12′ n. preceding.

60. ξ (FL. 5^m) Canis majoris ſequens ad boream.
Sept. 30, 1782. Double. About ½ degree n. following the 2d ad ξ, in a line from the 4th continued through the 5th Canis majoris nearly. Very unequal. L. rw.; ſ. d. With 227, 1½ diameter. Poſition 67° 36′ n. preceding.

61. π (FL. 47^m) Orionis ſequens ad auſtrum.
Oct. 2, 1782. Treble. About 1½ degree ſ. following π in a line parallel to φ and α Orionis; the ſmalleſt and moſt ſouth of three forming an arch. The two neareſt extremely unequal.

William Herschel

pozorování vybraných směrů, statistické vyhodnocování, hledání obecných zákonitostí v rozložení hvězd, předpoklad - všechny hvězd stejný zářivý výkon, model „Galaxie“



William Herschel

pozorování vybraných směrů, statistické vyhodnocování, hledání obecných zákonitostí v rozložení hvězd, předpoklad - všechny hvězd mají stejné zářivé výkony, jsou rovnoměrně rozloženy v naší hvězdné soustavě, z pozorování zjistil rozdílnost koncentrací hvězd, např. v pásu Mléčné dráhy či ve směru souhvězdí Velké Medvědice → opustil svůj předpoklad konstantní prostorové hustoty hvězd ve všech směrech, stejně jako myšlenku stejné vzdálenosti všech hvězd od sebe, jako Slunce – Sirius, zkoumal také možný pohyb Slunce, prostorový pohyb jasných hvězd, zjistil vzájemné přibližování Arktura a Vegy, naopak Sirius a Aldebaran se od sebe vzdalovaly, předpokládal pohyb Slunce k hvězdě λ Herculis.

William Herschel

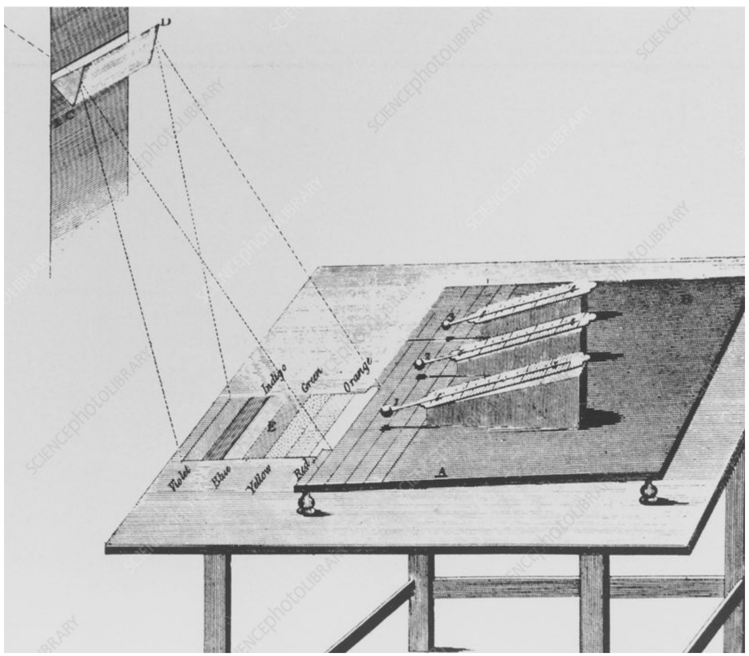
První katalog 1 000 mlhovin Williama Herschela r. 1786, 1789, 1802
Astronomická pozorování týkající se stavby nebes r. 1811

r. 1791:pokus o klasifikaci mlhovin, pravé ze zředěného plynu, nepravé - vzdálené hvězdné soustavy,
pozorování vybraných směrů, statistické vyhodnocování, hledání obecných zákonitostí v rozložení hvězd, Sestra **Lucretia Karolin Herschel 1750 – 1848,** pozorovala samostatně, objevila několik komet,
William zjistil antikorelaci mezi výskytem skvrn v daném roce a cenou obilí na londýnském trhu, skvrny měly být příčinou teplejšího počasí

William Herschel

objev infračerveného záření r. 1800, *měřil teplotu různých barev ve spektru Slunce,*

rozdělení intenzity ve viditelném záření, slabá tečkovaná křivka označená R, **červený obor spektra** uprostřed grafu - písmeno H



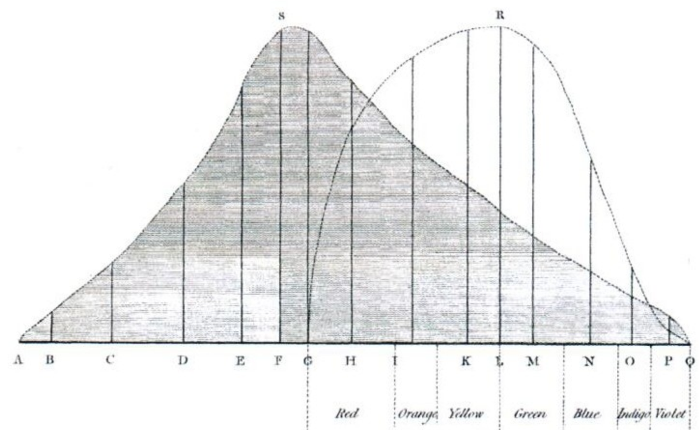
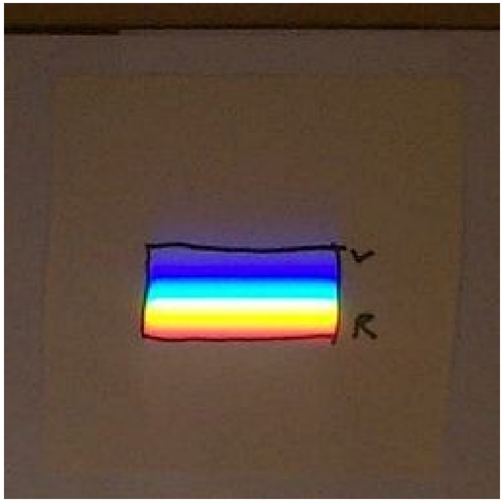
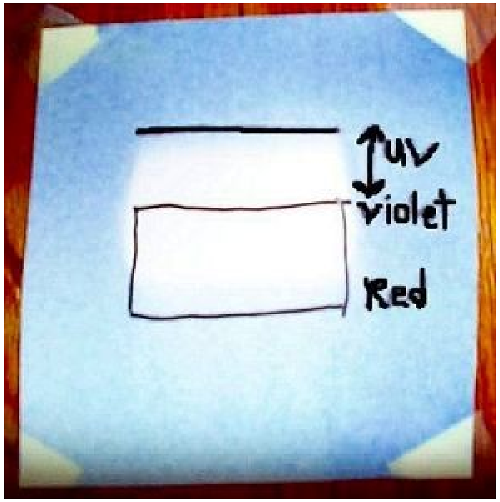


Figure 10. Spectral distribution of visible light and thermal radiation—thermal radiation on the left (A, S, Q, A represents the spectrum of heat), visible light distribution on the right (G, R, Q, G represents the spectrum of visible light)—original drawing from Herschel's article [10].

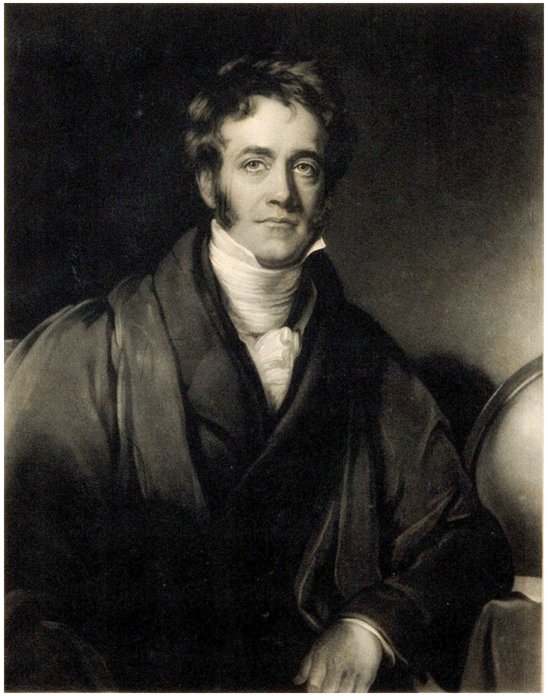
Johann Wilhelm Ritter 1776 - 1810

německý fyzik, objev ultrafialového záření r. 1800



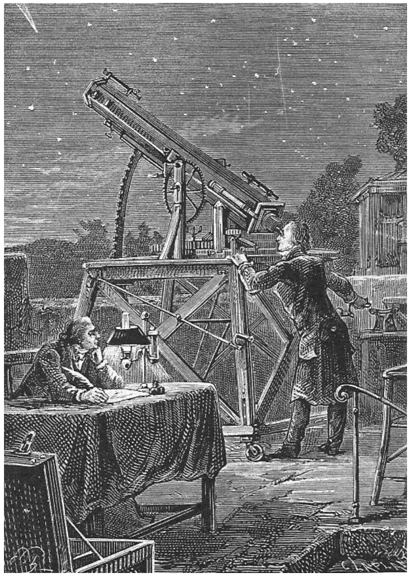


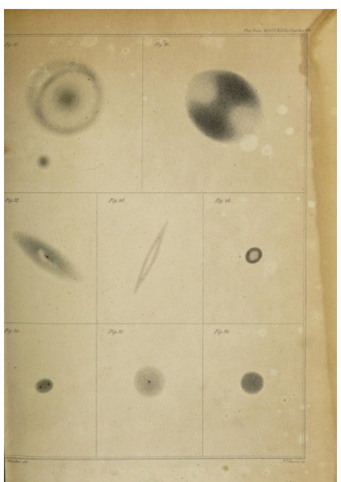
John Frederick William Herschel 1792 - 1871



r. 1834 mys Dobré Naděje, astronomická observatoř, dalekohled o průměru 50 cm, mapování jižní oblohy, rozšíření katalogů mlhovin a hvězdokup, →
Výsledky astronomických pozorování z průběhu let 1834, 5, 6, 7, 8 na Mysu Dobré naděje… r. 1847
autorem domněnky o rotaci Galaxie, první pokus o kalibraci jasnosti hvězd vizuálním fotometrem
zaváděl do praxe využívání fotografické metody, zavedl pojmy *fotografie, pozitiv, negativ*
v červenci 1842 pozoroval v Miláně úplné zatmění Slunce

John Frederick William Herschel





Náčrty astronomie r. 1849, učebnice, 10 x
Obecný katalog mlhovin a hvězdokup r. 1864,
objevil přes 5 000 mlhovin a hvězdokup,
observatoř,
Dopis Karolíny: „*Drahý synovče, jakmile bude Tvůj dalekohled postaven, přeji si, aby ses podíval zda není možné najít něco nápadného v jižní části Štíra. Pamatuji si totiž, že se Tvůj otec několik nocí a let vracel k oblasti v této části oblohy a nemohl si vysvětlit její neobyčejný vzhled. Bylo to více, než jen úplná absence hvězd“*

Stanovení paralaxy hvězd

německý astronom, **Friedrich Wilhelm Bessel 1784 – 1846**
přesné astrometrická měření, aplikace teorie pravděpodobnosti a metody nejmenších čtverců, ***Königsbergské tabulky r. 1930,***

II. A letter from Professor Bessel to Sir J. Herschel, Bart., dated Konigsberg, Oct. 23, 1838.

Esteemed Sir,—Having succeeded in obtaining a long-looked-for result, and presuming that it will interest so great and zealous an explorer of the heavens as yourself, I take the liberty of making a communication to you thereupon. Should you consider this communication of sufficient importance to lay before other friends of Astronomy, I not only have no objection, but request you to do so. With this view, I might have sent it to you through Mr. Baily; and I should have preferred this course, as it would have interfered less with the important affairs claiming your immediate attention on your return to England. But, to you, I can write in my own language, and thus secure my meaning from indistinctness.

After so many unsuccessful attempts to determine the parallax of a fixed star, I thought it worth while to try what might be accomplished by means of the accuracy which my great Fraunhofer Heliometer gives to the observations. I undertook to make this investigation upon the star 61 *Cygni*, which, by reason of its great proper motion, is perhaps the best of all; which affords the advantage of being a double star, and on that account may be observed with greater accuracy; and which is so near the pole that, with the exception of a small part of the year, it can always be observed at night at a sufficient distance from the horizon. I began the comparisons of this star in September 1834, by measuring

Stanovení paralaxy hvězd

Friedrich Wilhelm Bessel, *61 Cyg a, b, r. 1838*

the place of the earth by a. Then the expressions of the distances at the beginning of 1838 are—

For the star $a = \alpha + t\alpha' + a\alpha''$
For the star $b = \beta + t\beta' + a\beta''$

These expressions, as they were at the time of each observation, I have written against the observations; we can, therefore, by inspection, perceive how the observations agree with the theory.

OBSERVATIONS OF THE STAR a.

	1837.					1838.			
1	Aug. 18	462″·050	α−0·369 α′	+0·635 α″	34	May 16	461″·915	α+0·372 α′	+0·661 α″
2	19	1·619	−0·367	+0·624	35	17	2·015	+0·375	+0·680
3	20	1·693	−0·364	+0·611	36	19	1·813	+0·380	+0·701
4	28	1·726	−0·342	+0·513	37	21	1·902	+0·386	+0·721
5	30	1·940	−0·337	+0·487	38	22	1·840	+0·389	+0·730
6	Sept. 4	1·912	−0·323	+0·414	39	23	1·978	+0·392	+0·740
7	8	1·841	−0·312	+0·363	40	June 1	1·879	+0·416	+0·817
8	9	1·597	−0·309	+0·349	41	2	2·100	+0·419	+0·825
9	11	1·633	−0·304	+0·321	42	12	1·867	+0·446	+0·885
10	14	1·779	−0·296	+0·270	43	13	1·951	+0·449	+0·889
11	20	1·502	−0·279	+0·184	44	22	1·658	+0·474	+0·919
12	23	1·814	−0·271	+0·138	45	26	1·886	+0·485	+0·926
13	24	1·591	−0·268	+0·123	46	27	1·940	+0·488	+0·928
14	Oct. 1	1·614	−0·249	+0·012	47	28	2·111	+0·490	+0·928

Stanovení paralaxy hvězd

Friedrich Wilhelm Bessel, *61 Cyg α, β*

OBSERVATIONS OF THE STAR *b*.

	1838.					1838.			
1	Aug. 16	706″·572	β−0·375 β′	+0·436 β″	30	Feb. 1	706″·199	β+0·088 β′	−0·267 β″
2	18	6·434	−0·369	+0·462	31	5	6·123	+0·099	−0·326
3	19	6·783	−0·367	+0·474	32	10	6·127	+0·113	−0·398
4	20	6·684	−0·364	+0·487	33	19	5·887	+0·138	−0·519
5	28	6·147	−0·342	+0·585	34	Mar. 12	6·167	+0·195	−0·749
6	30	6·404	−0·337	+0·609	35	13	5·633	+0·198	−0·758
7	Sept. 4	6·373	−0·323	+0·653	36	May 2	6·083	+0·334	−0·861
8	9	6·650	−0·309	+0·711	37	3	6·075	+0·337	−0·857
9	11	6·296	−0·304	+0·725	38	4	6·214	+0·340	−0·852
10	14	6·567	−0·296	+0·752	39	6	6·303	+0·345	−0·842
11	20	6·594	−0·279	+0·795	40	12	6·301	+0·361	−0·806
12	23	6·517	−0·271	+0·815	41	16	6·270	+0·372	−0·778
13	24	6·354	−0·268	+0·823	42	17	6·094	+0·375	−0·771
14	Oct. 1	6·547	−0·249	+0·855	43	19	6·294	+0·380	−0·754

Stanovení paralaxy hvězd

Friedrich Wilhelm Bessel *61 Cyg α, β*

For the Star *a*.

Mean distance for the beginning of 1838	461″·6094	Mean Error.
Annual variation = +4″·3915−0″·0543	+4 ·3372	±0″·0398
Difference of annual parallax of 61 and *a* ... α″ =	+0 ·3690	±0 ·0283

For the Star *b*.

Mean distance for the beginning of 1838	706 ·2909	
Annual variation = −2″·825+0″·2426	−2 ·5824	±0 ·0434
Difference of annual parallax of 61 and *b* ... β″ =	+0 ·2605	±0 ·0278

The observations seem also to indicate, that the difference of the parallaxes of 61 and *b* is smaller than that of 61 and *a*; which must be the case, indeed, if *b* itself have a sensible parallax greater than *a*. The difference of the computed values of α″ and β″, in fact, exceeds the limits of the probable uncertainty of the observations; but it is to be observed that the probability of *equal* values of α″ and β″ is not so small that we should be inclined to consider the difference of the two as *proved* by the observations. Further observations will increase the weight of both results, and, at the same time, give more accurate values of the annual variations.

Stanovení paralaxy hvězd

Friedrich Wilhelm Bessel, ***61 Cyg α, β, r. 1838***

As the mean error of the annual parallax of 61 *Cygni* (=0″·3136) is only ± 0″·0202, and consequently not $\frac{1}{15}$ of its value computed; and as these comparisons shew that the progress of the influence of the parallax, which the observations indicate, follows the theory as nearly as can be expected considering its smallness, we can no longer doubt that this parallax is sensible. Assuming it 0″·3136, we find the distance of the star 61 *Cygni* from the sun 657700 mean distances of the earth from the sun: light employs 10·3 years to traverse this distance. As the annual proper motion of α *Cygni* amounts to 5″·123 of a great circle, the *relative* motion of this star and the sun must be considerably more than sixteen semidiameters of the earth's orbit, and the star must have a constant aberration of more than 52″. When we shall have succeeded in determining the elements of the motion of both the stars forming the double star, round their common centre of gravity, we shall be able also to determine the sum of their masses. I have

Stanovení paralaxy hvězd

ruský astronom německého původu, **Wilhelm Friedrich Georg Struve, Vasilij Jakovlevič Struve 1793 - 1864**

přesná astrometrická měření, ***Vega* *r.1837***

1840AN....

ASTRONOMISCHE NACHRICHTEN.

№. 396.

Ueber die Parallaxe des Sterns α Lyræ nach Micrometermessungen am grofsen Refractor der Dorpater Sternwarte.

Von Sr. Excellenz dem Herrn würklichen Staatsrath *v. Struve.*

In meinen Mensuris micrometricis stellarum duplicium u. s. w. p. CLIX hatte ich schon im Beginn des Jahres 1837 aus 17maligen mit dem Dorpater Refractor angestellten Messungen des Abstands zwischen α Lyræ und dem kleinen Stern, der 43″ von ihm absteht, den Versuch gemacht, die Parallaxe von α Lyræ, die des kleinen = 0 vorausgesetzt, zu bestimmen. Die daselbst ausgesprochene Hoffnung, dafs fortgesetzte Beobachtungen der Art bald die Parallaxe mit grösserer Sicherheit zu erkennen geben würden, ist in Erfüllung gegangen. In einem Additamentum in mensuras micrometricas, durch welches die Micrometermessungen der zusammengesetzten Sterne bis zu meinem Abgange von der Dorpater Sternwarte fortgeführt sind, und welches ich am $\frac{9\ \text{Oct.}}{27\ \text{Sept.}}$ dieses Jahres der Kaiserl. Akademie überreichte, gehen die Messungen von α Lyræ bis zum 18ten August 1838, so dafs die gegenseitige Stellung der 2 Sterne 96mal micrometrisch bestimmt ist. Der Umstand, dafs für das Gelingen dieser Messungen eine Vereinigung der gröfsten Durchsichtigkeit der Luft mit völliger Ruhe der Bilder erforderlich war, erklärt es, warum die Zahl derselben nicht gröfser geworden.

Aus diesen Messungen liefs sich nun die Parallaxe auf zwiefache Weise ableiten, nemlich sowohl aus den beobachteten Abständen, als aus den gemessenen Richtungen der die beiden Sterne verbindenden Linie gegen den Declinationskreis, den sogenannten Positionswinkeln. Da aber Umstände vor-

Nach Auflösung der 96 Gleichungen nach der Methode der kleinsten Quadrate ergab sich:

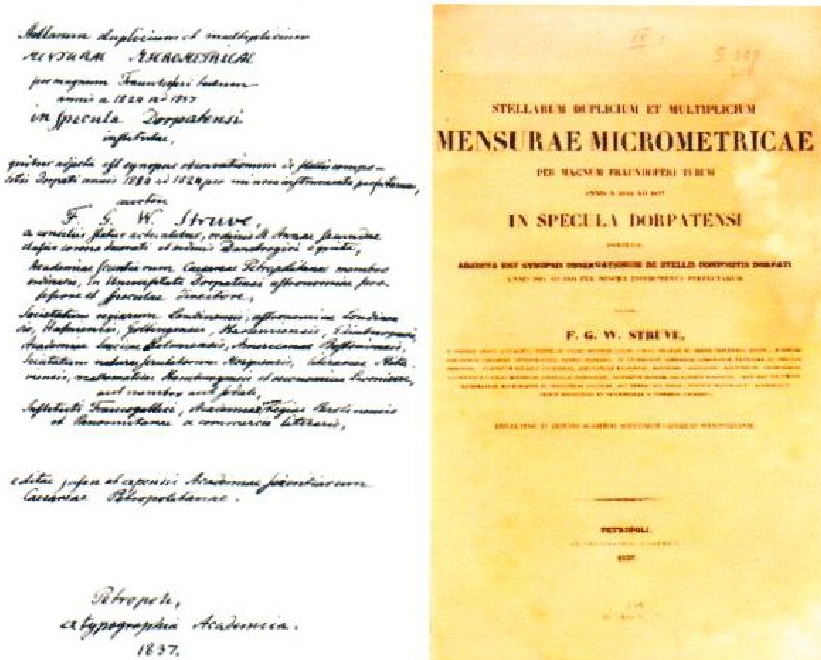
die Parallaxe = 0″2613, mit dem Gewichte 36,74 und dem wahrscheinlichen Fehler 0″0254.

Die Gewichteinheit ist hier das Gewicht eines einmaligen Abstandes, der jedesmal auf 5 Einstellungen zu beiden Seiten des unveränderten Coincidenzpunctes der Fäden bei 38,000 der Scale beruht, und für welchen aus den 96 Gleichungen der wahrscheinliche Fehler sich = 0″154 ergab. Es folgt hieraus, dafs das Fadenmicrometer selbst bei diesen höchst schwierigen Messungen des Abstandes zwischen einem Sterne 1r Gr. und einem 11r Gr. eine ganz ausgezeichnete Genauigkeit gewährte.

Da der für die Parallaxe gefundene Werth mehr als 10mal so grofs ist, als dessen wahrscheinlicher Fehler, da keine constant im Sinne der Parallaxe wirkende Fehlerquelle anzunehmen ist, indem namentlich der Einflufs der Wärme auf den Werth eines Schraubenumgangs mit solcher Genauigkeit bestimmt ist, dafs für 43″ Abstand auch bei den äufsersten Temperaturen keine relative Unsicherheit von 0″001 statt findet, so scheint mir kein Grund übrig zu bleiben, die gefundene Parallaxe in Zweifel zu ziehen, und ich setze ihr zufolge die Entfernung des Sterns α Lyrae vom Sonnensystem gleich 771400 Halbmessern der Erdbahn, welchen Raum das Licht in 12,08 Jahren durchläuft.

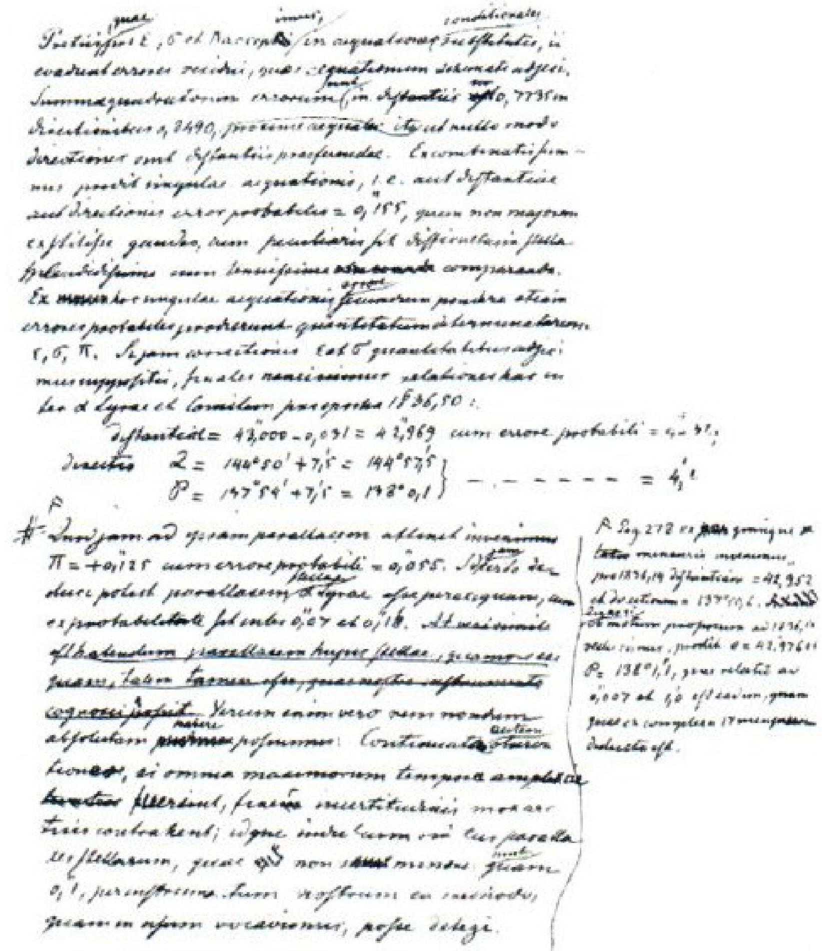
Stanovení paralaxy hvězd

Vasilij Jakovlevič Struve, *Stellarum duplicium et multiplicium, dvojnásobné a vícenásobné hvězdy r. 1837, výpočet paralaxy Vegy r. 1838*


Stellarum duplicium et multiplicium
Mensurae Micrometricae
per magnum Fraunhoferi tubum
annis a 1824 ad 1837
in specula Dorpatensi
institutae
F. G. W. Struve
Petropoli,
ex typographia Academica.
1837.

STELLARUM DUPLICIUM ET MULTIPLICIUM
MENSURAE MICROMETRICAE
PER MAGNUM FRAUNHOFERI TUBUM
IN SPECULA DORPATENSI
F. G. W. STRUVE.
PETROPOLI.
1837

Obr. 3 Titulní list monografie *Stellarum duplicium et multiplicium*… 1837



Obr. 2 Záznam výpočtu paralaxy Vegy

Stanovení paralaxy hvězd

Vasilij Jakovlevič Struve, *r. 1837*

INTELLIGENZBLATT
ZU
Nr. 327. DER ASTRONOMISCHEN NACHRICHTEN.

Stellarum duplicium et multiplicium mensurae micrometricae per magnum *Fraunhoferi* tubum annis a 1824 ad 1837 in specula Dorpatensi institutae

auctore

F. G. W. Struve

editae jussu et expensis Academiae Caesareae Petropolitanae.

Conspectus operis.

A. *Introductio.*

1. *Historia operis.*
2. *Apparatus micrometricus.* Notiones generales. Amplificationes. Fila. Eorum diametri et parallelismus. Contactus observati certitudo. Conjunctio filorum seu Coincidentia. Illuminatio duplex. Pretium revolutionis cochleae. Ejus ex temperatura mutatio.
3. *De motu telescopii parallactico opera horologii effecto.*
4. *Methodus observandi angulos positionis seu directionis inter duas stellas.* Punctum 0 in circulo positionis diviso motui diurno respondens = *T*. Observatio directionis. Correctio ex relatione inter polos coeli et instrumenti. Actio ponderis partium instrumenti in *T*.
5. *Methodus distantiarum observandarum.* Mutationes coincidentiae filorum ex duabus caussis. Methodi mensurarum usitatae pro distantiis, pro differentiis in declinatione. Methodi in minimis distantiis adhibitae.
6. *Accuratior totius operis expositio.* Stellae nonnullae catalogi anni 1827 pro mensuris exclusae variis ex caussis. Earum census. Supplementum II in catalogum. Corrigenda et addenda in catalogo duplicium. Stellarum denuo dissectarum catalogus. Numerus omnium stellarum micrometrice observatarum. Forma diarii originalis. Contractio. Notitiae generales variae mensurarum indolem et usum spectantes. Actio refractionis. Usus calculi probabilitatis in mensuris stellarum multiplicium apte reducendis.
7. *De fide mensurarum micrometricarum hoc opere contentarum.* Actiones athmosphaericae. Calculus errorum probabilium ex mensuris. Synopsis errorum probabilium et distantiarum et directionum in variis ordinibus. Eorum relationes. Usus errorum probabilium ad mutationes inveniendas. Observationes erroneae, earumque emendationes.
8. *De stellarum magnitudinibus.* Notatio magnitudinum. Relatio inter ordines, postremos *Herscheli II* meosque. Relationes inter ordines magnitudinis 1 ad 12. Comparatio inter notationes operis hujus, catalogi 1827 et mapparum Hardingianarum. Errores probabiles in singulis magnitudinum notationibus. Stellae duplices luminis variabilis.

Stanovení paralaxy hvězd

skotský astronom **Thomas Henderson 1798 - 1844,**
přesná astrometrická měření, v Jižní Africe

V. The Parallax of *α Centauri* deduced from Mr. Maclear's Observations at the Cape of Good Hope in the years 1839 and 1840. By Professor Henderson.

An abstract of the principal contents of this paper will be found in Professor Henderson's letter, contained in the last *Monthly Notice*, viz. that for March 1842. In addition, the author gives the following facts relating to the history of the observations of the star *α Centauri*. The earliest recorded observations which he has found are those of Richer, at Cayenne, in 1673, and of Halley, at St. Helena, in 1677; but neither of these astronomers mentions it as being double. Feuillée appears to have been the first person who observed it to be double, his observations being made at Conception, in Chili, in July 1709, with a telescope of 18-feet focal length. He estimates their magnitudes as being of the third and fourth, the smaller star being the more westerly, and their distance as equal to the apparent diameter of the smaller star (*Journal des Observations Physiques*, &c., par Louis Feuillée, tome i. p. 425; Paris, 1714).

Stanovení paralaxy hvězd

Thomas Henderson, Maclear,

XV. *The Parallax of α Centauri, deduced from Mr.* MACLEAR'S *Observations at the Cape of Good Hope, in the Years* 1839 *and* 1840. *By* THOMAS HENDERSON, *F.R.SS.L. and E., Professor of Practical Astronomy in the University of Edinburgh.*

Read April 8, 1842.

ON Mr. MACLEAR receiving my paper on the parallax of *α Centauri* (*Memoirs of Royal Astronomical Society*, Vol. XI. page 61), he immediately commenced a series of observations of that double star, with the view of ascertaining whether the supposed parallax would be confirmed or not. He has lately communicated to me his observations made with the mural circles of the Cape Observatory, extending from March 26th, 1839, to August 12th, 1840. From March 26th to June 28th, 1839, the observations were made with the old mural circle (the instrument with which my observations of declination were made), which is now at the Royal Observatory, Greenwich. Subsequently the observations were made with the new mural circle, formerly at Greenwich, and there known by the name of JONES's circle. Generally, both stars, α^1 and α^2, were observed by direct and reflected vision at the same meridian transit, in the mode adopted at the Observatories of Greenwich, Cambridge, and the Cape, which it is unnecessary to describe here.

Stanovení paralaxy hvězd

Thomas Henderson, paralaxa α Centauri

Mr. Henderson on the Parallax of α Centauri, deduced

Observations made with the new Circle (continued).

Date.	How observed.	Star.	Concluded Reading of Circle.	Barometer.	Thermometer. In.	Thermometer. Out.
1840.				Inches.		
April 30	R	α^1	187° 42′ 21″·11	30·161	63°·7	55°·5
	R	α^2	187 42 31·82			
	D	α^2	60 10 19·58			
	D	α^1	60 10 30·13			
May 1	R	α^1	187 42 21·49	30·158	63·4	59·8
	R	α^2	187 42 31·03			
	D	α^2	60 10 21·16			
	D	α^1	60 10 30·62			
8	R	α^1	187 42 20·55	30·128	60·3	49·4
	R	α^2	187 42 30·69			
	D	α^2	60 10 23·01			
	D	α^1	60 10 33·60			
9	R	α^1	187 42 18·95	30·179	59·3	49·8
	R	α^2	187 42 29·26			
	D	α^2	60 10 23·92			
	D	α^1	60 10 34·03			

Stanovení paralaxy hvězd

Thomas Henderson

V. *On the Parallax of α Centauri.* By THOMAS HENDERSON, *Esq., Astronomer Royal for Scotland, &c. &c.*

Read January 3, 1839.

THE two stars which are designated α^1 and α^2 *Centauri*, are situate within 19 seconds of space of each other.* On comparing the observations of LA CAILLE with those of the present time, it has been found that, although the stars have not sensibly changed their relative positions, each has an annual proper motion of 3″·6 of space. It thus appears that they form a binary system, having one of the greatest proper motions that have been observed; and, from this circumstance, and the brightness of the stars, it is reasonable to suppose that their parallax may be sufficiently sensible to powerful instruments.

On reducing their declinations from my observations made at the Cape of Good Hope, a sensible parallax appeared; but I delayed communicating the result till it should be seen whether it was confirmed by the observations of Right Ascension made by Lieutenant MEADOWS, with the transit instrument; for, as DELAMBRE has remarked, "*il semble qu'on ne sera jamais bien sûr de la parallaxe des étoiles, tant que les ascensions droites ne confirmeront pas les résultats tirés des déclinaisons.*" † I now find that the observations of right ascension also indicate a sensible parallax.

První stanovení paralaxy hvězd - srovnání

Friedrich Wilhelm BESSEL (1784 - 1846)

61 Cygni $\pi = 0{,}314'' \pm 0{,}014''$

13 pozorování; zpráva 1838, publikace 1839,

současná hodnota $\pi = 0{,}2871'' \pm 0{,}0015''$

Vasilij Jakovlevič STRUVE (1793 - 1864)

α Lyrae Vega $\pi = 0{,}125'' \pm 0{,}055''$

40 pozorování, publikace 1837

současná hodnota $\pi = 0{,}1289 \pm 0{,}0005''$

Thomas HENDERSON (1798 - 1844)

α Cen A Rigil Kent $\pi = 1{,}16'' \pm 0{,}11''$

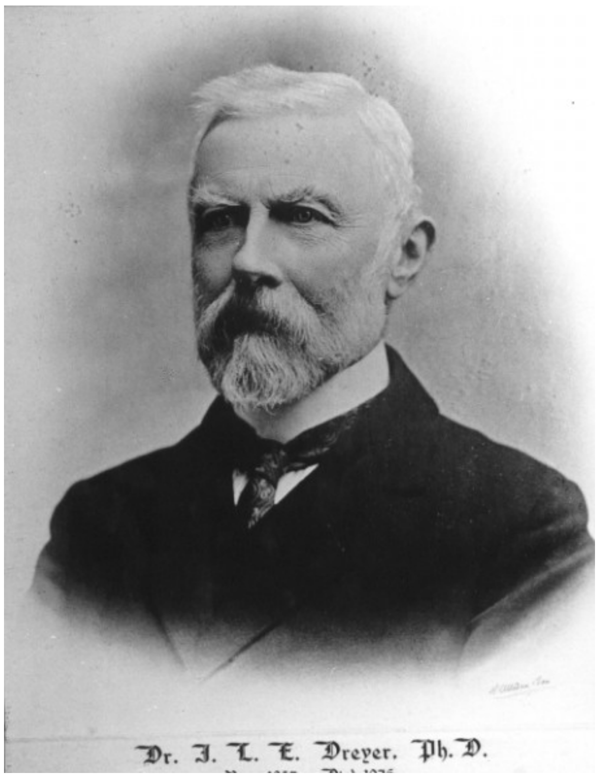
publikace 1839

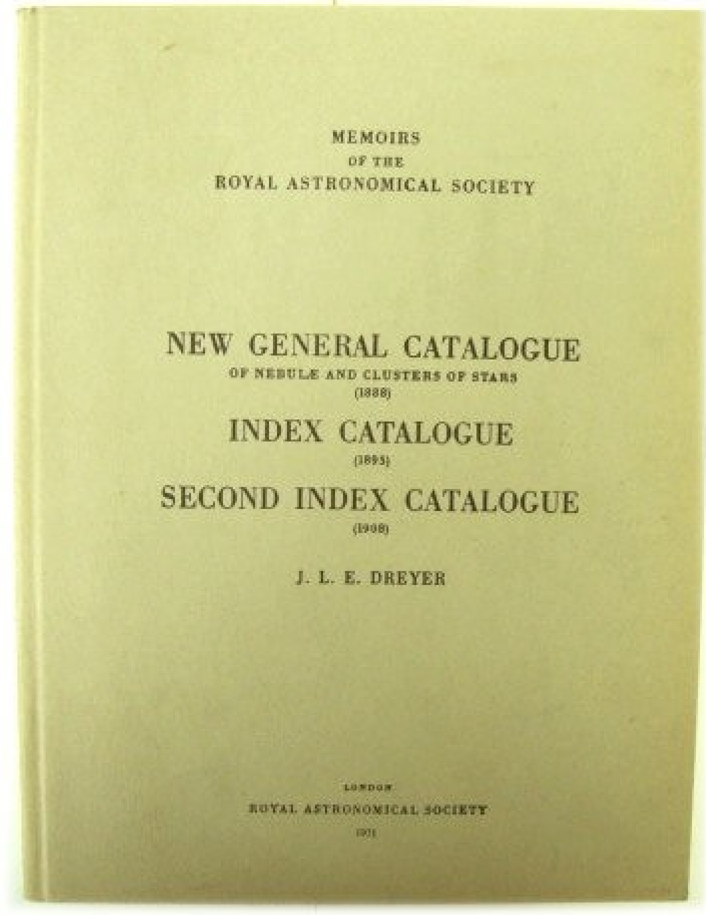
současná hodnota $\pi = 0{,}7421 \pm 0{,}0014''$

John Louis Emil Dreyer 1852 - 1926

irský astronom dánského původu, sestavil The New General Catalogue of Nebulae and Clusters of Stars - **NGC katalog**

Nový obecný katalog mlhovin a hvězdokup, Nový generální katalog r. 1888, obsáhl 7 840 objektů.





John Louis Emil Dreyer

Nový generální katalog, r. 1888, r. 1908 - 13 000 mlhovin

14 Dr. J. L. E. Dreyer, *A New General Catalogue*

Catalogue.

No.	G. C.	J. H.	W. H.	Other Observers.	Right Ascension, 1860·0.	Annual Precession, 1880.	North Polar Distance, 1860·0.	Annual Precession, 1880.	Summary Description.	Notes.
					h m s	s	° ′	″		
1	1	...	...	d'A	0 0 4	+3·07	63 4·3	−20·1	F, S, R, bet ✱11 and ✱14	
2	6246	...	...	Ld R*	0 0 6	3·07	63 6·0	20·1	vF, S, s of G.C. 1	
3	5080	...	...	m 1	0 0 6	3·07	82 28	20·1	F, vS, R, alm stell	
4	5081	...	...	m 2	0 0 16	3·07	82 23	20·1	eF	
5	...	...	...	St XII	0 0 37	3·08	55 25·0	20·1	vF, vS, N = ✱13, 14	
6	...	...	...	Sw II	0 1 5	3·08	58 15·6	20·1	eF, vS, cE	
7	2	4014	...	...	0 1 14	3·07	120 41·2	20·1	eF, cL, mE, vgvlbM	
8	5082	...	...	O Struve	0 1 17	3·08	66 59	20·1	vF, N in n end	
9	5083	...	...	O Struve	0 1 27	3·08	67 0	20·1	F, R, ✱9, 10 sf	
10	3	4015	...	...	0 1 28	3·06	124 38·9	20·1	F, cL, vlE, glbM	
11	...	...	...	St XII	0 1 29	3·08	53 19·9	20·1	vF, vS, vlE, 2 vF st inv	
12	4	1	III 868	...	0 1 34	3·07	86 10·2	20·1	eF, pL, vglbM	
13	5	2	III 866	...	0 1 35	3·08	57 20·8	20·1	vF, vS, S st + neb	
14	7	3	II 591	...	0 1 37	3·08	74 57·9	20·1	vF, pS, R, glbM	
15	5084	...	...	m 3	0 1 50	3·08	69 10	20·1	vF, vS, R, bM	
16	8 = 12	4 = 5	IV 15	...	0 1 52	3·08	63 3·0	20·1	pB, S, R, bM	✱
17	...	...	...	Mu II	0 1 58	3·07	102 54·0	20·1	vF, eS, iR, D ✱ 2′p	
18	5085	...	...	Schultz	0 2 11	3·08	63 2·8	20·1	F, vS, iR, mbM, h4 p19ˢ	✱
19	...	...	...	Sw II	0 2 13	3·08	57 55·6	20·1	eeF, lE, 3 vF st around	
20	6 = 5086	...	...	Ld R, Schultz	0 2 21	3·09	57 28·2	20·1	F, ✱10 at	
21	...	...	...	Sw II	0 2 25	3·08	57 34·1	20·1	eF, S, lE	
22	...	...	...	St XIII	0 2 36	3·08	62 56·9	20·1	vF, pS, R, lbM, r	
23	9	...	III 147	...	0 2 41	3·08	64 51·0	20·1	3 S st + neb	
24	10	2308	III 461	...	0 2 47	3·06	115 45·0	20·1	vF, cL, mE, gbM	
25	11	2309	...	...	0 2 57	3·05	147 48·2	20·1	vF, S, R	
26	5087	...	...	d'A	0 3 14	3·08	64 56·2	20·1	vF, pL, R, 2 F st n	
27	...	...	...	Sw I	0 3 15	3·09	61 47·3	20·1	eF, vS, E, B ✱ nr	
28	13	2310	...	...	0 3 25	3·03	147 46·4	20·1	eF, p of 2	
29	14	6	II 853	...	0 3 32	3·09	57 25·6	20·1	pB, pL, E 0°	
30	5088	...	...	m 4	0 3 38	3·08	68 49	20·1	Neb ✱13	
31	15	2311	...	...	0 3 39	3·02	147 46·4	20·1	eeF, S, R, f of 2	
32	16	...	...	J Schmidt	0 3 42	3·08	71 59·0	20·1	F (Auw. 1)	
33	5089	...	...	m 5	0 3 45	+3·07	87 6	−20·1	eF, vS, or neb st	

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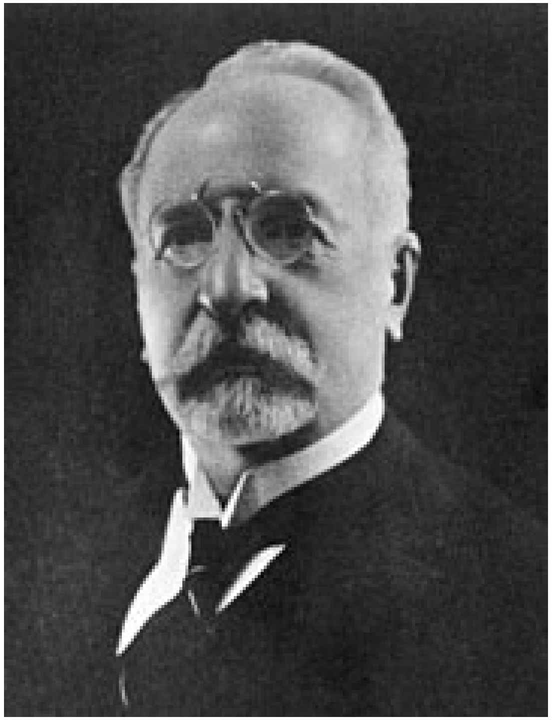
No.	G. C.	J. H.	W. H.	Other Observers.	Right Ascension, 1860·0.	Annual Precession, 1880.	North Polar Distance, 1860·0.	Annual Precession, 1880.	Summary Description.	Notes.
					h m s	s	° ′	″		
5224	3588	1633	III 926	...	13 28 7	+3·01	82 47·8	+18·6	vF, S, ✱9 nf inv?	✱
5225	3599	...	III 822	...	13 28 10	2·42	37 46·6	18·6	cF, pS, iR, lbM	
5226	...	...	...	Dreyer (R)	13 28 13	2·94	75 22·5	18·6	eF, pS, h 1637 sp	
5227	3600	1641	III 928	...	13 28 15	3·05	87 53·3	18·6	vF, S, R	
5228	3601	1642	III 408	...	13 28 17	2·71	54 29·4	18·6	vF, vS, R, f of 2	
5229	...	...	...	Sw III	13 28 23	2·50	41 22·2	18·6	eF, L, mE, v diffic	
5230	3597 = 3602	1639 = 1643	III 87	...	13 28 38	2·94	75 36·2	18·5	F, L, E, vgbM, 3rd of 3	✱
5231	5745	...	...	m 264	13 28 42	3·04	86 18	18·5	F, S, bM	
5232	5746	...	...	m 265	13 28 49	3·14	97 46	18·5	F, vS	
5233	3603	1645	III 425	...	13 28 52	2·71	54 36·8	18·5	F, S, R, vS ✱ nr	
5234	3604	3522	...	...	13 28 52	3·67	139 7·0	18·5	eeF, S, lE	
5235	3605	1644	III 100	...	13 28 58	3·01	82 41·5	18·5	vF, pS, vlE, ✱9 sp	
5236	3606	3523	...	M 83, Lac I 6, Δ 628	13 29 9	3·36	119 9·0	18·5	!! {(H,h) vB, vL, E 55°, esbMN (L) 3 branched spiral}	†
5237	3607	3524	...	...	13 29 21	3·54	132 8·0	18·5	F, pL, cE, vglbM	
5238	3609	...	III 823	...	13 29 27	2·41	37 39·6	18·5	cF, pL, R, vlbM	

Johannes Fritz Hartmann 1865 - 1936

německý astronom, ***Výzkum spektra a dráhy δ Orionis***, ***r. 1904***, spektrální čáry hvězdy posunuty, vápníkové čáry nikoliv – mezihvězdného původu



INVESTIGATIONS ON THE SPECTRUM AND ORBIT OF δ *ORIONIS*.[1]

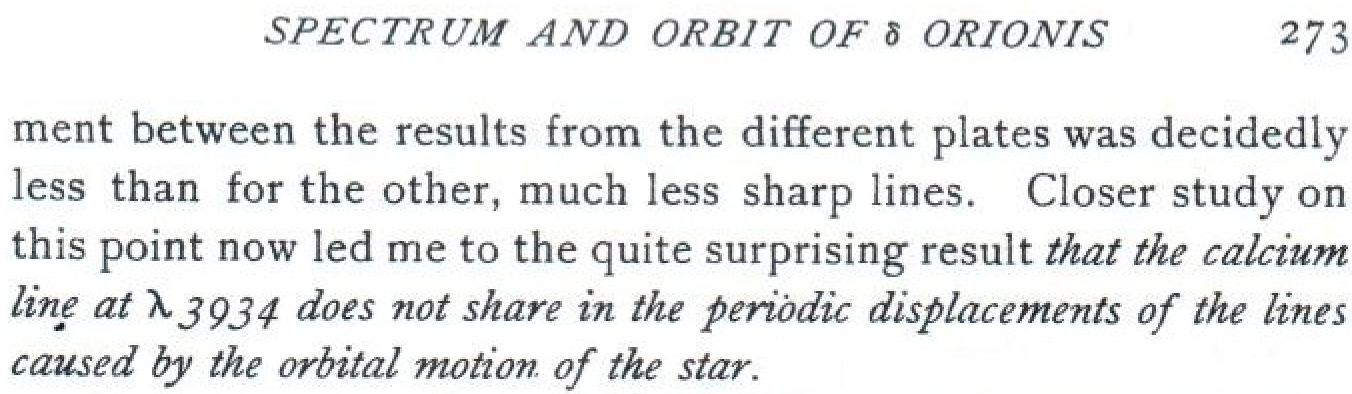
By J. HARTMANN.

ONE of the first results obtained by M. Deslandres with the new spectrograph attached to the 62 cm refractor of the observatory at Meudon was the discovery of the "oscillation" of δ *Orionis*. I use the term "oscillation" in place of the ponderous expression "variability of velocity in the line of sight;" but the idea of oscillation is still somewhat broader, as it includes every sort of periodic variation in the spectrum, without saying anything as to its explanation.

After the publication[2] of the discovery mentioned, which was communicated to the Paris Academy on February 12, 1900, Director Vogel instructed the observers in the field of stellar spectroscopy at Potsdam to undertake to confirm the interesting phenomenon, and the observations made with the four different spectrographs then in use here proved beyond a doubt that δ *Orionis* belongs to the number of oscillating stars. A confirmation of the discovery was also given by three observations by Wright with the Mills spectrograph of the Lick Observatory.

Johannes Fritz Hartmann

německý astronom, ***Výzkum spektra a dráhy δ Orionis***, ***r. 1904***, spektrální čáry hvězdy posunuty, vápníkové nikoliv – mezihvězdný původ, spektrální čára **K** Ca II, λ = 393,4 nm neměla periodické posuvy jako čáry vodíku a helia, vyvolané oběhem složek dvojhvězdy



SPECTRUM AND ORBIT OF δ ORIONIS 273

ment between the results from the different plates was decidedly less than for the other, much less sharp lines. Closer study on this point now led me to the quite surprising result *that the calcium line at λ 3934 does not share in the periodic displacements of the lines caused by the orbital motion of the star.*

Johannes Fritz Hartmann

německý astronom, ***Výzkum spektra a dráhy Orionis*, *r. 1904***, spektrální čáry hvězdy posunuty, vápníkové čáry nikoliv – mezihvězdného původu

column headed II in Table IV, the original measurements being given in column I. In this table I have arranged the plates in order of the values of *V*, the true velocity of the star relative to the Sun, computed from the orbit. The velocities deduced from the calcium line alone are designated by *C′* (relative to the Earth), and *C* (relative to the Sun).

TABLE IV.

Plate Number	*V*	*C′* from λ 3934			Reduction to Sun	*C*	Diff.
		I	II	Mean			
	km	km	km	km	km	km	km
I 247	+ 18.0	+44	+39	+42	−27	+15	− 1
I 254	+ 50.6	....	+44	+44	−27	+17	+ 1
I 153	+ 63.3	+11	+11	+11	+ 9	+20	+ 4
I 485	+133.2	+24	+19	+22	0	+22	+ 6
I 491	+ 63.5	+ 3	+ 7	+ 5	− 1	+ 4	−12
I 495	+ 35.8	....	+38	+38	−14	+24	+ 8
I 204	+ 23.5	+35	+25	+30	−16	+14	− 2
I 231	+ 3.0	....	+40	+40	−25	+15	− 1
I 232	− 61.1	+25	+32	+28	−25	+ 3	−13
I 266	− 66.2	+46	+49	+48	−26	+22	+ 6
I 215	− 65.1	....	+43	+43	−23	+20	+ 4
I 221	− 58.0	....	+42	+42	−24	+18	+ 2
						Mean +16 km	

Norman Robert Pogson 1829 - 1891

anglický astronom později pracující v Indii, ***Magnitudy třiceti šesti malých planet pro první den každého měsíce roku 1857, r. 1856***

12 *Mr. Pogson, Magnitudes of Thirty-six Minor Planets.*

Magnitudes of Thirty-six of the Minor Planets for the First Day of each Month of the Year 1857. By Norman Pogson, Esq., Assistant at the Radcliffe Observatory, Oxford.

(*Communicated by M. J. Johnson, Esq., Radcliffe Observer.*)

No.	Planet.	M.	Jan.	Feb.	Mar.	Apri.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	1858. Jan.
1	Ceres	7·5	7·4	7·1	7·1	7·4	7·8	8·1	8·4	8·6	8·8	8·9	9·0	8·9	8·8
2	Pallas......	7·9	6·8	6·7	6·8	7·1	7·6	8·0	8·4	8·7	9·0	9·1	9·2	9·2	9·1
3	Juno	8·7	9·4	9·4	9·5	9·4	9·4	9·3	9·2	9·1	9·0	8·8	8·6	8·3	8·1
4	Vesta	6·4	7·0	7·3	7·6	8·0	8·2	8·4	8·5	8·5	8·4	8·3	8·1	7·8	7·5
5	Astræa	9·9	12·2	12·3	12·3	12·2	12·0	11·8	11·4	11·0	10·6	10·3	10·2	10·4	10·6
6	Hebe	8·5	9·2	9·1	9·2	9·6	10·0	10·4	10·7	10·9	11·0	11·1	11·0	10·9	10·7
7	Isis........	8·5	10·5	10·2	9·9	9·7	9·7	9·9	10·3	10·6	10·8	11·0	11·1	11·1	11·0
8	Flora	8·7	10·4	10·4	10·4	10·3	10·2	10·1	9·9	9·7	9·5	9·3	8·9	8·6	8·4
9	Metis......	8·7	10·5	10·6	10·5	10·5	10·3	10·1	9·9	9·5	9·1	8·7	8·2	7·9	8·0
10	Hygeia	9·8	11·1	11·3	11·4	11·4	11·4	11·3	11·1	10·9	10·6	10·3	10·3	10·4	10·7
11	Parthenope .	9·6	10·6	10·2	10·1	10·3	10·6	11·0	11·2	11·4	11·5	11·6	11·5	11·4	11·3
12	Victoria	9·8	11·2	10·9	10·5	10·1	9·6	9·1	8·7	8·4	8·4	8·9	9·5	10·1	10·6
13	Egeria	9·7	11·4	11·2	11·0	10·7	10·3	10·1	10·2	10·4	10·8	11·1	11·4	11·6	11·7
14	Irene	9·8	11·8	12·0	12·1	12·1	12·1	11·9	11·7	11·4	11·1	10·7	10·4	10·3	10·5
15	Eunomia ...	8·5	8·2	8·7	9·0	9·3	9·6	9·8	9·9	10·0	10·0	9·9	9·8	9·6	9·3
16	Psyche.....	10·0	10·7	10·5	10·5	10·7	11·1	11·4	11·7	11·9	12·0	12·0	12·0	11·9	11·7
17	Thetis	9·9	11·3	11·3	11·3	11·2	11·0	10·8	10·5	10·2	10·0	10·0	10·3	10·7	11·2
18	Melpomene .	9·4	9·0	9·6	10·1	10·6	10·9	11·2	11·5	11·6	11·7	11·7	11·6	11·4	11·1
19	Fortuna	9·5	9·6	10·0	10·3	10·6	10·8	11·0	11·1	11·2	11·2	11·1	11·0	10·7	10·4
20	Massilia....	9·2	9·1	9·5	9·8	10·1	10·3	10·4	10·6	10·7	10·7	10·7	10·6	10·5	10·3
21	Lutetia	10·5	10·9	11·4	11·8	12·2	12·5	12·7	12·8	12·9	12·9	12·8	12·6	12·3	12·0
22	Calliope....	10·2	11·1	11·3	11·4	11·4	11·4	11·3	11·1	10·9	10·6	10·3	9·9	9·7	9·7
23	Thalia	10·7	11·0	11·3	11·4	11·5	11·6	11·6	11·5	11·5	11·4	11·3	11·1	10·9	10·7
24	Themis	11·6	12·3	12·6	12·8	12·9	12·9	12·9	12·8	12·6	12·4	12·1	11·7	11·3	11·1
25	Phocea.....	10·7	12·0	11·6	11·1	10·6	10·0	9·5	9·2	9·2	9·5	9·9	10·4	10·9	11·3
26	Proserpine..	10·8	11·3	10·9	10·6	10·6	10·9	11·2	11·5	11·8	12·0	12·1	12·2	12·2	12·1
27	Euterpe....	10·2	11·7	11·8	11·8	11·8	11·7	11·6	11·4	11·2	11·0	10·8	10·4	10·1	9·7
28	Bellona	10·3	11·7	11·9	11·9	12·0	11·9	11·7	11·5	11·3	10·9	10·5	10·1	9·7	9·6
29	Amphitrite .	9·1	9·0	9·4	9·8	10·1	10·4	10·6	10·7	10·8	10·8	10·8	10·6	10·4	10·1
30	Urania.....	10·1	12·1	11·8	11·5	11·1	10·8	10·7	11·0	11·3	11·6	11·8	12·0	12·1	12·1
31	Euphrosyne.	11·3	12·6	12·4	12·1	11·9	11·8	12·0	12·3	12·6	12·9	13·2	13·3	13·4	13·4
32	Pomona	11·0	12·4	12·2	12·0	11·7	11·4	11·1	10·9	11·1	11·5	11·9	12·3	12·6	12·8
33	Polyhymnia.	11·2	13·2	12·9	12·7	12·7	12·8	13·1	13·3	13·4	13·5	13·5	13·4	13·3	13·0
34	Circe	11·6	13·5	13·6	13·7	13·6	13·5	13·3	13·0	12·7	12·3	12·0	11·8	12·0	12·3
35	Atalanta....	12·5	13·1	12·9	12·9	13·1	13·6	14·0	14·4	14·6	14·8	15·0	15·0	14·9	14·8
36	Fides	10·8	11·0	10·7	10·7	11·0	11·4	11·9	12·3	12·6	12·8	12·9	13·0	13·0	12·9

Norman Robert Pogson

Magnitudy třiceti šesti malých planet pro první den každého měsíce roku 1857, r. 1856

tance. It must, however, be remembered, that an error in the assumed value of M for any planet will cause a corresponding error in the ephemeris throughout the year, and at present these quantities are by no means satisfactorily determined, especially for the more recently discovered planets. But, perhaps, the greatest use of such an ephemeris will be on the occasion of the earliest observations after conjunction, when an approximate knowledge of the magnitude may save the annoyance of mistaking an adjacent star for the object sought, an accident of too common occurrence even to experienced observers. Six planets have been omitted for want of ephemerides: for one of these, *Daphne*, no elements have yet been computed. For the remaining five, the numbers M may be taken as follows:—*Leucothæa*, 12·5; *Leda*, 11·5; *Lætitia*, 8·8; *Harmonia*, 8·5; and *Isis*, 10·3. Their magnitudes at any time may then be found by the formula,—

$$m = M - 5 \log (a \,.\, \overline{a - 1}) + 5 (\log r + \log \Delta).$$

The magnitude-ephemeris will also be a severe test of the truth of the adopted light ratio; for if that ratio be really the one employed by the majority of observers, the correction for any one planet will be the constant one due to the number in the column M; but if, on

Williamina Paton Fleming 1857 - 1911

americká astrofyzička původem ze Skotska***, Fotografická studia proměnných hvězd r. 1907,*** cefeidy, stanovení vzdálenosti

ANNALS

OF

THE ASTRONOMICAL OBSERVATORY OF HARVARD COLLEGE

VOLUME XLVII — PART I

A PHOTOGRAPHIC STUDY OF VARIABLE STARS

FORMING A PART OF

THE HENRY DRAPER MEMORIAL

PREPARED BY

WILLIAMINA P. FLEMING

CURATOR OF ASTRONOMICAL PHOTOGRAPHS

UNDER THE DIRECTION OF

EDWARD C. PICKERING

DIRECTOR OF THE OBSERVATORY

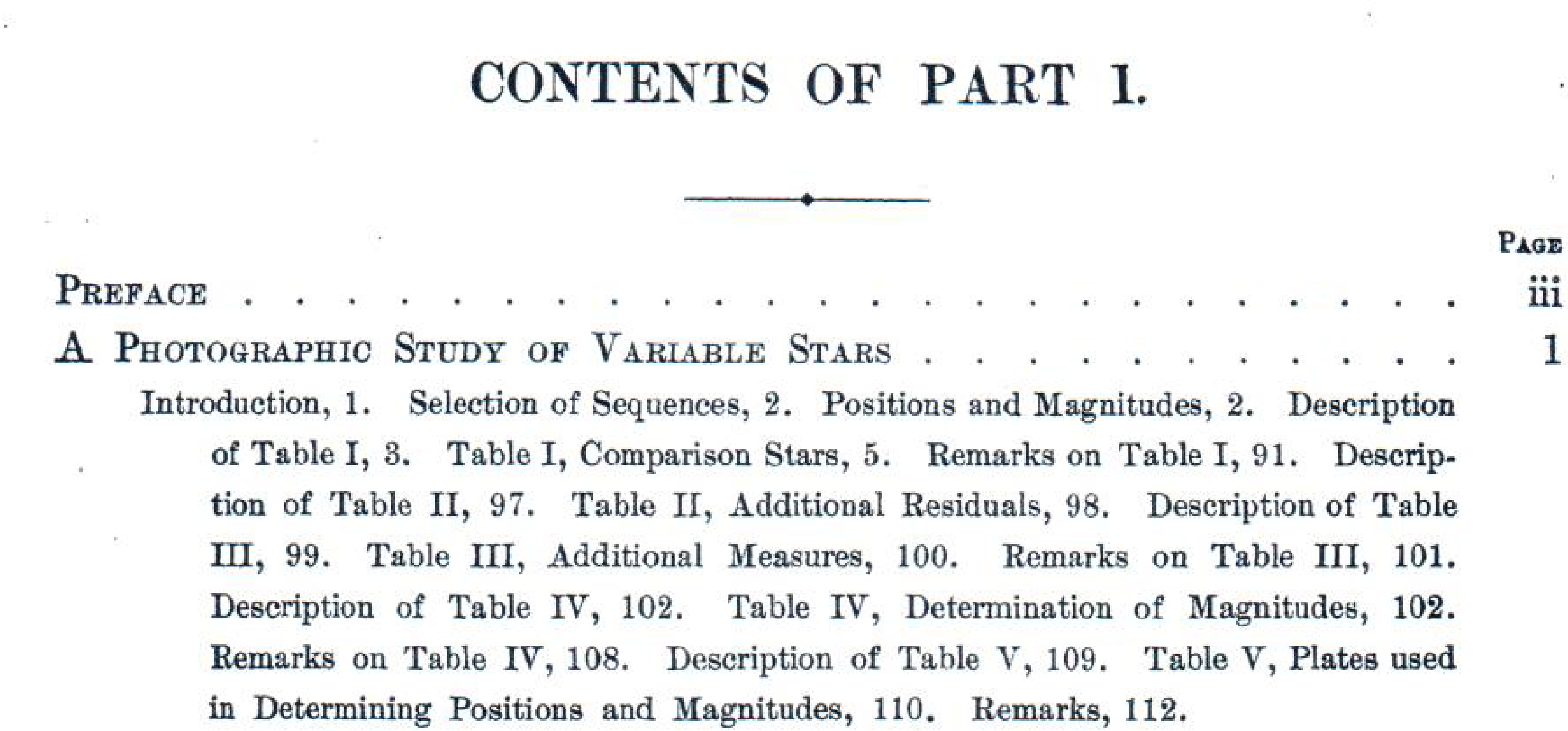
CAMBRIDGE, MASS.

Published by the Observatory

1907

Williamina Paton Fleming

Fotografická studia proměnných hvězd r. 1907



CONTENTS OF PART I.

Williamina Paton Fleming

Fotografická studia proměnných hvězd r. 1907, cefeidy, stanovení vzdálenosti

THE examination of the photographs of the Henry Draper Memorial has led to the discovery of a large number of variable stars of long period. The greater portion of these has been found from the characteristic spectrum, Md, which indicates the third type traversed by bright hydrogen lines. While many variable stars of long period have spectra of the fourth type, and a few have spectra of the third type in which the hydrogen lines are not bright in the photographs, no case has yet been found in which a star having the spectrum, Md, described above, is not variable. The number of these stars, and the fact that many of them were too far south for observation in Cambridge, rendered it necessary that their positions and variations in light should be determined photographically. The collection of photographs stored at Cambridge furnished excellent means for doing this. When a new variable is discovered in any portion of the sky we generally have from one to two hundred photographs of the region from which its position and brightness can be determined. The methods employed have been described in Volume XXVI, Chapters XII and XIII. When a star was found whose spectrum was of the third type having also bright hydrogen lines, the photograph was laid upon the corresponding chart of the Durchmusterung, and the approximate position was read. It was then looked for in a card catalogue in which all known variables had been entered. When the star was not contained in this catalogue, about a dozen chart plates of the region were selected, and the image of the object was compared with those of adjacent stars on each plate. When the evidence of variability was unmis-

Williamina Paton Fleming

Fotografická studia proměnných hvězd r. 1907, cefeidy, stanovení vzdálenosti

Des.	Cat. No.	Magn.	R. A.	Dec.	x	y	Δx	Δy	x	y	Δα	Δδ	Mean.	Resid.	Magn.
6. U Persei. R. A. $1^h\ 53^m.0$, Dec. +54° 20′.															
			h. m. s.	° ′					″	″	s.	″			
V	+54°431	9.0	1 49 59.7	+54 7.0	5.69	3.27	01,01	02,02	0	0	..	..	..	....	..
a	+53°440	7.9	1 53 47.7	+53 59.7	6.60	0.68	00,00	03,02	+2003	− 422	..	..	82	1101	8.48
b	+54°439	9.1	1 52 27.2	+54 1.5	2.30	1.30	00,00	00,00	+1302	− 321	..	..	32	1200	9.30
c	+54°438	9.0	1 52 19.0	+54 5.4	1.80	2.75	00,00	00,00	+1221	− 85	..	..	30	0011	9.62
d	+54°435	9.5	1 51 50.5	+54 4.6	0.30	2.35	00,00	00,00	+ 976	− 150	..	..	65	0110	9.92
e	.. ..	..	.. .. ..	.. .. ..	3.58	1.48	02,03	03,02	+ 344	− 292	..	..	25	0101	10.57
f	.. ..	..	.. .. ..	.. .. ..	5.00	2.72	00,00	02,03	+ 112	− 90	..	..	22	0010	10.82
g	.. ..	..	.. .. ..	.. .. ..	3.50	2.90	00,00	00,00	+ 357	− 60	..	..	30	0000	11.04
h	.. ..	..	.. .. ..	.. .. ..	5.35	6.22	00,00	03,02	+ 55	+ 481	..	..	25	1001	11.34
k	.. ..	..	.. .. ..	.. .. ..	5.70	6.82	00,00	03,02	− 2	+ 579	..	..	30	0000	11.59
l	.. ..	..	.. .. ..	.. .. ..	4.65	5.58	00,00	02,03	+ 170	+ 377	..	..	..	....	11.89
7. V Persei. R. A. $1^h\ 55^m.1$, Dec. +56° 15′.															
			h. m. s.	° ′					″	″	s.	″			
V	.. ..	..	1 52 4.1	+56 2.0	2.25	3.25	00,00	00,00	0	0	..	..	..	....	..
a	+56°416	8.7	1 54 48.4	+56 23.4	9.90	10.32	00,00	03,02	+1369	+1266	0.2	18	40	0000	8.63
b	+56°417	8.8	1 54 56.6	+56 18.7	10.30	8.78	00,00	02,03	+1441	+ 990	0.6	12	52	1101	9.03
c	+55°486	9.1	1 54 43.2	+55 51.0	....	....	....	....	....	....	..	..	35	1111	9.55
d	.. ..	..	.. .. ..	.. .. ..	1.80	4.90	00,00	00,00	− 81	+ 295	..	..	20	3151	9.90
e	+56°403	9.4	1 51 2.6	+56 15.8	0.60	8.05	00,00	00,00	− 510	+ 859	0.4	30	68	1240	10.10
f	+56°404	9.5	1 51 21.0	+56 4.8	0.18	4.18	03,02	03,02	− 371	+ 166	1.3	0	18	2012	10.78
g	.. ..	..	.. .. ..	.. .. ..	1.10	3.50	00,00	00,00	− 206	+ 45	..	..	68	3121	10.96
h	.. ..	..	.. .. ..	.. .. ..	1.30	3.65	00,00	00,00	− 170	+ 72	..	..	40	000.	11.64
k	.. ..	..	.. .. ..	.. .. ..	0.30	3.70	00,00	00,00	− 349	+ 81	..	..	50	00..	12.04
l	.. ..	..	.. .. ..	.. .. ..	2.15	4.62	00,00	03,02	− 18	+ 245	..	..	35	01..	12.54
m	.. ..	..	.. .. ..	.. .. ..	2.70	3.62	00,00	03,02	+ 81	+ 66	..	..	..	....	12.89

Henrietta Swan Leavitt 1868 - 1921

americká astrofyzička***, 1777 proměných hvězd v Magellanových oblacích r. 1908, Periody 25 proměnných hvězd v Malém Magellanově oblaku r. 1912***

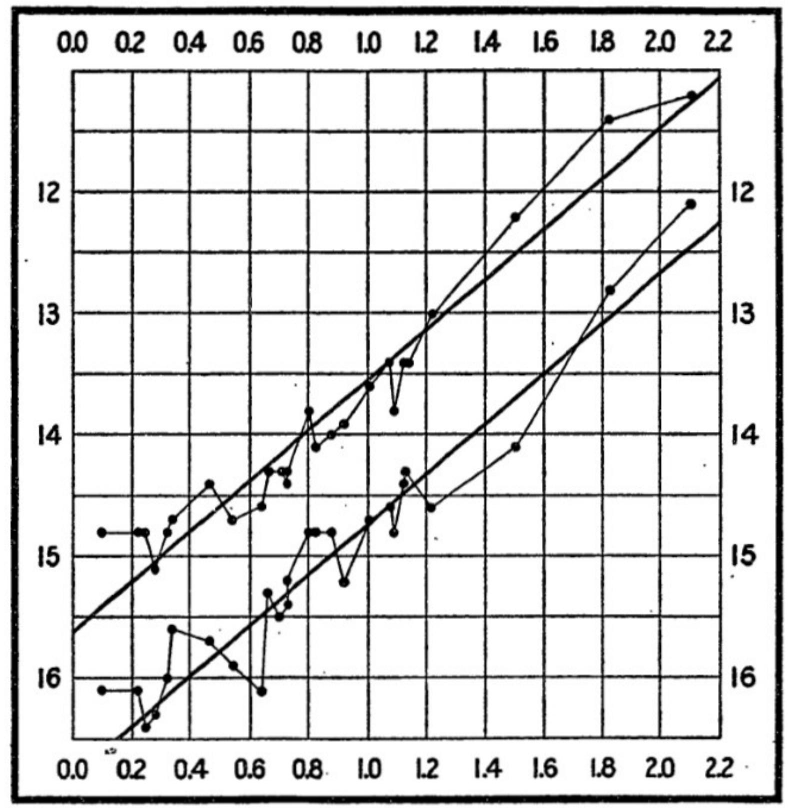


FIG. 2.

Henrietta Swan Leavitt

1777 proměnných hvězd v Magellanových oblacích r. 1908

ANNALS OF HARVARD COLLEGE OBSERVATORY. VOL. LX. NO. IV.

1777 VARIABLES IN THE MAGELLANIC CLOUDS.

BY HENRIETTA S. LEAVITT.

IN the spring of 1904, a comparison of two photographs of the Small Magellanic Cloud, taken with the 24-inch Bruce Telescope, led to the discovery of a number of faint variable stars. As the region appeared to be interesting, other plates were examined, and although the quality of most of these was below the usual high standard of excellence of the later plates, 57 new variables were found, and announced in Circular 79. In order to furnish material for determining their periods, a series of sixteen plates, having exposures of from two to four hours, was taken with the Bruce Telescope the following autumn. When they arrived at Cambridge, in January, 1905, a comparison of one of them with an early plate led immediately to the discovery of an extraordinary number of new variable stars. It was found, also, that plates, taken within two or three days of each other, could be compared with equally interesting results, showing that the periods of many of the variables are short. The number thus discovered, up to the present time, is 969. Adding to these 23 previously known, the total number of variables in this region is 992. The Large Magellanic Cloud has also been examined on 18 photographs taken with the 24-inch Bruce Telescope, and 808 new variables have been found, of which 152 were announced in Circular 82. As much time will be required for the discussion of these variables, the provisional catalogues given below have been prepared.

Henrietta Swan Leavitt

Periody 25 proměnných hvězd v Malém Magellanově oblaku r. 1912

A selection of catalogue stars in the region of the Small Magellanic Cloud is contained in Table I, in which the first three columns give the number in the Argentine General Catalogue, the right ascension, and the declination for 1900. Unfortunately, a large proportion of the stars are double, although the photographic images give no evidence of the fact. The positions in the Table are, in such cases, those of the preceding components as given in the Catalogue. The fourth and fifth columns give the coordinates in x and y, as measured from the south-preceding corner of the plate. The approximate centre of the plate has the coordinates, $x = 12752''$, $y = 10393''$, and its position is in R.A. $= 0^h\ 50^m.9$, Dec. $= -73°\ 7'$ (1900). Owing to the great distance of the region from the equator, the order of the coordinates in x frequently differs from that of right ascension.

Henrietta Swan Leavitt

Periody 25 proměnných hvězd v Malém Magellanově oblaku r. 1912

HARVARD COLLEGE OBSERVATORY.

CIRCULAR 173.

PERIODS OF 25 VARIABLE STARS IN THE SMALL MAGELLANIC CLOUD.

The following statement regarding the periods of 25 variable stars in the Small Magellanic Cloud has been prepared by Miss Leavitt.

A Catalogue of 1777 variable stars in the two Magellanic Clouds is given in H.A. 60, No. 4. The measurement and discussion of these objects present problems of unusual difficulty, on account of the large area covered by the two regions, the extremely crowded distribution of the stars contained in them, the faintness of the variables, and the shortness of their periods. As many of them never become brighter than the fifteenth magnitude, while very few exceed the thirteenth magnitude at maximum, long exposures are necessary, and the number of available photographs is small. The determination of absolute magnitudes for widely separated sequences of comparison stars of this degree of faintness may not be satisfactorily completed for some time to come. With the adoption of an absolute scale of magnitudes for stars in the North Polar Sequence, however, the way is open for such a determination.

Henrietta Swan Leavitt

Periody 25 proměnných hvězd v Malém Magellanově oblaku r. 1912

have the longer periods, but at that time it was felt that the number was too small to warrant the drawing of general conclusions. The periods of 8 additional variables which have been determined since that time, however, conform to the same law.

TABLE I.

PERIODS OF VARIABLE STARS IN THE SMALL MAGELLANIC CLOUD.

H.	Max.	Min.	Epoch.	Period.	Res. *M*.	Res. *m*.	H.	Max.	Min.	Epoch.	Period.	Res. *M*.	Res. *m*.
			d.	d.						d.	d.		
1505	14.8	16.1	0.02	1.25336	−0.6	−0.5	1400	14.1	14.8	4.0	6.650	+0.2	−0.3
1436	14.8	16.4	0.02	1.6637	−0.3	+0.1	*1355*	14.0	14.8	4.8	7.483	+0.2	−0.2
1446	14.8	16.4	1.38	1.7620	−0.3	+0.1	1374	13.9	15.2	6.0	8.397	+0.2	−0.3
1506	15.1	16.3	1.08	1.87502	+0.1	+0.1	818	13.6	14.7	4.0	10.336	0.0	0.0
1413	14.7	15.6	0.35	2.17352	−0.2	−0.5	*1610*	13.4	14.6	11.0	11.645	0.0	0.0
1460	14.4	15.7	0.00	2.913	−0.3	−0.1	*1365*	13.8	14.8	9.6	12.417	+0.4	+0.2
1422	14.7	15.9	0.6	3.501	+0.2	+0.2	*1351*	13.4	14.4	4.0	13.08	+0.1	−0.1
842	14.6	16.1	2.61	4.2897	+0.3	+0.6	827	13.4	14.3	11.6	13.47	+0.1	−0.2
1425	14.3	15.3	2.8	4.547	0.0	−0.1	*822*	13.0	14.6	13.0	16.75	−0.1	+0.3
1742	14.3	15.5	0.95	4.9866	+0.1	+0.2	823	12.2	14.1	2.9	31.94	−0.3	+0.4
1646	14.4	15.4	4.30	5.311	+0.3	+0.1	824	11.4	12.8	4.	65.8	−0.4	−0.2
1649	14.3	15.2	5.05	5.323	+0.2	−0.1	821	11.2	12.1	97.	127.0	−0.1	−0.4
1492	13.8	14.8	0.6	6.2926	−0.2	−0.4							

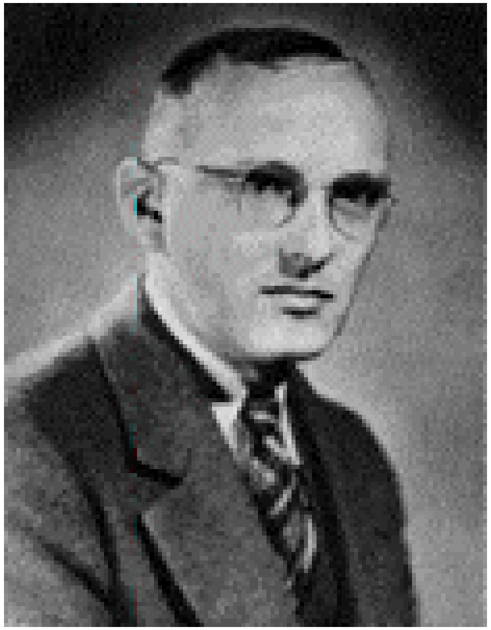
Henrietta Swan Leavitt

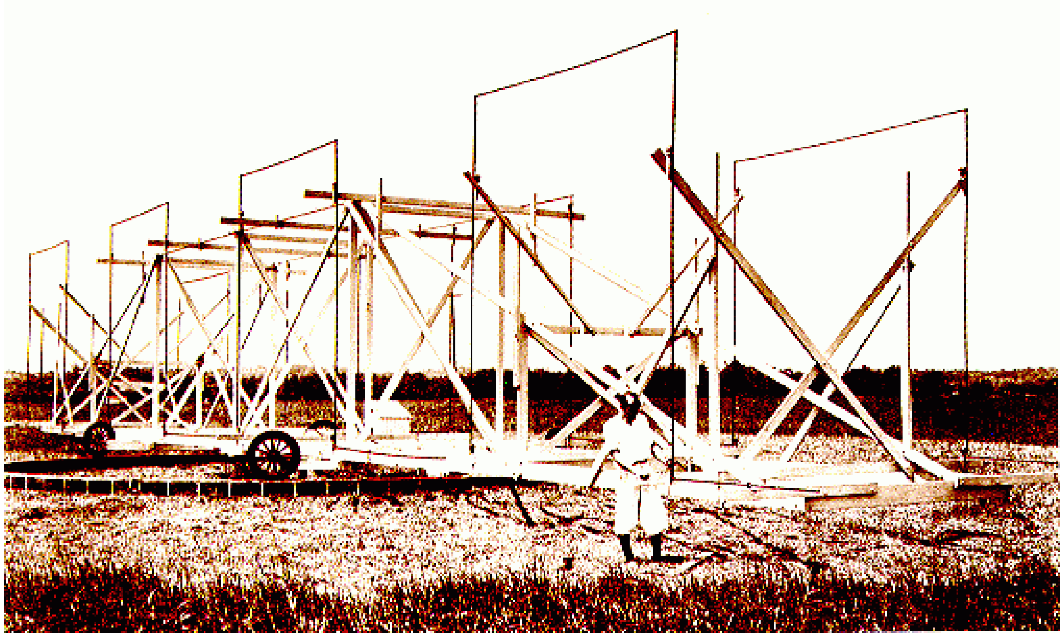
Periody 25 proměnných hvězd v Malém Magellanově oblaku r. 1912

A selection of catalogue stars in the region of the Small Magellanic Cloud is contained in Table I, in which the first three columns give the number in the Argentine General Catalogue, the right ascension, and the declination for 1900. Unfortunately, a large proportion of the stars are double, although the photographic images give no evidence of the fact. The positions in the Table are, in such cases, those of the preceding components as given in the Catalogue. The fourth and fifth columns give the coordinates in x and y, as measured from the south-preceding corner of the plate. The approximate centre of the plate has the coordinates, $x = 12752''$, $y = 10393''$, and its position is in R.A. $= 0^h\ 50^m.9$, Dec. $= -73°\ 7'$ (1900). Owing to the great distance of the region from the equator, the order of the coordinates in x frequently differs from that of right ascension.

Karl Guthe Jansky 1905 - 1950

americký fyzik, radioinženýr, objev rádiové záření z centra Galaxie, r. 1932, λ = 14,6 m





Karl Guthe Jansky

Rádiové vlny mimo Sluneční soustavu r. 1933

Radio Waves from Outside the Solar System

IN a recent paper[1] on the direction of arrival of high-frequency atmospherics, curves were given showing the horizontal component of the direction of arrival of an electromagnetic disturbance, which I termed hiss type atmospherics, plotted against time of day. These curves showed that the horizontal component of the direction of arrival changed nearly 360° in 24 hours and, at the time the paper was written, this component was approximately the same as the azimuth of the sun, leading to the assumption that the source of this disturbance was somehow associated with the sun.

Records have now been taken of this phenomenon for more than a year, but the data obtained from them are not consistent with the assumptions made in the above paper. The curves of the horizontal component of the direction of arrival plotted against time of day for the different months show a uniformly progressive shift with respect to the time of day, which at the end of one sidereal year brings the curve back to its initial position. Consideration of this shift and the shape of the individual curves leads to the conclusion that the direction of arrival of this disturbance remains fixed in space, that is to say, the source of this noise is located in some region that is stationary with respect to the stars. Although the right ascension of this region can be determined from the data with considerable accuracy, the error not being greater than ± 30 minutes of right ascension, the limitations of the apparatus and the errors that might be caused by the ionised layers of the earth's atmosphere and by attenuation of the waves in passing over the surface of the earth are such that the declination of the region can be determined only very approximately. Thus the value obtained from the data might be in error by as much as ± 30°.

The data give for the co-ordinates of the region from which the disturbance comes, a right ascension of 18 hours and declination of − 10°.

A more detailed description of the experiments and the results will be given later.

KARL G. JANSKY.

Bell Telephone Laboratories, Inc.,
New York, N. Y.
May 8.

[1] Karl G. Jansky, "Directional Studies of Atmospherics at High Frequencies", *Proc. Inst. Rad. Eng.*, **20**, 1920; 1932.

are made from one sheet of paper, it will only be necessary to calibrate one of them. The change in weight, after transferring from 40 per cent humidity, expressed as a percentage of the weight at 40 per cent, will be the same for all the hygrometers exposed to any particular humidity.

There are many applications for this method of hygrometry. It is possible to measure the humidity at the surface of a leaf, or among vegetation, without disturbing the air.

KENNETH MELLANBY.

Department of Entomology,
London School of Hygiene
and Tropical Medicine,
Keppel Street, W.C.1.
May 26.

Co-operative Industrial Research

THE leading article in NATURE of June 10 on this subject appears to me to be of profound significance. It brings into prominence the fundamental issues in regard to industrial research and the application of science to industry, which are so seldom taken into consideration.

I do not write in any critical spirit, but I feel that the end of the War left us—statesmen, administrators, scientific workers, and the nation at large—obsessed with the idea that the benefits to be derived from the application of science to industry were mainly external to the human mind and purely materialistic. We were very confident then that the so-called rationalisation of industry, the elimination of hand labour, the development of machinery and processes and the standardisation of mass-produced articles, were going to make us all happy and prosperous. A good many industrialists have learned since then that cheapness and efficiency in production are by no means everything; it is what is produced that matters most.

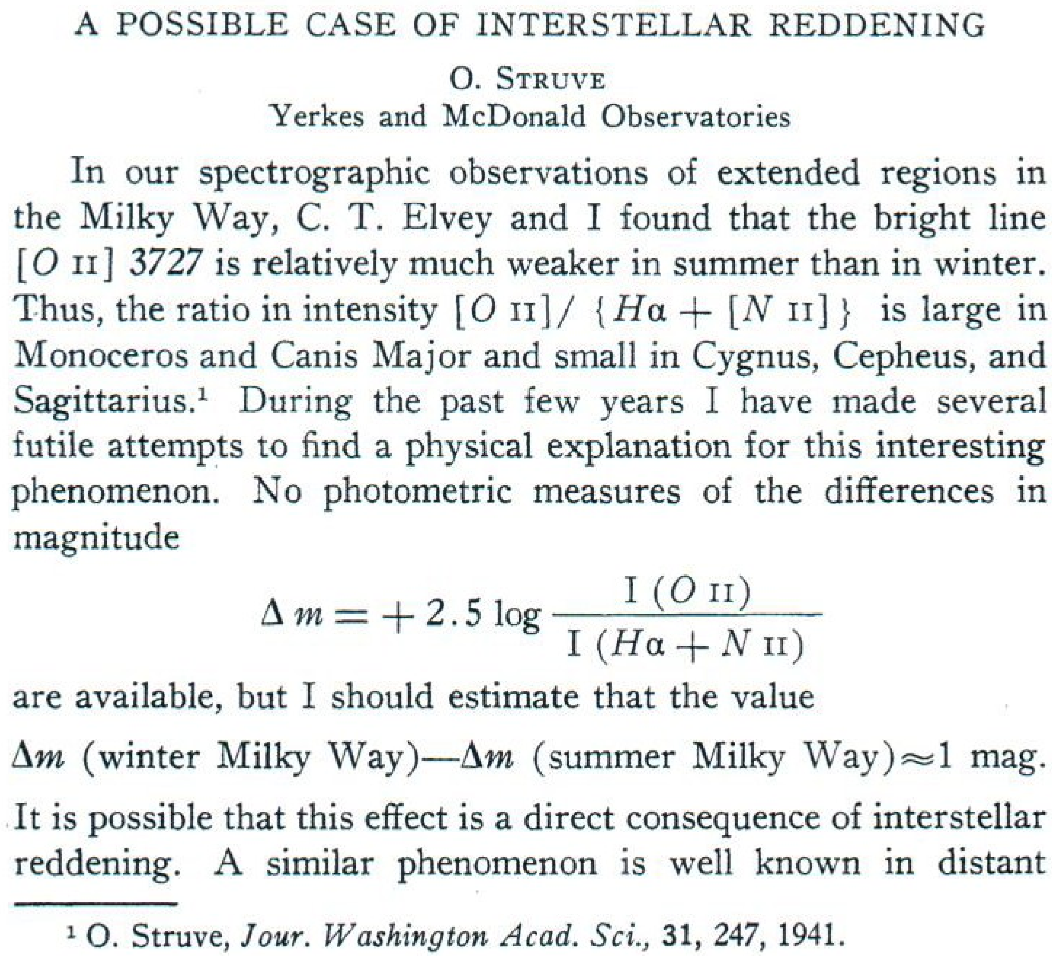
The vital thing about any manufactured product is the purpose it serves in the life of man, not the processes of its manufacture. Consideration of purpose leads to the investigation of design. Design is usually stated to include three factors, beauty, distinctiveness and utility. The relative importance of these factors will vary with the product, but it seems to me that to concentrate almost all industrial

Otto Struve 1897 - 1963

americký astronom německého původu, **mezihvězdná látka**

O možném případu mezihvězdného zčervenání r. 1946,

absorpční a rozptylové vlastnosti mezihvězdné látky, absorpce narůstá podél galaktického rovníku



A POSSIBLE CASE OF INTERSTELLAR REDDENING

O. STRUVE
Yerkes and McDonald Observatories

In our spectrographic observations of extended regions in the Milky Way, C. T. Elvey and I found that the bright line [*O* II] 3727 is relatively much weaker in summer than in winter. Thus, the ratio in intensity $[O\ \text{II}]/\{H\alpha + [N\ \text{II}]\}$ is large in Monoceros and Canis Major and small in Cygnus, Cepheus, and Sagittarius.[1] During the past few years I have made several futile attempts to find a physical explanation for this interesting phenomenon. No photometric measures of the differences in magnitude

$$\Delta m = +2.5 \log \frac{\text{I}\ (O\ \text{II})}{\text{I}\ (H\alpha + N\ \text{II})}$$

are available, but I should estimate that the value

Δm (winter Milky Way)—Δm (summer Milky Way)$\approx$1 mag.

It is possible that this effect is a direct consequence of interstellar reddening. A similar phenomenon is well known in distant

[1] O. Struve, *Jour. Washington Acad. Sci.*, 31, 247, 1941.

Otto Struve

O možném případu mezihvězdného zčervenání r. 1946

planetary nebulae. It agrees in character with the results of stellar observations by Stebbins, Huffer, and Whitford, who also found particularly heavy reddening in the region of Cygnus, and in neighboring portions of the Milky Way.

If the total absorption at λ 4250 is 0.75 mag. per 1000 parsecs, then in accordance with the expression

$$\delta m = cr\lambda^{-1} \qquad (1)$$

we obtain

at λ 3727 : $\delta m = 0.85$ mag., for $r = 1000$ psc.
at λ 6562 : $\delta m = 0.49$ mag., for $r = 1000$ psc.

It would seem that the average distance of the diffuse nebulous areas in the Milky Way is much greater than 1000 parsecs. It may be as large as 2500 or 3000 parsecs. However, this conclusion depends not only upon equation (1), but also upon the two facts which we shall discuss presently.

Otto Struve

Jasná čára Ca II ve spektru RW Comae Berenices, r. 1950

NOTES

BRIGHT LINES OF *Ca* II IN THE SPECTRUM OF RW COMAE BERENICES

RW Comae Berenices, with a period of only 0.237 day, is a typical W Ursae Majoris binary with two components of spectral type G2 each. Although the apparent magnitude of the system is 11.3 pg at maximum and 12.03 and 11.86 pg at the two minima, I observed the spectrum at the McDonald Observatory in January, 1950. With the dispersion used in this work, namely, 100 A/mm at λ 3933, the two components were not completely resolved during the elongations, but the lines are much broader than they are during the conjunctions. As is the case in other systems of the same type, the violet components of the double absorption lines seem to be the stronger, irrespective of whether they belong to the more massive or to the less massive star.

Of particular interest is the presence of a fairly strong emission line of *Ca* II, which is clearly visible in the center of a broad, blended absorption line, at each of the two conjunctions. Figure 1 illustrates this phenomenon. It is similar to the one recently found in the spectrum of W Ursae Majoris.[1] During the elongations, at phases near 0.25 and 0.75*P*, counted from the middle of the principal eclipse as zero, the emission lines are weak and difficult to discern. On some of my spectrograms they look complex in structure, and it is possible that both stars are accompanied by emitting *Ca* gases. In the case of W Ursae Majoris, the emission seemed to be associated with the more massive component of the system.

The presence of fairly strong emission lines of *Ca* II in normal G-type spectra is somewhat unusual. Their existence in two systems of the W Ursae Majoris type should probably be regarded as a symptom indicating the presence of a gaseous ring or tidal extension analogous to those inferred previously from the intensities of the absorption lines.

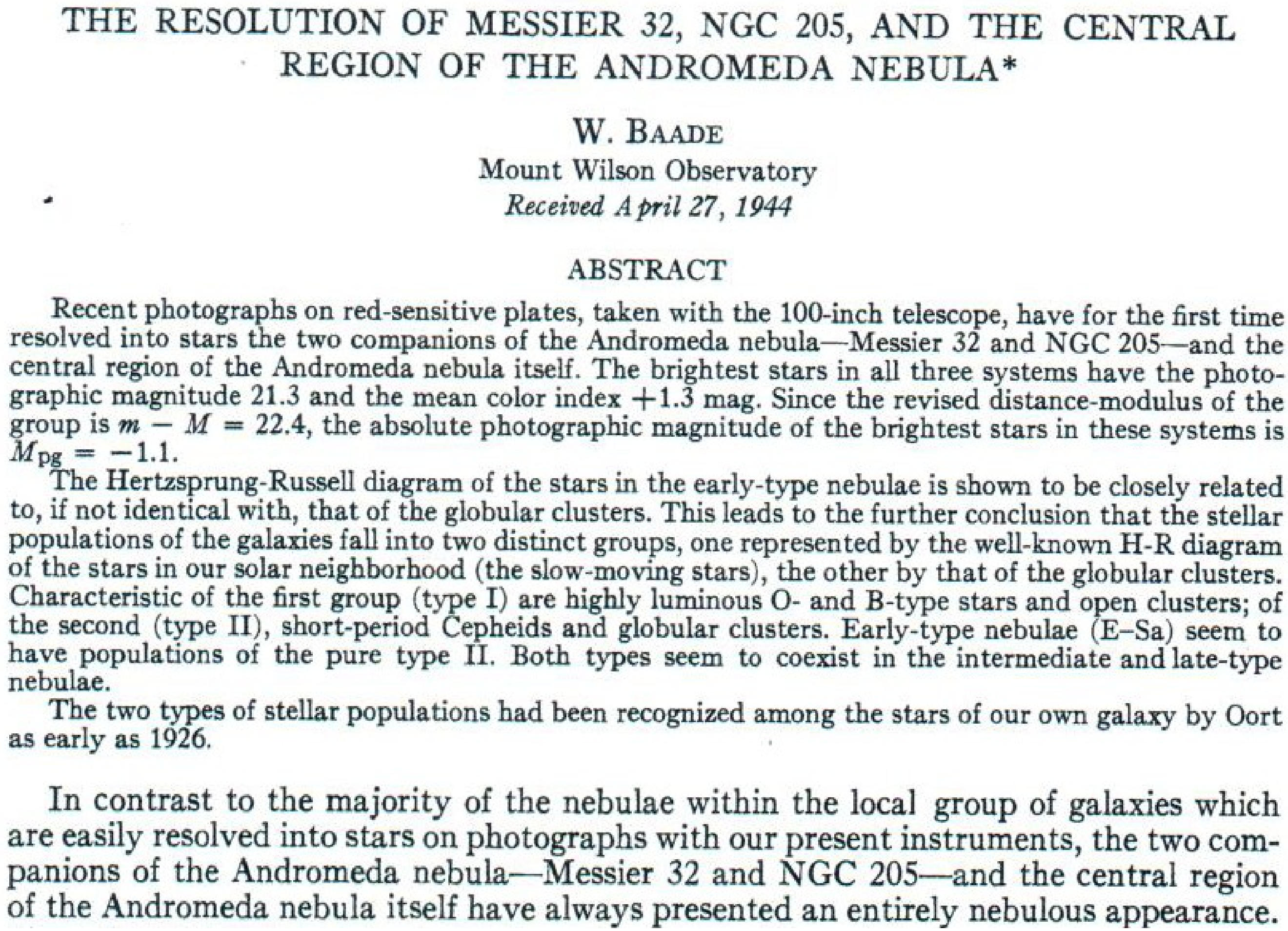
OTTO STRUVE

YERKES AND MCDONALD OBSERVATORIES
March 15, 1950

1950, Jan. 7.525 Ph. 573
RW COMAE BERENICES

Walter Baade 1893 - 1960

americký astronom německého původu **Walter Baade 1893-1960** ***Rozlišení M 32, NGC 205 a centrální oblasti mlhoviny Andromedy, r. 1944***, koncepce rozlišení populace I a populace II.



THE RESOLUTION OF MESSIER 32, NGC 205, AND THE CENTRAL REGION OF THE ANDROMEDA NEBULA*

W. Baade
Mount Wilson Observatory
Received April 27, 1944

ABSTRACT

Recent photographs on red-sensitive plates, taken with the 100-inch telescope, have for the first time resolved into stars the two companions of the Andromeda nebula—Messier 32 and NGC 205—and the central region of the Andromeda nebula itself. The brightest stars in all three systems have the photographic magnitude 21.3 and the mean color index +1.3 mag. Since the revised distance-modulus of the group is $m - M = 22.4$, the absolute photographic magnitude of the brightest stars in these systems is $M_{pg} = -1.1$.

The Hertzsprung-Russell diagram of the stars in the early-type nebulae is shown to be closely related to, if not identical with, that of the globular clusters. This leads to the further conclusion that the stellar populations of the galaxies fall into two distinct groups, one represented by the well-known H-R diagram of the stars in our solar neighborhood (the slow-moving stars), the other by that of the globular clusters. Characteristic of the first group (type I) are highly luminous O- and B-type stars and open clusters; of the second (type II), short-period Cepheids and globular clusters. Early-type nebulae (E–Sa) seem to have populations of the pure type II. Both types seem to coexist in the intermediate and late-type nebulae.

The two types of stellar populations had been recognized among the stars of our own galaxy by Oort as early as 1926.

In contrast to the majority of the nebulae within the local group of galaxies which are easily resolved into stars on photographs with our present instruments, the two companions of the Andromeda nebula—Messier 32 and NGC 205—and the central region of the Andromeda nebula itself have always presented an entirely nebulous appearance.

Walter Baade

Rozlišení M 32, NGC 205 a centrální oblasti mlhoviny Andromedy, r. 1944

reasonable exposure times is close to $m_{pr} = 20.0$, the limiting photographic magnitude being $m_{pg} = 21.0$. These figures make it clear at once that stars beyond the reach of the blue-sensitive plates can be recorded in the red only if their color indices are larger than +1.0 mag.—the larger, the better. Now there are good reasons to believe that the brightest stars in the unresolved early-type galaxies actually have large color indices. When a few years ago the Sculptor and Fornax systems were discovered at the Harvard Observatory, Shapley introduced these members of the local group of galaxies as stellar systems of a new kind.[1] Shortly afterward, however, Hubble and the writer pointed out that in all essential characteristics, particularly the absence of highly luminous O- and B-type stars, these systems are closely related to the unresolved members of the local group.[2] It was therefore suggested that in dealing with the Sculptor and Fornax systems "we are now observing extragalactic systems which lack supergiants and are yet close enough to be resolved." Since the brightest stars in the Sculptor system, according to later observations by the present writer, have large color indices (suggesting spectral type K), it appeared probable that this would hold true for the brightest stars in the unresolved members of the Andromeda group. Altogether there was good reason to expect that the resolution of these systems could be achieved with the 100-inch reflector on fast red-sensitive plates if every precaution were taken to utilize to the fullest extent the small margin available in the present circumstances.

Walter Baade

Rozlišení M 32, NGC 205 a centrální oblasti mlhoviny Andromedy, r. 1944

These corrections refer to Hubble's region 4 (48′ south preceding the nucleus), where most of his variables are located. They are probably representative of the whole material. A final discussion will be presented later after all intercomparisons of S.A. 68 with M 31 have been reduced.

Since Hubble used m_{max} instead of m_{med} in the period-luminosity relation and since his values of m_{max} range from 18.1 to 19.3, the scale correction to be applied to the distance modulus turns out to be +0.45 mag. But Hubble's distance modulus is based on the old period-luminosity relation of *Harvard Circular*, No. 280, the zero point of which requires the correction of −0.23 mag. in order to reduce it to the one commonly used in recent years. The distance modulus of the Andromeda nebula on the present system is therefore $m - M = 22.4$. If this value is adopted, the absolute photographic magnitude of the brightest stars in the central region of the Andromeda nebula and in Messier 32 and NGC 205 becomes $M_{pg} = -1.1$.

TABLE 1

m_{pg} (Hubble)	Correction
18.30	+0.35 mag.
18.85	+ .42
19.23	+ .47
19.74	+ .57
20.00	+0.63

Walter Baade

Rozlišení M 32, NGC 205 a centrální oblasti mlhoviny Andromedy, r. 1944

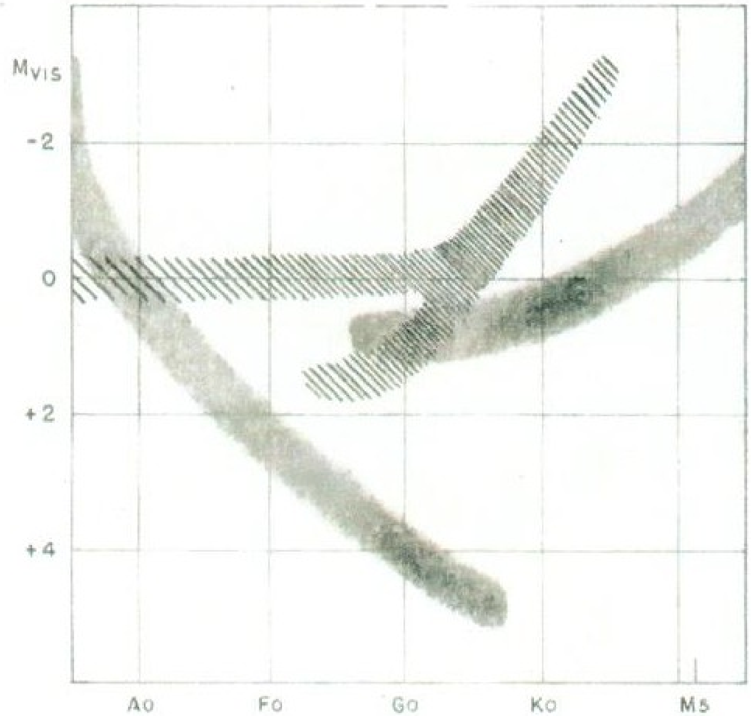


Fig. 1.—Shaded areas: ordinary H-R diagram (type I). Hatched area: H-R diagram of stars in globular clusters (type II).

Figure 1 represents schematically the H-R diagrams of the stars in the neighborhood of the sun (*shaded*) and of those in globular clusters (*hatched*). To conform with the usual practice, photovisual magnitudes have been used for the absolute magnitudes; hence the brightest stars in globular clusters appear now as stars of $M_{pv} = -2.4$. Both the dispersion and the frequency of the stars have been roughly indicated to convey an idea of the distribution of the two groups of stars in the H-R plane.

Walter Baade

Rozlišení M 32, NGC 205 a centrální oblasti mlhoviny Andromedy, r. 1944

We thus have two strong arguments which indicate that the H-R diagrams of globular clusters and of early-type nebulae are similar, if not identical:

1. In both populations the brightest stars are K-type stars of $M_{pg} \sim -1.1$.
2. In both populations the distribution in the H-R plane is characterized by high density in the Hertzsprung gap, with the resulting appearance of cluster-type variables.

But we can advance a third argument which explains at the same time why the globular clusters happen to be the prototypes of this peculiar type of stellar population which we will call type II in distinction from populations defined by the ordinary H-R diagram—type I. This is the fact that, as far as the present evidence goes, globular clusters are always associated with stellar populations of type II. A good example is our own galaxy, where the globular clusters clearly have the same spatial distribution as the cluster-type variables which are representative of the stars of the second type. It is also significant that among the nebulae composed solely of stars of type II even the absolutely faintest usually have one or two globular clusters. Examples are NGC 205, the Fornax system, and the two faint globular nebulae NGC 147 and NGC 185, discussed in the following paper. This association suggests that globular clusters are properly regarded as condensations in stellar populations of the second type. Under these circumstances it is hardly surprising that their H-R diagram should be essentially identical with that of the larger populations of which they are members.[12]

Walter Baade

Závislost zářivý výkon - perioda cefeid, r. 1956, korekce vzdáleností ve vesmíru

PUBLICATIONS OF THE
ASTRONOMICAL SOCIETY OF THE PACIFIC

Vol. 68 February 1956 No. 400

THE PERIOD-LUMINOSITY RELATION OF THE CEPHEIDS*

W. BAADE

Mount Wilson and Palomar Observatories
Carnegie Institution of Washington
California Institute of Technology

Around the turn of the century two investigations were started at the Harvard Observatory that had a far-reaching influence on the further development of astronomy: Henrietta S. Leavitt's investigation of the variable stars in the two Magellanic Clouds and Solon I. Bailey's investigation of the variable stars in globular clusters. The Magellanic Clouds turned out to be veritable mines of cepheids with periods longer than one day. In contrast, the overwhelming majority of the variables in globular clusters were cepheids with periods shorter than one day; they were so characteristic of globular clusters that Bailey proposed for them the name "cluster-type variables." Further investigations of these variables led to two very remarkable results. The most striking was Miss Leavitt's discovery that the brightness of the cepheids in the Magellanic Clouds is a function of the period of the light-

Walter Baade

Závislost zářivý výkon - perioda cefeid, r. 1956

With regard to the cluster-type variables, the situation seemed to be even simpler. Although their periods range from about 0.2 to 1.0 day, Bailey found little or no dependence of luminosity upon period. His observations justified the assumption that all cluster-type variables have about the same absolute magnitude, the dispersion around the mean not exceeding 0.1 magnitude.

Miss Leavitt's and Bailey's results thus made it clear that both cepheids and cluster-type variables could be used as accurate and powerful photometric distance indicators, if their absolute magnitudes could be determined accurately enough. The first one to use Miss Leavitt's observed period–apparent magnitude relation of the cepheids in the Small Magellanic Cloud for the determination of stellar distances was E. Hertzsprung,[1] who had already shown that the cepheids are stars of high luminosity. From the proper motions of 13 cepheids in the Boss *Preliminary General Catalogue* he obtained $M_{vis} = -2.3 \pm 0.3$ for a cepheid with $P = 6.6$ days. The resulting value for the distance of the Small Magellanic Cloud was 33,000 light-years.

Walter Baade

Závislost zářivý výkon - perioda cefeid, r. 1956

recent reviewers of the problem have rather glibly stated that the discrepancy in the luminosities of the globular clusters implied already a change in the zero point of the period-luminosity relation. It is obvious that no change in the zero point could remove the discrepancy as long as the accepted form of the period-luminosity relation was retained.

It was only after the recognition of the two stellar populations that the first serious doubts arose concerning the accepted form of the period-luminosity relation. The arguments were as follows. Miss Leavitt's cepheids in the Magellanic Clouds and the classical cepheids in our galaxy are clearly members of population I, while the cluster-type variables and the long-period cepheids of the globular clusters are members of population II. Since the color-magnitude diagrams of the two populations leave no doubt that in the two cases we are dealing with stars in different physical states, there was no a priori reason to expect that two cepheids of the same period, the one a member of population I, the other of population II, should have the same luminosity. Moreover, a

Walter Baade

Závislost zářivý výkon - perioda cefeid, r. 1956

discrepancy such as that noted by Hubble in the globular clusters. To remove this discrepancy, it was necessary to shift the period-luminosity relation of the type I cepheids upward by about 1.5 magnitudes relative to the cluster-type variables.

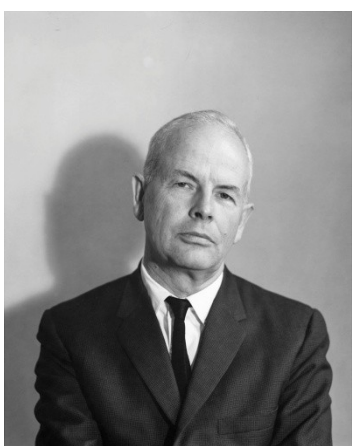
This was the situation when the 200-inch telescope was nearing completion and we were discussing the first observing programs for the new instrument. Naturally I was very eager to settle these disturbing questions which had arisen regarding the accepted period-luminosity relation. It was also perfectly clear how to proceed. One would have to select a near-by galaxy which contained both stellar populations in order to study in properly selected fields the two kinds of cepheids side by side, so to speak. The results of such an investigation would show whether or not the accepted period-luminosity relation represents the true state of affairs. There was no doubt that the Andromeda nebula was the most suitable object for such an investigation and that the 200-inch could answer the questions in which I was interested.

UBV fotometrický systém

americký astrofyzik **Herold Lester Johnson 1921 - 1980**

americký astrofyzik **William Wilson Morgan 1906 - 1994**

Základ hvězdné fotometrie pro standardy spektrálních typů, r. 1953



THE ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

VOLUME 117 MAY 1953 NUMBER 3

FUNDAMENTAL STELLAR PHOTOMETRY FOR STANDARDS OF SPECTRAL TYPE ON THE REVISED SYSTEM OF THE YERKES SPECTRAL *ATLAS**

H. L. Johnson and W. W. Morgan

Yerkes and McDonald Observatories

Received November 29, 1952

ABSTRACT

A system of photoelectric photometry is outlined which utilizes the revised zero point of the visual magnitude scale of the North Polar Sequence and which returns to the original definition for the zero point of color indices in terms of main-sequence stars of class A0; the interval A0–gK0 is 1 mag. The revised Yerkes *Atlas* system (MK) of spectral classification is taken as standard. The latter is described briefly, and a list of standard stars is included.

Magnitudes and color indices from measures in three wave-length bands are given for stars selected by spectral type and luminosity class to be representative of the principal regions of the H-R diagram. A few white dwarfs are also included.

A standard main sequence is defined for the new color–absolute magnitude diagram by the use of stars of large parallax, together with the galactic clusters NGC 2362, the Pleiades, the Ursa Major nucleus, and Praesepe. A standard main sequence is also defined for the relationship between the two systems of color index.

A purely photometric method for determining spectral types and space reddening for B stars in galactic clusters is described.

UBV fotometrický systém

Herold Lester Johnson + William Wilson Morgan

Základ hvězdné fotometrie pro standardy spektrálních typů, r. 1953

This value is larger than that given[3] from rather limited data; the value here is to be preferred. Let us now define a quantity, ϵ, so that

$$\epsilon = \frac{10 \times \overline{\sec Z}}{\sqrt{n}}, \tag{3}$$

where n is the number of observations on a particular star. The quantity $0^m.001\,\epsilon$ is the average probable error of $B - V$ for each individual star; it is a much better criterion (when n is small) of the quality of the observations of an individual star than is the average deviation of the observations of that star from the mean.

Similar computations lead to the probable errors for the other observed quantities in terms of ϵ given in Table 1. The mean values for all stars are also given in the table.

TABLE 1

PROBABLE ERRORS OF THE PHOTOMETRY (P.E., MAG.)

	Individual	Mean for All Stars
V	$\pm 0^m.002\epsilon$	$\pm 0^m.017$
$B-V$	$\pm .001\epsilon$	$\pm .009$
$U-B$	$\pm 0.002\epsilon$	± 0.017

It has been found, from data given for the North Polar Sequence,[3] that

$$V = IP\,v + 0.000 + 0.002\,(B - V) \pm 0.006 \pm 0.005\ \text{(p.e.)}, \tag{4}$$

UBV fotometrický systém

Herold Lester Johnson + William Wilson Morgan

Základ hvězdné fotometrie pro standardy spektrálních typů, r. 1953

TABLE 2

STANDARDS OF MK SYSTEM

Class Ia	
O9.5 Ia	α Cam
O9.5 Ia	195592
B0 Ia	ϵ Ori
B0 Ia	15 Sgr
B0.5 Ia	κ Ori
B0.5 Ia	194839
B1 Ia	κ Cas
B1 Ia	216411
B1.5 Ia	190603
B1.5 Ia	194279
B2 Ia	14143
B2 Ia	χ^2 Ori
B3 Ia	14134
B3 Ia	o^2 CMa
B3 Ia	55 Cyg
B5 Ia	13267
B5 Ia	η CMa
B5 Ia	167838
B6 Ia	15497
B7 Ia	183143
B8 Ia	14542
B8 Ia	β Ori
B8 Ia	199478
B9 Ia	17088
B9 Ia	21291

Class Iab—*Continued*	
B9 Iab	4 Lac
F5 Iab	44 Cyg
K3 Iab	o^1 CMa
M0 Iab	ψ^1 Aur
M2 Iab	α Ori

Class Ib	
O9 Ib	210809
O9.5 Ib	ζ Ori
O9.5 Ib	19 Cep
B0 Ib	69 Cyg
B0.5 Ib	192422
B1 Ib	ζ Per
B1 Ib	ρ Leo
B1 Ib	190919
B1.5 Ib	193183
B2 Ib	13841
B2 Ib	13866
B2 Ib	9 Cep
B2.5 Ib	3 Gem
B5 Ib	9311
B5 Ib	67 Oph
B8 Ib	53 Cas
B8 Ib	13 Cep

Class II	
O9 II	16 Sgr
O9.5 II	δ Ori
B0 II	43818
B1 II	1383
B1 II	199216
B2 II	ϵ CMa
B3 II	ι CMa
B3 II	194779
B8 II	γ CMa
B9 II	43836
A5 II	19 Aur
F0 II	HR 1242
F2 II	22 And
F2 II	ν Her
F5 II	ν Per
F5 II	41 Cyg
G0 II	ϵ Leo
G0 II	α Sge
G2 II	β Dra
G5 II	ω Gem
G5 II	β Sct
G8 II	56 UMa
G8 II	ζ Cyg
K0 II	θ Lyr
K1 II	HR 2334

UBV fotometrický systém

Herold Lester Johnson + William Wilson Morgan

Základ hvězdné fotometrie pro standardy spektrálních typů, r. 1953

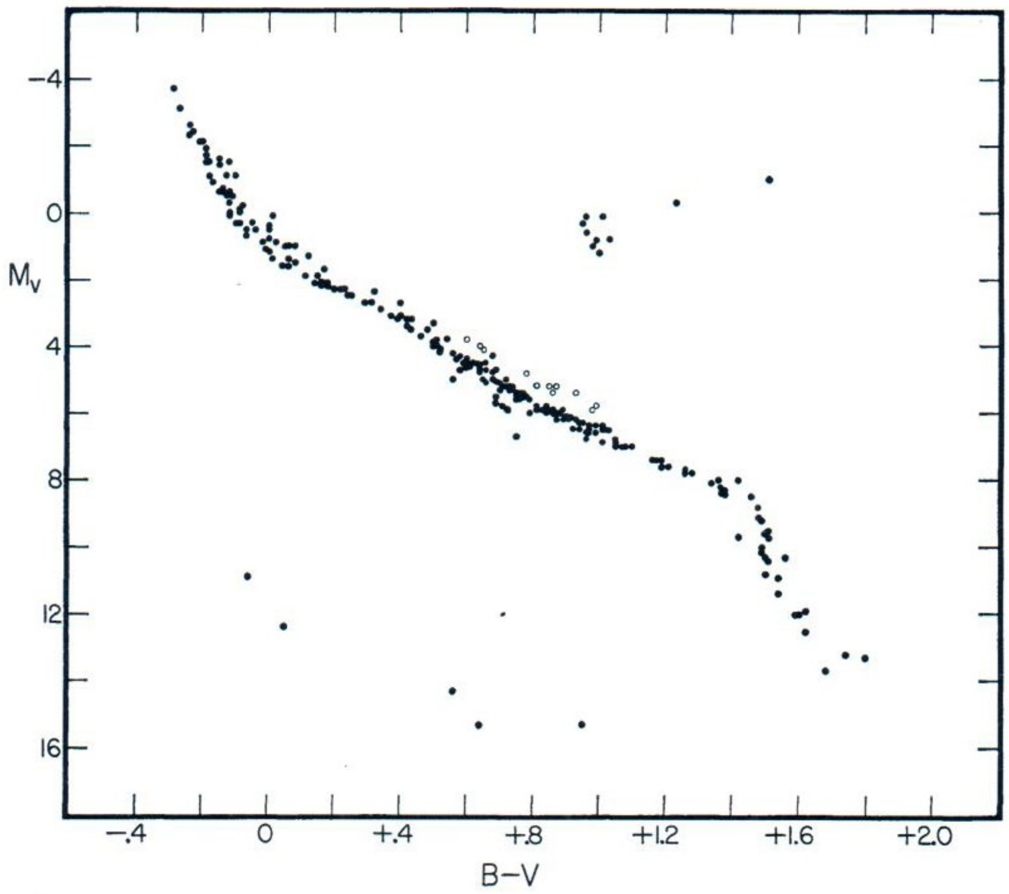


FIG. 5.—A standard main sequence for the color system $B - V$ and the absolute-magnitude system M_V. The stars plotted include main-sequence objects: (*a*), which have trigonometric parallaxes $\geqslant 0\overset{''}{.}100$; (*b*) the Pleiades, corrected for a mean interstellar reddening (one highly reddened A star omitted); (*c*) Praesepe; (*d*) NGC 2362 corrected for a mean interstellar reddening. In addition, five white dwarfs, three yellow giants from the Hyades, and several other yellow giants of large parallax are included. The open circles refer to a few stars lying above the main sequence in Praesepe which may be binaries.

Rudolph Minkowski 1895 - 1976

americký astronom německého původu, ***Rádiové zdroje, galaxie a kupy galaxií r. 1963,*** objev radiogalaxií

RADIO SOURCES, GALAXIES, AND CLUSTERS OF GALAXIES

BY R. MINKOWSKI*

MOUNT WILSON AND PALOMAR OBSERVATORIES, CARNEGIE INSTITUTION OF WASHINGTON, CALIFORNIA INSTITUTE OF TECHNOLOGY

The identification of radio sources at high galactic latitudes has progressed to a stage at which it is possible to make the first tentative attempts at a statistical exploration of the results. The identification of the source 3C 48 shows that galactic sources may occur at high galactic latitudes, but the results of the determination of diameters of sources support the generally accepted assumption that most sources at high galactic latitudes are extragalactic.

The great majority of the extragalactic objects with which sources have been identified seem to be completely normal; they show no features which mark them as peculiar in any manner, either in their appearance or in their spectra where these are available. This is in sharp contrast to the early identifications, most of which pointed to highly peculiar objects. Most of the identifications thus are not supported by peculiarities of the objects, but rest entirely on positional coincidence. In this case, an identification with a given object is accepted if the statistical chance

Rudolph Minkowski

Rádiové zdroje, galaxie a kupy galaxií r. 1963

tion of all objects with the 200-inch telescope. The area has been searched completely by the author and by Mills on the plates of the National Geographic Society-Palomar Observatory Sky Survey to $m_p = 9.2$. An area of roughly 3 steradians is available if the area within 12° from the galactic equator is excluded. The limit for the search was set at $m_p = 16$ for single galaxies, at $m_p = 18$ for double galaxies. The 48-inch plates are adequate to recognize such double galaxies and it can be assumed that the list is essentially complete to the stated limits, but it seems probable that it is incomplete in one respect. The double galaxies considered as identifications are close doubles for which the apparent distance of the components is smaller than the sum of the largest apparent diameters. If the separation was larger, the components were considered as individual galaxies, but the positional accuracy is then not sufficient to make an identification. The identifications must therefore be incomplete with regard to objects forming wide optical or physical pairs.

Rudolph Minkowski

Rádiové zdroje, galaxie a kupy galaxií r. 1963,

Among the double galaxies identified as sources are many double elliptical galaxies. In the past, this has been considered as an indication of stimulation of radio emission in double galaxies, since single elliptical galaxies seemed in general to be weak emitters. Since a substantial number of sources have now been identified with single elliptical galaxies of normal appearance, the argument no longer is valid. The apparently large number of double galaxies has been considered as another indication of peculiar effects in such systems. This interpretation also cannot be maintained. Actually, the incidence of doubles is not larger than expected in view of the fact that the limit of search for identifications was fainter for double galaxies than for single galaxies.

A fainter limit of search for double galaxies follows from the condition $\epsilon^2 n(m_p) < 0.1$, which permits an extension of the search for a given class of objects to that magnitude m_p at which the number $n(m_p)$ of objects in the class fulfils the condition. For each class, the total number of objects available for identifications is therefore the same.

The choice of the limit of search for double galaxies was based on counts of the number of close double galaxies in sample areas. These turned out to be in substantial agreement with the data given by Holmberg,[7] who found that 22 out of 100 galaxies are in double or multiple galaxies. Doubles of the kind considered here

Jan Hendrik Oort 1900 - 1992

holandský astronom, zabývající se studiem stavby a dynamiky Galaxie

Pozorovací důkazy potvrzující Lindbladovu hypotézu o rotaci galaktického systému, r. 1927

BULLETIN OF THE ASTRONOMICAL INSTITUTES OF THE NETHERLANDS.

1927 April 14 Volume III. No. 120.

COMMUNICATION FROM THE OBSERVATORY AT LEIDEN.

Observational evidence confirming Lindblad's hypothesis of a rotation of the galactic system, by *J. H. Oort*.

1. *Introduction.*

It is well known that the motions of the globular clusters and RR Lyrae variables differ considerably from those of the brighter stars in our neighbourhood. The former give evidence of a systematic drift of some 200 or 300 *km/sec* with respect to the bright stars, while their peculiar velocity averages about 80 *km/sec* in one component, which is nearly six times higher than the average velocity of the bright stars.

Because the globular clusters and the bright stars seem to possess rather accurately the same plane of symmetry, we are easily led to the assumption that there exists a connection between the two. But what is the nature of the connection?

It is clear that we must not arrange the hypothetical universe in such a way that it is very far from dynamical equilibrium. Following KAPTEYN *) and JEANS **) let members of a local cloud which is moving at fairly high speed inside a larger galactic system, of dimensions comparable to those of the globular cluster system. We must then postulate the existence of a number of similar clouds, in order to provide a gravitational potential which is sufficiently large to keep the globular clusters from dispersing into space too rapidly. The argument that we cannot observe these large masses outside the Kapteyn-system is not at all conclusive against the supposition. There are indications that enough dark matter exists to blot out all galactic starclouds beyond the limits of the Kapteyn-system *).

LINDBLAD **) has recently put forward an extremely suggestive hypothesis, giving a beautiful explanation of the general character of the systematic motions of the stars of high velocity. He supposes that the greater

Jan Hendrik Oort

Pozorovací důkazy potvrzující Lindbladovu hypotézu o rotaci galaktického systému, r. 1927, Oortovy konstanty…

clouds and take into consideration only the forces arising from the greater galactic system as a whole. The gravitational force, K, is consequently directed to the centre of this system and is only a function of the distance, R, from this centre.

Let us now consider a group of stars at a distance r from the sun and let us suppose that r/R is so small that all terms of second or higher order in r/R can be neglected, then it is easily seen that the residual velocity caused by the rotation is equal to

$$rA \sin 2(l - l_0)$$

in radial direction, and to

$$rA \cos 2(l - l_0) + rB$$

in transverse direction, if l_0 represents the galactic longitude of the centre (about 325°), l the longitude of the stars considered, R the distance of the sun from the centre,

$$V = \sqrt{RK}$$

the circular velocity near the sun,

$$A = \frac{V}{4R}\left(1 - \frac{R}{K}\frac{\partial K}{\partial R}\right)$$

and

$$B = A - \frac{V}{R} \quad . \; .$$

The rotation is supposed to take place in right-hand direction as observed from a point North of the galactic plane.

If, as LINDBLAD tentatively supposed, the principal part of the greater galactic system is formed by an ellipsoid of constant density, the force K will be proportional to R. In this case

$$A = 0 \text{ and } B = -\frac{V}{R} \; ,$$

the system rotates as a solid body and we shall not find any indications of rotation in the radial velocities, but the proper motions in galactic longitude should be systematically negative for stars in all longitudes.

Jan Hendrik Oort

Pozorovací důkazy potvrzující Lindbladovu hypotézu o rotaci galaktického systému, r. 1927

longitude, and minima at 100° and 280°, with a semi-amplitude of $\frac{3}{4}\frac{r}{R}V$. Now the most distant objects observed for radial velocity are at distances of about 1000 parsecs; with $R = 10\,000$ parsecs and $V = 300$ *km/sec* this gives a semi-amplitude of over 20 *km/sec*, which might well be verifiable. With the same assumptions the maximum effect in the proper motions in galactic longitude would be equal to $-0.''005$ per annum. The maximum will occur 90° from the direction towards the centre. In the direction of the centre and in the opposite direction the average proper motion in longitude should be equal to about $+0.''002$. The proper motion effects are, of course, independent of the distance of the objects considered.

3. *Discussion of the radial velocities.*

statistical study of the *c*-stars SCHILT has remarked upon the deviations from zero of the mean peculiar velocities of stars in different longitudes *). His table of residuals is reproduced below.

TABLE I.

Average longitude	Average peculiar velocity	mean error	sin 2 (l—325°)
30°	+ 8 *km/sec*	± 3.5 *km/sec*	+ .77
90	— 8	± 2.7	— .94
150	0	± 3.6	+ .17
210	+ 10	± 3.9	+ .77
270	— 7	± 4.3	— .94
330	0	± 3.5	+ .17

Jan Hendrik Oort

Pozorovací důkazy potvrzující Lindbladovu hypotézu o rotaci galaktického systému, r. 1927

The *O*-type stars were mainly taken from *Victoria Publications*, **2**, 316. They were divided into two groups according to the Harvard spectrum. To the *Oe*5 group were added the stars classed as *O* by PLASKETT and as *B* by miss CANNON. Both the *Oe*5 stars and the Wolf-Rayet stars are very unevenly distributed over the different longitudes so that it was found impossible to solve both for the rotation-effect and the solar motion. In view of the moderate residual velocities it seemed fairly safe to assume a value of 20 *km/sec* for the *Oe*5 stars. The *K*-correction was assumed to be negligible; the residuals seem to show however that there might exist a considerable positive *K*-term for the *Oe*5 stars. After appliciation of the rotation term the average residual velocity of the *Oe*5 stars is only 16 *km/sec*, thus of the same order as the average velocity of the ordinary giants.

been arranged in order of decreasing mean parallax. It appears that the better determinations give evidence that the value of $\bar{r}A$ increases proportional with the mean distance, as it should do if the term is interpreted as a rotation. The determinations with a relative mean error of less than a third are put together in the following table.

TABLE 3.

Type	$\bar{\pi}$	$\bar{r}A$	m. e.
B3 — B5	″.0058	+ 5.7 *km/sec*	± 1.0
B0 — B2	.0037	+ 9.3	± 1.5
bright *c*-stars	.0028	+ 9.1	± 3.0
Oe5	.0020	+ 19.	± 5.
faint *c*-stars	.0015	+ 25.1	± 2.7

Bertil Lindblad 1895 - 1965

švédský astronom, vytvořený obraz hvězdných proudů - důsledek rotace Galaxie***, Elipsoid rychlostí, Galaktické rotace a rozměrů hvězdné soustavy, r. 1930***

The Velocity Ellipsoid, Galactic Rotation, and the Dimensions of the Stellar System. By Professor Bertil Lindblad.

(*Communicated by the Secretaries.*)

According to the theory of the stellar system developed by Oort and the present writer, there should be a definite relation between the coefficient A of the differential galactic rotation * and the ratio of the two axes σ_1 and σ_2 of the velocity ellipsoid which lie in the galactic plane. If σ_1 is the axis which points toward the centre of the system, the relation in question is †

$$(1) \quad . \quad . \quad . \quad . \quad A = \omega\left[1 - \left(\frac{\sigma_2}{\sigma_1}\right)^2\right],$$

where ω is the angular speed of rotation around the centre of the system at our distance from this centre. ω is reckoned positive in the retrograde direction. The significance of this relation is twofold. Firstly, by co-ordinating the measured quantities A and $\frac{\sigma_2}{\sigma_1}$ for different groups of stars we may hope to get a valuable control on the theory itself; and secondly, we may in this way actually determine the quantity ω, which must otherwise be obtained by direct analysis of proper motions. The mean proper motion B in galactic longitude is connected with A and ω through the relation

$$(2) \quad . \quad . \quad . \quad . \quad B = A - \omega.$$

The value of B derived directly from the proper motions has to be compared with the value given by (2).

Bertil Lindblad

Elipsoid rychlostí, Galaktické rotace a rozměrů hvězdné soustavy, r. 1930

areas in the sky. This mean has to be identified with the rotation effect, which can be written

$$(3) \quad \bar{r} A \cos^2 b \sin 2(l - l_0),$$

where l and b are the galactic co-ordinates, and l_0 is the galactic longitude of the centre.

The sky was divided into 48 equal "galactic" areas according to Charlier's scheme. For the rotation effect only the 24 areas around the galactic equator were used, because in this case the areas of higher galactic latitude have very little weight, and their inclusion would rather tend to make the material non-homogeneous. Opposite areas

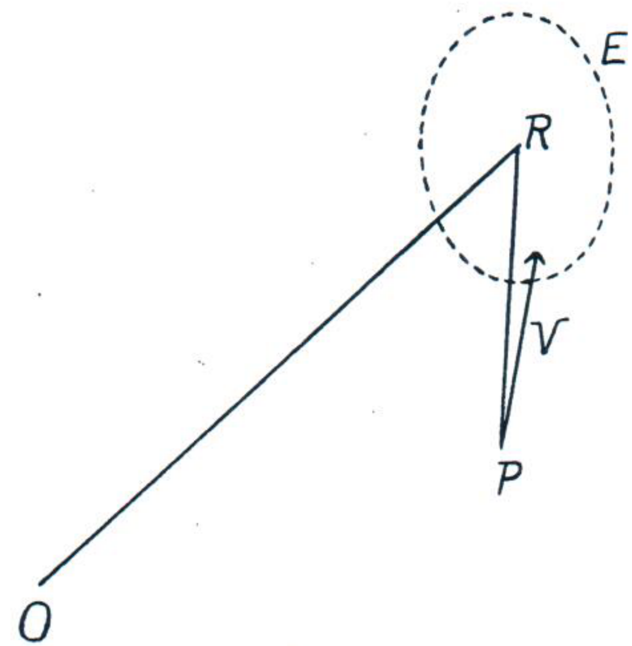


FIG. 1.

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švédský astronom, vytvořený obraz hvězdných proudů – důledek rotace Galaxie***, Elipsoid rychlostí, Galaktické rotace a rozměrů hvězdné soustavy, r. 1930***

will be eliminated, at the same time as the parallactic motion, as soon as the stream is uniform enough to enter into the two areas in the same abundance, in which case it affects the mean radial velocities of the two regions by equal amounts but with opposite signs.

We get in this way our final value

$$A = +\,0{\cdot}015 \pm 0{\cdot}005 \text{ km. per sec. per parsec.}$$

for $l_0 = 324°$. Without any assumption regarding l_0 we get

$$A = +\,0{\cdot}017 \pm 0{\cdot}004, \qquad l_0 = 338° \pm 8.$$

Thus the final value of A agrees with the value of A found for the group F–K, I, separately. We remember that this group gives a velocity ellipsoid in close agreement with the theoretical demands. In accordance with our previous discussion, we have reasons to suppose that the values of $\frac{\sigma_2'}{\sigma_1'}$ for the B and A stars may be seriously affected by accidental streamings, and we are therefore obliged to adopt the

Bertil Lindblad

Dynamická teorie spirální struktury, r. 1948

On the Dynamical Theory of Spiral Structure.

Comparison between Theory and Observation.

By

BERTIL LINDBLAD.

Introduction.

The outlines of a dynamical theory of spiral structure have been given by the author in a number of previous papers.[1] The present treatise is a continuation of the two papers in the Stockholm Annals (13, No. 10 and 14, No. 1), which will be referred to below as papers No. I and II, respectively. The general theory of mass motions in a stellar system has recently been developed very fully by R. Coutrez.[2]

The aim of the present paper is to give a summary of the theoretical developments, with a few modifications which are thought to be actual improvements, and to give a comparison between theory and observation on some points which appear to be of outstanding importance and which have only been partly discussed in previous works. The observational experience concerning the question of the true tilt of the equatorial planes of nebulae has been discussed recently by Lindblad and Brahde[3] and a few comments on further evidence on this question will be given in the last paragraph.

Bertil Lindblad

Dynamická teorie spirální struktury, r. 1948

$$\left.\begin{aligned}\xi &= \frac{c_0}{2(\omega_c - A_c)} + c\cos\varkappa(t-t_0)\\ \eta &= -\frac{A_c}{\omega_c - A_c}c_0(t-t_1) - c\sqrt{\frac{\omega_c}{\omega_c - A_c}}\sin\varkappa(t-t_0)\end{aligned}\right\} \qquad (1)$$

where

$$\varkappa = 2\sqrt{\omega_c(\omega_c - A_c)}.$$

A_c is OORT's constant of differential rotation for the circular motions surrounding $r = r_0$, thus

$$A_c = \frac{1}{4\,\omega_c}\left(\frac{\partial^2\varphi}{\partial r^2} - \frac{1}{r}\frac{\partial\varphi}{\partial r}\right), \qquad (2)$$

where φ is the potential function, while c, c_0, t_0, t_1 are arbitrary constants. The frequency $\varkappa$ of the oscillation is given by

$$\varkappa^2 = -\left(\frac{\partial^2\varphi}{\partial r^2} + \frac{3}{r}\frac{\partial\varphi}{\partial r}\right) = 4\,\omega_c(\omega_c - A_c) = \frac{8\,\omega_c A_c p}{r^2(1+4\,\omega_c^2)^{3/2}} = 4\pi G\bar{\varrho}\left(\frac{\omega_c^2}{2\pi G\bar{\varrho}} + \frac{\varrho}{\bar{\varrho}} - 1\right). \qquad (3)$$

Here p is the radius of curvature of the envelope curve E of the »characteristic diagram», in which the area integral I_2 and the energy integral I_1 are the coordinate axes; p is reckoned positive in the direction away from the origin in the diagram. Further ϱ is the density of matter and the quantity $\bar{\varrho}$ is determined by

$$\frac{\partial^2\varphi}{\partial z^2} = -4\pi G\bar{\varrho}. \qquad (4)$$

According to Poisson's equation we have

$$\frac{\partial^2\varphi}{\partial r^2} + \frac{1}{r}\frac{\partial\varphi}{\partial r} + \frac{\partial^2\varphi}{\partial z^2} = -4\pi G\varrho. \qquad (5)$$

The condition for stable circular orbits, $\varkappa^2 > 0$, may then be expressed

$$\frac{\omega_c^2}{2\pi G\bar{\varrho}} + \frac{\varrho}{\bar{\varrho}} > 1. \qquad (6)$$

Bertil Lindblad

vytvořený obraz hvězdných proudů - důsledek rotace Galaxie***, Elipsoid rychlostí, Galaktické rotace a rozměrů hvězdné soustavy, r. 1930***

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512 *Prof. Bertil Lindblad, Velocity Ellipsoid, Galactic* XC. 5

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Carl Keenan Seyfert 1911 - 1960

americký astronom, výzkum vysoce excitovaných emisních čar z jádra spirálních galaxií - Seyfertových galaxií***, Nukleární emise ve spirálních mlhovinách, r. 1943***

NUCLEAR EMISSION IN SPIRAL NEBULAE*

CARL K. SEYFERT†

ABSTRACT

Spectrograms of dispersion 37–200 A/mm have been obtained of six extragalactic nebulae with high-excitation nuclear emission lines superposed on a normal G-type spectrum. All the stronger emission lines from λ 3727 to λ 6731 found in planetaries like NGC 7027 appear in the spectra of the two brightest spirals observed, NGC 1068 and NGC 4151.

Apparent relative intensities of the emission lines in the six spirals were reduced to true relative intensities. Color temperatures of the continua of each spiral were determined for this purpose.

The observed relative intensities of the emission lines exhibit large variations from nebula to nebula. Profiles of the emission lines show that all the lines are broadened, presumably by Doppler motion, by amounts varying up to 8500 km/sec for the total width of the hydrogen lines in NGC 3516 and NGC 7469. The hydrogen lines in NGC 4151 have relatively narrow cores with wide wings, 7500 km/sec in total breadth. Similar wings are found for the Balmer lines in NGC 7469. The lines of the other ions show no evidence of wide wings. Some of the lines exhibit strong asymmetries, usually in the sense that the violet side of the line is stronger than the red.

In NGC 7469 the absorption K line of *Ca* II is shallow and 50 A wide, at least twice as wide as in normal spirals.

Absorption minima are found in six of the stronger emission lines in NGC 1068, in one line in NGC 4151, and one in NGC 7469. Evidence from measures of wave length and equivalent widths suggests that these absorption minima arise from the G-type spectra on which the emissions are superposed.

The maximum width of the Balmer emission lines seems to increase with the absolute magnitude of the nucleus and with the ratio of the light in the nucleus to the total light of the nebula. The emission lines in the brightest diffuse nebulae in other extragalactic objects do not appear to have wide emission lines similar to those found in the nuclei of emission spirals.

Carl Keenan Seyfert

Nukleární emise ve spirálních mlhovinách, r. 1943

I. THE OBSERVATIONAL MATERIAL

The present investigation is an intensive study of six of the brightest extragalactic nebulae showing emission bands in their nuclei (Table 1). Of these six, special emphasis was placed on the three having the brightest nuclei, NGC 1068, 3516, and 4151, because

TABLE 1*

EMISSION SPIRALS OBSERVED

NGC	1950 R.A.	1950 Dec.	TYPE	m_{total}	$m_{nucl.}$	SPECT.	MODULUS	NO. OF PLATES
1068	$2^h40.1$	− 0° 14	Sb	10.0	13.0	G3	$26^m.0$	17
1275	3 15.6	+41 18	E:	13.0	15.5	G3	30.0	4
3516	11 3.4	+72 50	Sa	12.2	13.7	G2:	28.5	6
4051	12 0.6	+44 48	Sb	11.7	14.0	G2	26.0	4
4151	12 8.0	+39 41	Sb	11.2	12.0	G2	26.0	12
7469	23 0.7	+ 8 36	Sa	13.0	14.3:	G0:	29.8	2

* The total apparent photographic magnitudes are from the *Shapley-Ames Catalogue of External Galaxies* (*Harv. Ann.*, **88**, 43, 1932). The apparent magnitudes (photographic) of the nuclei were estimated from short-exposure plates, taken in series with selected areas. The distance moduli are new determinations derived from magnitudes of resolved stars in the arms (NGC 1068), radial velocity (NGC 1068, 3516, 7469), or from association with recognized clusters or groups (NGC 1275, 4051, 4151). The plates used for determinations of nuclear magnitudes and most of the data for computing the distance moduli were supplied by E. P. Hubble. The spectral types were determined by M. L. Humason.

Carl Keenan Seyfert

Nukleární emise ve spirálních mlhovinách, r. 1943

TABLE 3

INTENSITIES OF EMISSION LINES IN SIX EXTRAGALACTIC NEBULAE

Atom	λ	NGC 1068	NGC 1275	NGC 3516	NGC 4051	NGC 4151 Core	NGC 4151 Wing	NGC 4151 Core+Wing	NGC 7469 Core	NGC 7469 Core+Wing	NGC 7027*
[O II].......	3726.2	80:	140:	......	......	100:	......	25:	48:	15:	8
[O II].......	3729.7										4
[Ne III]......	3869	65:†	35:	......	P	65:	......	15:	......	......	40
H ζ........	3889.1	5:	......	......	......	......	......	......	......	......	7
[Ne III]......	3968	25:†	20:	......	......	25:	......	5:	......	......	15
H ε........	3970.1										8
[S II]........	4068.5	20	50	......	......	25	......	5	......	......	5
[S II]........	4076.5										2
H δ........	4101.8	20	10:	25	......	20	20	20	......	35:	12
H γ........	4340.5	40	50	40‡	40	35	30	35	......	60:‡	20
[O III].......	4363.2	35	40	......	20	75	......	18	......	......	10
C IV[Fe III]..	4658.6	......	......	......	......	5	......	1	......	......	0.9
He II.......	4685.8	40	......	......	25	25	......	5	......	......	40
[A IV].......	4711.4	......	......	......	......	10	......	2	......	......	3
[A IV].......	4740.3	......	......	......	......	10	......	2	......	......	7
H β........	4861.3	100§	100	100	100	100	100	100	100	100	100
[O III].......	4959.5	400§	80	15	55	375	......	90	125	35	430
[O III].......	5007.6	1200§	270	40	190	1150	......	275	300	80	1190
[Fe VII]......	5158.3	5	......	......	......	P‖	......	P	......	......	2
[N I]........	5199.2	25	......	......	......	15	......	5	......	......	3
[Fe VII]......	5276.1	5:	......	......	......	P:	......	P:	......	......	1.5±
	5670.5	......	......	......	......	P	......	P	......	......	......
[Fe VII]......	5720.9	10	......	......	......	20	......	5	......	......	4
[N II].......	5755.0	10	......	......	......	......	......	......	......	......	20
He I........	5875.6	15:	......	......	......	30	......	5	......	......	35
[Fe VII] [Ca V]	6085.7	30	......	......	......	35	......	10	......	......	5
[O I]........	6300.2	85	100	......	30	150	......	35	......	......	40
[S III].......	6310.2										15
[O I]........	6363.9	30	40	......	20	50	......	10	......	......	20
[N II].......	6548.4				25:	100		25	......	......	90
H α........	6562.8	1000¶	700	600	600	400	375	400	......	......	420
[N II].......	6583.9				50:	200		50	......	......	190
[S II]........	6717.3	140	210	......	40:	180	......	40	......	......	8
[S II]........	6731.5										15

Carl Keenan Seyfert

Nukleární emise ve spirálních mlhovinách, r. 1943

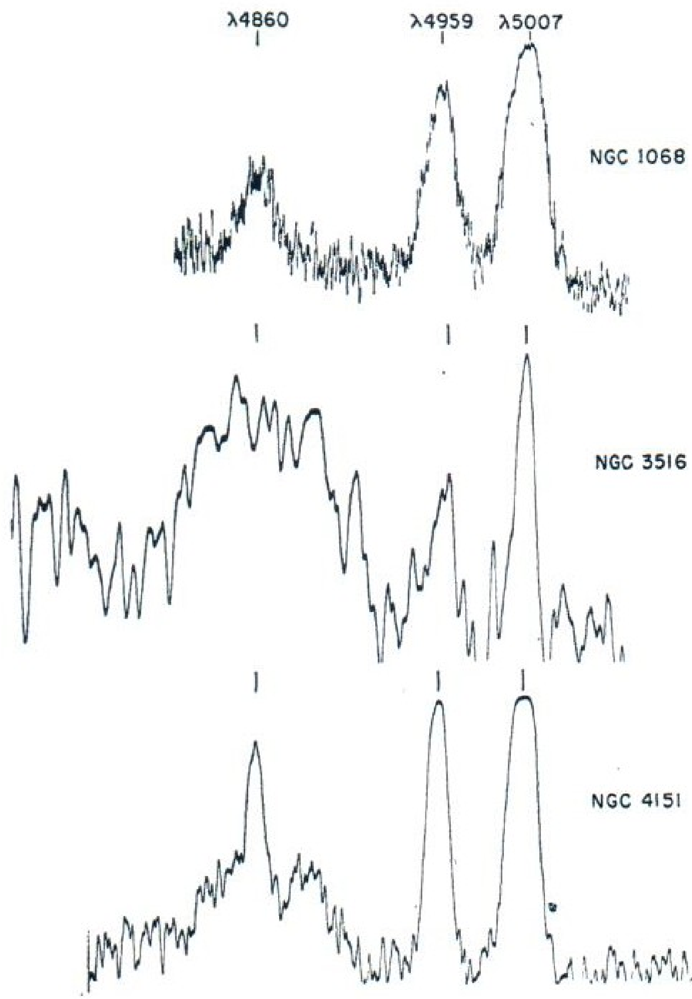
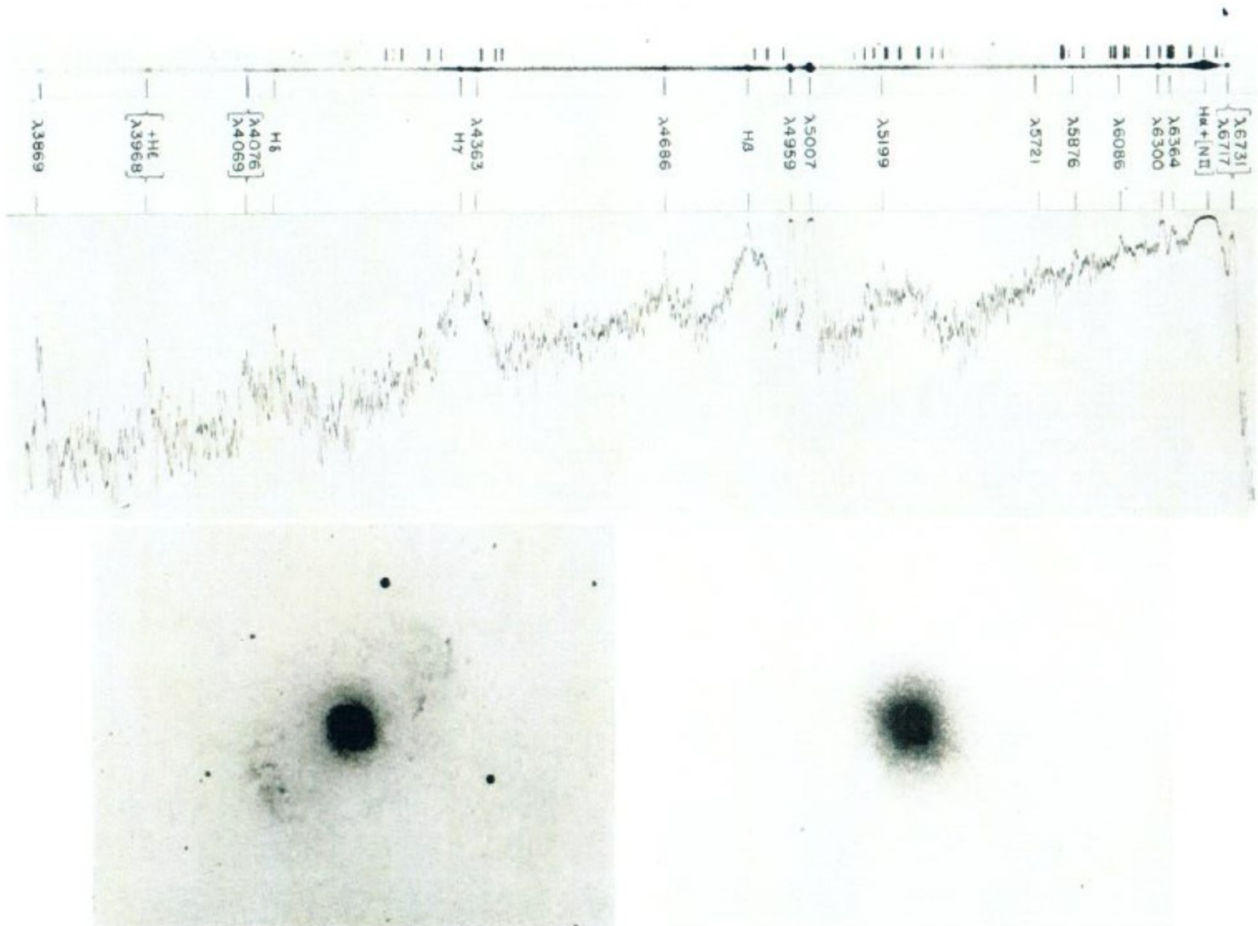


FIG. 1.—Microphotometer tracings of the emission lines λλ 4860 ($H\beta$), 4959 and 5007 [O III] in the nebulae NGC 1068, 3516, and 4151.

Carl Keenan Seyfert

Nukleární emise ve spirálních mlhovinách, r. 1943



NGC 4151

Spectrum, microphotometer tracing, and direct photographs. The spectrum is an enlargement from a 325^m exposure taken with the one-prism Cassegrain spectrograph and 10-inch camera at the 60-inch reflector. The photographs (enlargements from a plate taken with the 100-inch reflector) show the weak, amorphous arms on the left and the semistellar nucleus on the right.

van der Hulst 1911 - 1960

holandský astronom, ***Galaktický systém jako spirální mlhovina r. 1959***

REPORTS ON THE PROGRESS OF ASTRONOMY

THE GALACTIC SYSTEM AS A SPIRAL NEBULA

1. *Introduction.*—The view that the Galaxy might have a spiral structure has been expressed almost since the first discoveries of spiral structure in nebulae. The oldest explicit reference to this seems to be in a paper by Stephen Alexander (1). Both he and Proctor (2), seventeen years later, tried to find support for their spiral theory and to construct to some extent the galactic spiral from the appearance of the Milky Way as inferred mainly from the observations of the Herschels*. In 1900, and more completely again in 1913, Easton (3), apparently quite independently and unaware of these earlier suggestions, made a very careful study of the Milky Way as shown by visual and photographic observations, especially with a view to delineating the course of the possible spiral arms of the Galactic System; he placed the centre of the spiral in the direction of Cygnus.

Later developments have made it clear that this representation can hardly resemble the real structure of the Galaxy, the main cause of its failure and of the failure of all attempts to find spiral-like structure being the strong and uneven absorption near the galactic plane; for there is little doubt that many of the features of the apparent Milky Way structure are determined rather by the distribution of absorbing material than by that of the stars.

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ionized hydrogen becomes appreciable. With decimetre waves the most distant parts of the Galaxy can be explored. Observations in the decimetre continuum can only give the integrated radiation over the line of sight. The 21-cm line gives discrimination in distance. But although the 21-cm observations give discrimination in distance they cannot by themselves provide actual distances. The distance distribution in a given direction can only be inferred from radial velocities. For this we have to suppose that in each part of the Galactic System the average motion of the gas coincides with the circular velocity at the corresponding distance from the centre. Observations of stellar motions indicate that this condition is probably fulfilled to a fair approximation in the neighbourhood of the Sun. It seems plausible to assume that it holds as well for other parts of the Galactic System. But the possibility of deviations must certainly be kept in mind. The 21-cm observations themselves have given clear evidence of systematic divergence from circular motion in some fairly large regions. Moreover, it is certain that the hypothesis is no longer correct in the nuclear part. Within about 3 kpc from the centre the radio observations show that the large-scale motion of the gas deviates greatly from circular motion. We shall return to this below.

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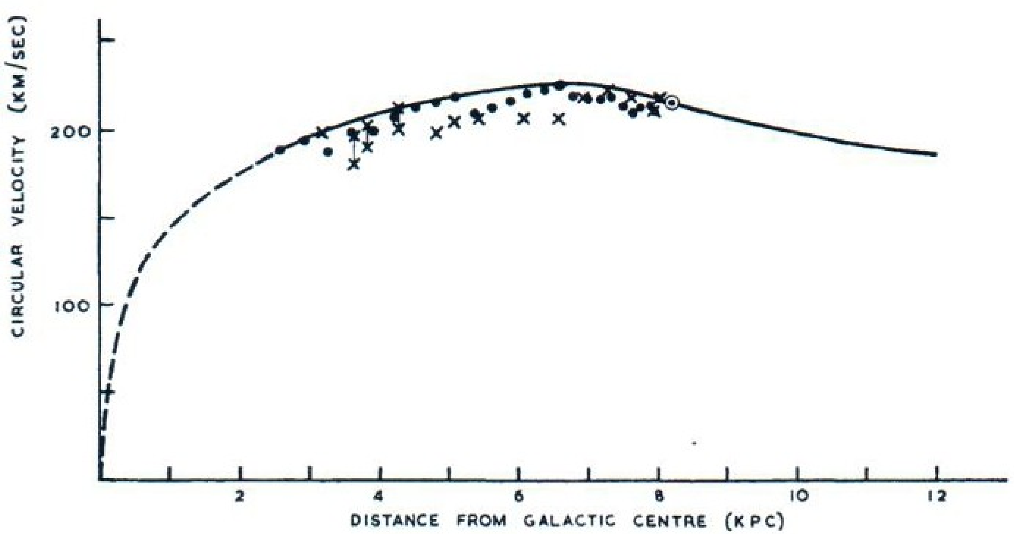
For the regions situated farther from the centre than the Sun the rotational velocities cannot be determined from radio observations. Here we must rely on values computed from the mass densities in these outer parts, the distribution of mass density being inferred from the star density. For $R > R_0 + 2$ kpc the densities become very uncertain and this affects the calculated rotation curve. The resulting systematic uncertainty in the distances may be 10 per cent.

The rotation curve, as derived by M. Schmidt (7) from all available data, is shown in Fig. 2 (full-drawn curve). For the part within $R = 8{\cdot}2$ kpc it is based on 21-cm data discussed by Kwee, Muller and Westerhout (8). These referred to the quadrant from 328° to 58° longitude and are shown as dots. Data for the quadrant at the other side of the centre, measured by Kerr and Hindman, are shown as crosses. Taking into account that in the southern longitudes the



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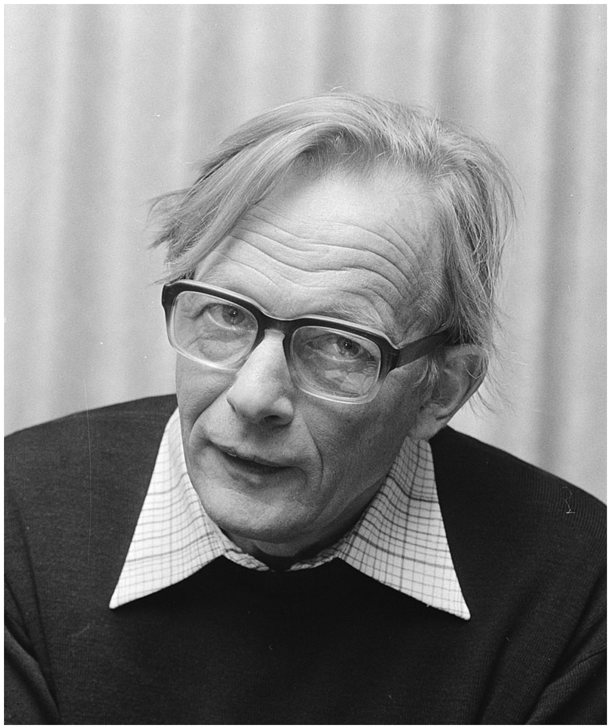

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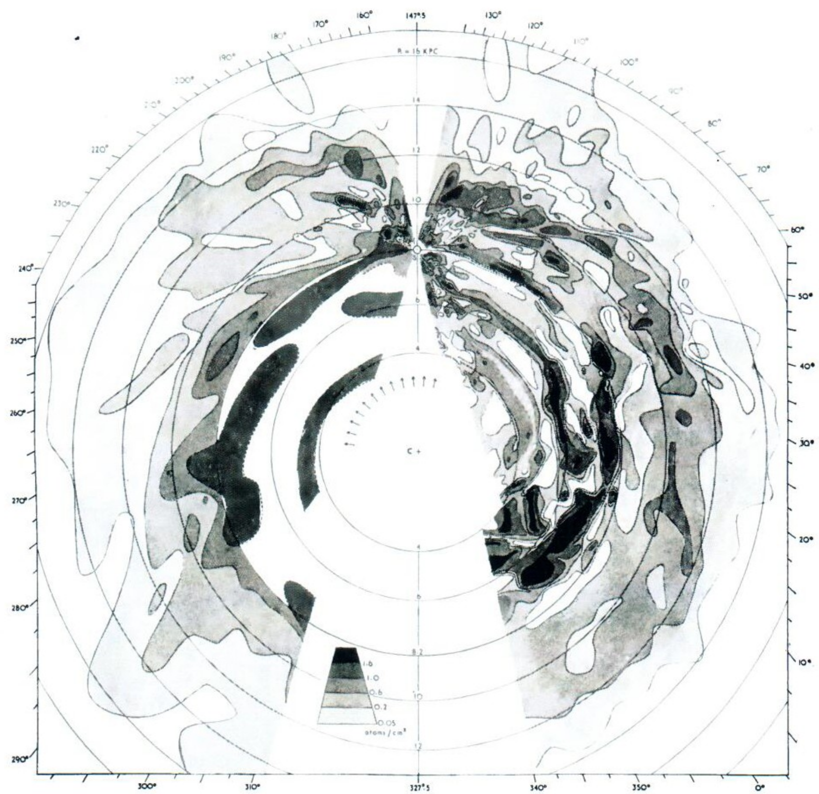

FIG. 4.—*Distribution of neutral hydrogen in the Galactic System. The maximum densities in the z-direction are projected on the galactic plane, and contours are drawn through the points.*

Teorie hustotních vln, spirální struktura galaxií

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Spirální struktura disku galaxií, r. 1964

ON THE SPIRAL STRUCTURE OF DISK GALAXIES

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Received March 20, 1964

ABSTRACT

It is shown that gravitational instability is a plausible basis for the formation of the spiral pattern in disk galaxies An explicit asymptotic formula is obtained for the form of the spiral. It gives reasonable numerical results for the galaxy, and qualitatively satisfactory trends for normal spirals of various types.

I. INTRODUCTION

The mechanism for the formation of the spiral patterns observed in most disk-shaped galaxies has not yet been fully understood. There is little doubt, from the observational data available, that these magnificent manifestations are associated with the interstellar gas and the brilliant young stars born in them. But could the old stars also play an important role in the formation of the spiral structure?

To construct a theory of the spiral structure, one must bear in mind the following important components of a galaxy:

a) *The stars*—with their gravitational forces, circular velocity, and velocity dispersion
b) *The interstellar gas*—with *its* gravitational field and pressure
c) *The magnetic field*—which exerts its influence through the highly conducting interstellar gas.

A complete theory should take all these components and forces into account, and put their relative importance into perspective. Such a theory is not yet available.

There are at least two possible types of spiral theories. The first alternative is to associate every spiral arm with a *given body of matter;* e.g., such an arm might essentially be a tube of gas primarily constrained by the interstellar magnetic field. The difficulty with the disrupting influence of differential rotation in such a theory is well known. The various issues associated with this point of view have been thoroughly discussed recently by Oort (1962). The second alternative is to regard the spiral structure as a *wave pattern*, which either remains stationary, or at least quasi-stationary, in a frame of reference rotating around the center of the galaxy at a proper angular speed (possibly zero).

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that leads to the distortion of acoustic waves. In that case, a density decrease in the direction of wave propagation tends to be accentuated into a compression shock, whereas a density decrease would tend to be smoothed out by the motion of the fluid. Thus, it is conceivable that only trailing waves are stable in the presence of non-linear effects.

In the case of axisymmetrical disturbances, $n = 0$, the formula (12) reduces to one already obtained by Toomre (1964) for a local wavenumber in terms of an assumed frequency. The present asymptotic approach can also yield the slowly varying amplitude distribution over the disk, which is not available from the local theory. The importance of this approximate analysis over the whole disk will be seen in Section IV.

The present study shows that non-axisymmetrical disturbances can propagate around the disk without change of shape even *in the presence of differential rotation.* Indeed, for the range $r_1 < r < r_2$ in which expression (13) applies, the geometrical form of the spiral pattern is found from equations (7) and (12) to be given by

$$n(\theta - \theta_0) = -\int_{r_0}^{r} (2\pi G\mu_0)^{-1}[\kappa^2 + \omega_i^2 + (\omega_r - n\Omega)^2]\,dr\,. \qquad (14)$$

The end points of this range, $r = r_1$ and r_2, correspond to the points of *local gravitational resonance* in the neutral case (cf. Sec. IV). As a typical example, if we refer to the density data given by Schmidt (1956) and the velocity data given by P. O. Lindblad (1960, Table 2) on the basis of Schmidt's model, and take $\omega_r = 20$ km/sec kpc and $\omega_i = 50$ km/sec kpc (which is somewhat less than the value of κ at 5 kpc from galactic center),

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Since we are working with a cylindrical coordinate system, the convenient form for the basic equation is

$$\frac{\partial^2\phi}{\partial r^2}+\frac{1}{r}\frac{\partial\phi}{\partial r}+\frac{\partial^2\phi}{\partial z^2}+\frac{1}{r^2}\frac{\partial^2\phi}{\partial\theta^2}=-4\pi G\sigma(r,\theta)\delta(z). \tag{A1}$$

In other words, we look for solutions of Poisson's equation for $z > 0$ and for $z < 0$ such that, at $z = 0$, there is a discontinuity in ϕ_z given by

$$\left[\frac{\partial\phi}{\partial z}\right]=\phi_z(r,\theta,0+)-\phi_z(r,\theta,0-)=-4\pi G\sigma(r,\theta). \tag{A2}$$

Since the problem is linear, we may consider the individual harmonic components in

$$\sigma=\sigma_n(r)\cos n\theta\,,\qquad \phi=F_n(r,z)\cos n\theta \tag{A3}$$

and obtain the general solution by superposition. We thus have the partial differential equation

$$\frac{\partial^2 F_n}{\partial r^2}+\frac{1}{r}\frac{\partial F_n}{\partial r}+\frac{\partial^2 F_n}{\partial z^2}-\frac{n^2F_n}{r^2}=-4\pi G\sigma_n(r)\delta(z) \tag{A4}$$

to be solved under the condition

$$\left[\frac{\partial F_n}{\partial z}\right]=-4\pi G\sigma_n\,. \tag{A5}$$

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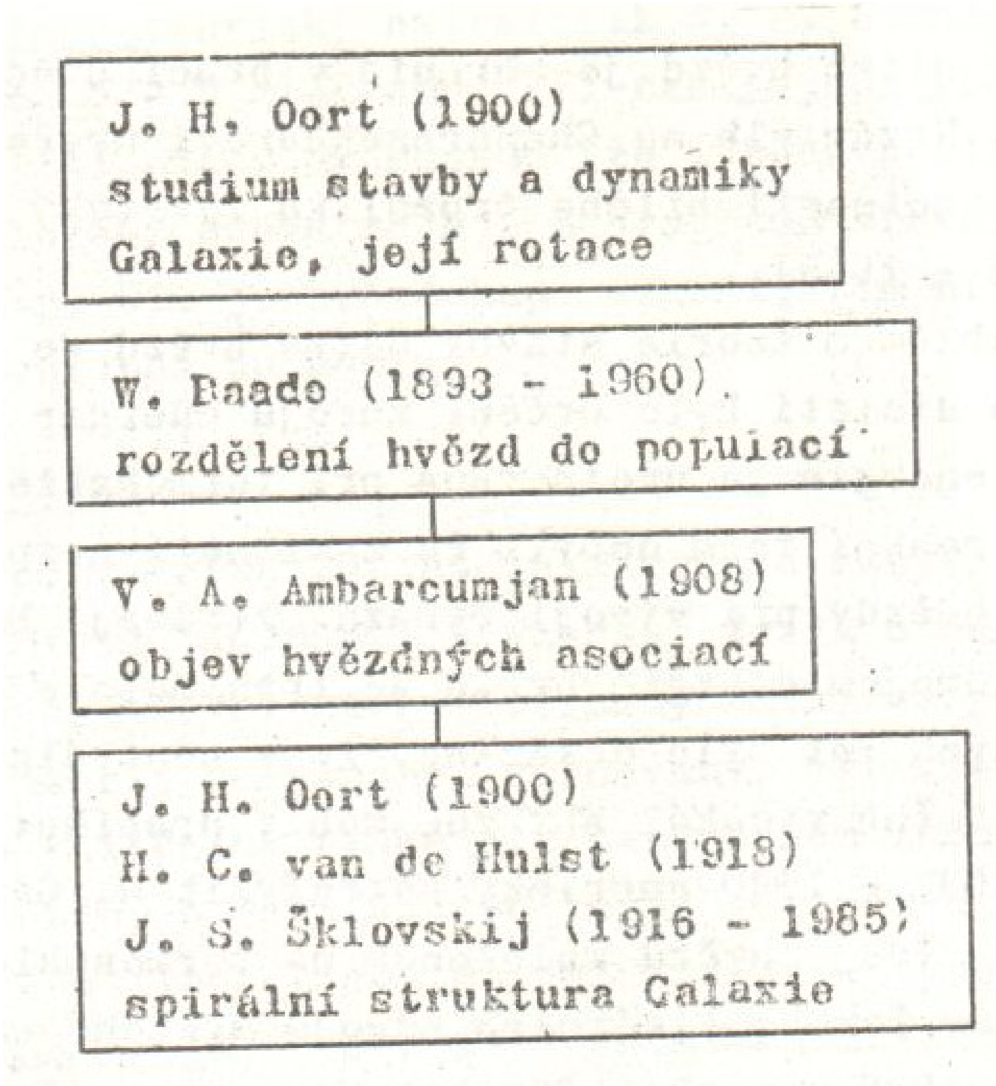

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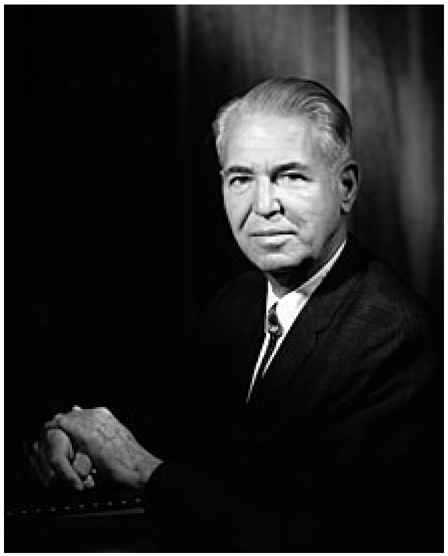

PUBLICATIONS OF THE
ASTRONOMICAL SOCIETY OF THE PACIFIC

Vol. 69 | August 1957 | No. 409

A SPECTRAL CLASSIFICATION OF GALAXIES*

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I. INTRODUCTION

There is at least one advantage in a classification of galaxies based on their spectra: the absorption and emission features, despite their composite nature, contain significant information bearing on the stellar populations of the systems. Such a classification, however, should be regarded as complementary to the classical Hubble sequence based on form and degree of resolution. The reason is that the spectral characteristics considered here seem to correlate rather well with the appearance of spiral structure and central concentration, which are two properties of galaxies that show progressive changes in Hubble's scheme. Thus the classification proposed here will incorporate additional information that did not, in general, enter into Hubble's assignments of nebular types.

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reflector, and with the Cassegrain spectrograph of the 82-inch McDonald reflector.

II. GENERAL CHARACTERISTICS OF THE SPECTRA OF GALAXIES

In the case of spectroscopically composite systems such as galaxies it is to be expected that the spectral types deduced will depend upon the wavelength region observed; if a mixture of early- and late-type stars is present, the integrated spectral type will tend to become progressively earlier on passing toward regions of shorter wavelength. Moreover, the features observed in any one spectral region may indicate a considerable range in type for the contributing stars. We shall first review briefly some aspects of the spectral classification system of Humason.[2]

Humason's Spectral Classification System

For galaxies having absorption-line spectra, Humason estimated spectral types by comparison with standard spectrograms of M 32 (NGC 221), for which Adams, Joy, and Humason had

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Criteria for a Spectroscopic Classification of Galaxies

With the great improvements made in recent years in instrumentation and photographic emulsions, it now seems worth while to attempt a more precise spectroscopic classification of the integrated spectra of galaxies. This classification system has the following four properties:

1. It refers in general to two principal parts of a galaxy: (*a*) The system as a whole when there is little or no central concentration, and (*b*) the nuclear region when it dominates the system. In the first case, if there is any appreciable variation over the system, the spectral type corresponds to a weighted-mean sample of the main contributors to the total light.

2. A narrow interval in wavelength is used to obtain the spectral classification; in the present investigation it is that between λ 3850 and λ 4100. For a complete description of the composite spectrum of a galaxy, a spectral classification should be made for

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would give an integrated spectrum similar to the one observed for the nuclear region of the Andromeda Nebula. This is illustrated by the vertical lines in Figure 1, where the areas covered

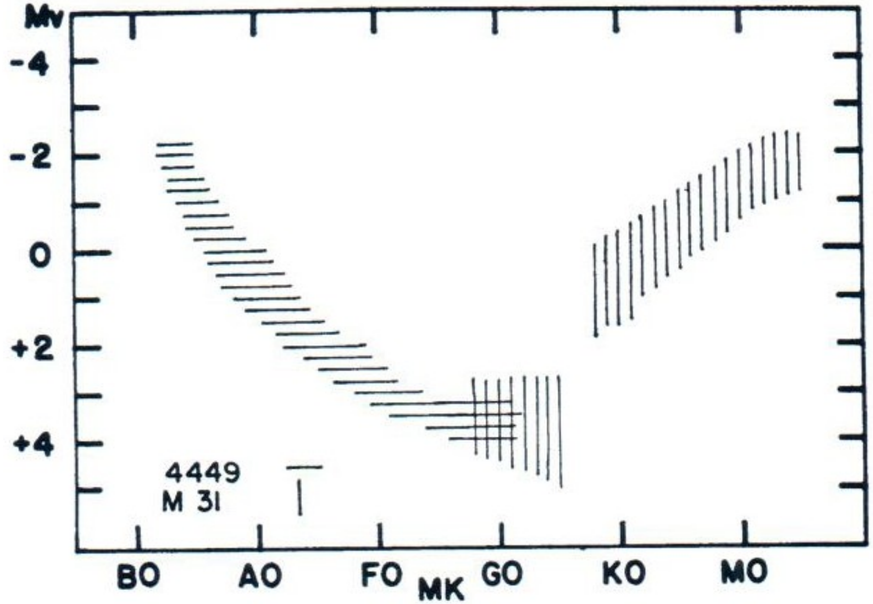

FIG. 1.—Hypothetical H-R diagram for the principal contributors to the light of the inner part of M 31 (vertical lines) and of NGC 4449 (horizontal lines). The plot for NGC 4449 is less complete than that for M 31, since spectra in the yellow and red regions were not available.