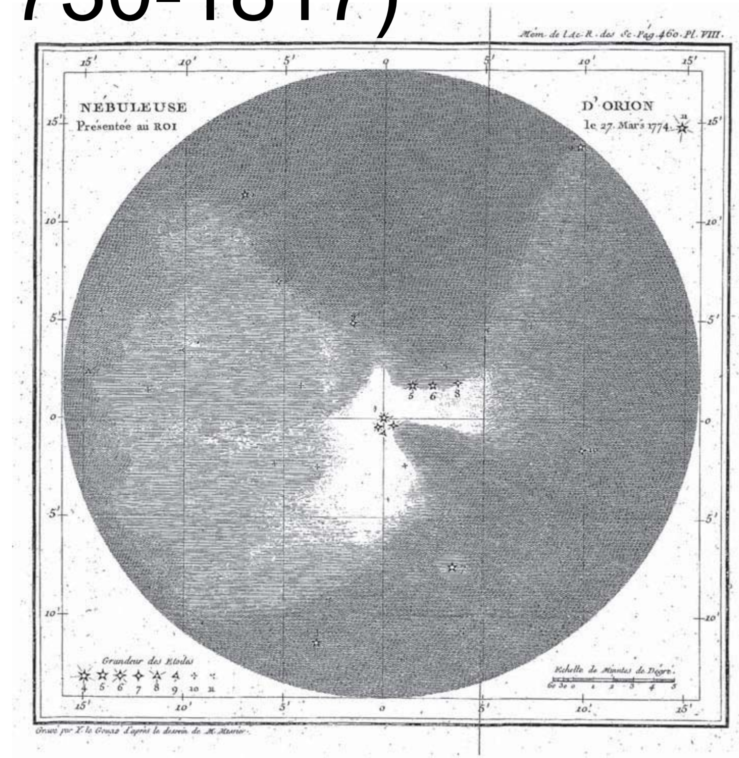
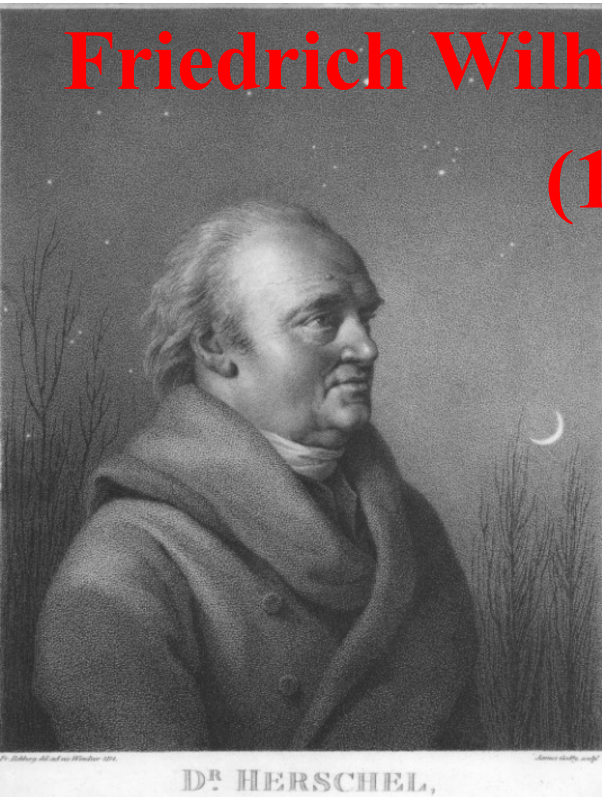
Мир галактик

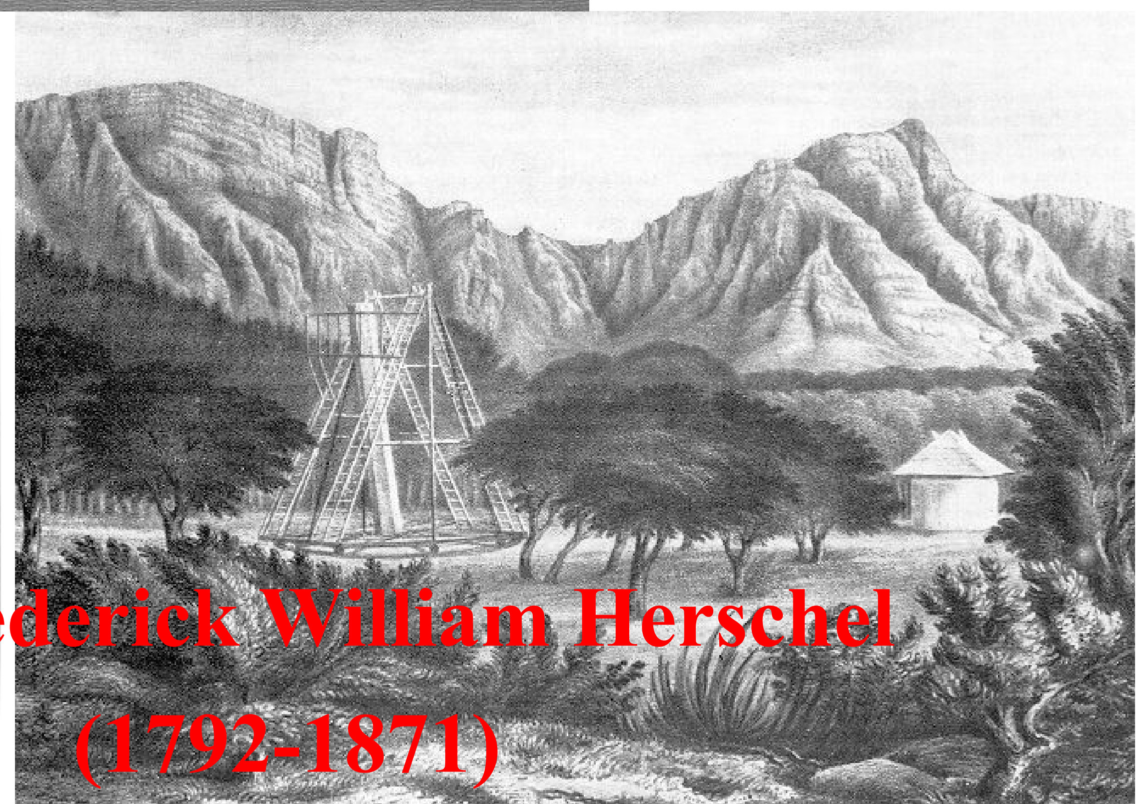
Д.И. Макаров

Charles Messier (1730-1817)



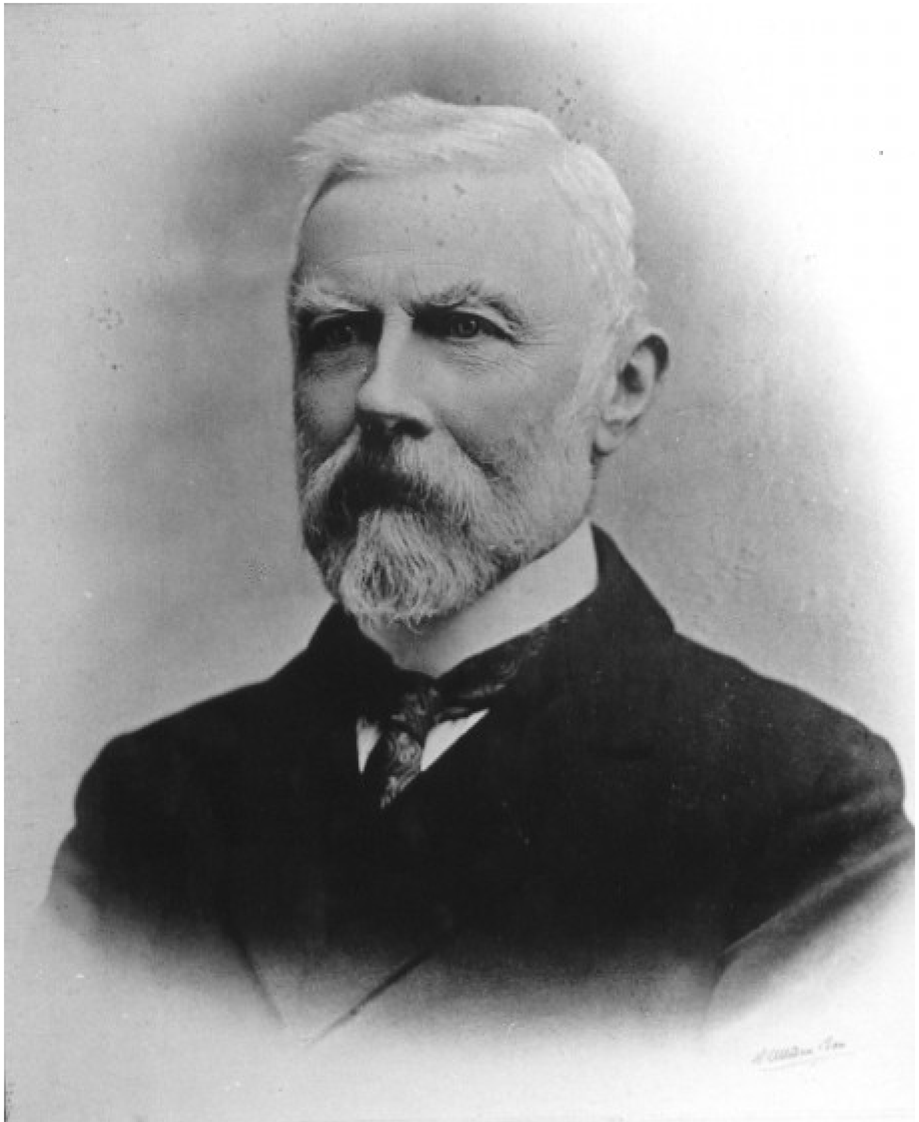
Friedrich Wilhelm (William) Herschel
(1738-1822)





John Frederick William Herschel
(1792-1871)

John Louis Emil Dreyer (1852-1926)

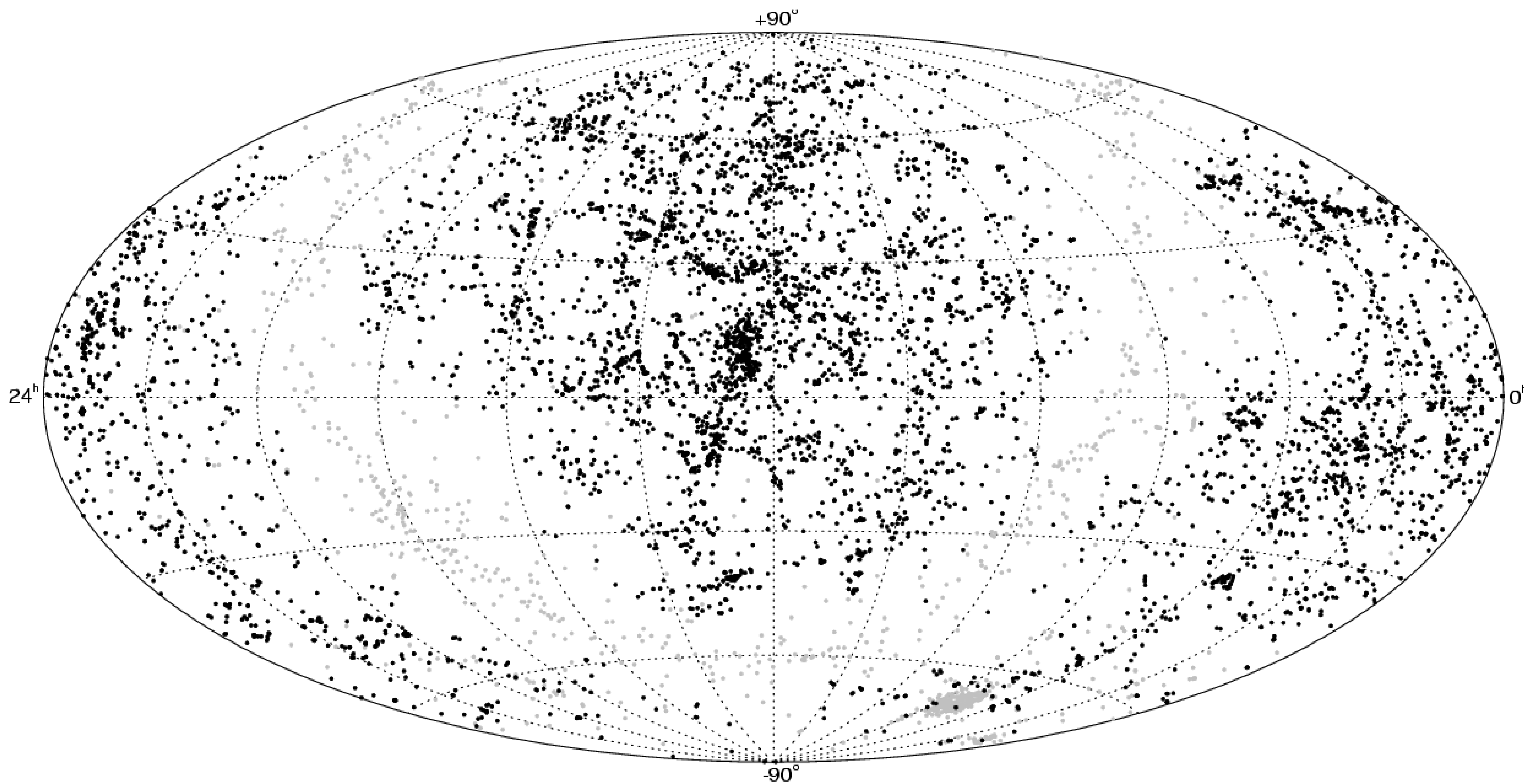


Dr. J. L. E. Dreyer. Ph. D.

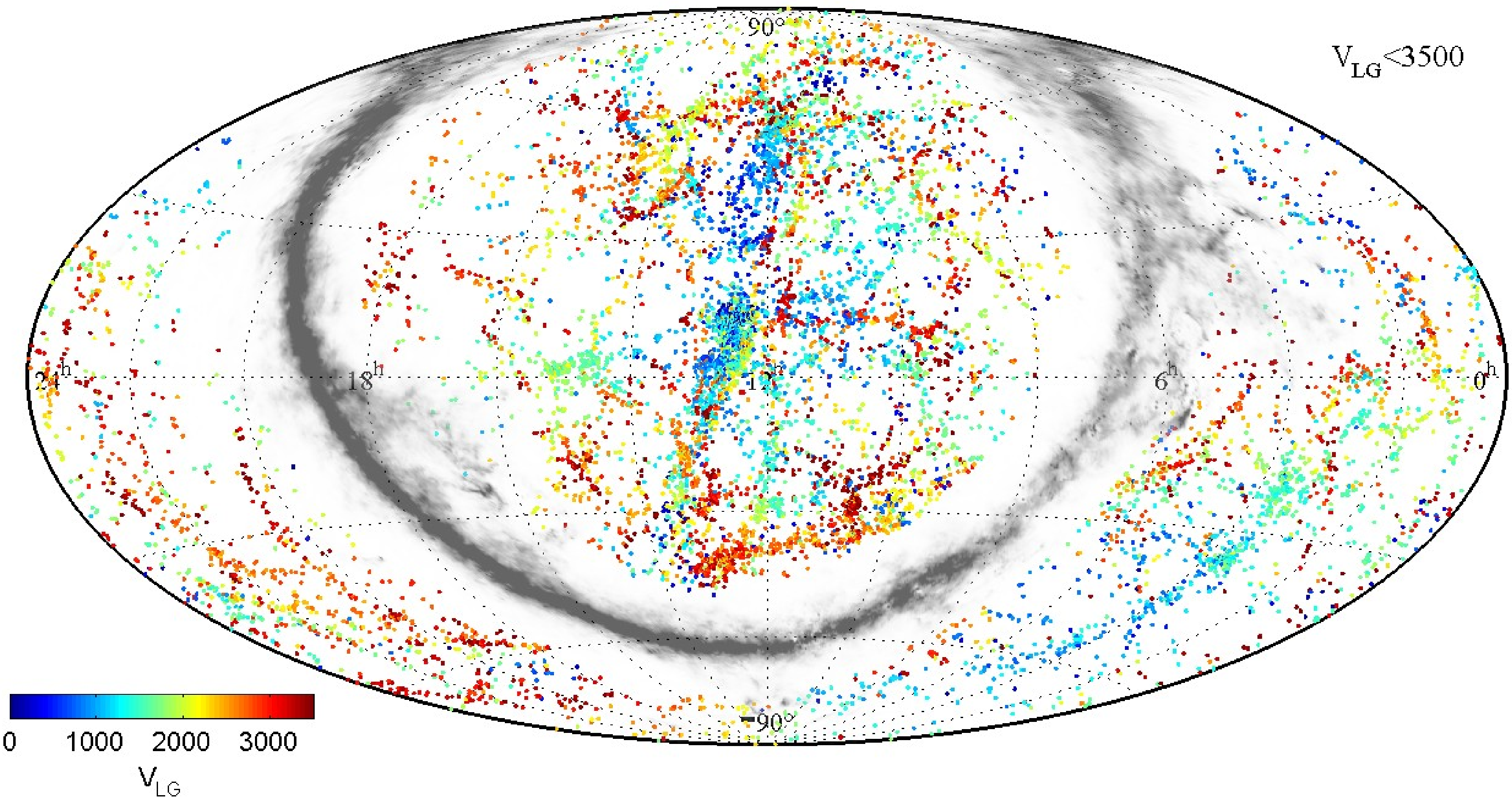
A New General Catalogue of Nebulæ and Clusters of Stars, being the Catalogue of the late Sir John F. W. Herschel, Bart., revised, corrected, and enlarged. By J. L. E. Dreyer, Ph.D.

The General Catalogue of Nebulæ which the late Sir John Herschel published in the *Philosophical Transactions* for 1864 was almost entirely founded on his father's and his own observations. Out of 5,079 objects which it contained only about 450 positions were due to other observers, while the places of the remainder were deduced from all the observations of Sir William and Sir John Herschel, those of the former having been reduced independently by Caroline Herschel and by Auwers. But already, before the appearance of this valuable work, several astronomers had commenced determining accurate positions of nebulæ. In 1853 Laugier made the beginning by publishing the places of fifty-three bright nebulæ determined at the Paris Observatory, and in 1856 appeared d'Arrest's first series of micrometric observations of nebulæ made at the Leipzig Observatory. These observations having shown how many objects were within the reach of comparatively small instruments, Schönfeld and Schultz devoted themselves for a number of years to the determination of positions of nebulæ, each observing about 500 objects. Less extensive series of observations have been made by Auwers, G. Rümker, Vogel, J. Schmidt, and B. von Engelhardt. None of these results were, however, available when Herschel's General Catalogue was compiled (except d'Arrest's first series), and what is more to be regretted, the great work of d'Arrest's, *Siderum Nebulosorum Observationes Havnienses*, founded on zone observations made with the 11-inch Refractor at Copenhagen, was not completed until three years after Herschel's

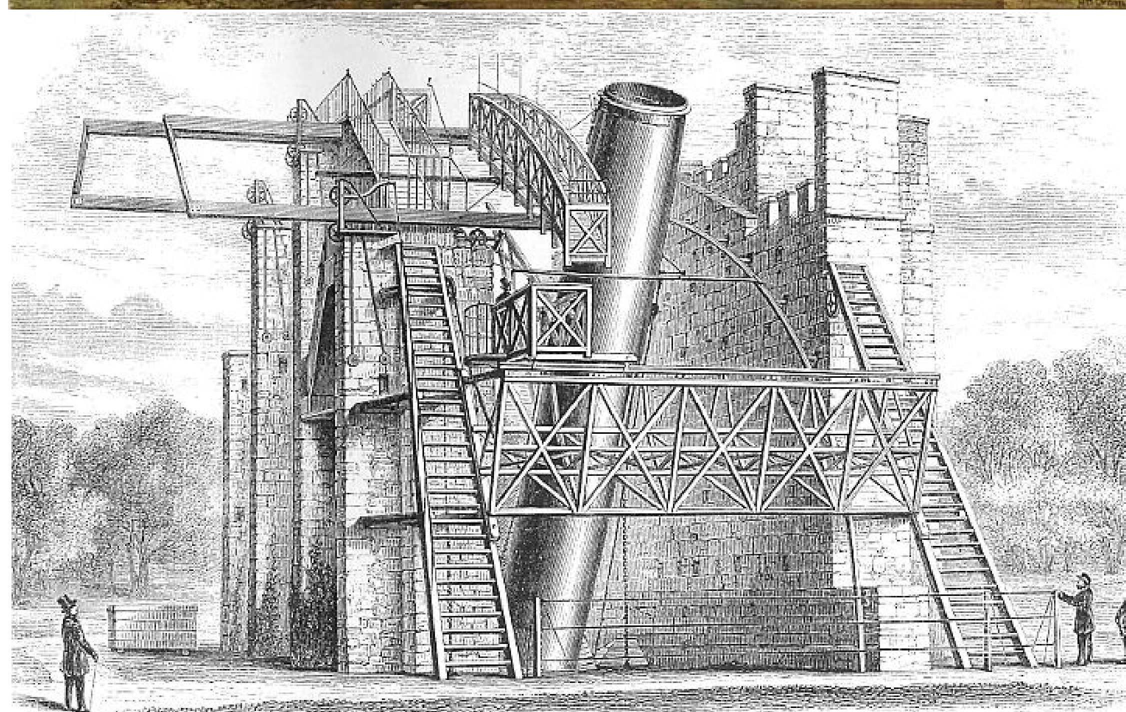
Распределение NGC объектов



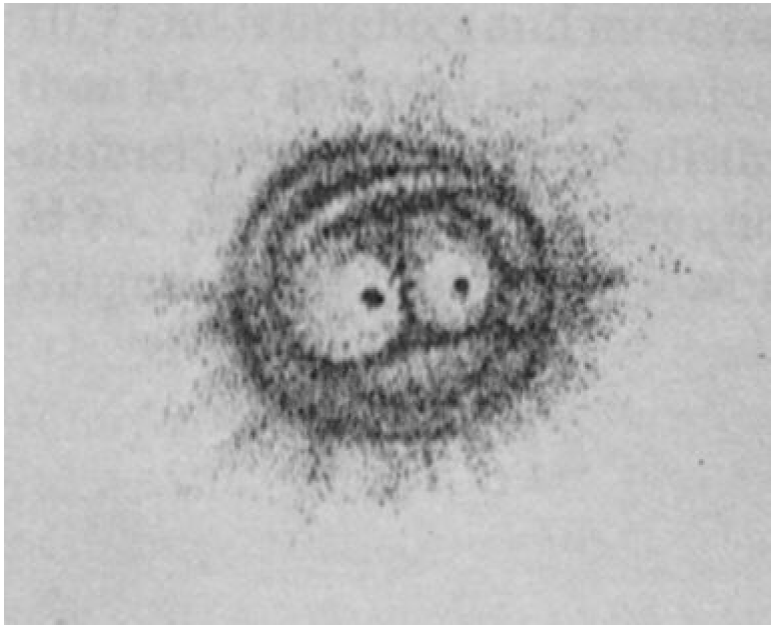
Распределение галактик в Местном Сверхскоплении



William Parsons, 3rd Earl of Rosse (1800-1867)



Messier 97 (Сова)



Messier 1 (Краб)

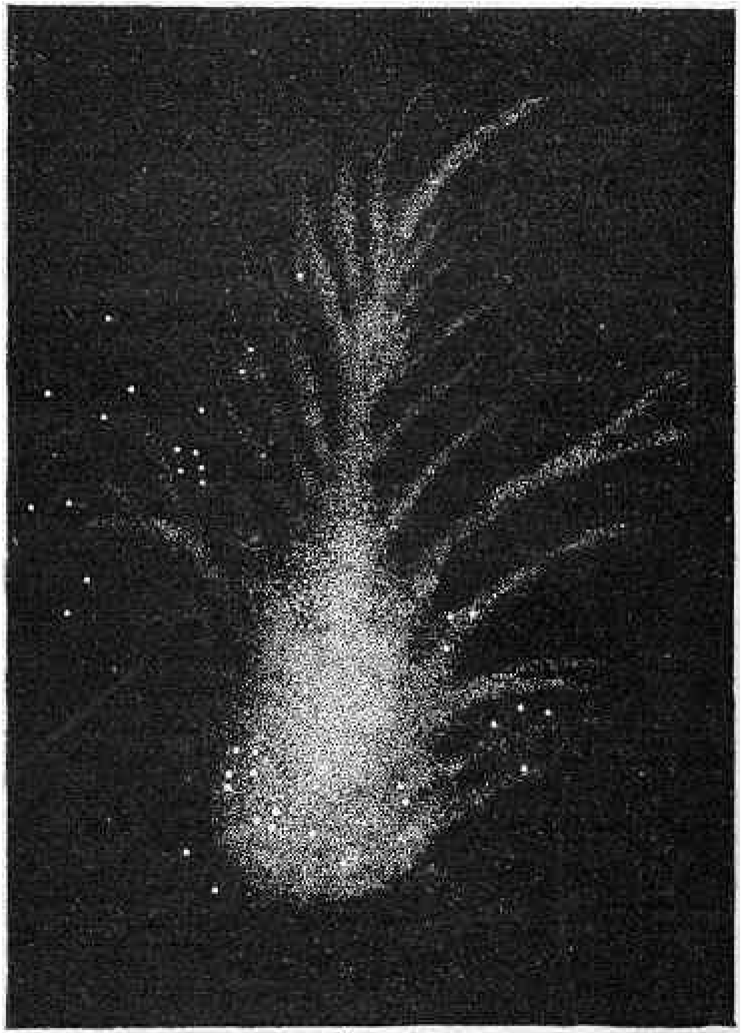
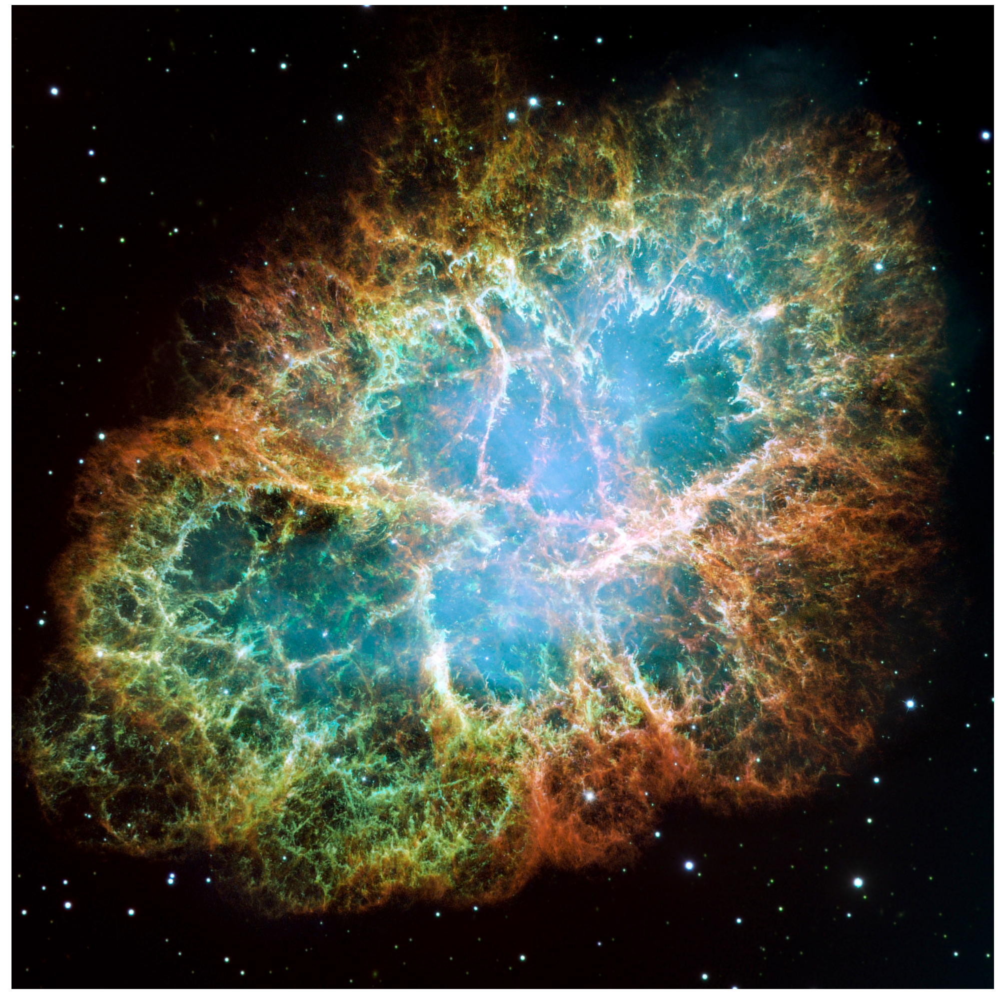
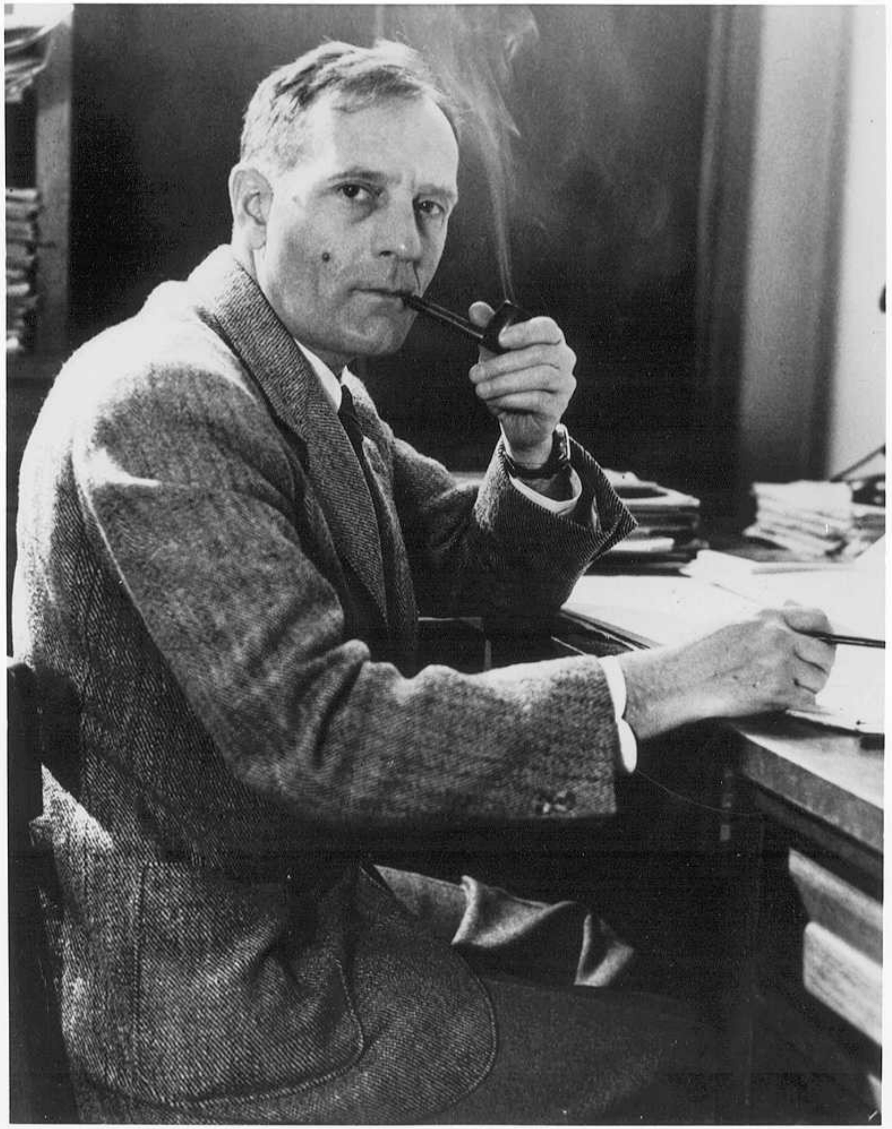


Fig. 438.



Messier 51 (Водорот)

Edwin Powell Hubble (1889-1953)



Cepheids in Spiral Nebulæ *.

Messier 31 † and 33, the only spirals that can be seen with the naked eye, have recently been made the subject of detailed investigations with the 100-inch and 60-inch reflectors of the Mount Wilson Observatory. Novæ are a common phenomenon in M 31, and Duncan has reported three variables within the area covered by M 33 ‡. With these exceptions there seems to have been no

* Abstract of paper read at the Thirty-Third Meeting of the American Astronomical Society. From *Popular Astronomy*, vol. xxxiii. No. 4, April 1925.

† Messier 31 is the Andromeda Nebula.

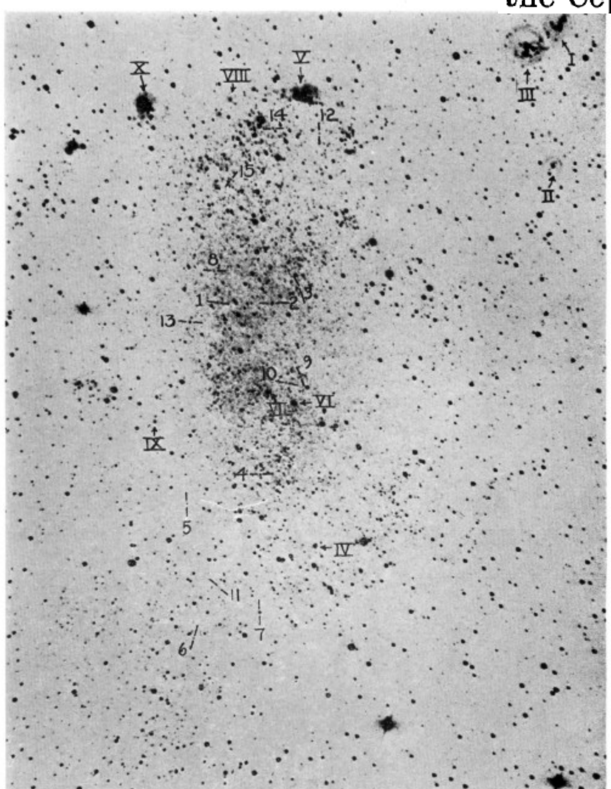
‡ *Publications of the Astronomical Society of the Pacific*, xxxv. p. 290 (1922).

definite evidence of actual stars involved in spirals. Under good observing conditions, however, the outer regions of both spirals are resolved into dense swarms of images in no way differing from those of ordinary stars. A survey of the plates made with the blink-comparator has revealed many variables among the stars, a large proportion of which show the characteristic light-curve of the Cepheids.

N

E

W



N.G.C. 6822

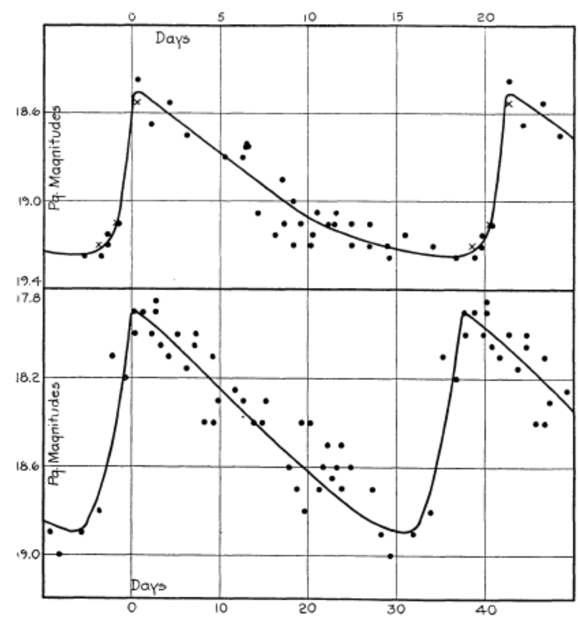


Fig. 1.—Light curves for two Cepheids in N.G.C. 6822. Upper curve, variable No. 6. Period 21.06 days; range 18.5–19.25. Lower curve, variable No. 2. Period 37.45 days; range 17.9–18.9. The three crosses on the rising slope of the upper curve represent observations on successive days and illustrate the rapid brightening of the variables.

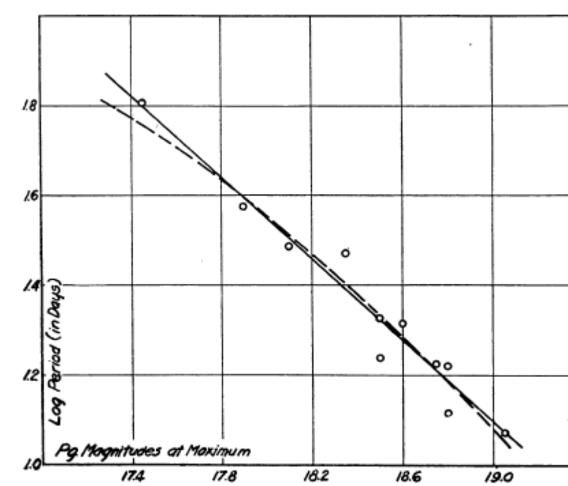


Fig. 2.—Period-luminosity relation among Cepheids in N.G.C. 6822. The continuous line represents the correlation curve, $m(\max) = 21.40 - 2.19 \log P$. The broken curve indicates the corresponding portion of Shapley's general period-luminosity curve reduced to the scale of photographic magnitudes.

Туманность Андромеды

Туманность М83

M81

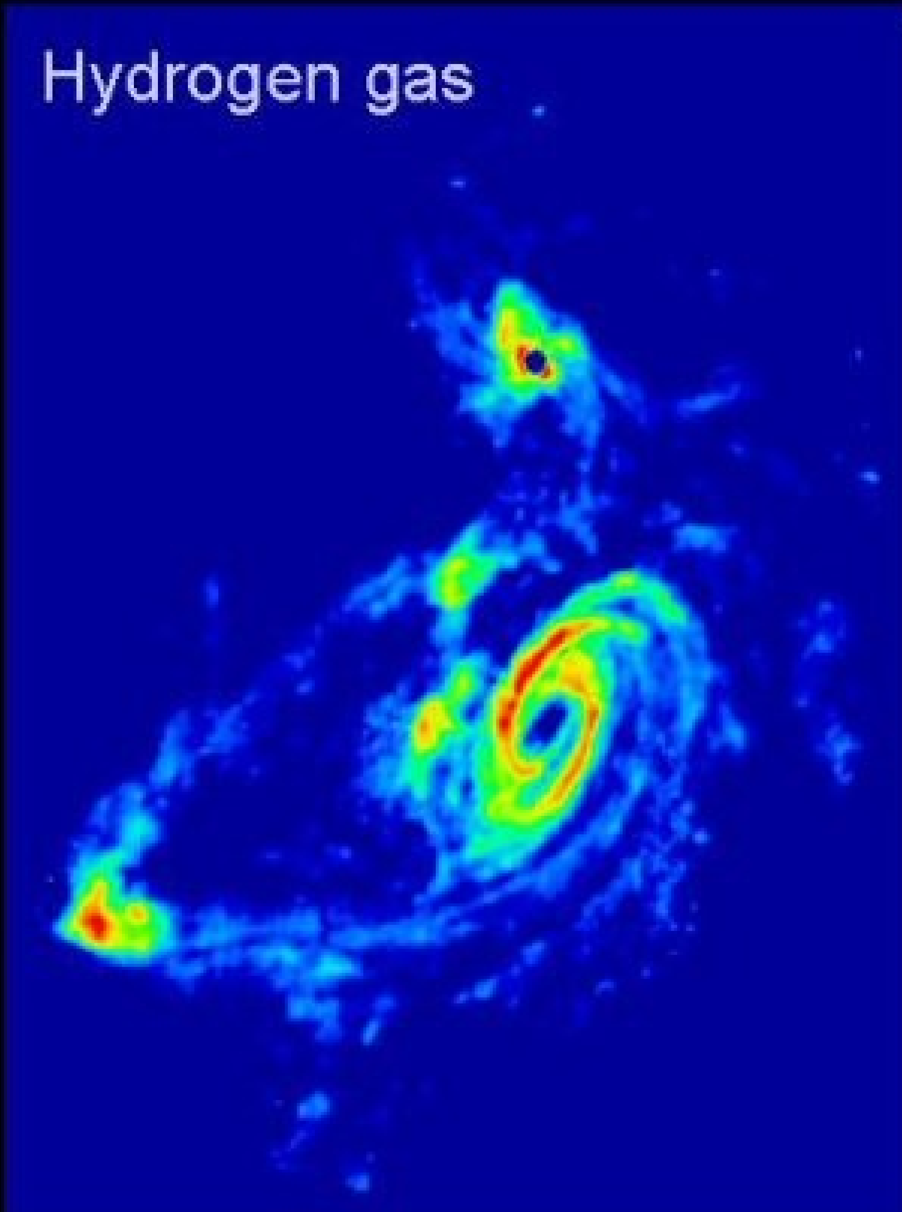
Туманность M81

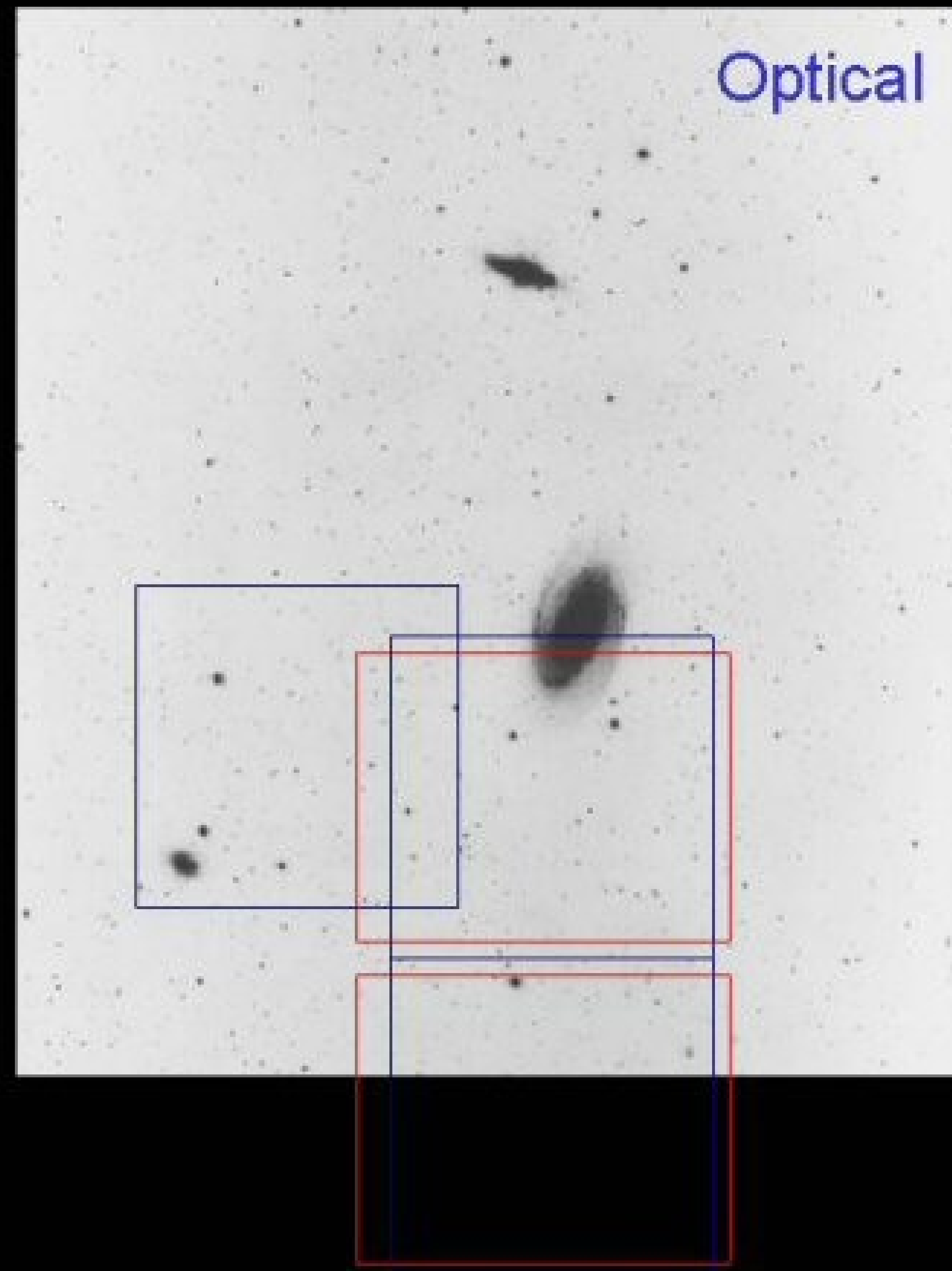
M81+M82

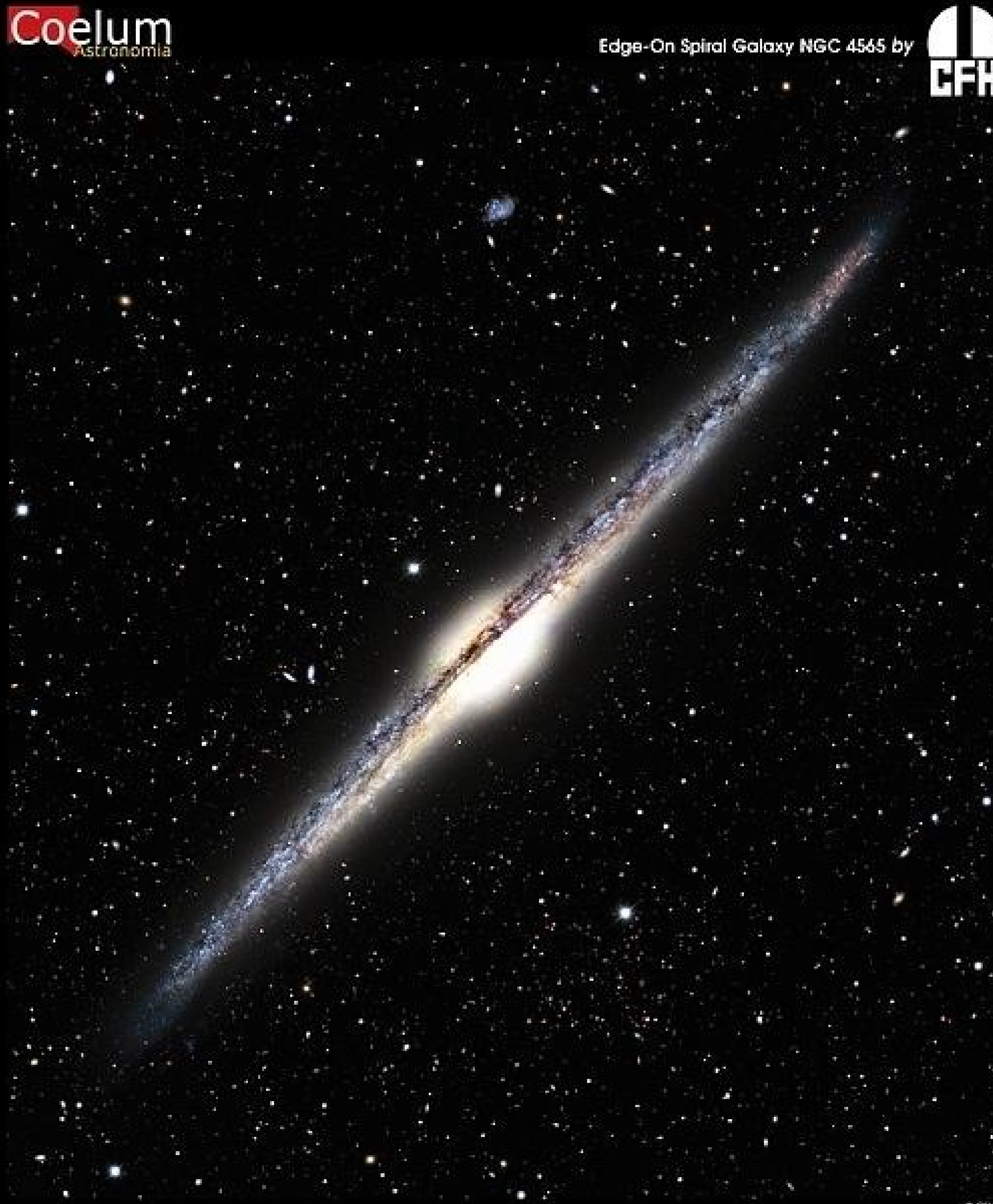
Туманность M82

Туманность M82 (HST+Spitzer+Chandra

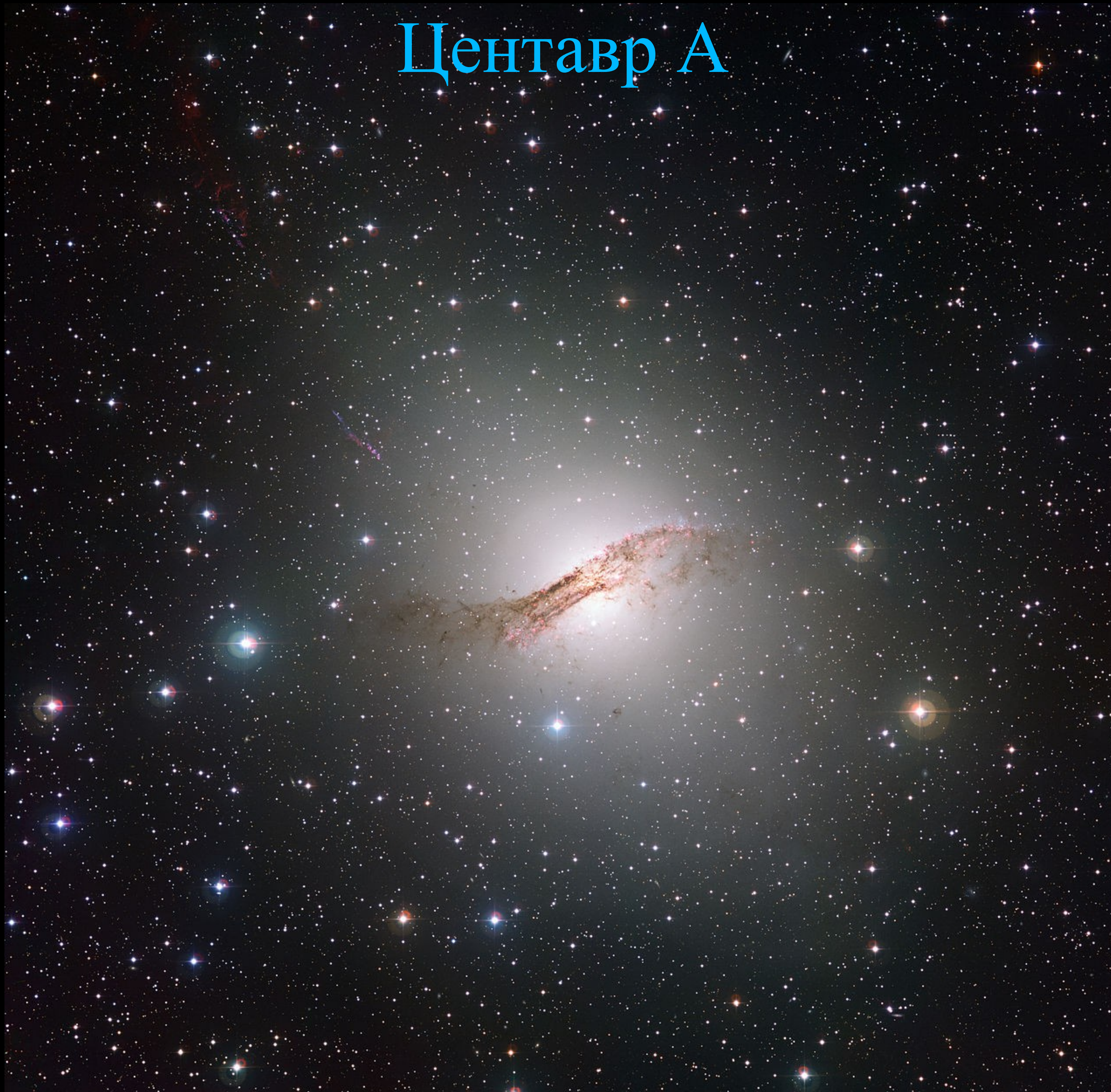
The M81 Group of Galaxies



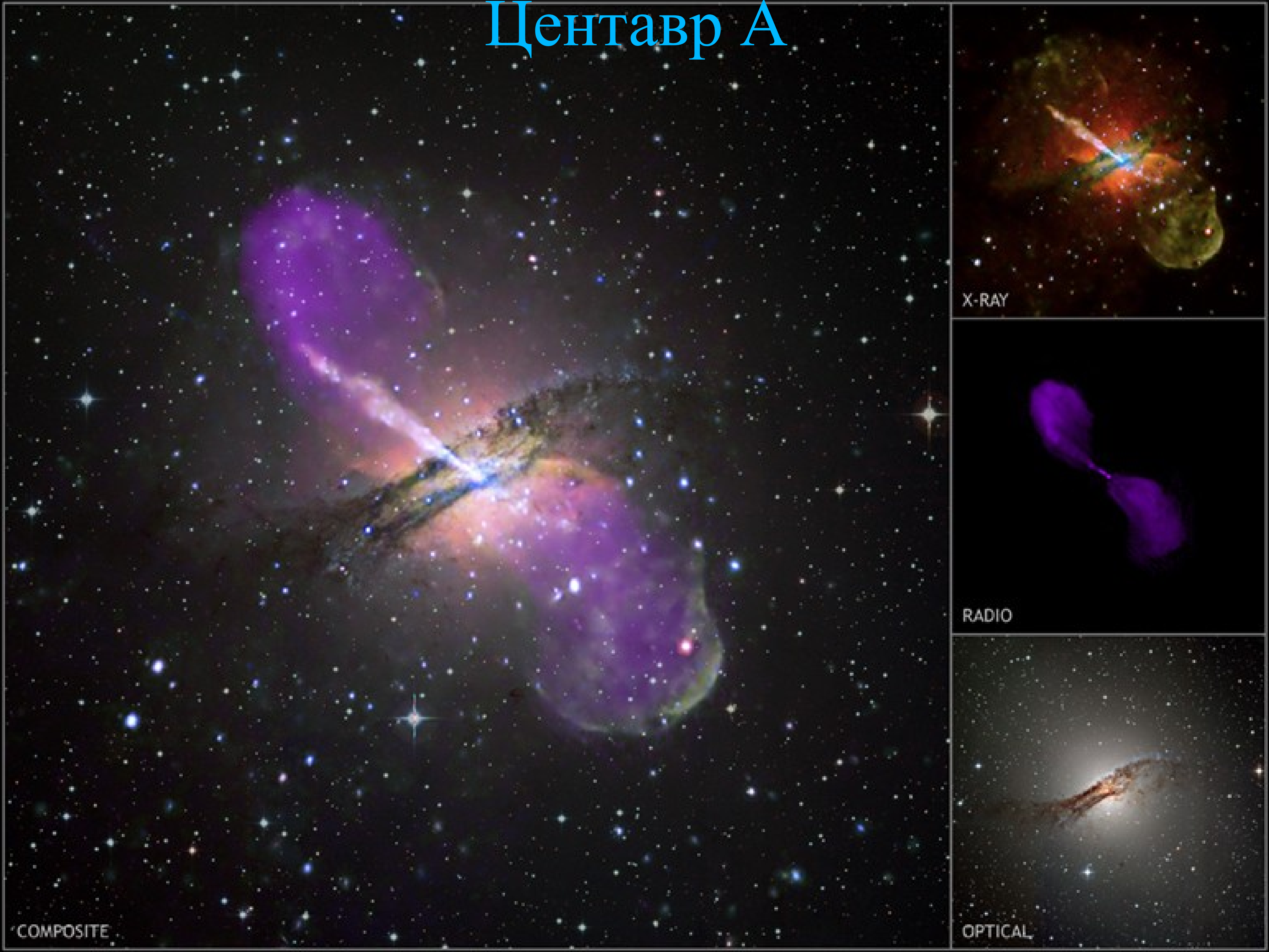



Coelum
Astronomia
Edge-On Spiral Galaxy NGC 4565 by
CFH

Центавр А

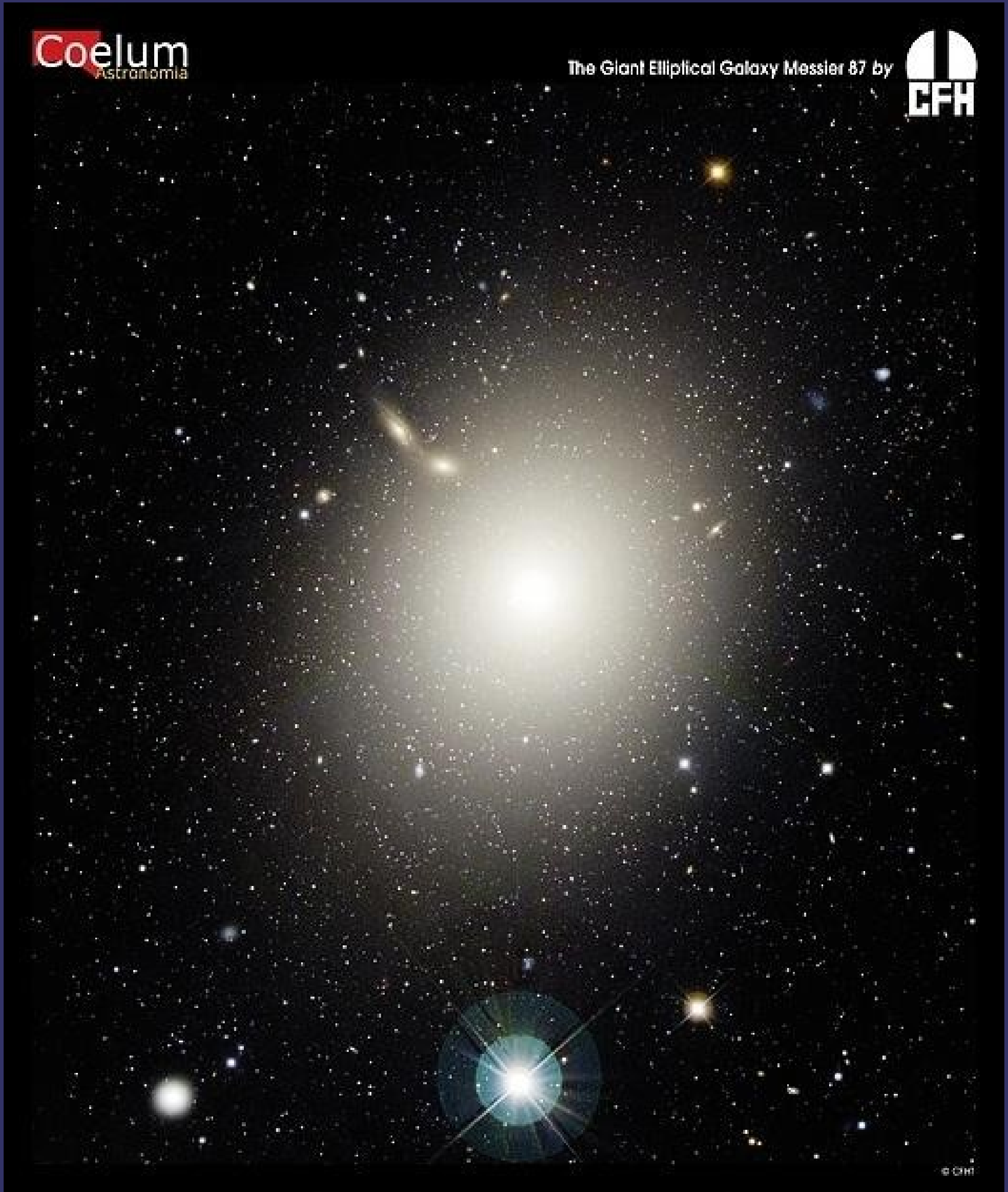


Центавр А

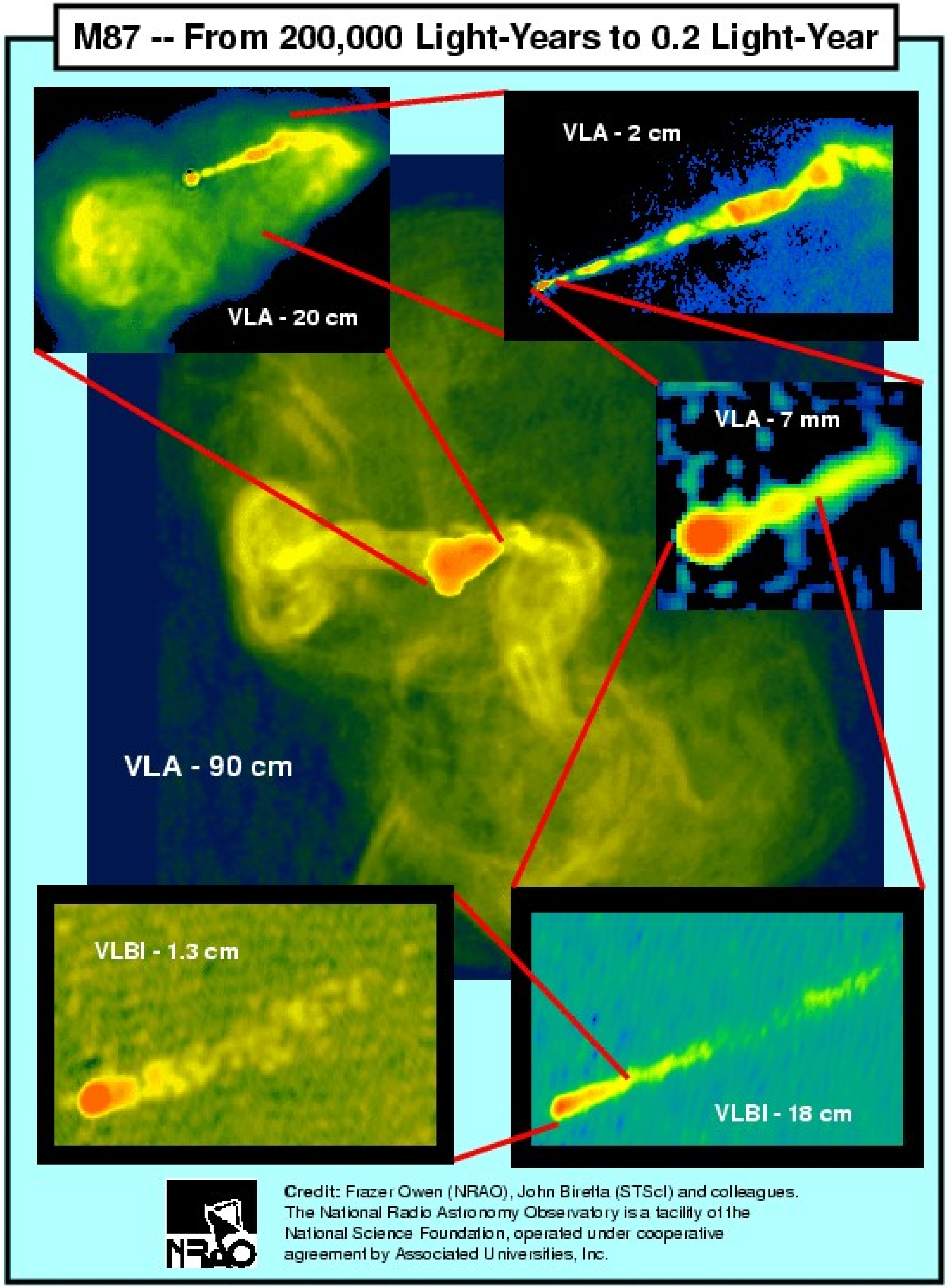


Туманность M49

M87

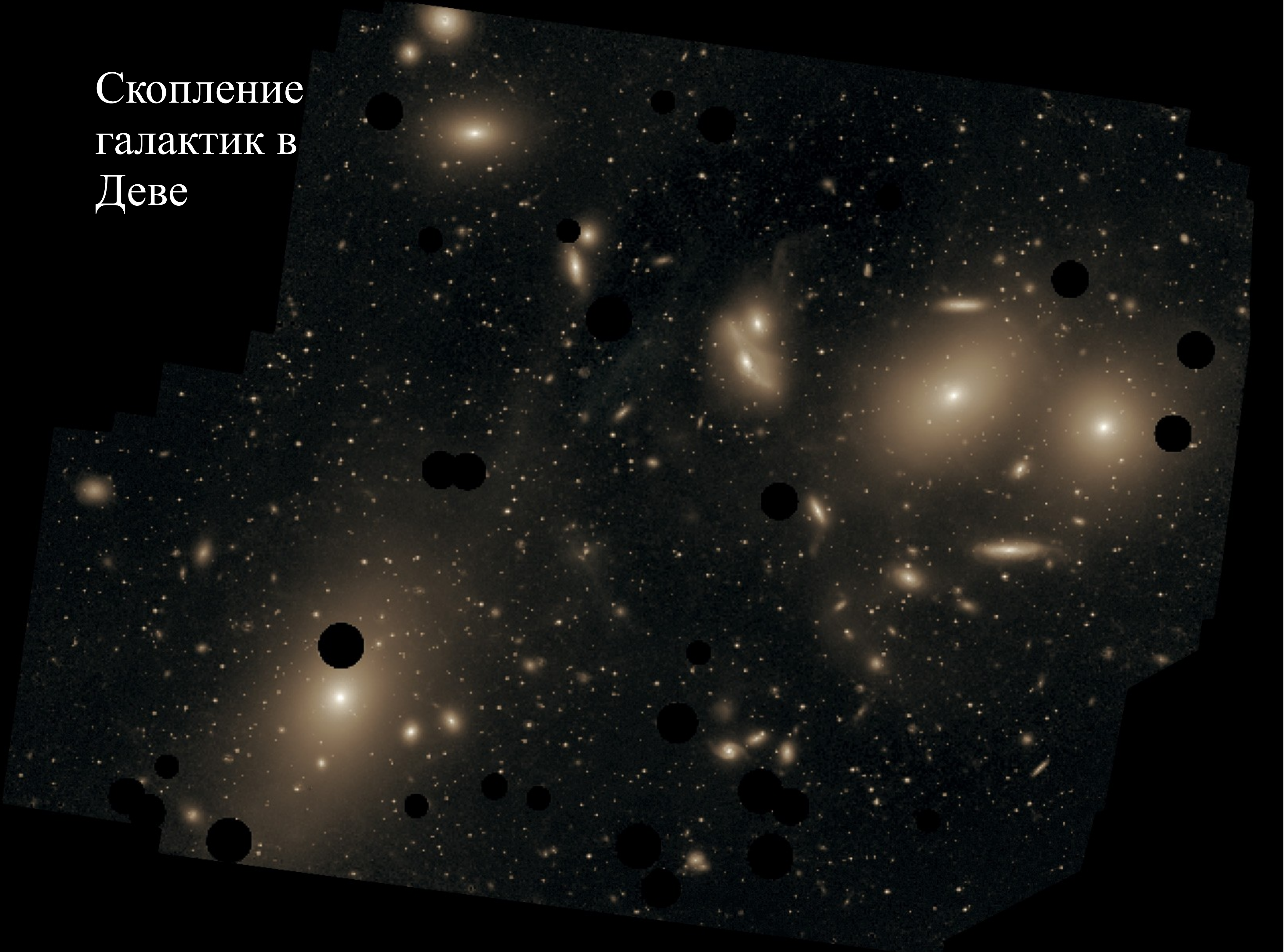

Coelum
Astronomia
The Giant Elliptical Galaxy Messier 87 by
CFH

Туманность M87 (jet)

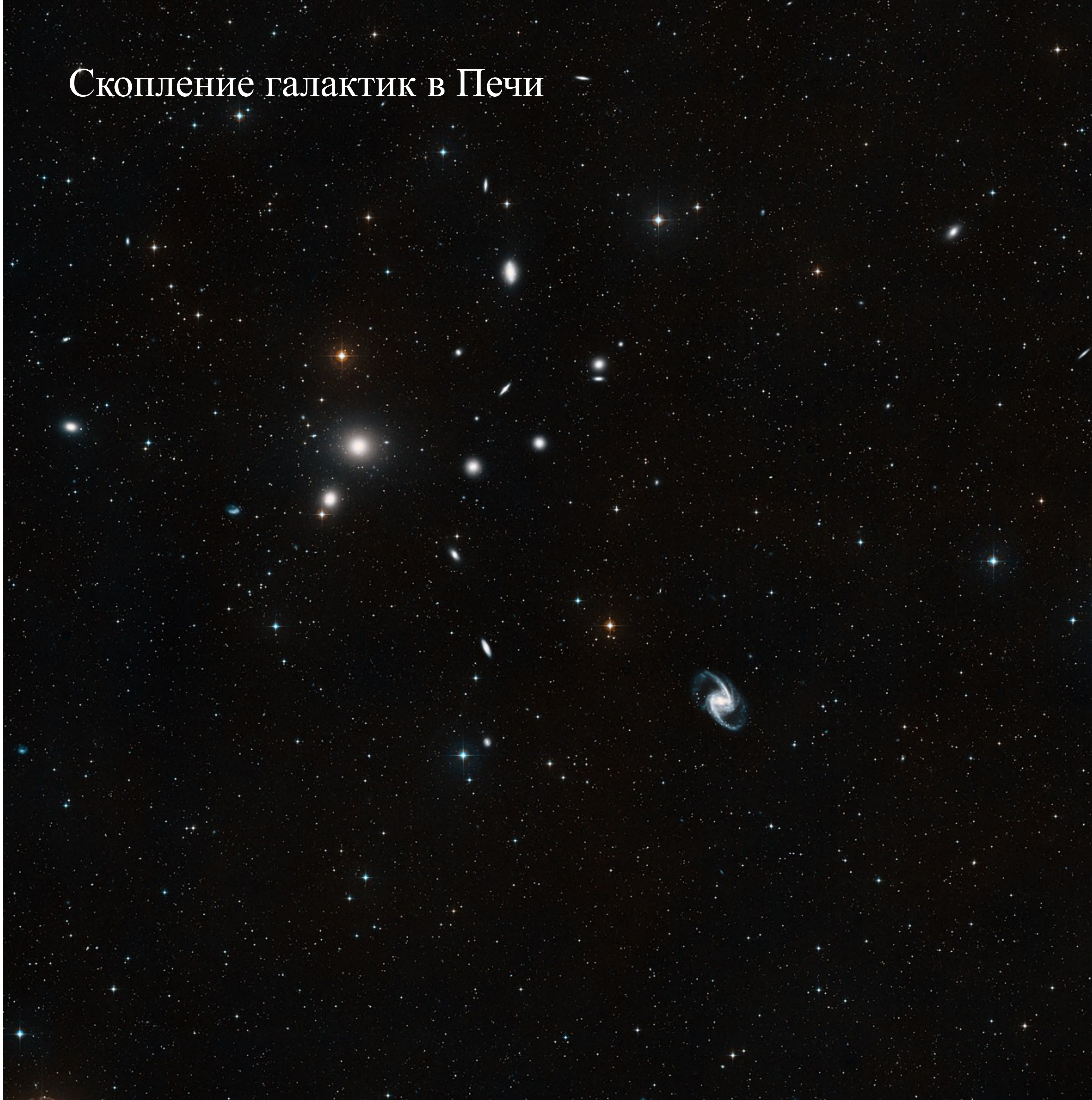

M87 -- From 200,000 Light-Years to 0.2 Light-Year
VLA - 20 cm
VLA - 2 cm
VLA - 7 mm
VLA - 90 cm
VLBI - 1.3 cm
VLBI - 18 cm
NRAO
Credit: Frazer Owen (NRAO), John Biretta (STScI) and colleagues.
The National Radio Astronomy Observatory is a facility of the
National Science Foundation, operated under cooperative
agreement by Associated Universities, Inc.

M84+M86+NGC4388+NGC4413

Скопление галактик в Деве



Скопление галактик в Печи



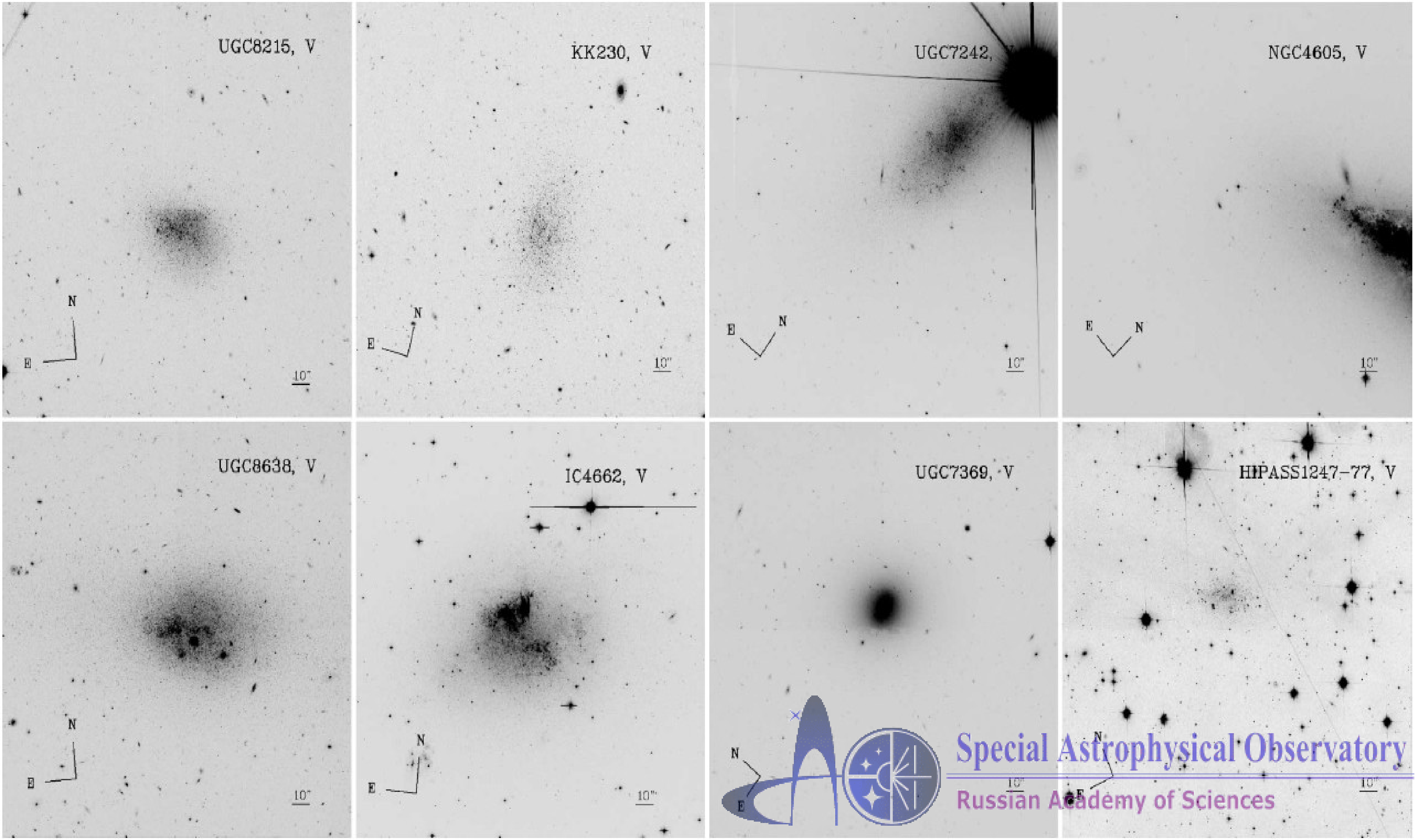

Скопление галактик в
Волосах Вероники

Большое Магелланово Облако

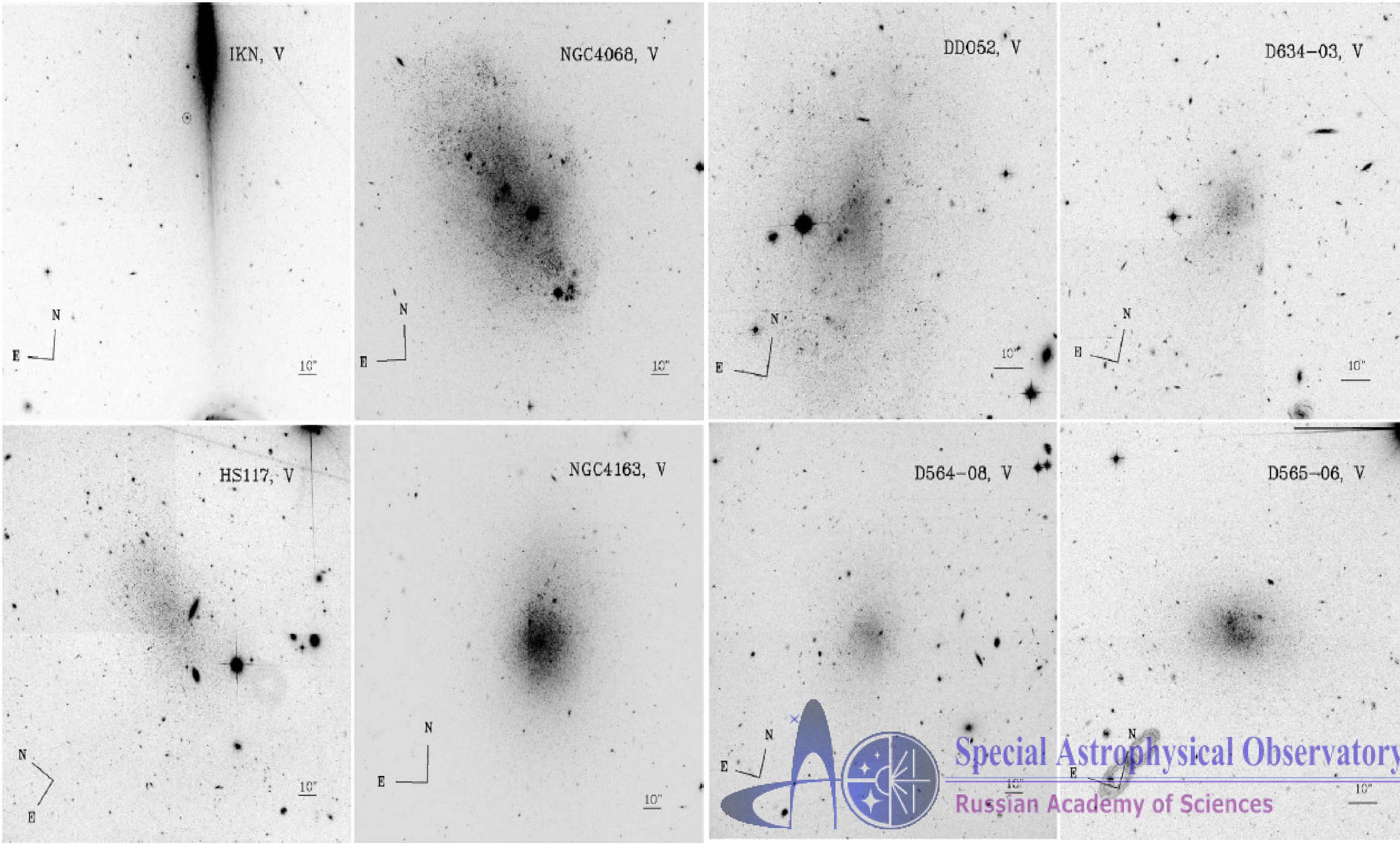
Sextans A, KPNO 2m telescope

I Zwicky 18 (HST)

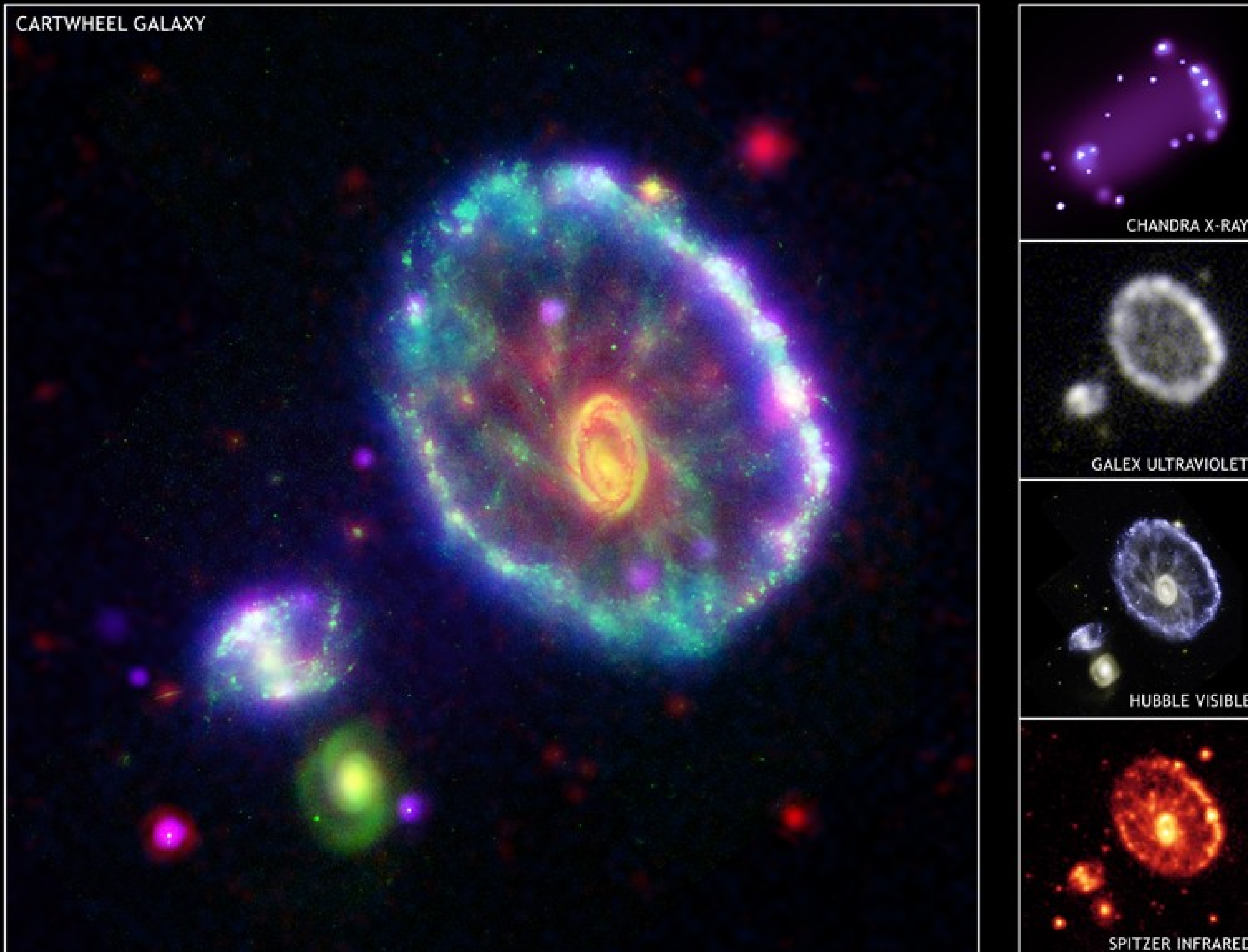
Галерея близких карликовых галактик



Галерея близких карликовых галактик

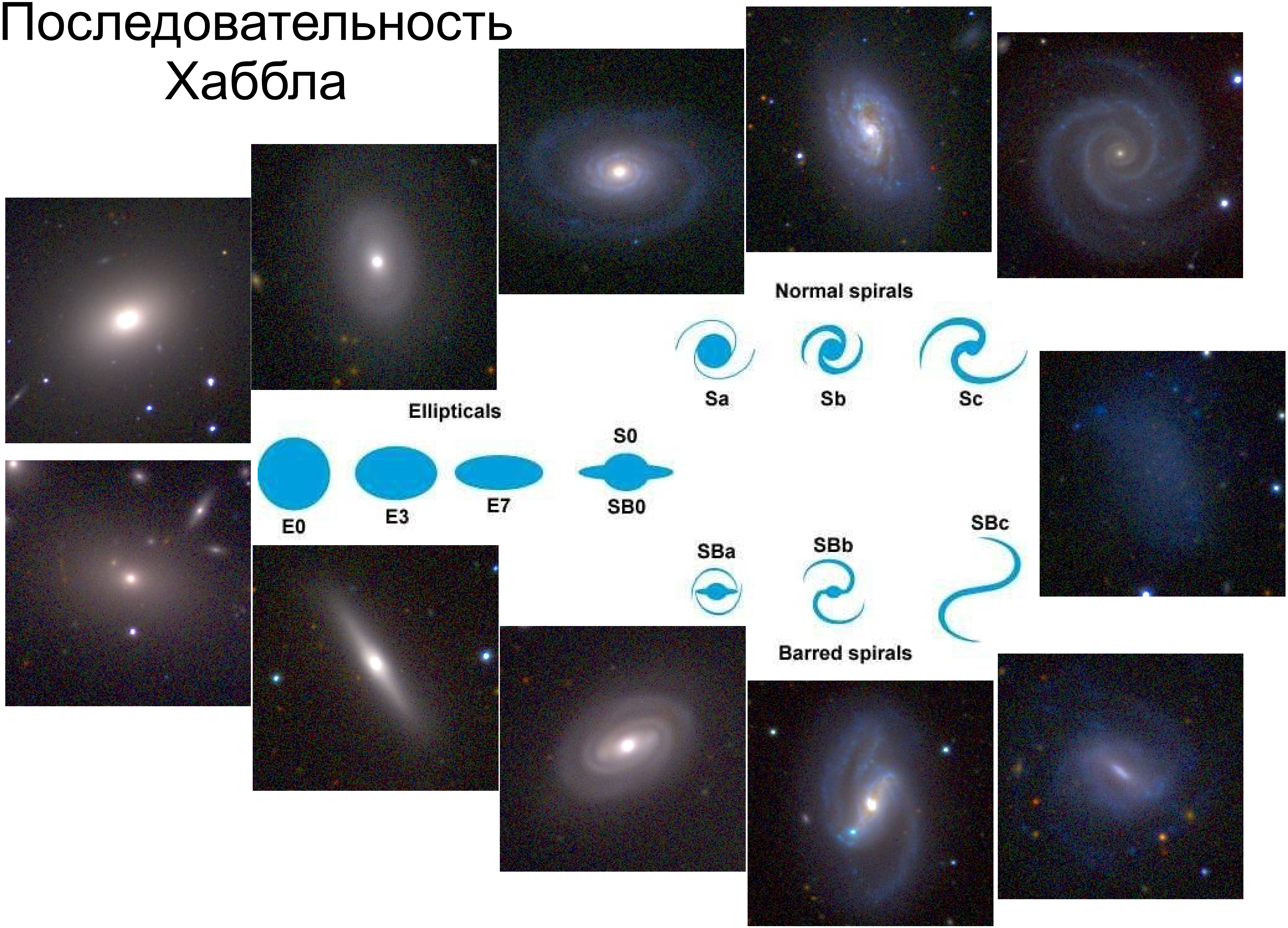


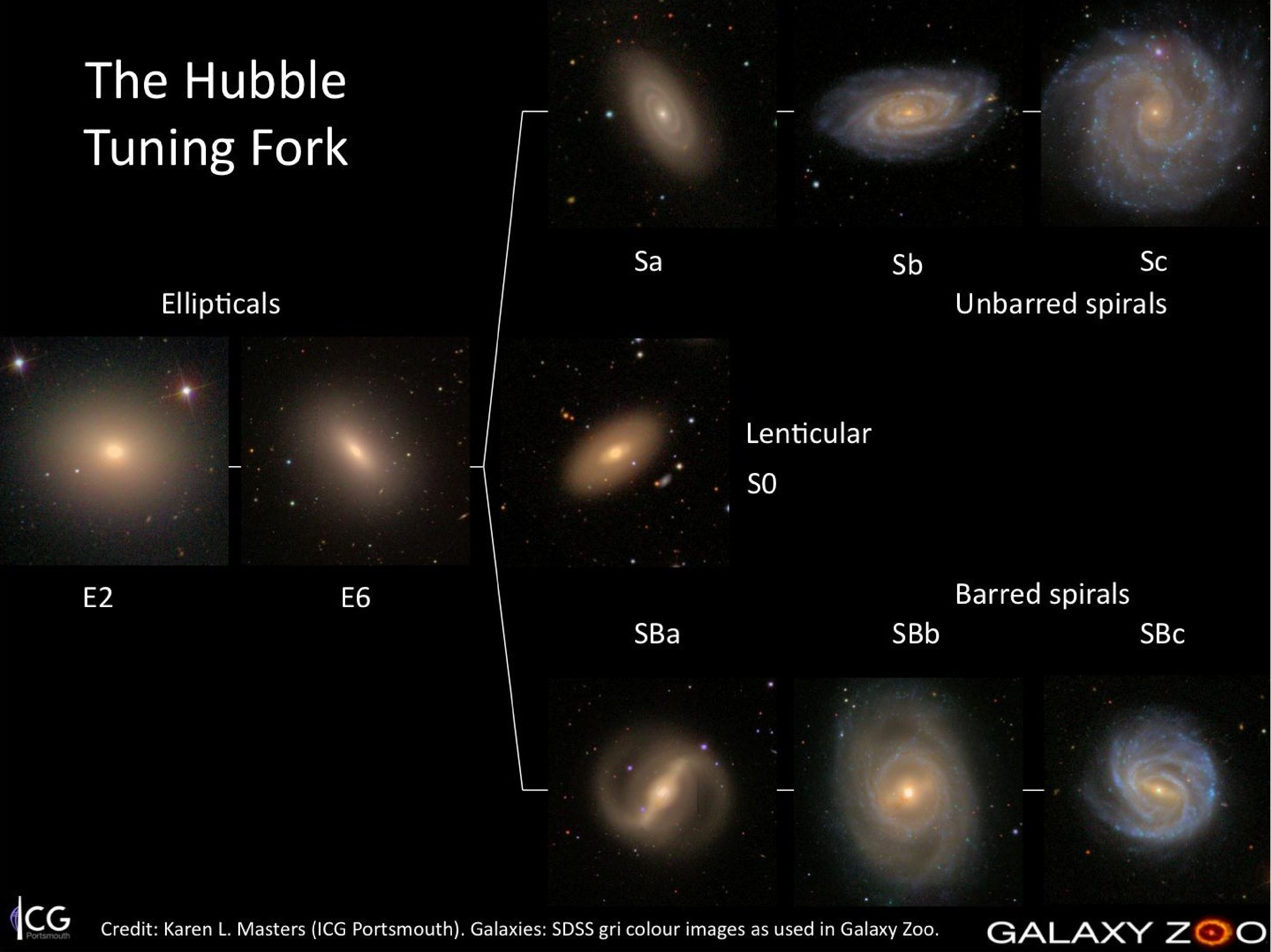
Antennae Galaxies


CARTWHEEL GALAXY
CHANDRA X-RAY
GALEX ULTRAVIOLET
HUBBLE VISIBLE
SPITZER INFRARED

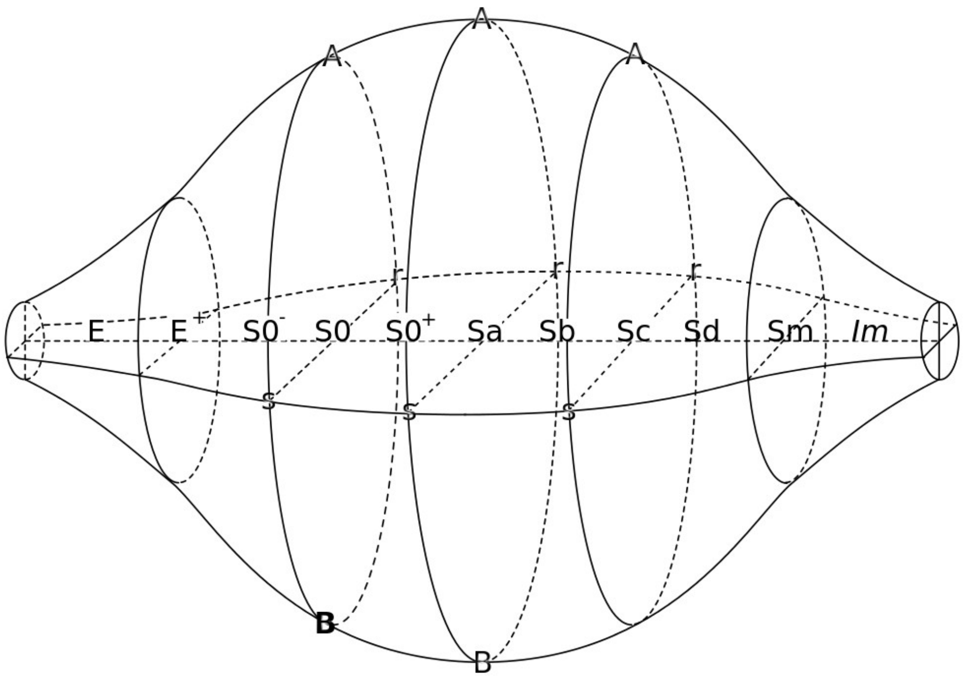
Морфологическая классификация галактик

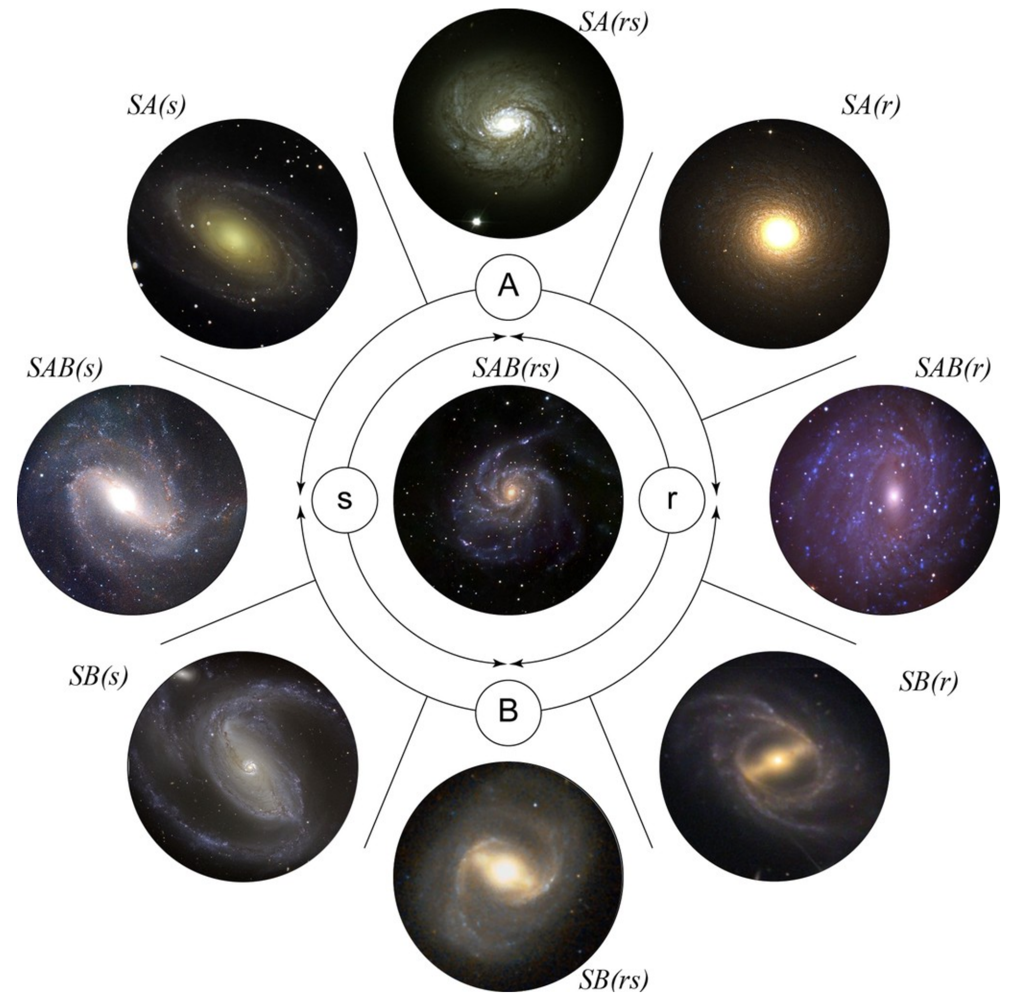
Последовательность Хаббла



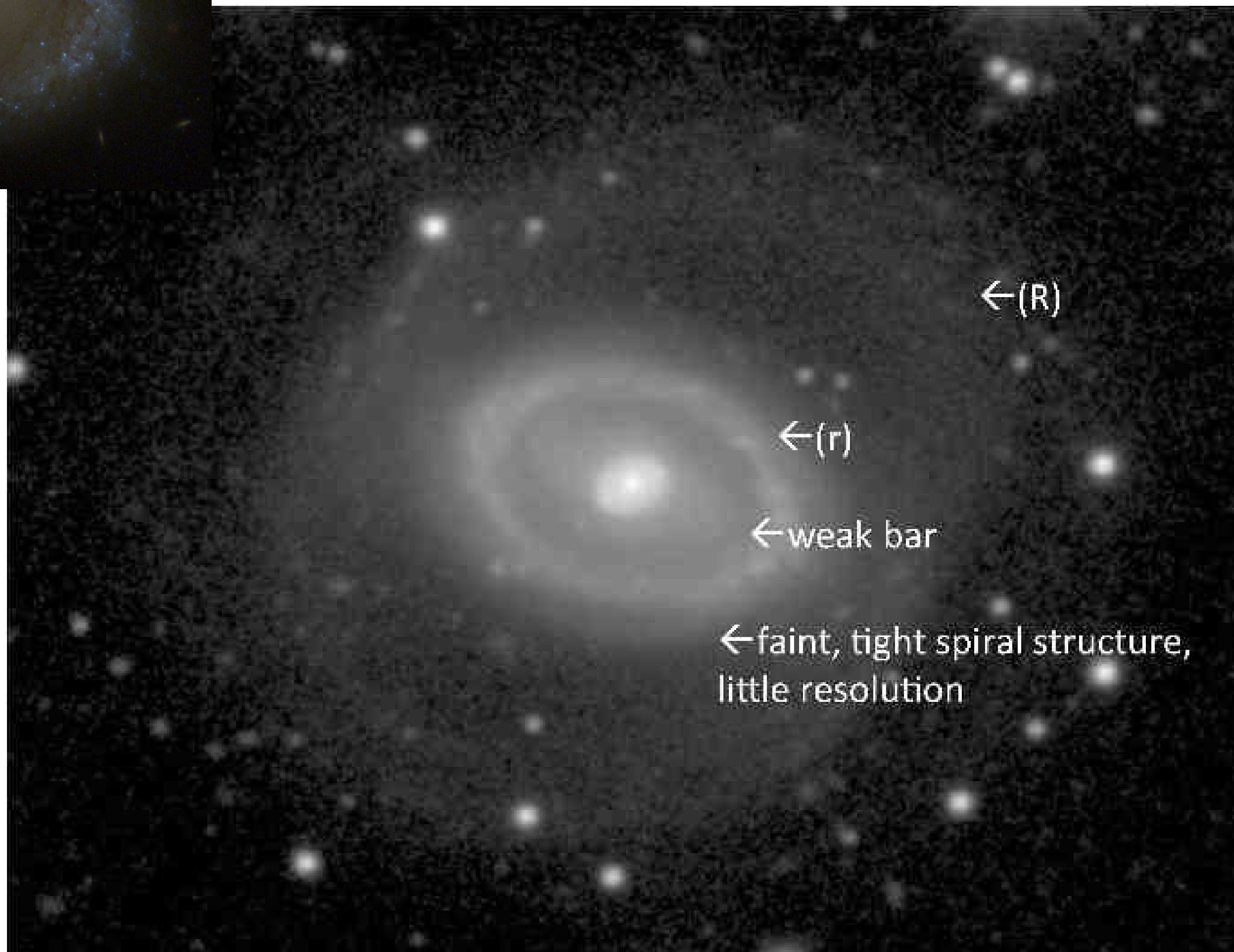

The Hubble
Tuning Fork
Ellipticals
E2
E6
Sa
Sb
Sc
Unbarred spirals
Lenticular
S0
Barred spirals
SBa
SBb
SBc
ICG Portsmouth
Credit: Karen L. Masters (ICG Portsmouth). Galaxies: SDSS gri colour images as used in Galaxy Zoo.
GALAXY ZOO

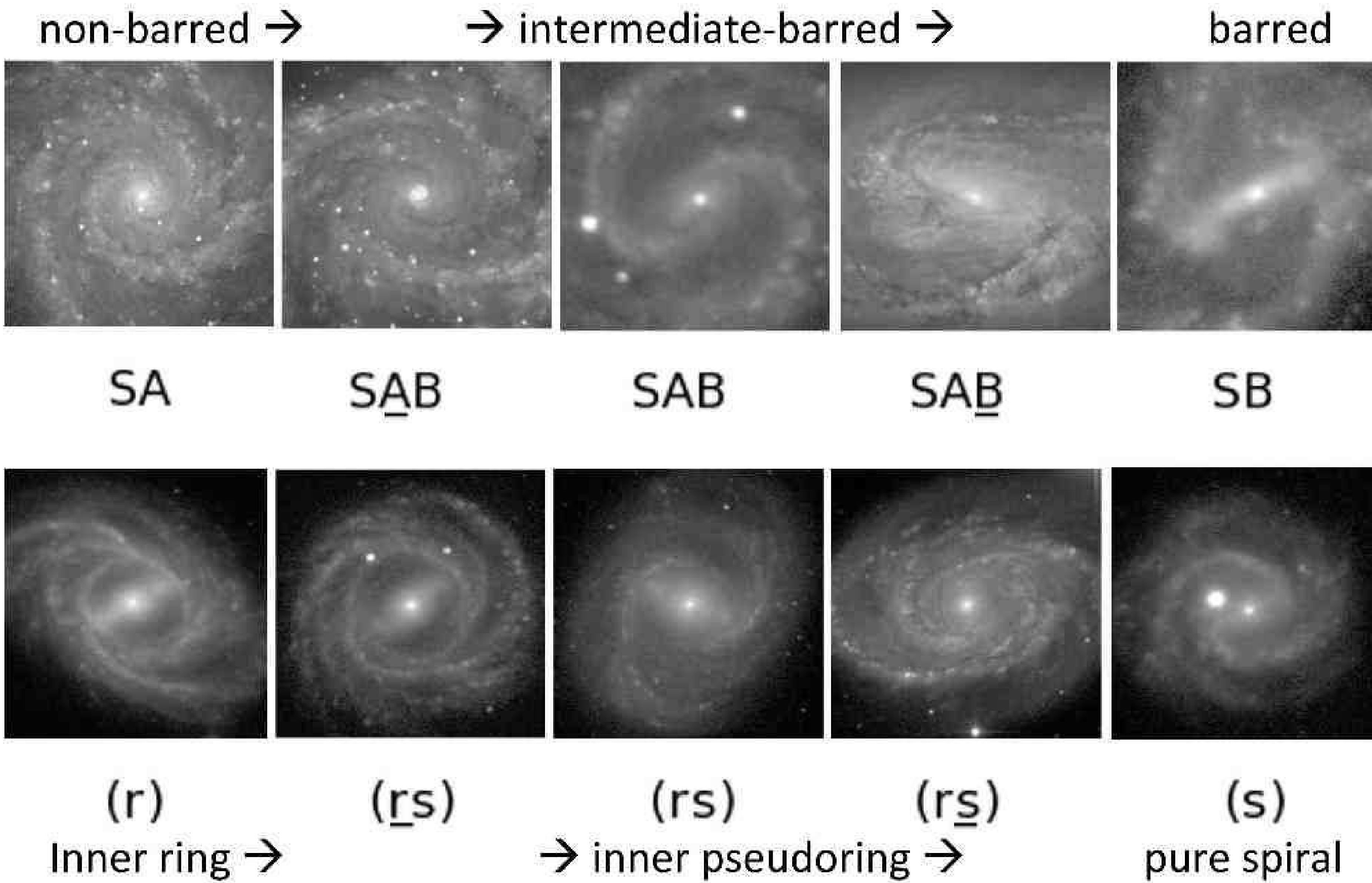
Система де Вокулёра





NGC 3081 (R)SAB(r)0/a

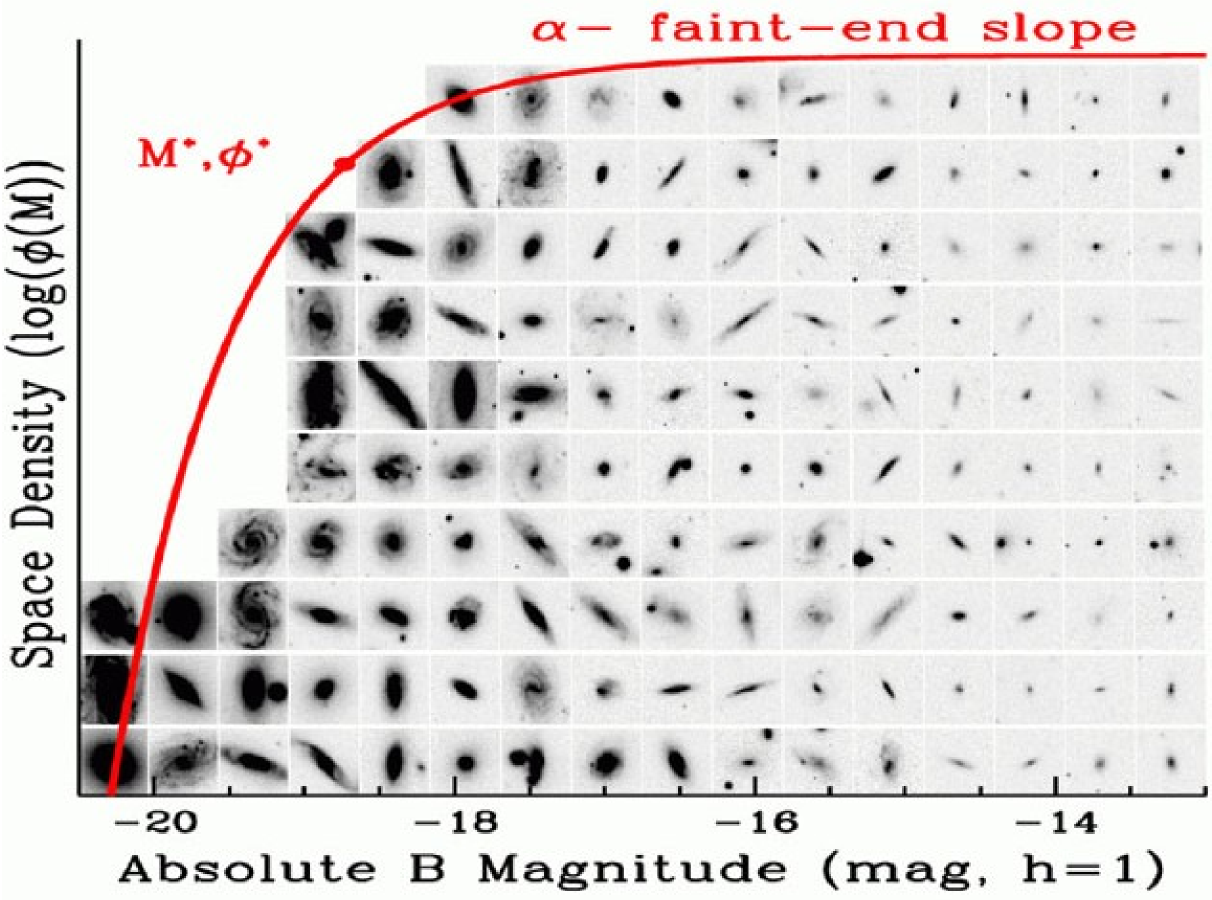




non-barred →
→ intermediate-barred →
barred
SA
SAB
SAB
SAB
SB
(r)
(rs)
(rs)
(rs)
(s)
Inner ring →
→ inner pseudoring →
pure spiral

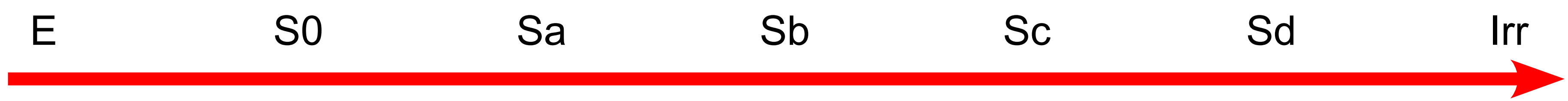
Классификация галактик

	Эллиптические			Линзы			Спирали										
Hubble type	cE	E	cD	S0-	S0o	S0+	S0/a	Sa	Sab	Sb	Sbc	Sc	Scd	Sd	Sdm	Sm	Ir
RC3 code	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10



Свойства галактик вдоль последовательности Хаббла

Последовательность Хаббла дает на удивление хорошее описание галактик. Многие, хотя и не все, физические свойства галактик коррелируют с морфологией галактик.



Хаотические движения	-	Круговые движения
Красные цвет	-	Голубой цвет
Старые звезды	-	Молодые звезды
Горячий газ	-	Холодный газ и пыль
Высокая поверхностная яркость	-	Низкая поверхностная яркость

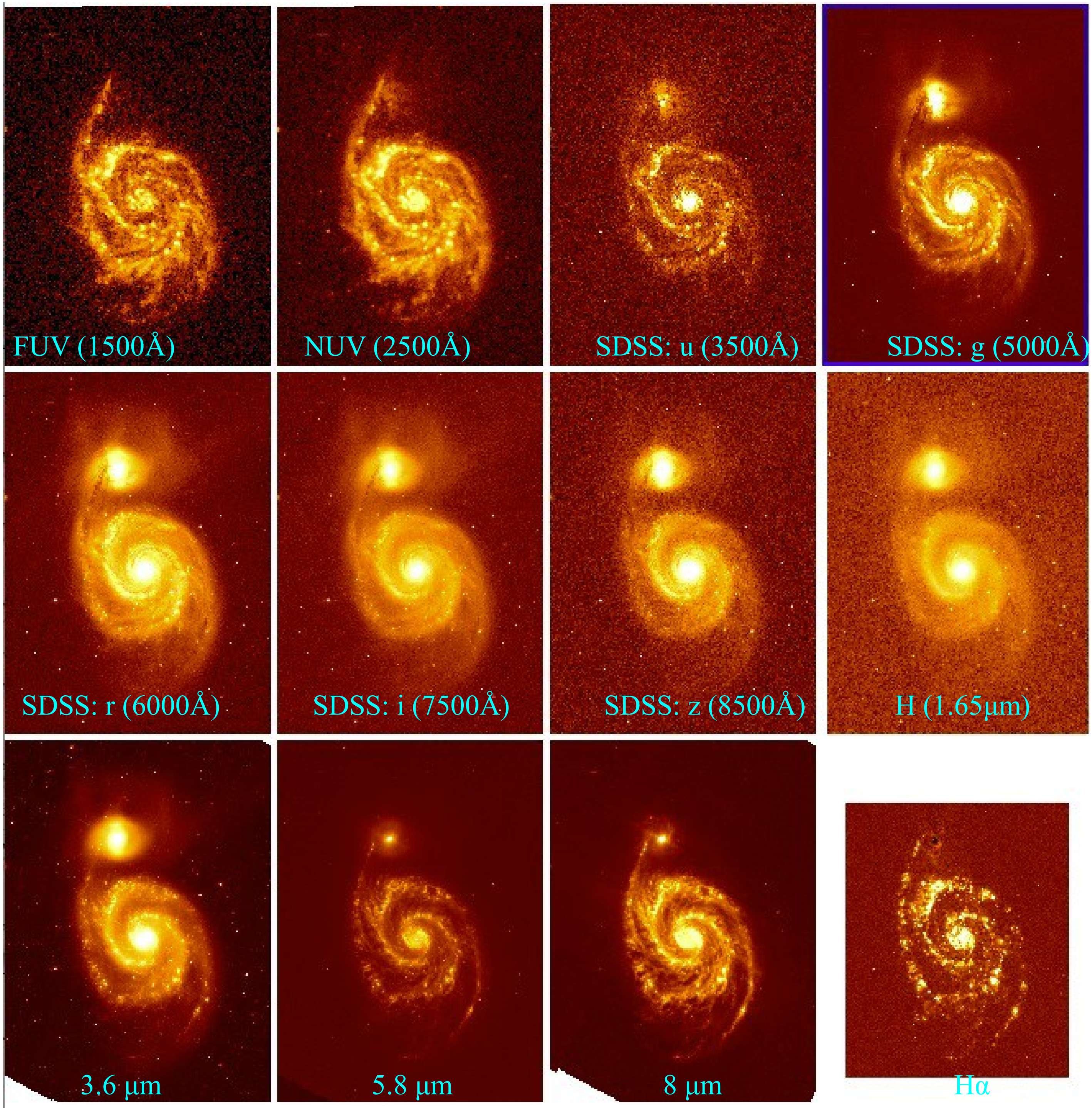
С другой стороны, массы, светимости и размеры коррелируют с Хаббловским типом не так хорошо: внутри каждого типа есть большой разброс галактик по этим параметрам.

Автоматическая классификация

- ✓Разложение на балдж-диск
- ✓Анализ профиля яркости (профиль Серсика)

- ✓Индекс концентрации: $C = 5\log\left(\frac{r_{80}}{r_{20}}\right)$
- ✓Индекс асимметрии: $A_0 = \frac{\sum |I_0 - I_R|}{\sum I_0}$
- ✓Индекс клочковатости: $S = 10\frac{\sum I_0 - I_S}{\sum I_0}$

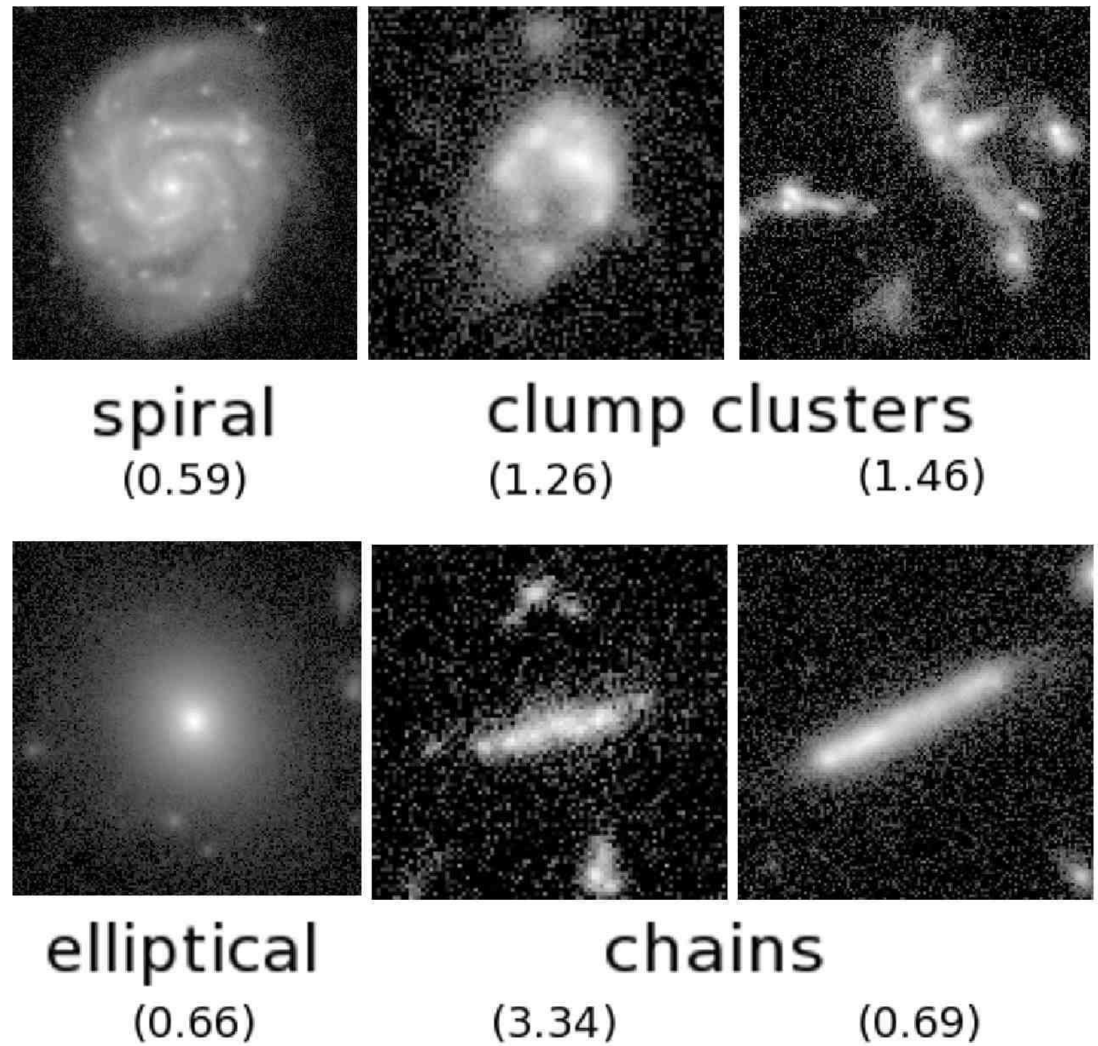
Вид M51 в разных спектральных диапазонах




NGC 5907

Галактики на больших красных смещениях: конец классической морфологии?

- С увеличением z классические галактики типы галактик становятся все более редкими.
- Растет доля иррегулярных галактик
- Появляются новые типы



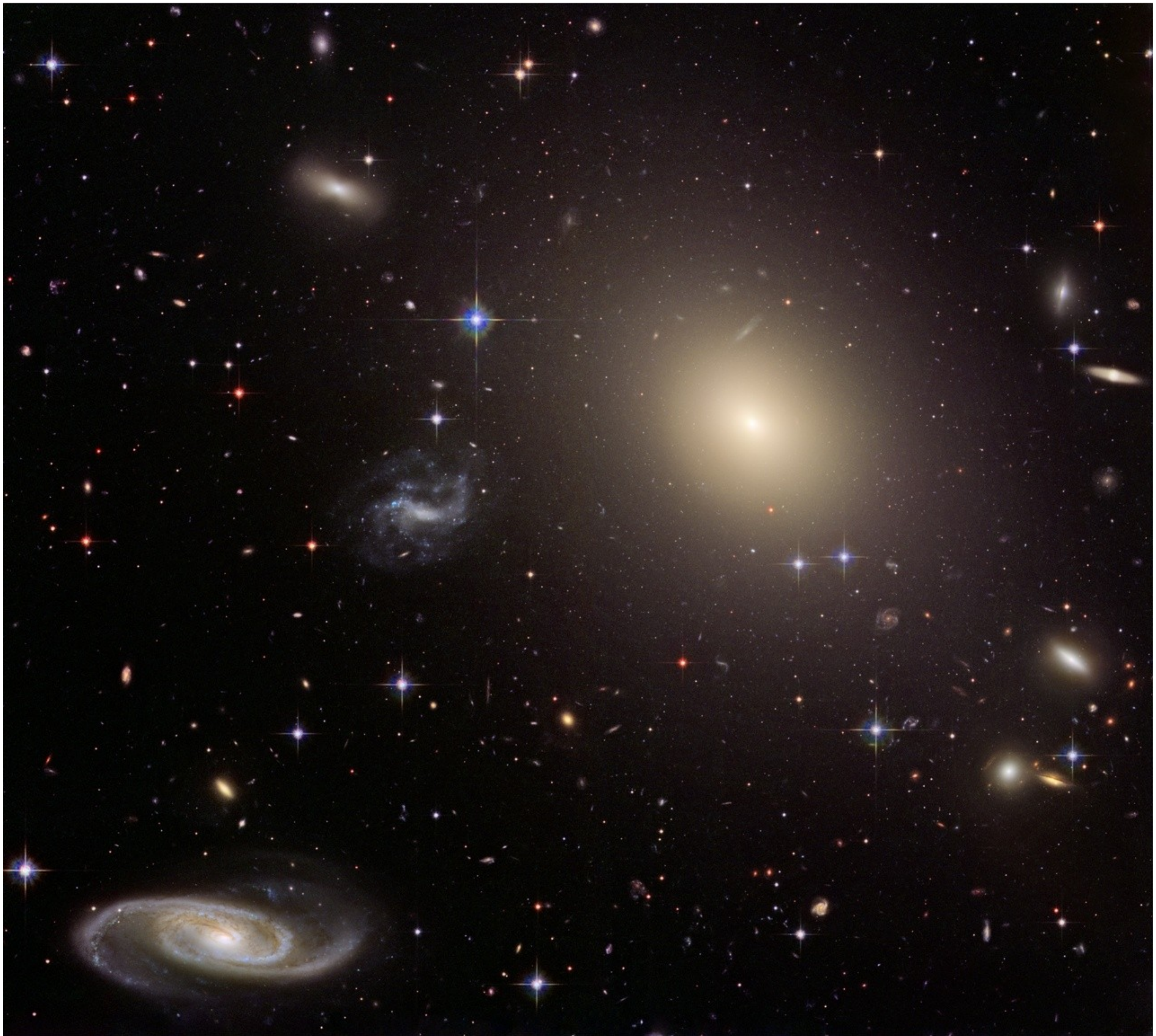
Распределение вещества в галактиках

Sombrero Galaxy • M104

Hubble Heritage

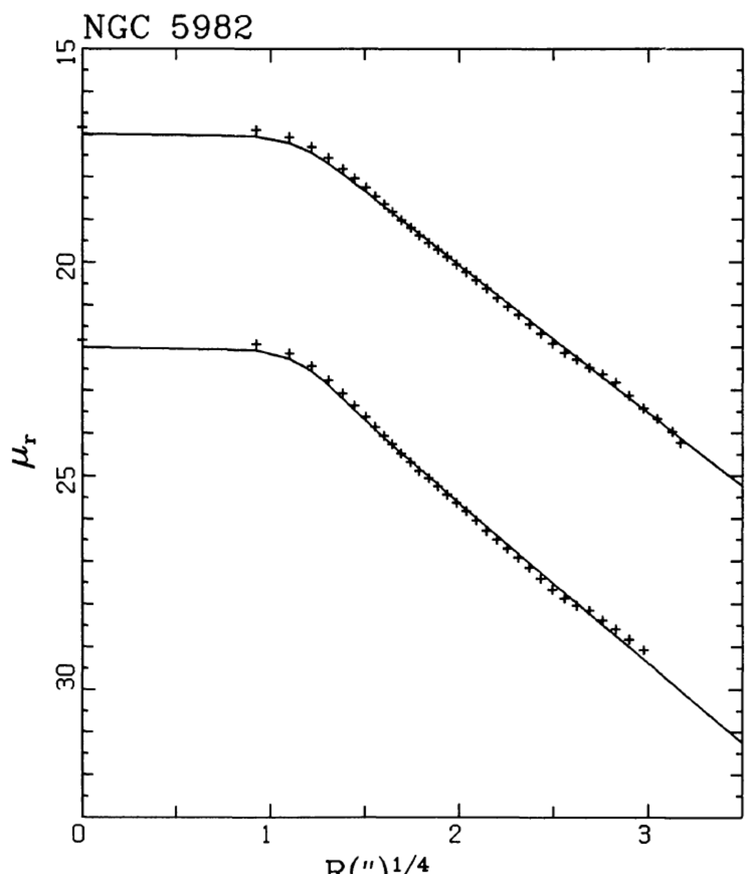
NASA and The Hubble Heritage Team (STScI/AURA) • Hubble Space Telescope ACS • STScI-PRC03-28

Эллиптические галактики



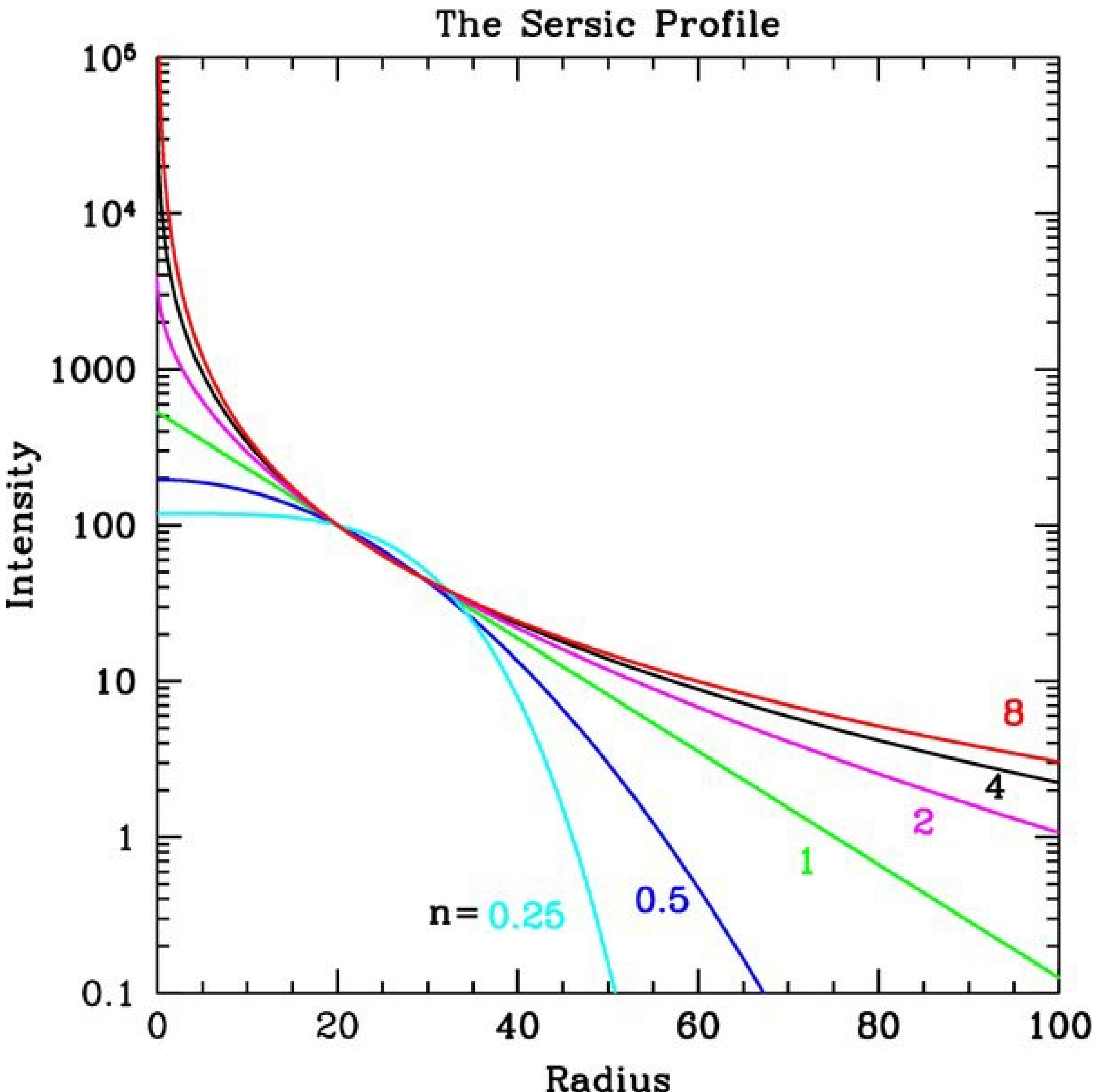
Профиль де Вокулёра

$$\log\frac{I(r)}{I_e} = -3.33\left[\left(\frac{r}{r_e}\right)^{\frac{1}{4}} - 1\right]$$

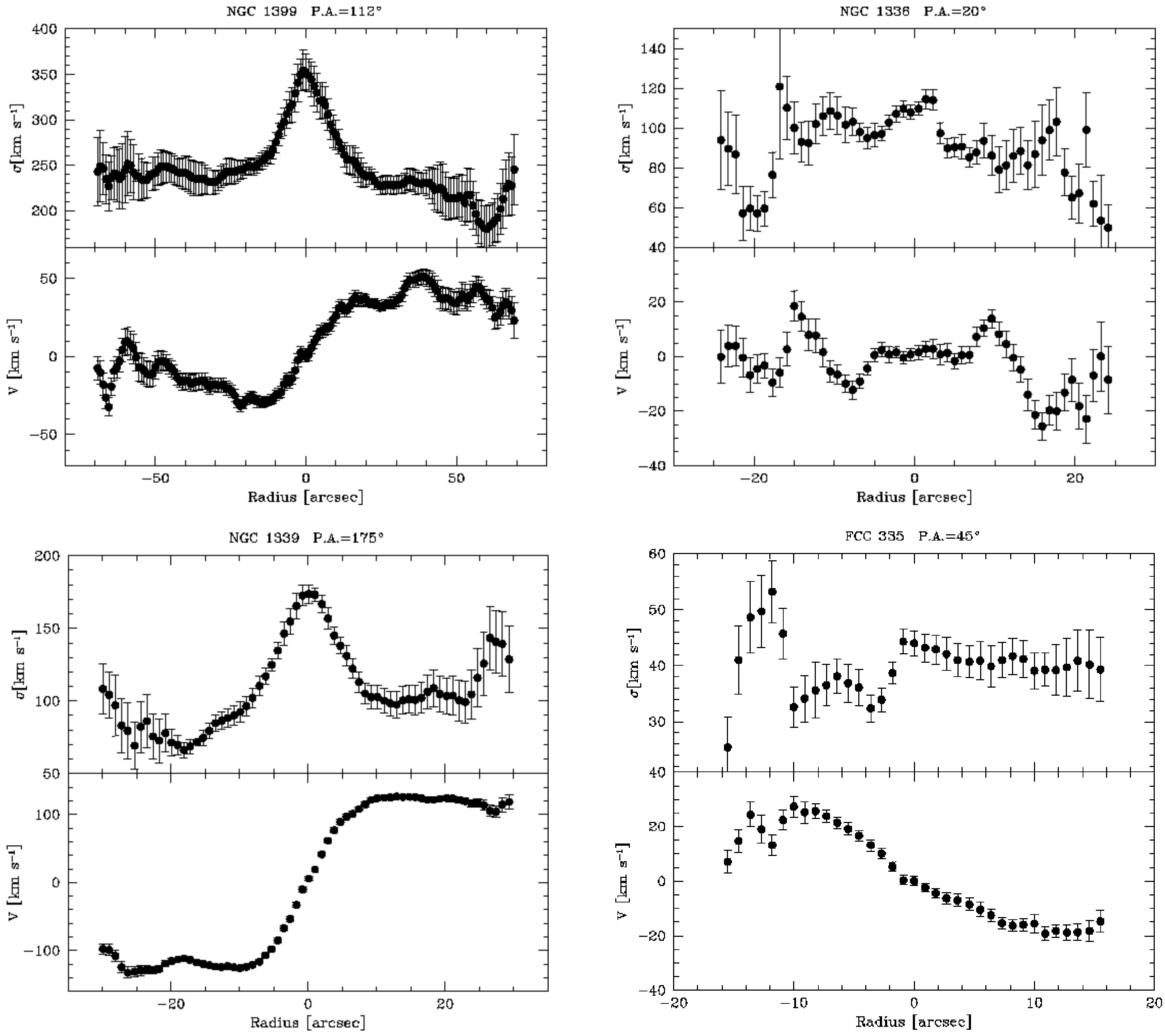


Профиль Серсика

$$I(r) = I_e e^{-\nu_n[(r/r_e)^{1/n}-1]}$$



Кинематика эллиптических галактик



Распределение массы

$$M(r) = M_{sph}(r) + M_h(r).$$

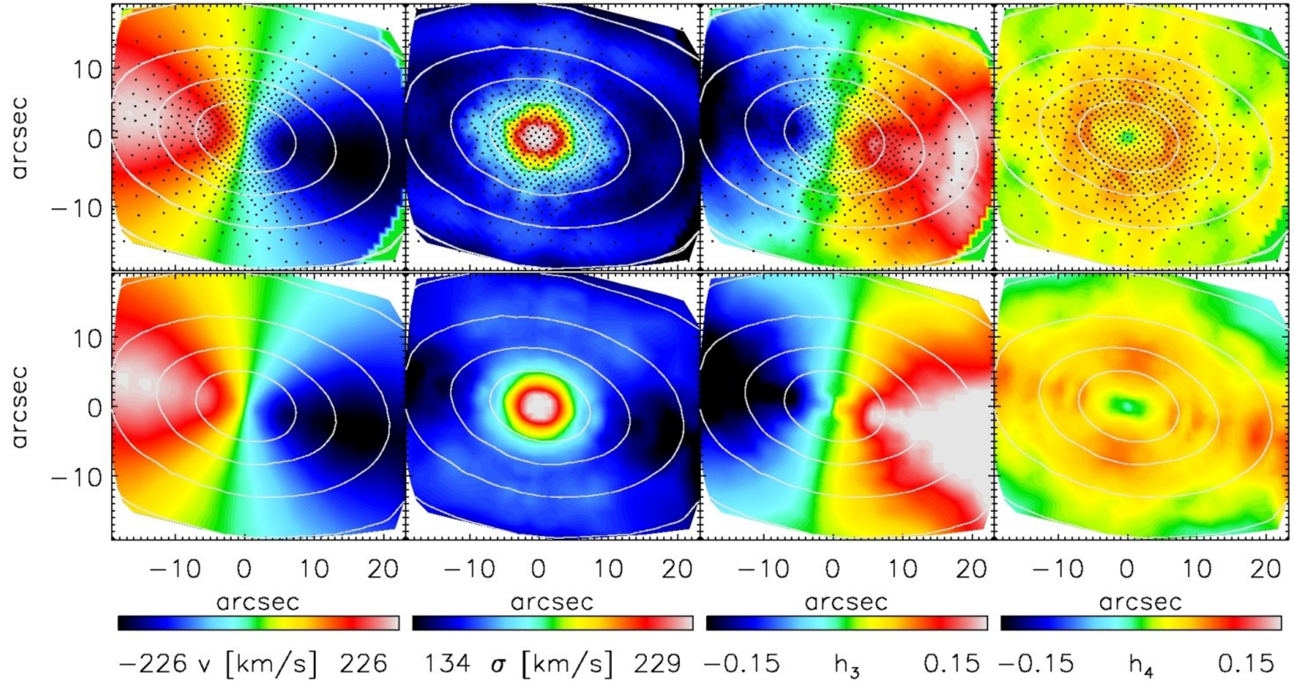
$$\sigma_r^2(r) = \frac{G}{\rho_{sph}(r)} \int_r^\infty \frac{\rho_{sph}(r')M(r')}{r'^2}\, dr'$$

$$\sigma_P^2(R) = \frac{2}{I(R)} \int_R^\infty \frac{\rho_{sph}(r)\ \sigma_r^2(r)\ r}{\sqrt{r^2 - R^2}}\, dr$$

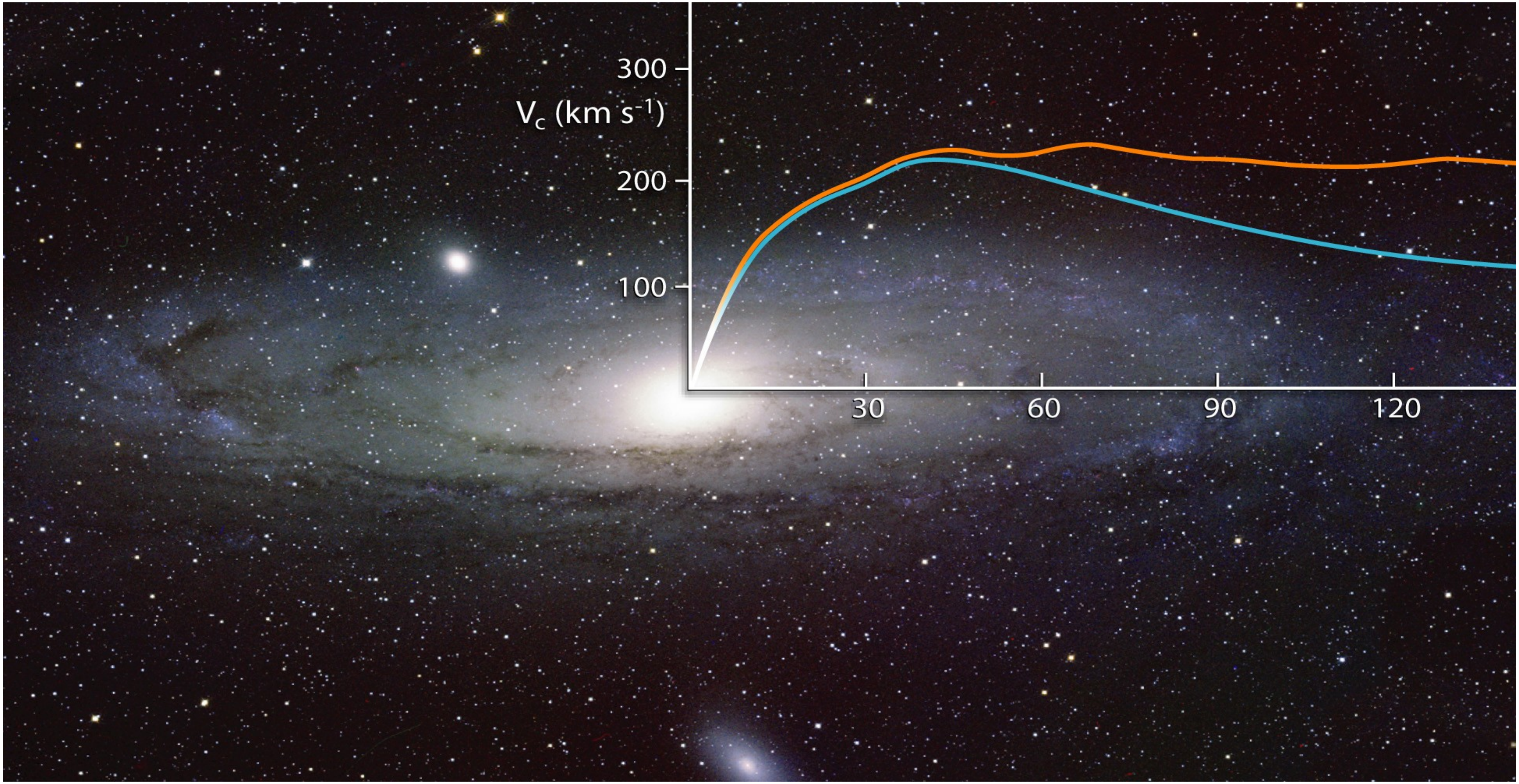
$$\sigma_A^2(R_A) = \frac{2\pi}{L(R_A)} \int_0^{R_A} \sigma_P^2(R)\ I(R)\ R\ dR$$

$$L(R) = 2\pi \int I(R)\ R\ dR$$

N 2974
SAURON data



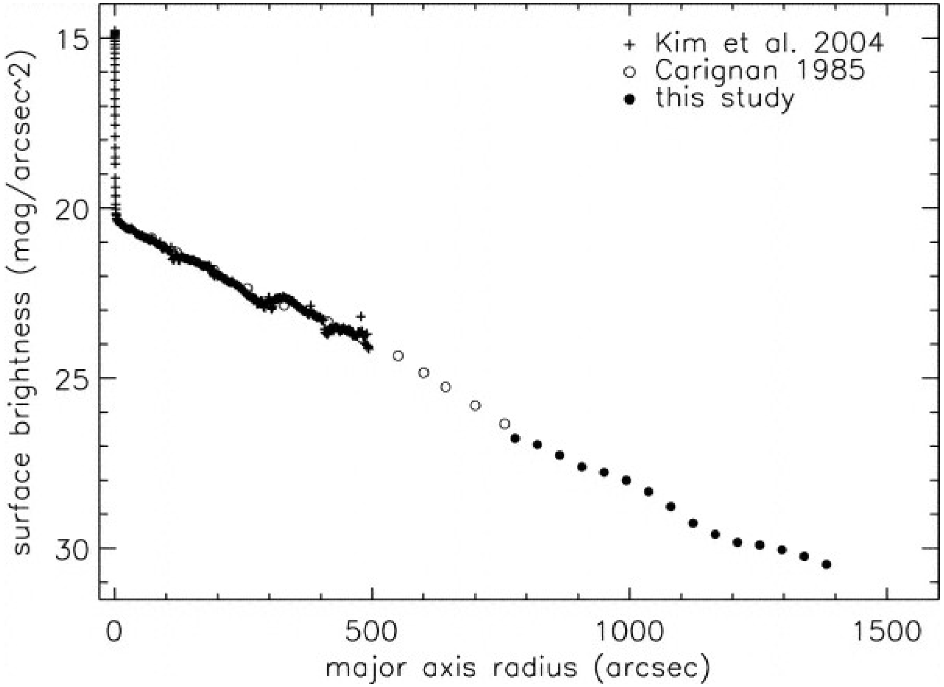
Спиральные галактики

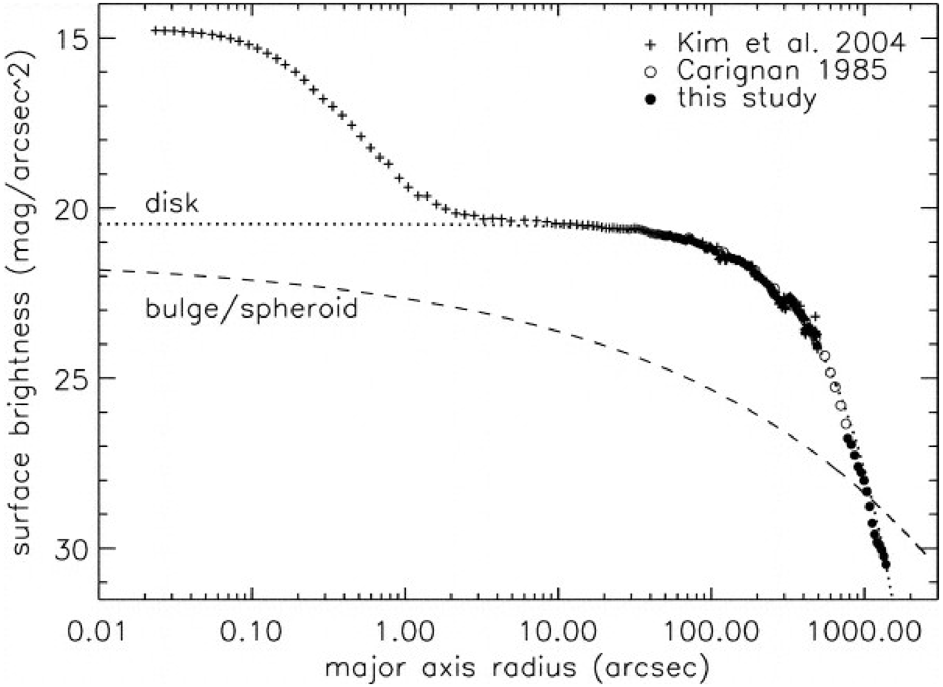


Звездные диски

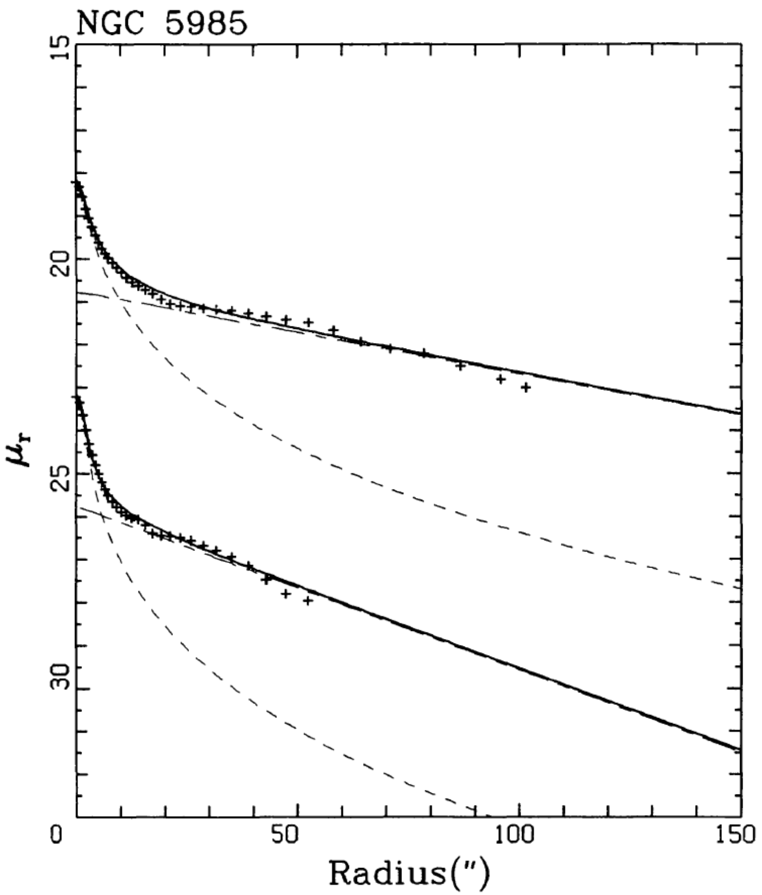
$$I(r) = I_0 e^{-r/h}$$

NGC 300
Звездный диск простирается как минимум на 10 шкал
(Bland-Hawthorn, 2005, ApJ, 629, 239)

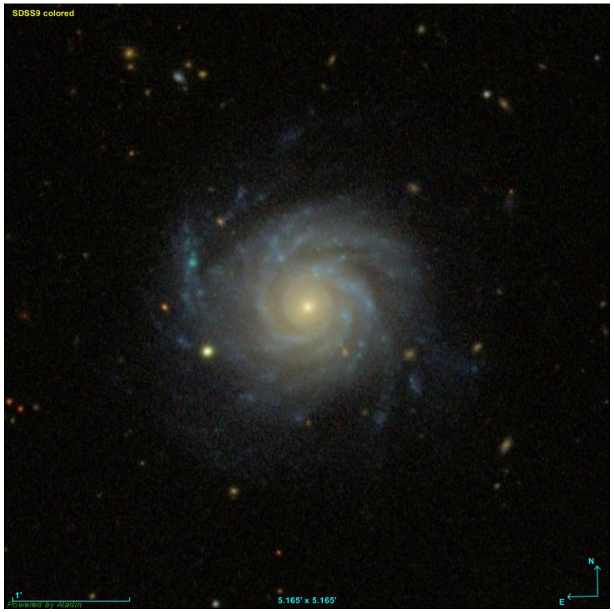


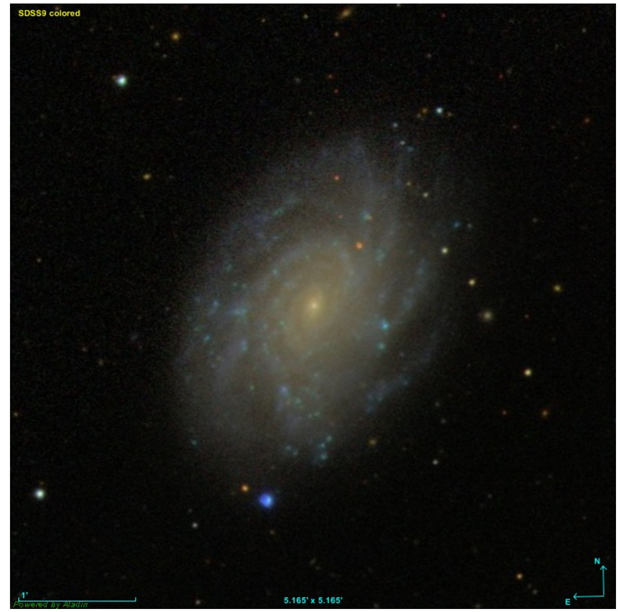


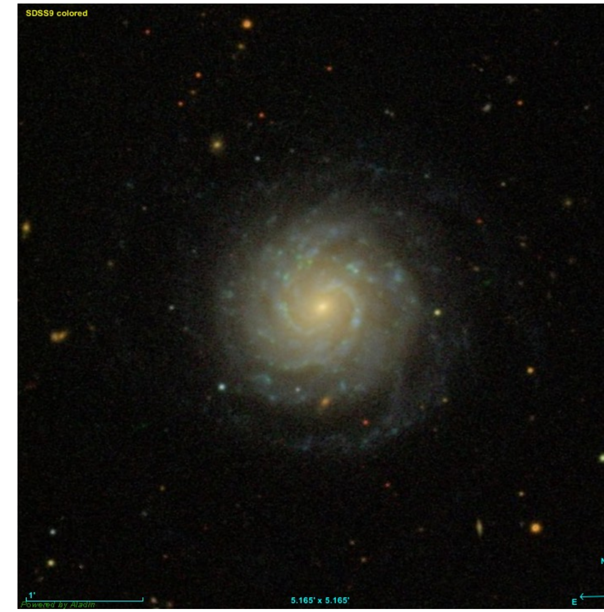
Разложение на балдж-диск

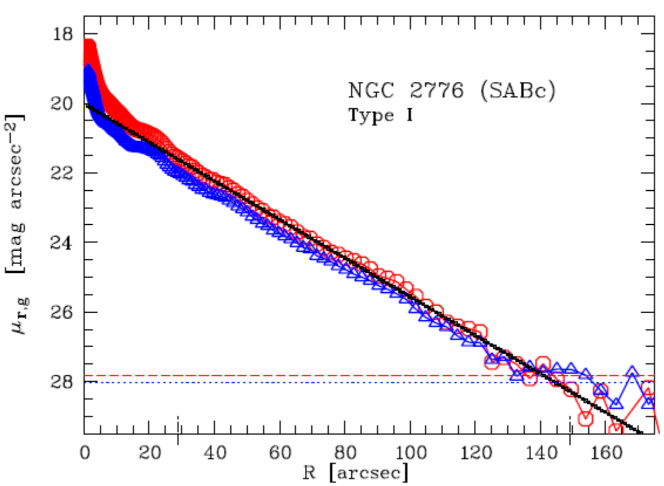


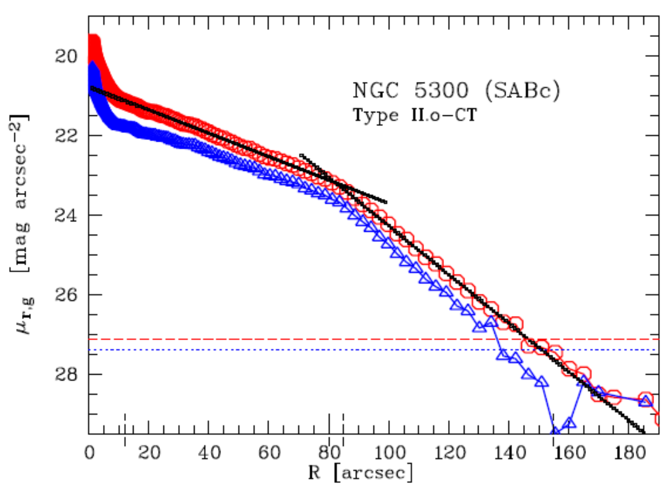
Разнообразие дисков

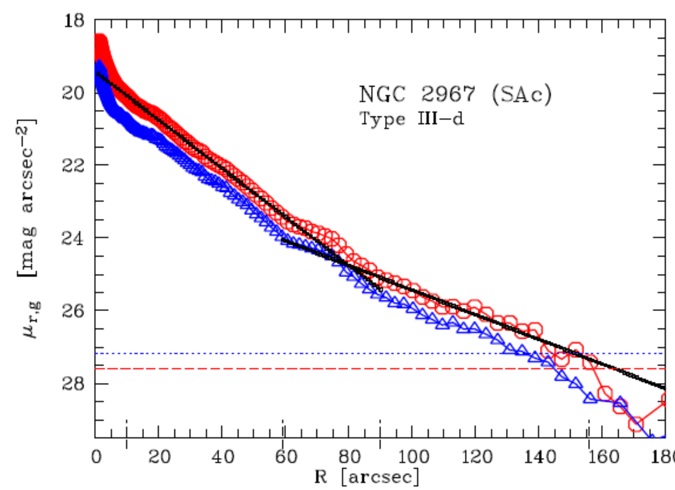










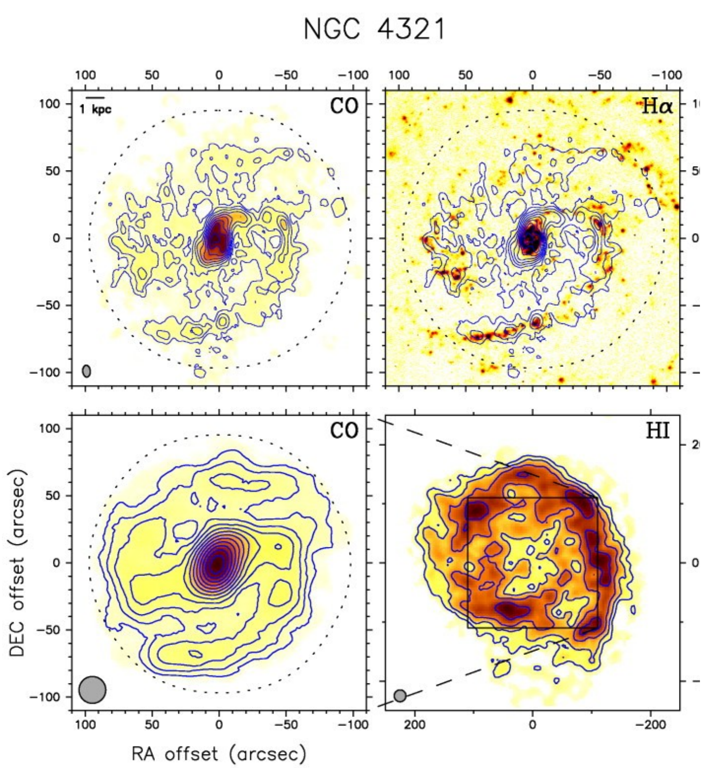


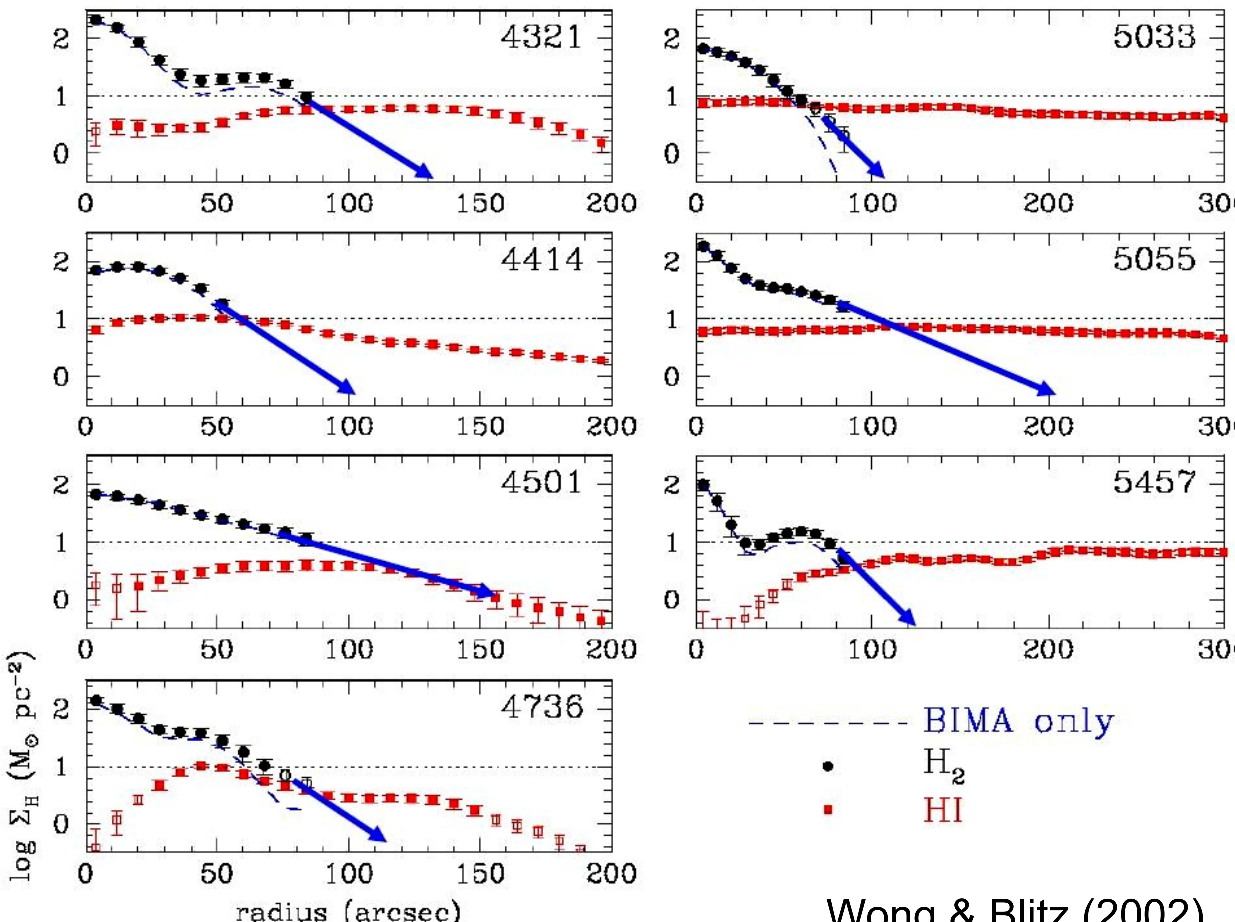
Pohlen et al. 2008, ASPC, 390, 247 “Three Types of Galaxy Disks”

Распределение газа

H I: плоское распределение, дефицит в центре
CO & H_2: незначительное количество

Wong & Blitz, 2002, ApJ, 569, 157

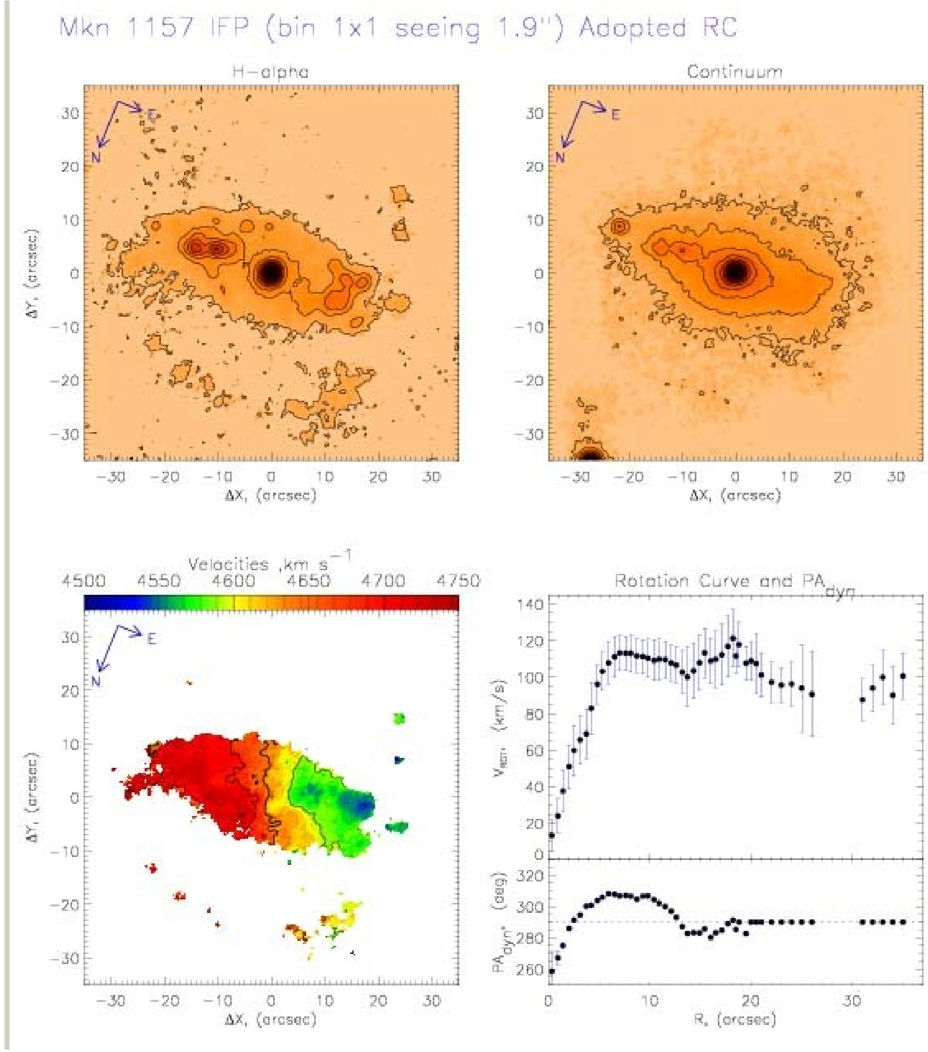




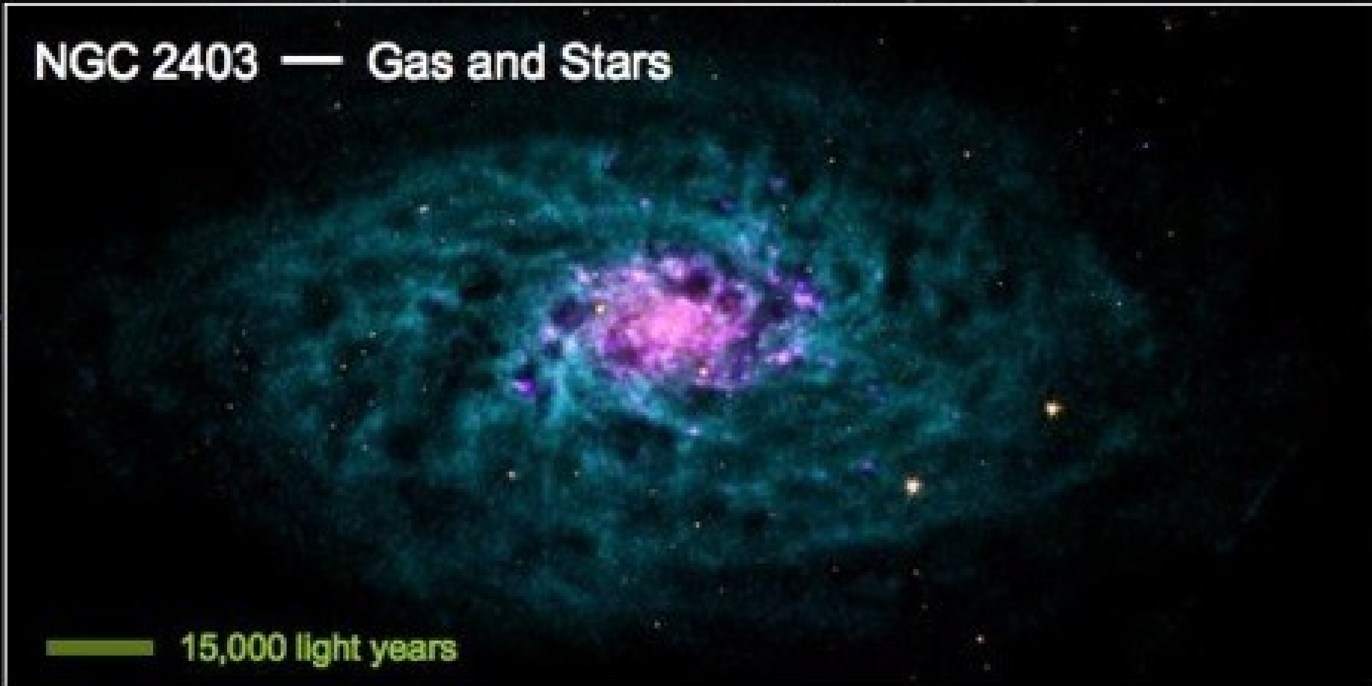
Wong & Blitz (2002)

Наблюдение кривых вращения галактик

БТА, SCORPIO, ИФП
Программа S. Ciroi (Italy)

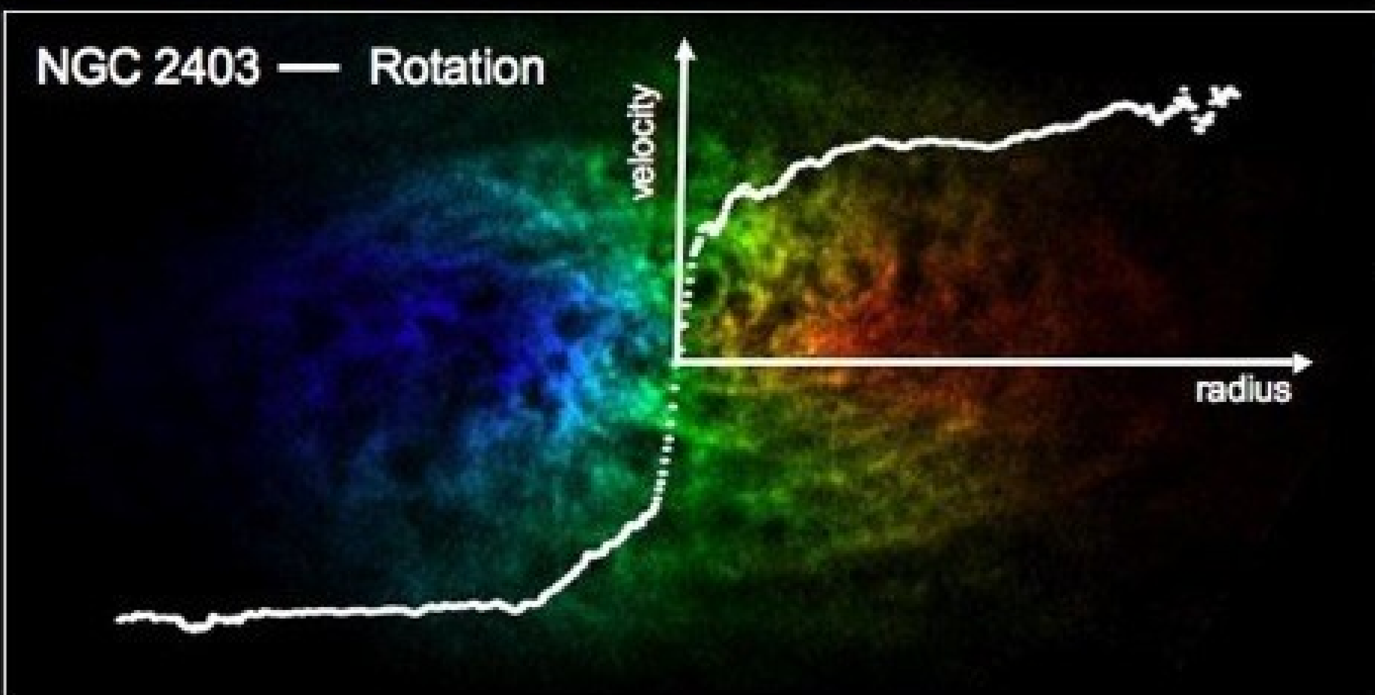


Galaxy Dynamics in THINGS — The HI Nearby Galaxy Survey



THINGS
The HI Nearby Galaxy Survey

Color Coding:
THINGS Atomic Hydrogen
(Very Large Array)
Old stars
(Spitzer Space Telescope)
Star Formation
(GALEX & Spitzer)



Color coding:
THINGS HI distribution:
Red-shifted (receding)
Blue-shifted (approaching)
Rotation Curve

Image credits:
VLA THINGS: Walter et al. 08
Spitzer SINGS: Kennicutt et al. 03
GALEX NGS: Gil de Paz et al. 07
Rotation Curve: de Blok et al. 08

THE ASTROPHYSICAL JOURNAL, **238**:471–487, 1980 June 1

ROTATIONAL PROPERTIES OF 21 Sc GALAXIES WITH A LARGE RANGE OF LUMINOSITIES AND RADII, FROM NGC 4605 ($R = 4$ kpc) TO UGC 2885 ($R = 122$ kpc)

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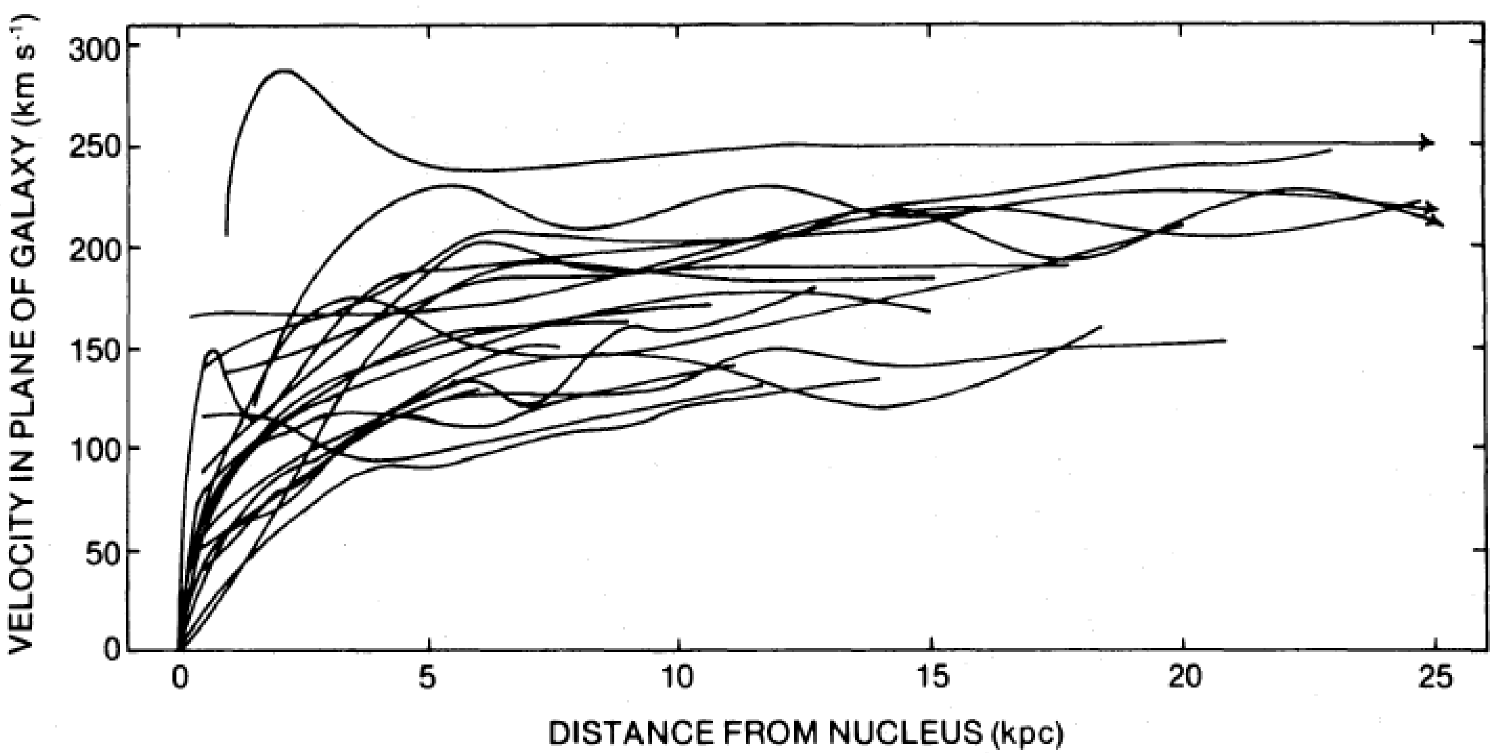
Department of Terrestrial Magnetism, Carnegie Institution of Washington
Received 1979 October 11; accepted 1979 November 29

initial parts of the rotation curves for the larger galaxies. All curves show a fairly rapid velocity rise to $V \sim 125$ km s^{-1} at $R \sim 5$ kpc, and a slower rise thereafter. Most rotation curves are rising slowly even at the farthest measured point. Neither high nor low luminosity Sc galaxies have falling rotation curves. Sc galaxies of all luminosities must have significant mass located beyond the optical image. A linear relation between log V_{max} and log R follows from the shape of the



Распределение темного вещества

Navaro, Frenk, White, 1997, ApJ, 490, 493

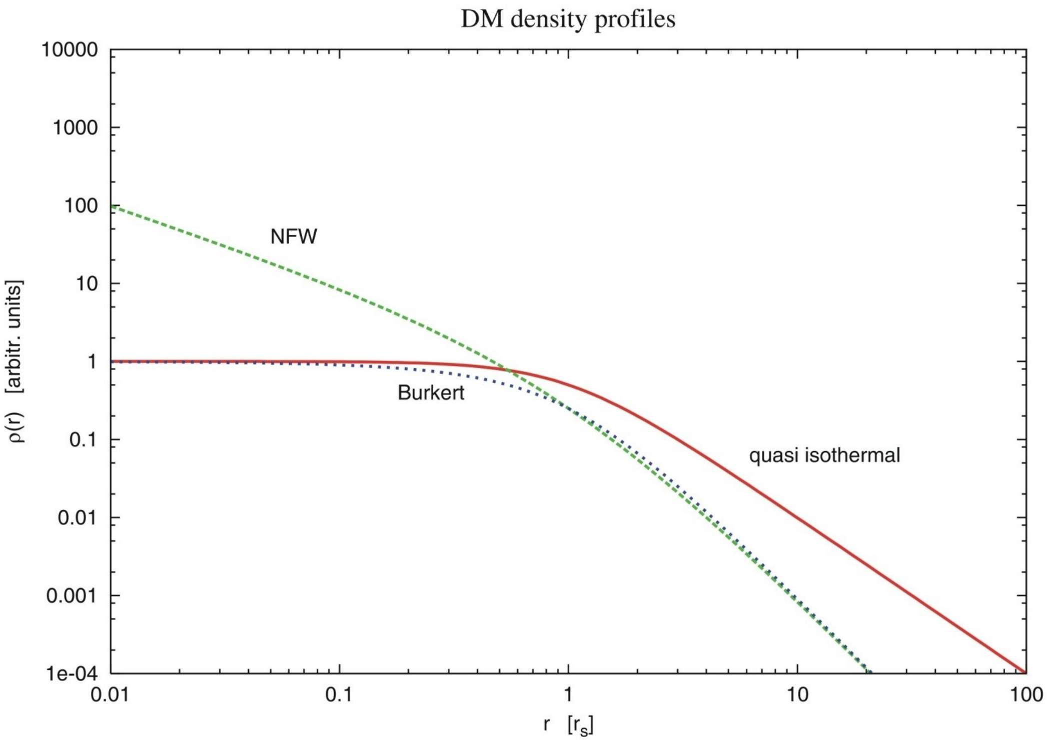
$$\rho_{NFW}(r) = \frac{\rho_s}{(r/r_s)(1 + r/r_s)^2}$$

Изотермическое гало

$$\rho_{iso}(r) = \frac{\rho_0}{1 + (r/r_c)^2}$$

Burket 1995, ApJ, 447, 25

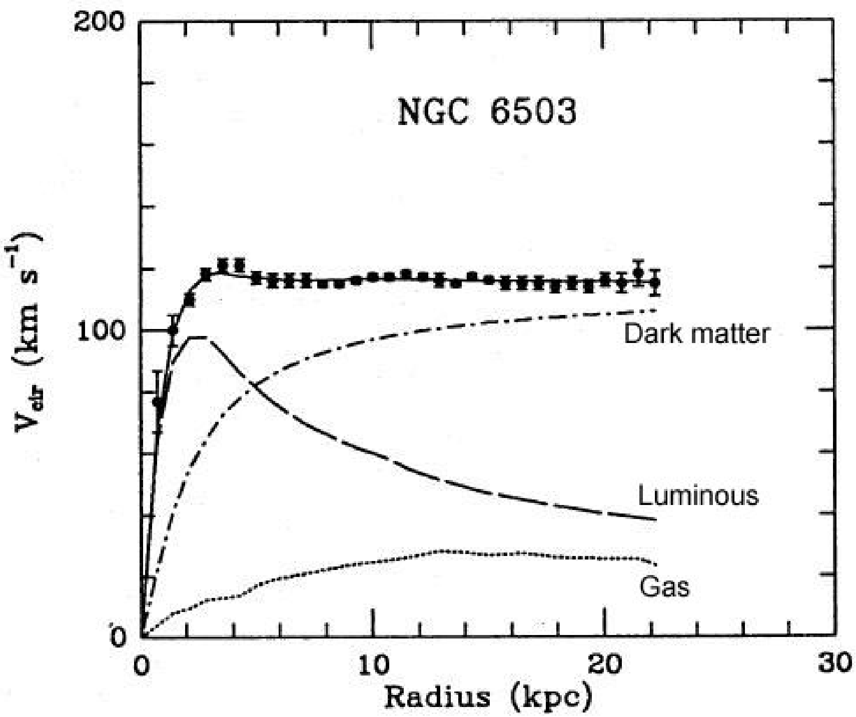
$$\rho_{burket}(r) = \frac{\rho_0}{(1 + r/r_c)(1 + (r/r_c)^2)}$$



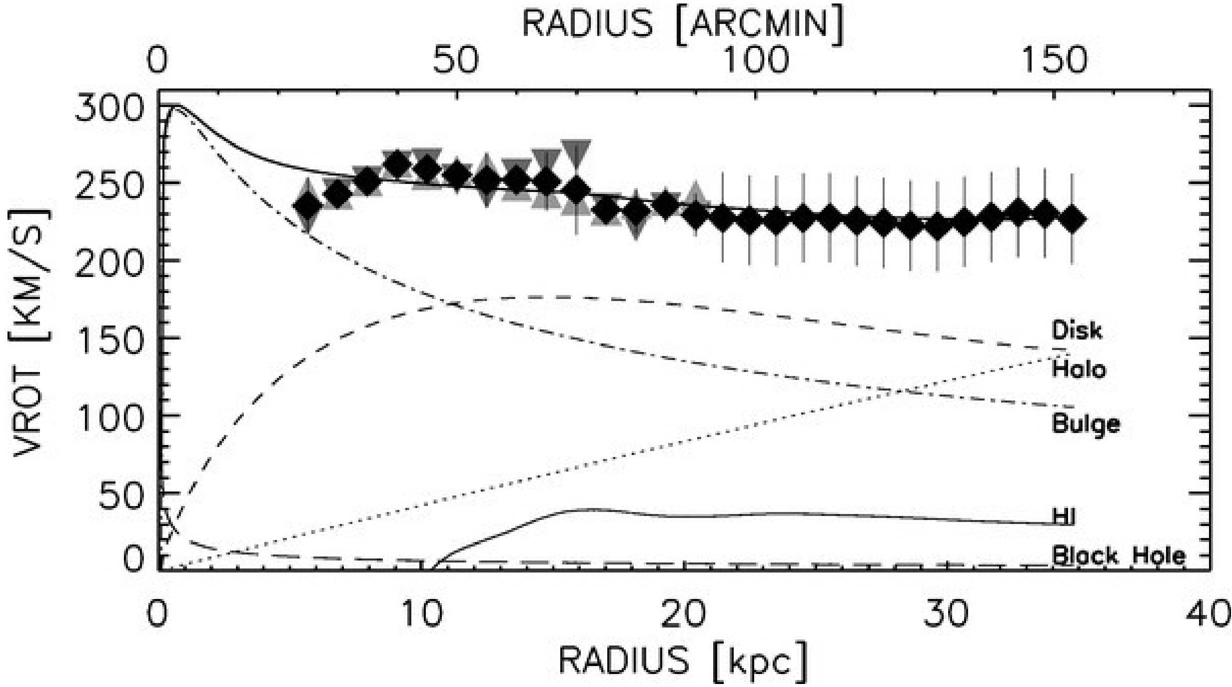
Распределение вещества

$$\phi_{tot} = \phi_{star} + \phi_{gas} + \phi_{DM}$$

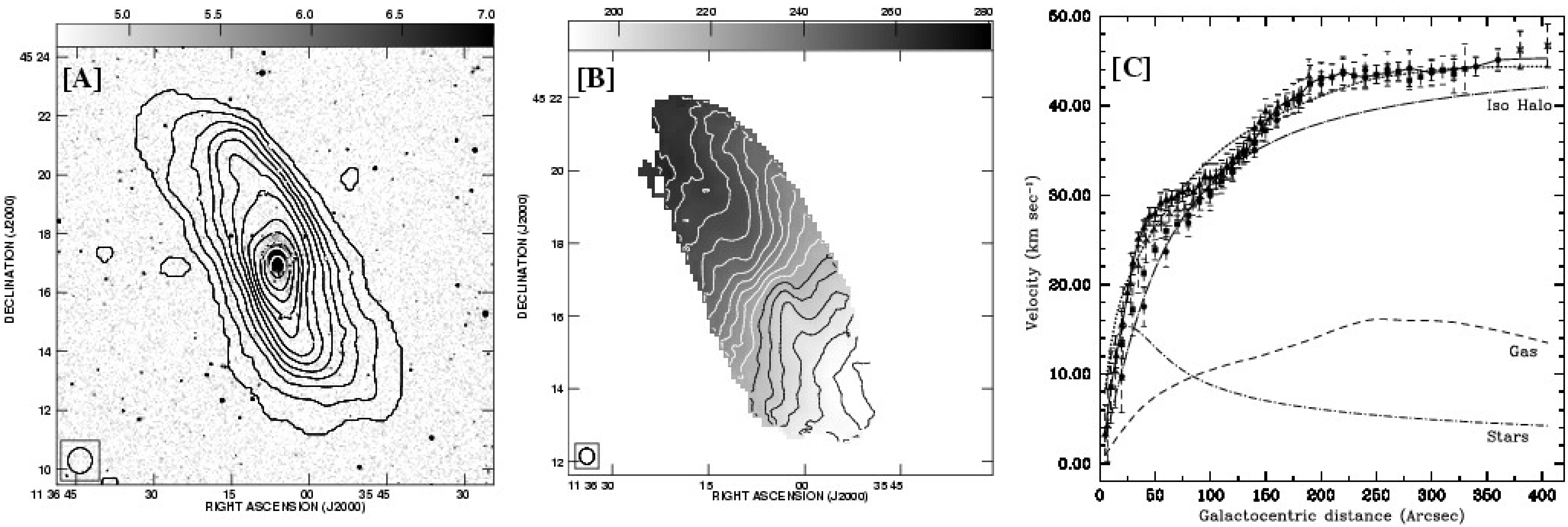
$$V^2_{tot}(r) = r\frac{d}{dr}\phi_{tot} = V^2_{star} + V^2_{gas} + V^2_{DM}$$



M 31



NGC 3741 – карликовая галактика с гигантским водородным диском



$M_B \sim -13.13$ $R_{HI} \sim 8.3\ R_{Holm}$

$M_{HI} = 1.6\pm0.4\times10^8\ M_\odot$ $M_{HI}/L_B = 5.8\pm1.4$

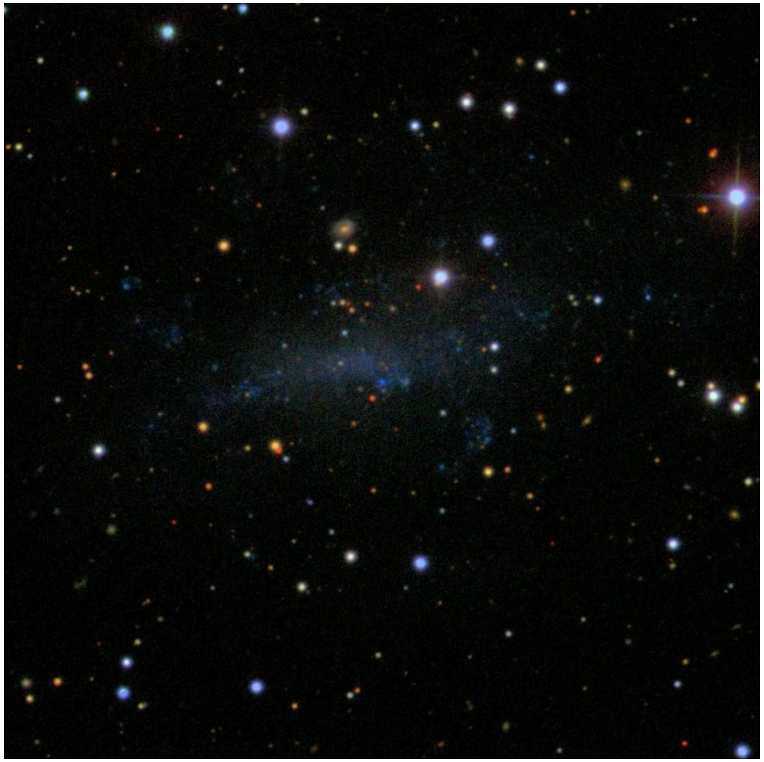
$M_{tot} = 3.0\pm0.4\times10^9\ M_\odot$ $M_{tot}/L_B = 107\pm16$ $M_{tot}/M_{bar} \sim 8$

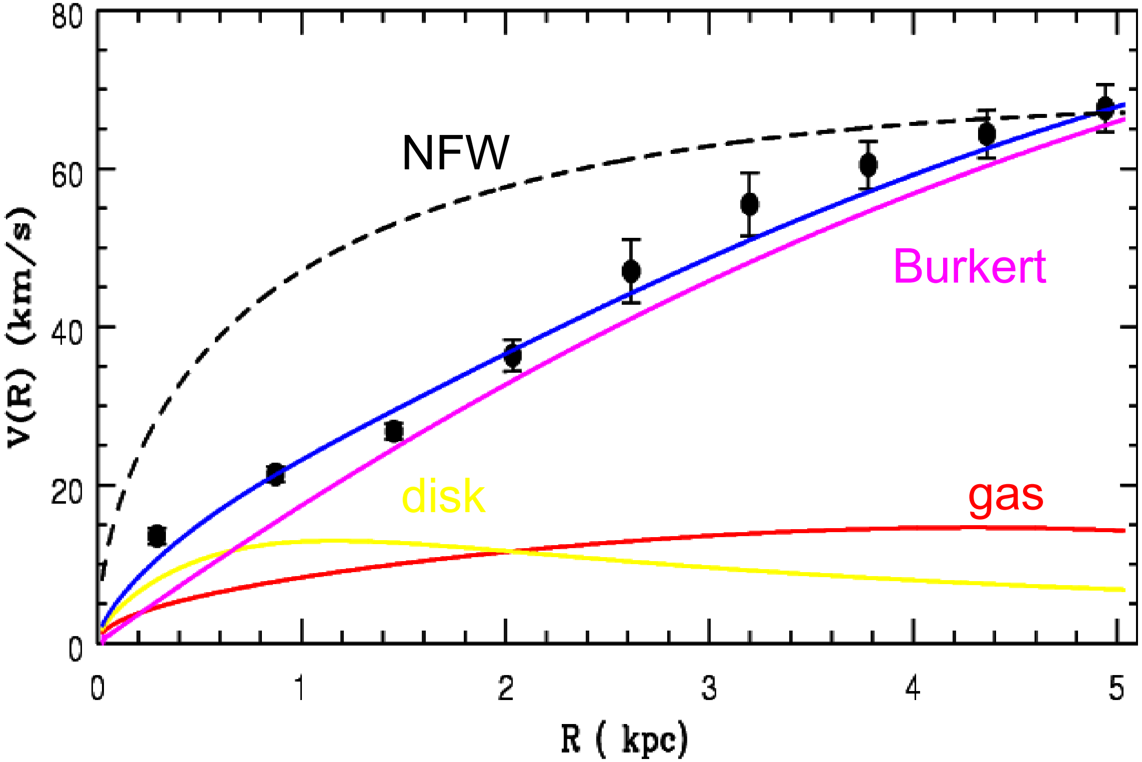
The Astrophysical Journal, 634:L145–L148, 2005 December 1

THE DWARF GALAXY DDO 47 AS A DARK MATTER LABORATORY: TESTING CUSPS HIDING IN TRIAXIAL HALOS

G. Gentile,[1] A. Burkert,[2] P. Salucci,[1] U. Klein,[3] and F. Walter[4]
Received 2005 June 22; accepted 2005 October 19; published 2005 November 22

and an NFW halo is inconsistent with the data. We analyze the velocity field through the higher order harmonic terms in order to search for kinematical signatures of alleged noncircular motions needed to "hide" a cusp: the result is that globally noncircular motions are at a level of 2–3 km s^{-1}, and they are more likely to be associated with the presence of some spiral structure than with a global elongated potential (e.g., a triaxial halo). These noncircular motions are far from being sufficient to account for the discrepancy with the ΛCDM predictions. We therefore conclude that the dark matter halo around the dwarf galaxy DDO 47 is truly cored and that a cusp cannot be hidden by noncircular motions.





Спасибо за внимание

Распределение галактик по морфологии в зависимости от окружения