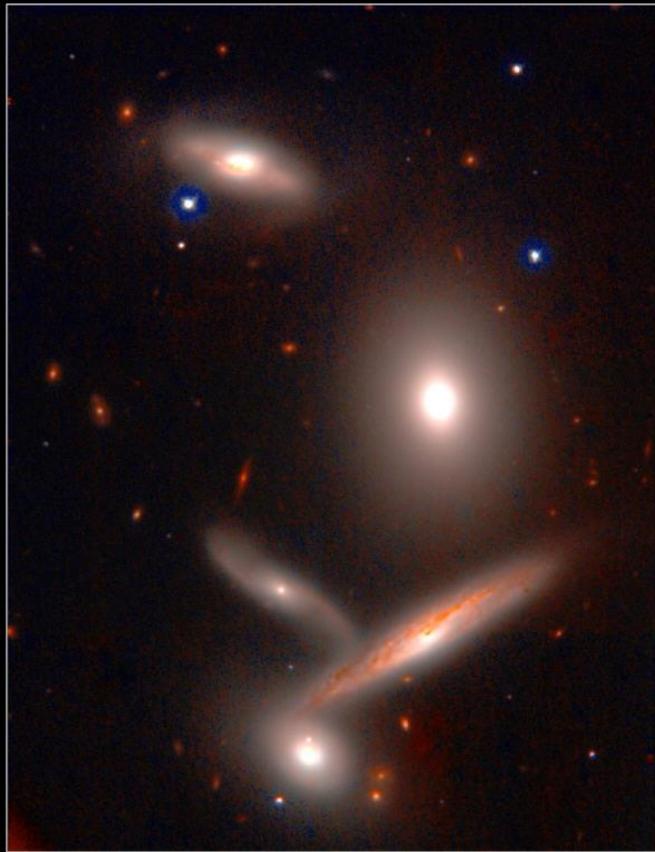


Оптическая спектроскопия галактик

Сильченко О.К.

Галактики – протяженные объекты, НЕ разрешаемые в общем случае на звезды



Hickson Compact Group 40

Subaru Telescope, National Astronomical Observatory of Japan

CISCO (J & K')

January 28, 1999



The Sombrero Galaxy (VLT ANTU + FORS1)

ESO PR Photo 07a/00 (22 February 2000)

© European Southern Observatory

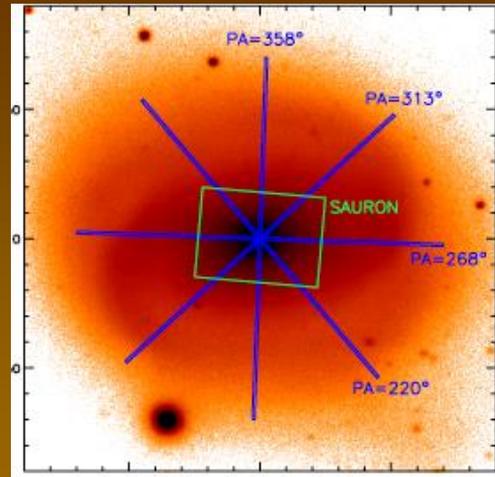


Спектроскопия с длинной щелью: NGC 7743

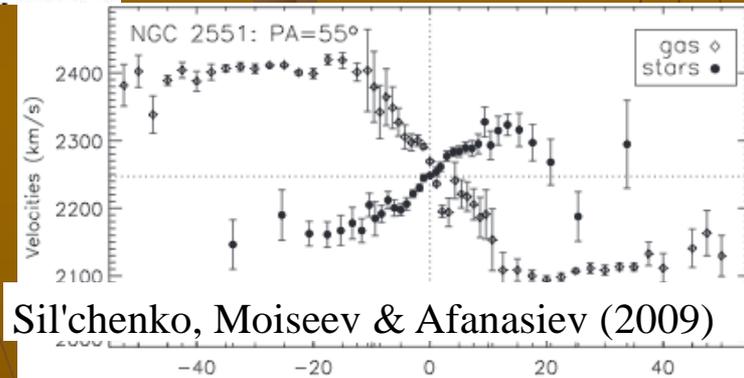
Одномерный разрез:
спектры от каждой точки
вдоль щели.

Можно сориентировать
щель вдоль линии узлов
диска галактики и
померять лучевую
скорость звездного
компонента и/или
ионизованного газа
вдоль щели – получить
кривую вращения
галактики.

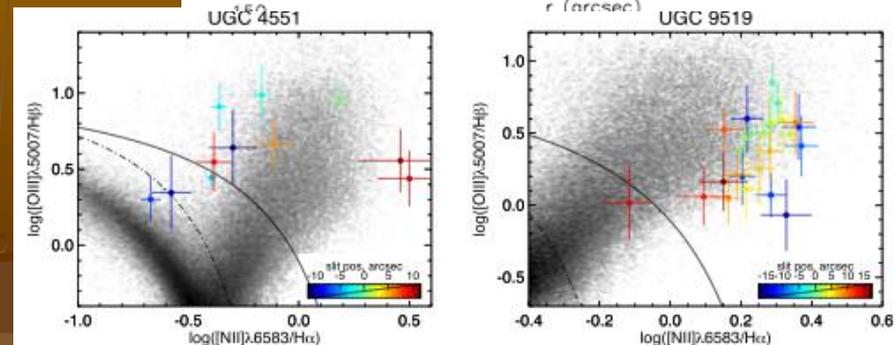
Можно измерить поток в
эмиссионных линиях
вдоль щели и
определить по ним
характер возбуждения и
содержание отдельных
химических элементов.



NGC 7743:
Katkov, Moiseev & Sil'chenko 2011

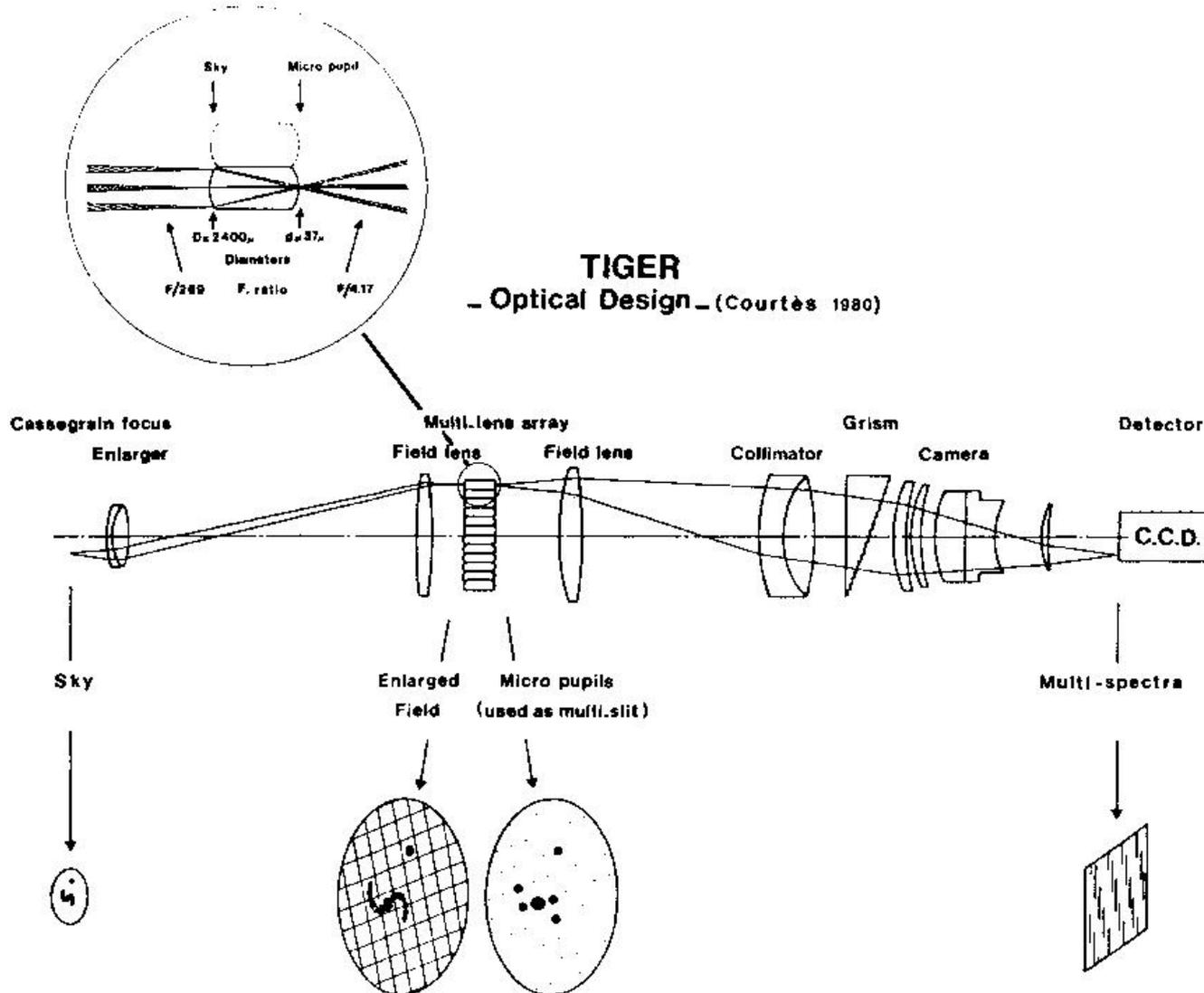


Sil'chenko, Moiseev & Afanasiev (2009)

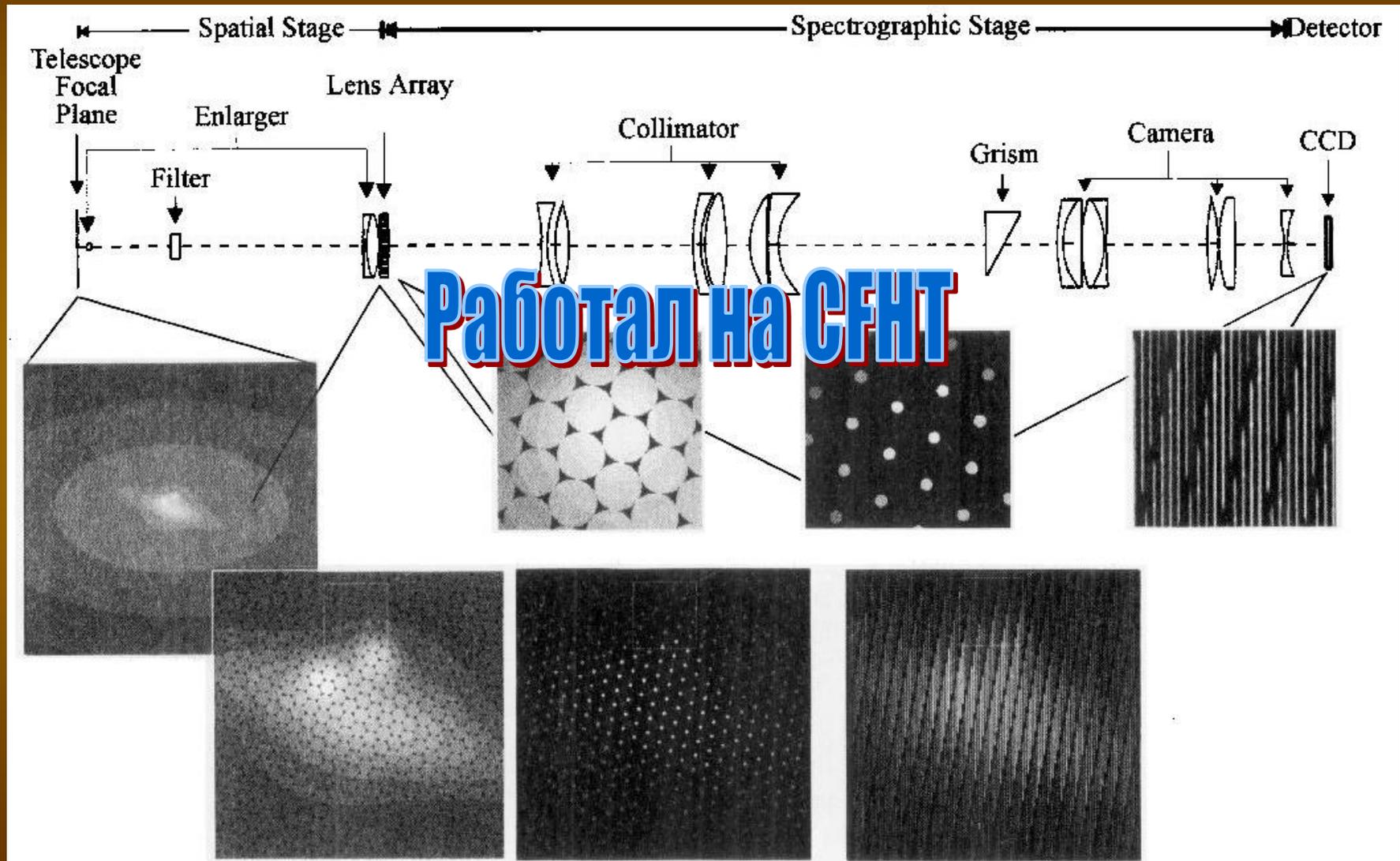


Katkov, Sil'chenko & Afanasiev (2014)

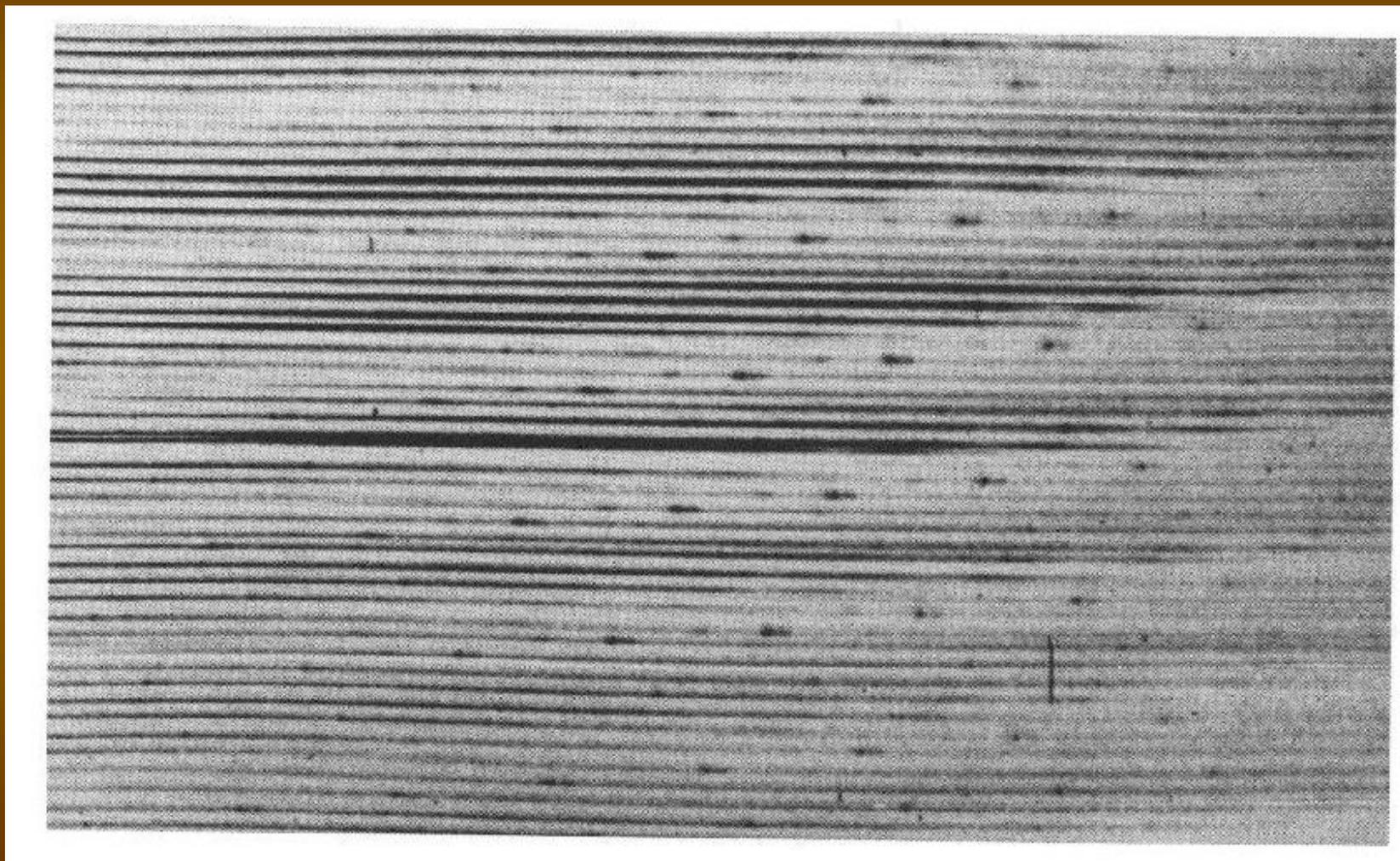
Начало панорамной спектроскопии: TIGER



TIGER: оптическая схема



Как выглядят спектры на приемнике



Поле зрения 10"x10" (sampling 0.61")

Наследник TIGERa - SAURON

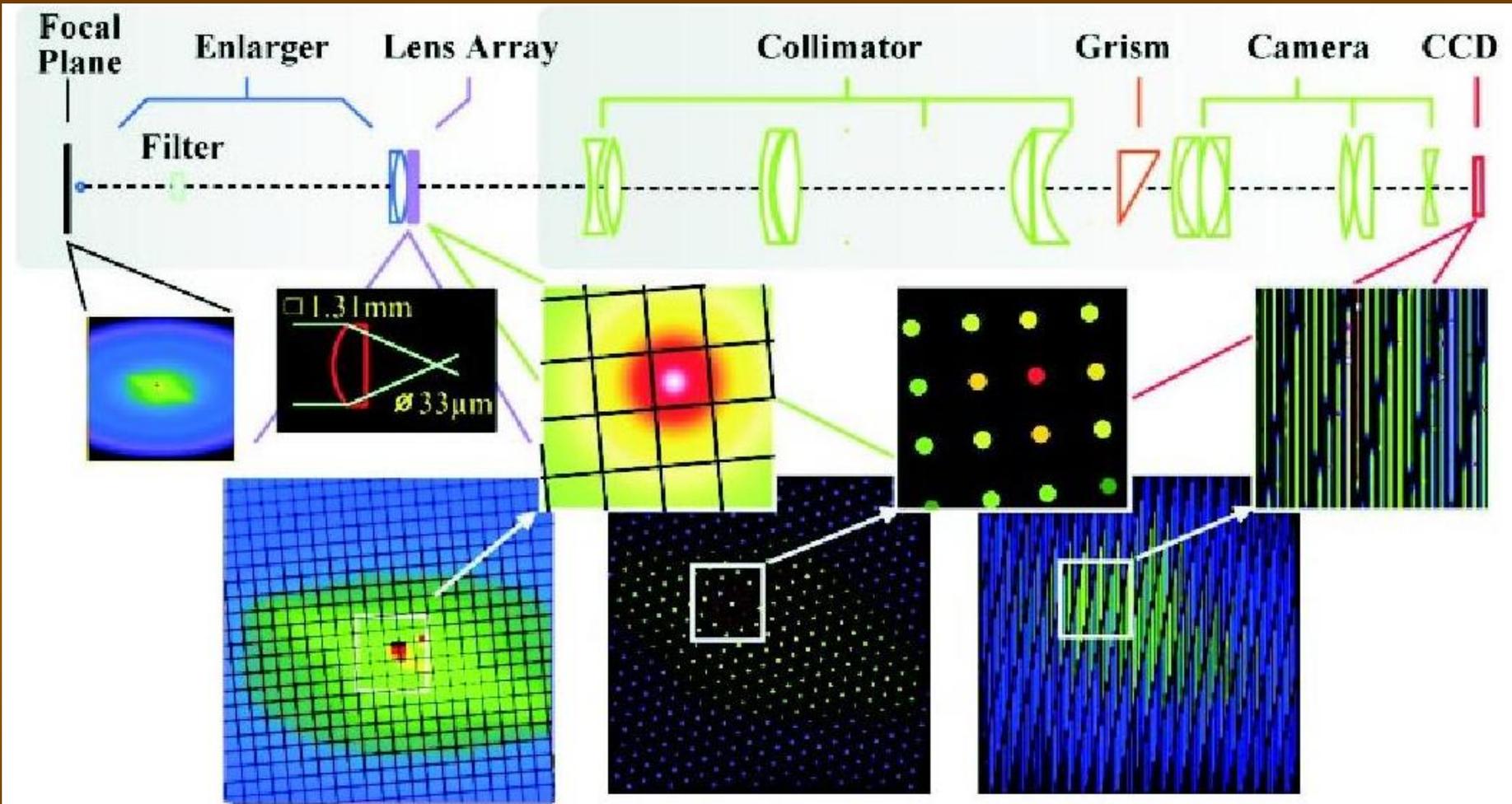


Figure 1. Optical layout of SAURON. The main optical elements are displayed from the telescope focal plane (left) to the detector plane (right). The image of a

Работал на WHT

SAURON: параметры прибора

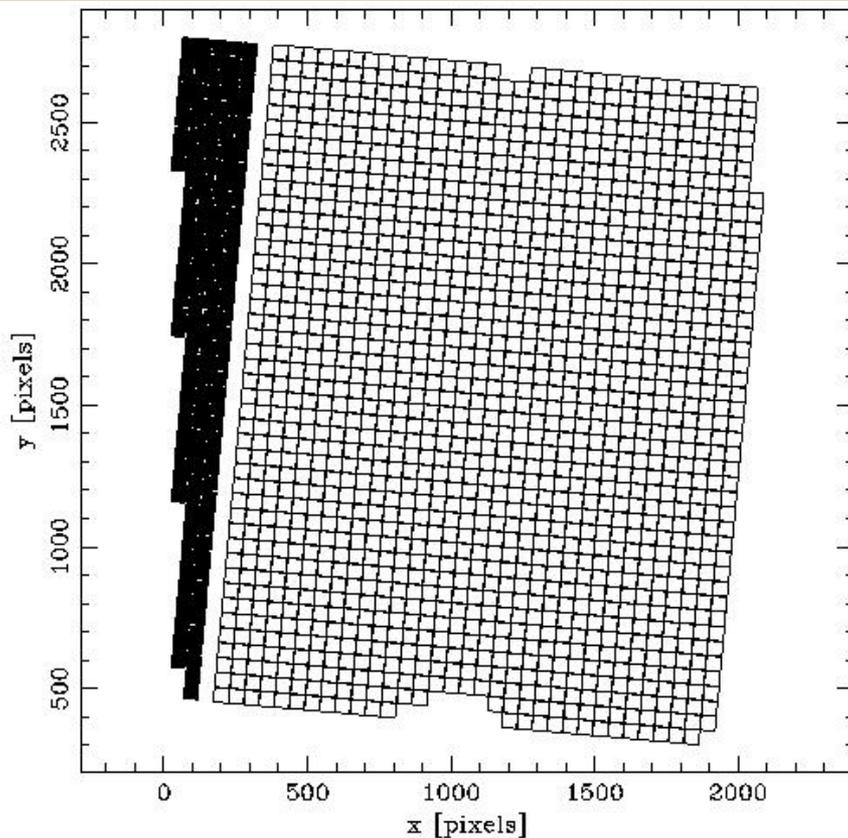
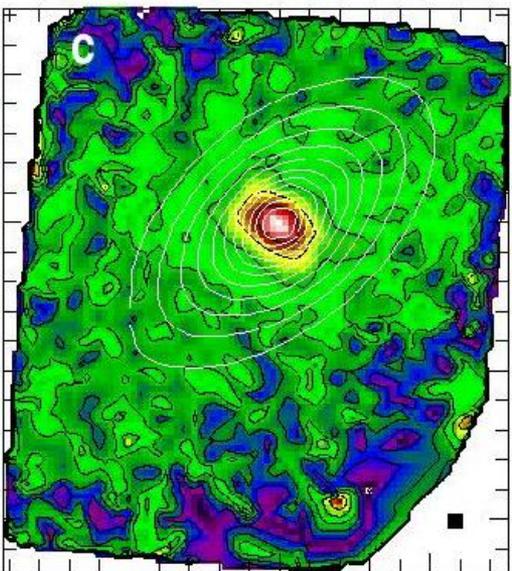
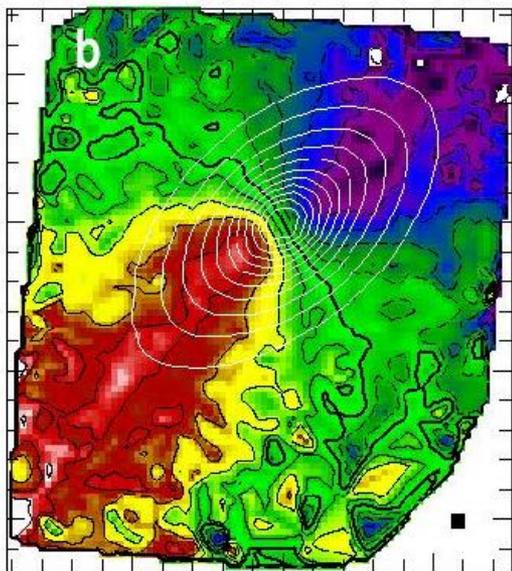
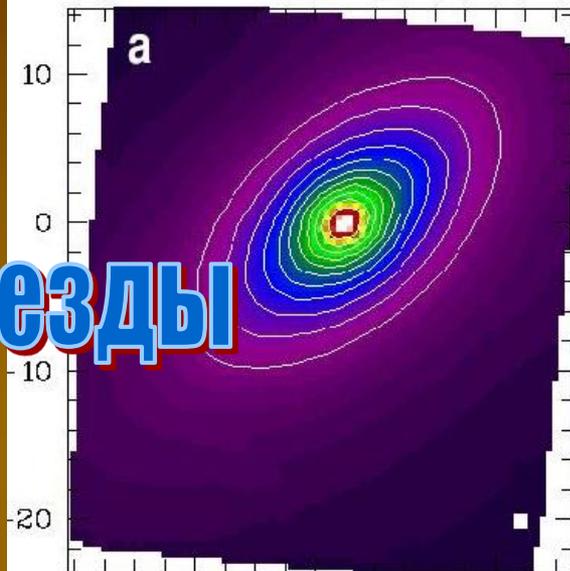


Table 1. Current specification of SAURON on the WHT.

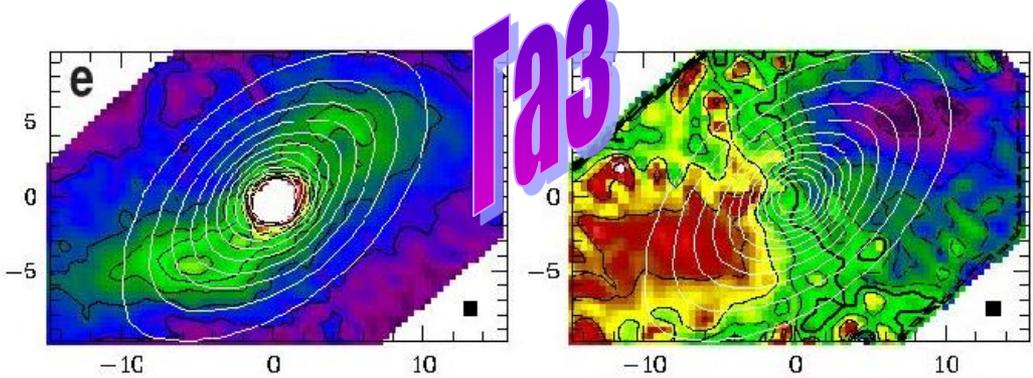
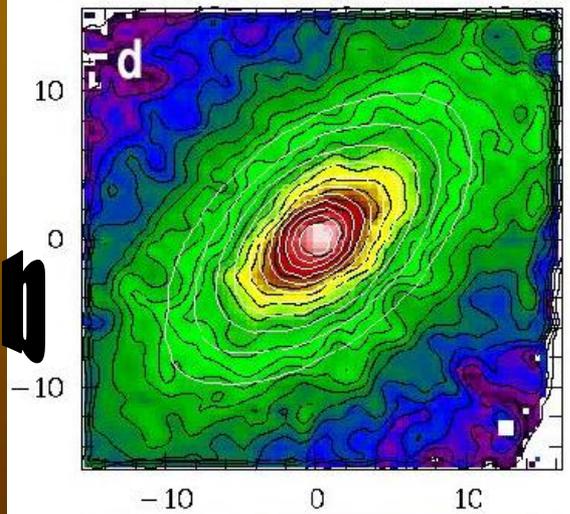
	HR mode	LR mode
Spatial sampling	0".27	0".94
Field of view	9" × 11"	33" × 41"
Spectral resolution (FWHM)	2.8 Å	3.6 Å
Instrumental dispersion (σ_{inst})	90 km s ⁻¹	105 km s ⁻¹
Spectral sampling	1.1 Å pix ⁻¹	
Wavelength range	4500–7000 Å	
Initial spectral window	4760–5400 Å	
Calibration lamps	Ne, Ar, W	
Detector	EEV 12 2148 × 4200	
Pixel size	13.5 μm	
Instrument Efficiency	35 per cent	
Total Efficiency	14.7 per cent	

Набор данных, получаемых SAURON

Звезды

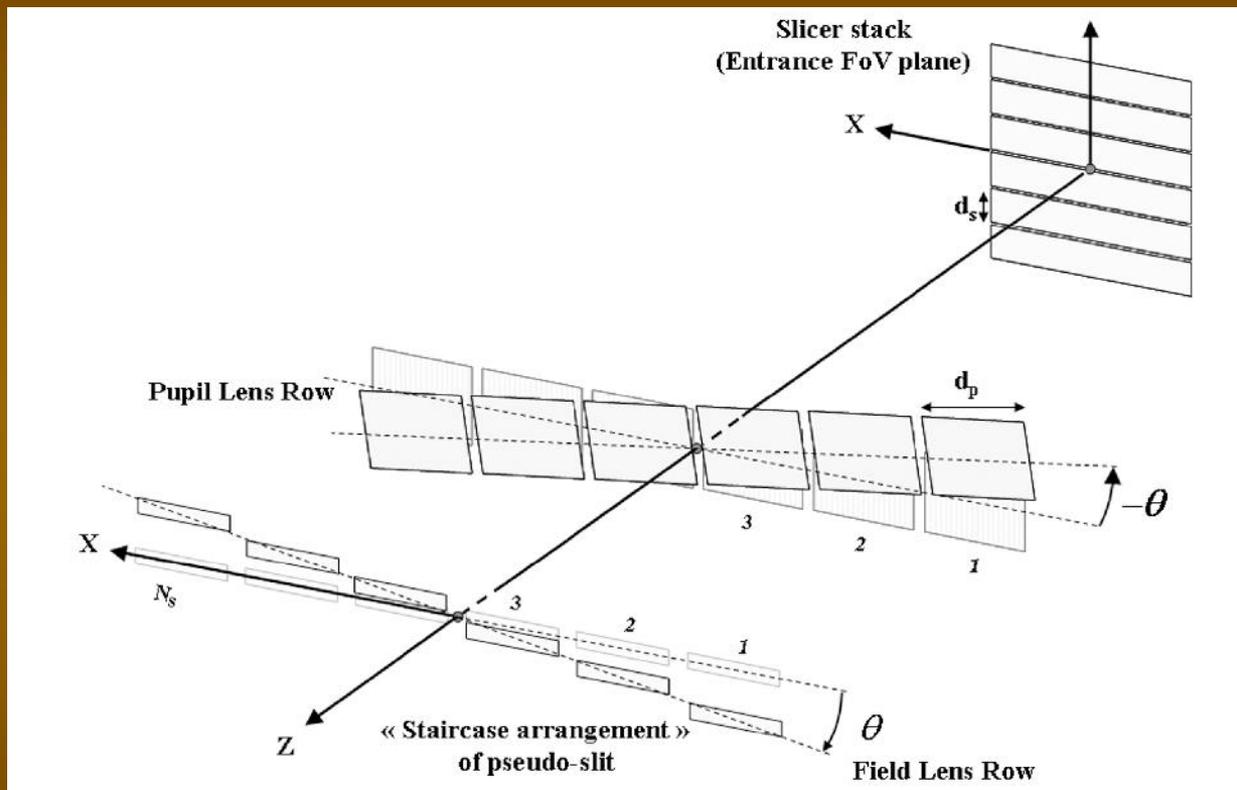


Mgb



газ

Последний суперприбор: MUSE/MLT



Всего 24 слайсера, полное поле — минута дуги

Широкопольные фиберные IFU

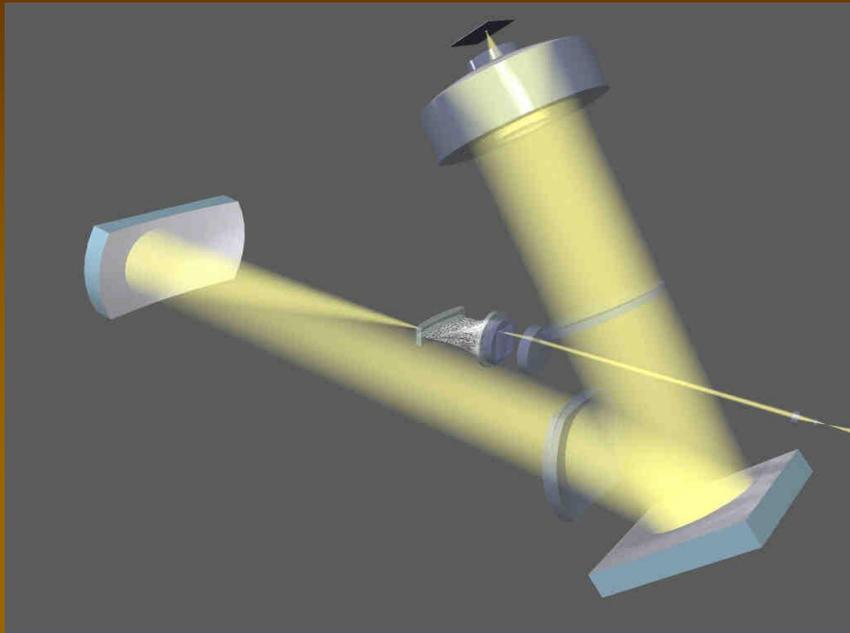


The Sydney-AAO Multi-object Integral field spectrograph (SAMI)

- › 1 degree diameter field-of-view.
- › 13 x 61 fibre IFUs using hexabundles (Bland-Hawthorn et al. 2011; Bryant et al. 2014) with high fill factor: 75%.
- › 15" diameter IFUs, 1.6" diameter fibres.
- › Feed AAT's AAOmega spectrograph:
 - Blue: 3700-5800A, $R \sim 1750$, $\sigma = 70 \text{ km/s}$
 - Red: 6300-7400A, $R \sim 4500$, $\sigma = 30 \text{ km/s}$
- › Instrument description: Croom, Lawrence, Bland-Hawthorn et al. (2012).
- › **SAMI: 793 fibres across 13 objects.**
- › **CALIFA: 331 fibres targeting one galaxy.**



Панорамная спектроскопия на БТА



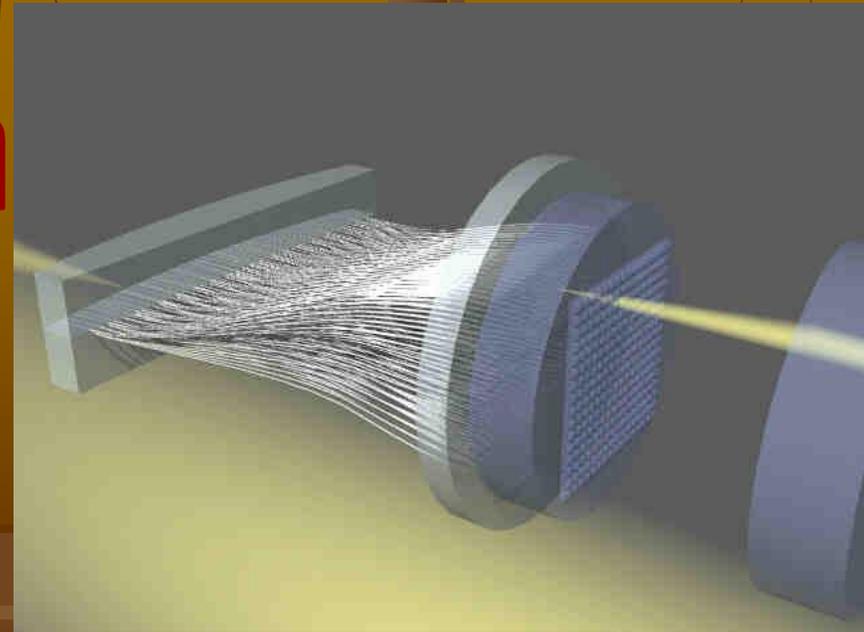
MPFS=Multi-Pupil Fiber Spectrograph

Поле 16"x16"

Полный диапазон 3600-9600 А

Набор решеток с дисперсиями
от 0.75 до 3.0 А/рх

Квантовая эффективность –
проценты.

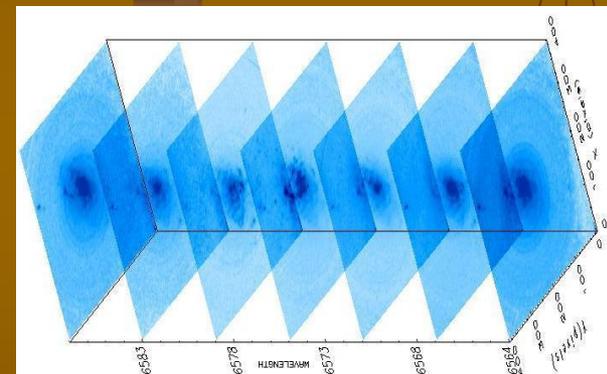


Панорамная спектроскопия на БТА



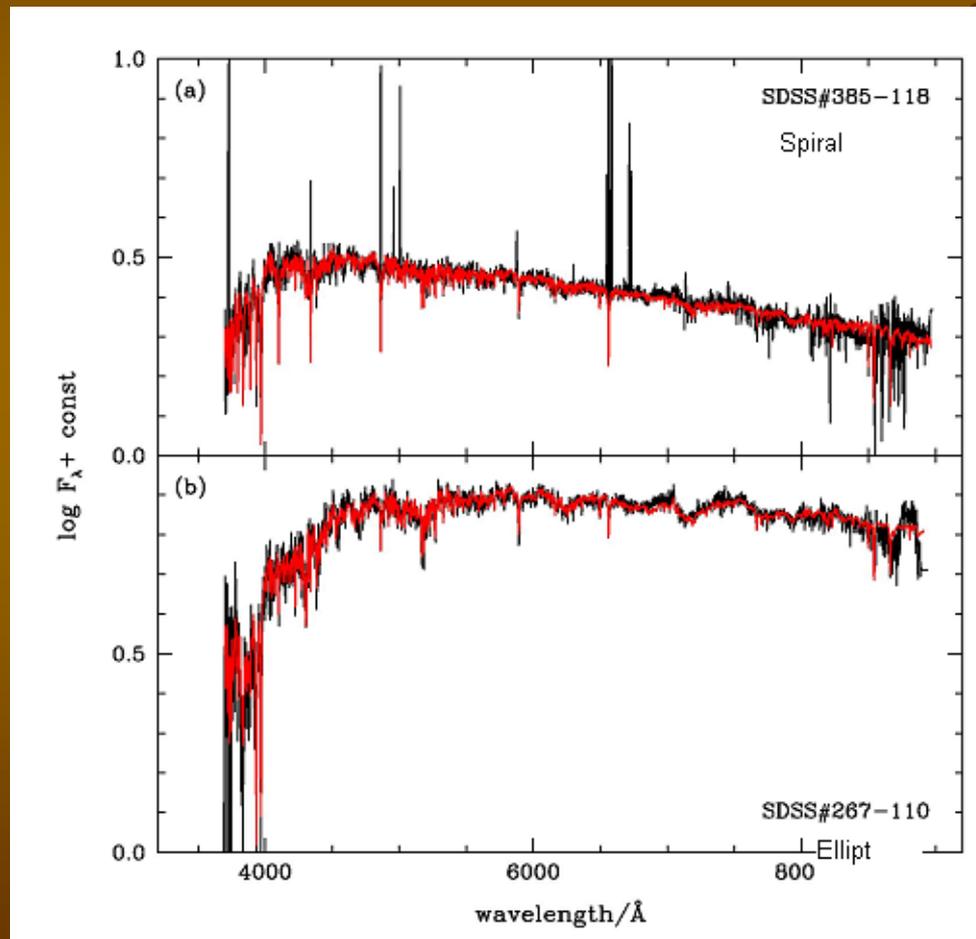
Multi-mode SCORPIO-2 focal reducer with a scanning Fabry-Perot interferometer (Afanasiev & Moiseev 11)
Emission lines : [NII]6583, [OIII]5007, H α

Field of view: 6.1 x 6.1 arcmin
Spatial sampling: 0.70 arcsec/px
Vel. Resolution (FWHM): 70-120 km/s

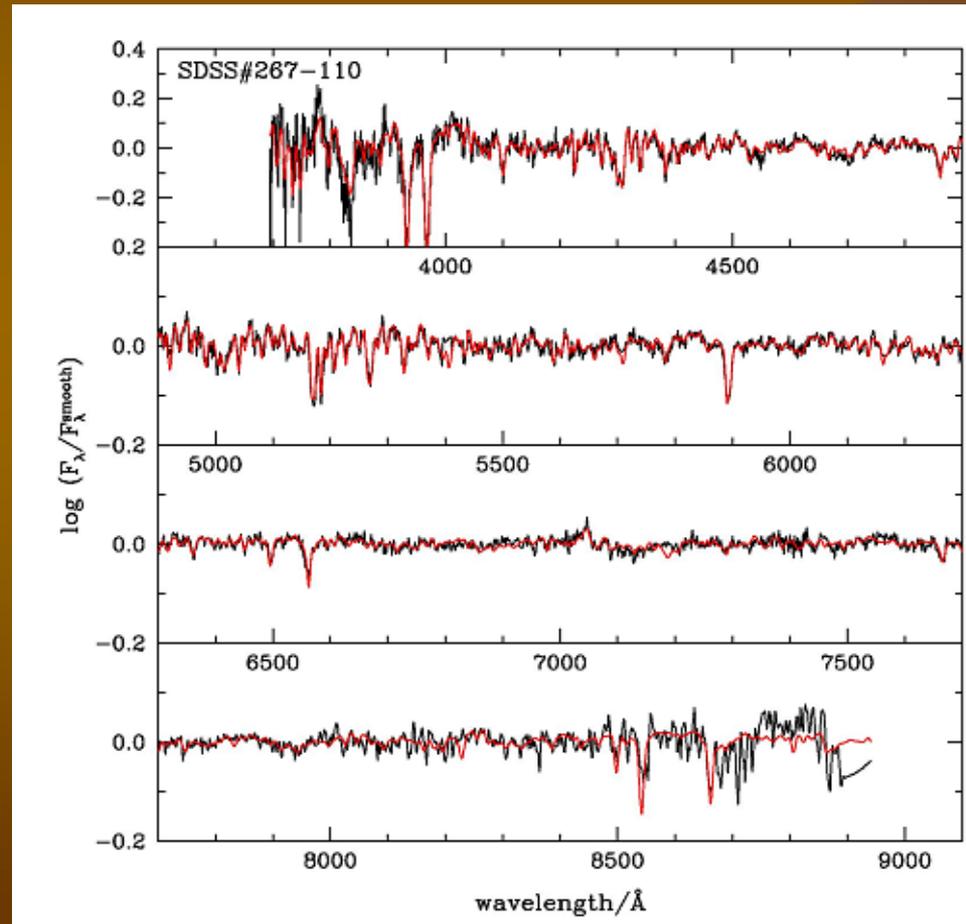


<http://www.sao.ru>

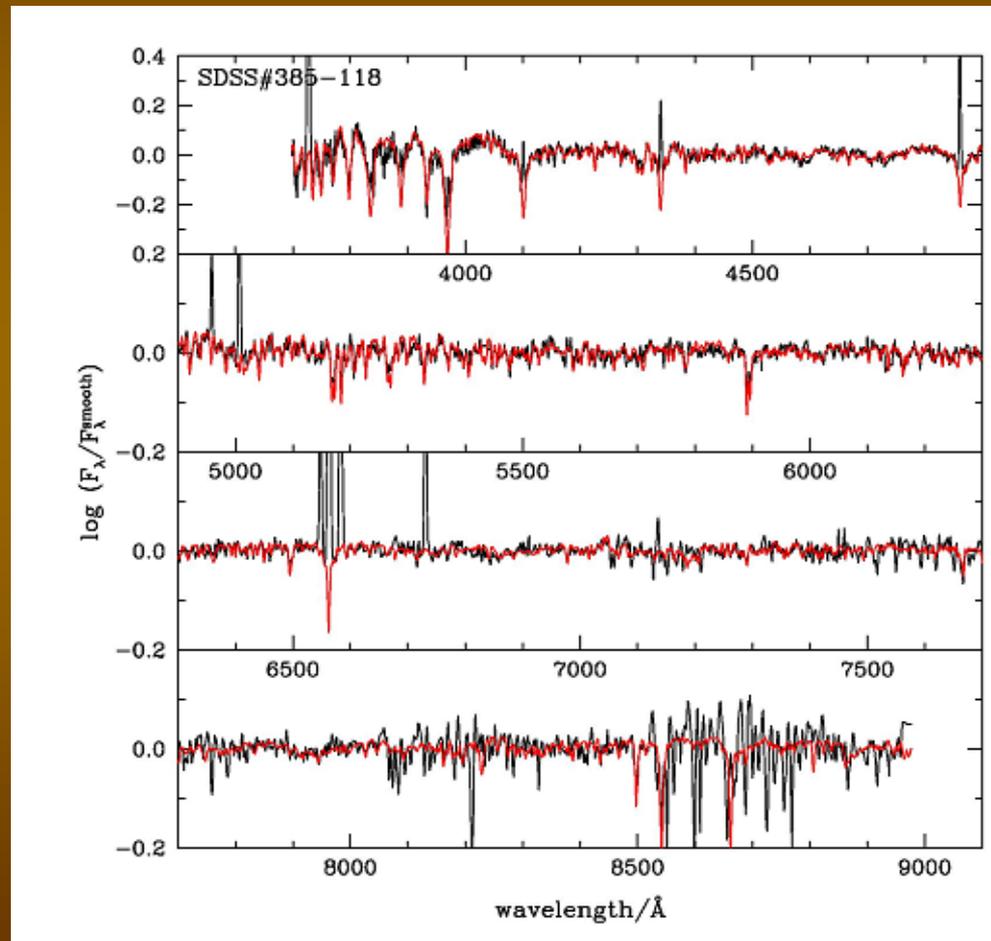
Типичные спектры галактик: в оптике вклад от звезд и теплого газа



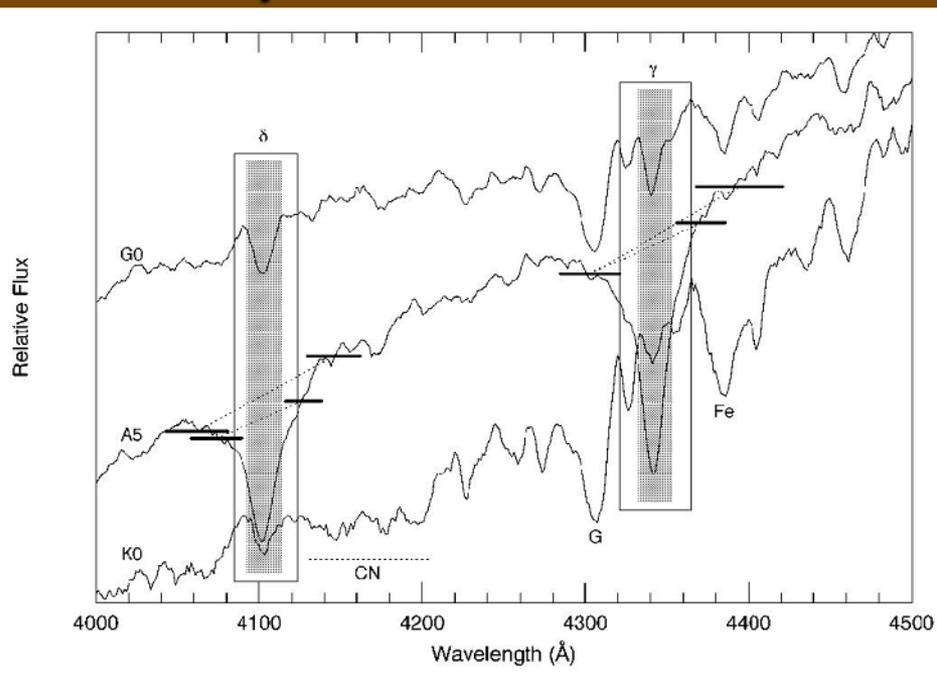
Подгонка спектров ЗВЕЗДНОГО КОМПОНЕНТА методом ЭВОЛЮЦИОННОГО СИНТЕЗА



Подгонка спектров методом ЭВОЛЮЦИОННОГО СИНТЕЗА



Ликские индексы: унифицированное спектральное описание линий поглощения



- Расчет эквивалентных ширин линий в рамках Ликской системы: зафиксированы границы полос континуума и полосы, включающей линию

INDEX DEFINITIONS		
BANDPASS (Å)		
Index	Blue	Red
4083.50–4122.25	4041.60–4079.75	4128.50–4161.00
4319.75–4363.50	4283.50–4319.75	4367.25–4419.75
4091.00–4112.25	4057.25–4088.50	4114.75–4137.25
4331.25–4352.25	4283.50–4319.75	4354.75–4384.75

Определение Ликских индексов

curves (see below). Twenty-one absorption feature indices are added as well. The absorption features are measured in an “index passband” that is flanked by two “pseudocontinua” and expressed either in angstroms of equivalent width or as a flux difference in magnitudes (see Worthey et al. 1994). Each stellar flux along the isochrone is used to place the pseudocontinua by integrating under the defined bandpasses. The “continuum” is placed at the center wavelength of the index passband by drawing a line between the centers of the two pseudocontinua. The absorption in the index passband is given by polynomial fitting functions as a function of T_e , $\log g$, and $[\text{Fe}/\text{H}]$ (Worthey et al. 1994). The continuum flux and the continuum flux minus the absorption are added for all stellar parcels in the isochrone. After addition along the isochrone, the indices are reexpressed in equivalent widths or magnitudes. An index expressed in magnitudes is

$$\text{Mag} = -2.5 \log (F_I / F_C), \quad (4)$$

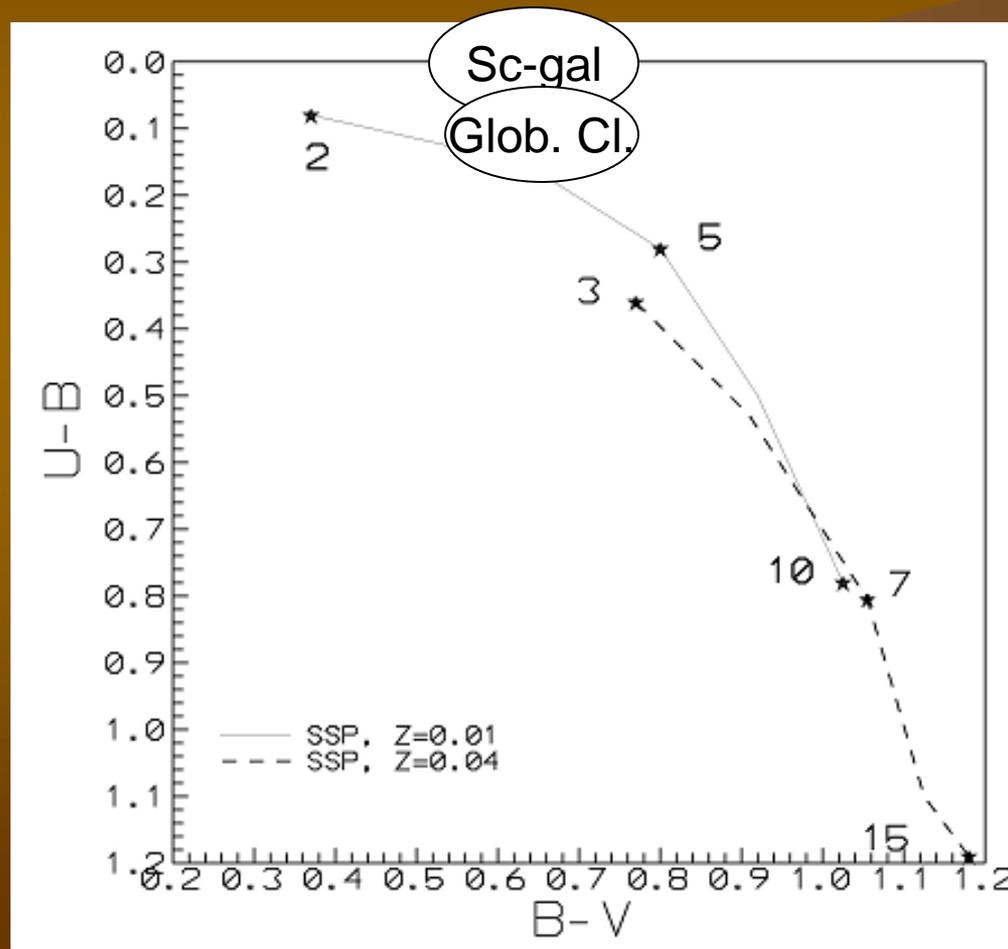
where F_C is the continuum flux and F_I is the continuum flux minus the absorption. An equivalent width is

$$\text{EW} = (\lambda_2 - \lambda_1)(1 - F_I / F_C), \quad (5)$$

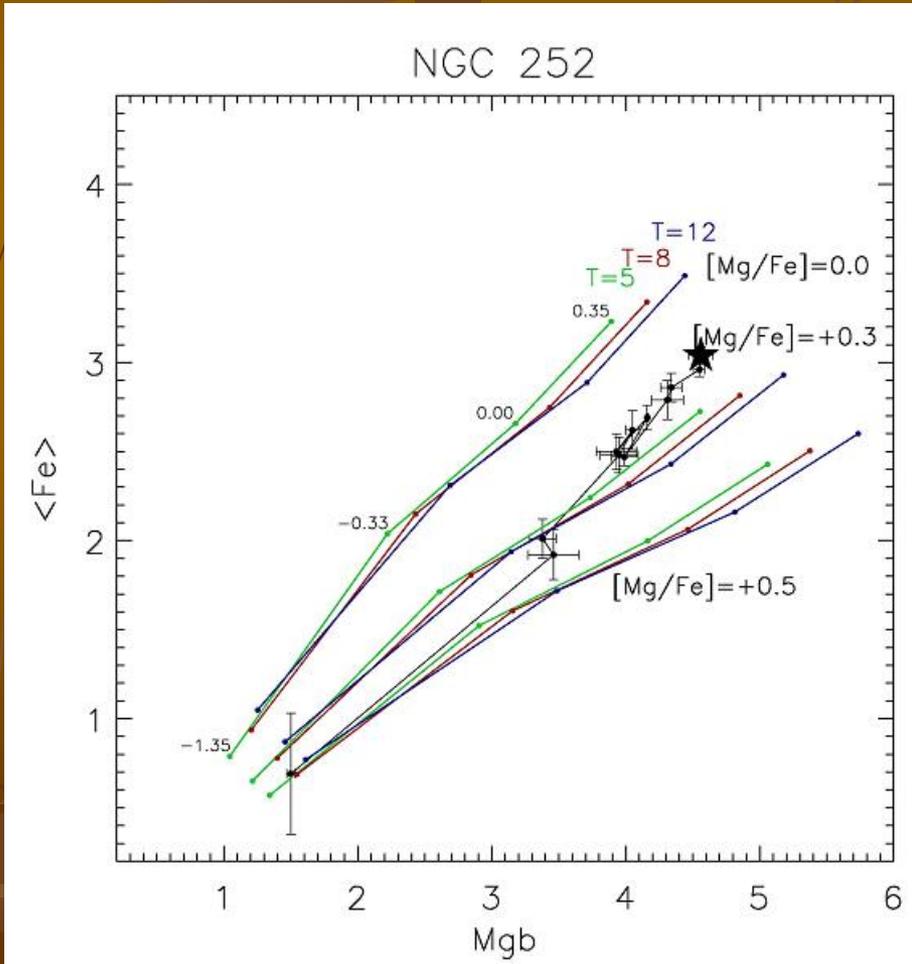
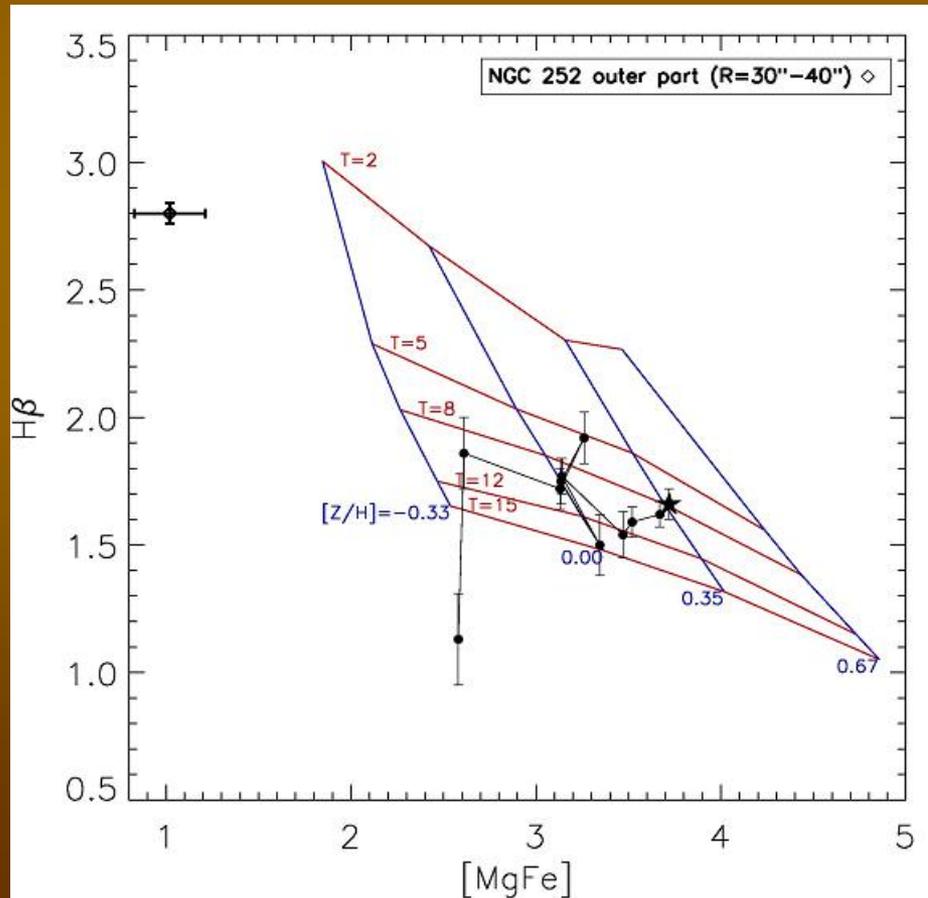
where λ_2 and λ_1 are the defined red and blue wavelength bounds of the index passband (Table 1 of Worthey et al. 1994).



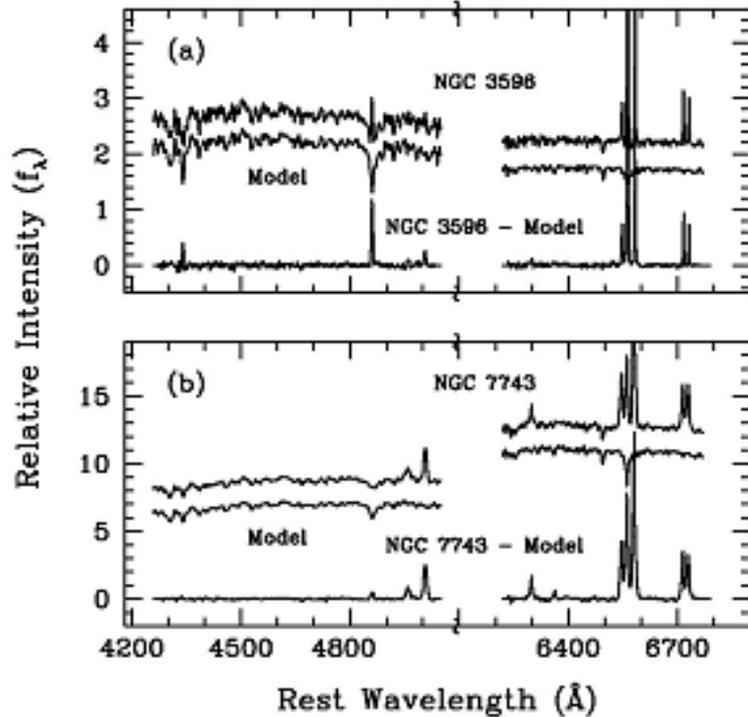
Вырождение эффектов возраста и металличности в цвете и спектре (Засов, Сильченко 1983)



Как снять “вырождение” эффектов возраста и металличности с помощью Ликских индексов?

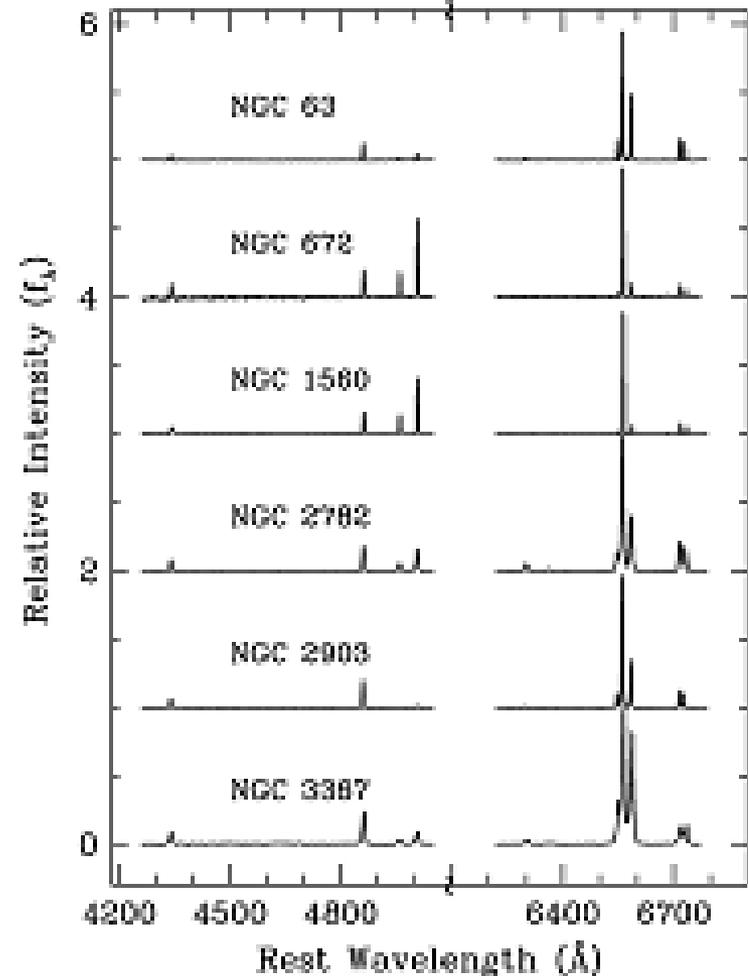


Спектральный обзор ядер 500 близких галактик Но, Filippenko & Sargent 1995-1997: основные эмиссионные линии



Vol. 1, 1997

SEARCH FOR "DWARF" SEYFERT NUCLEI. III.



Эмиссионные спектры галактик: диагностика механизма возбуждения

фотоионизация...

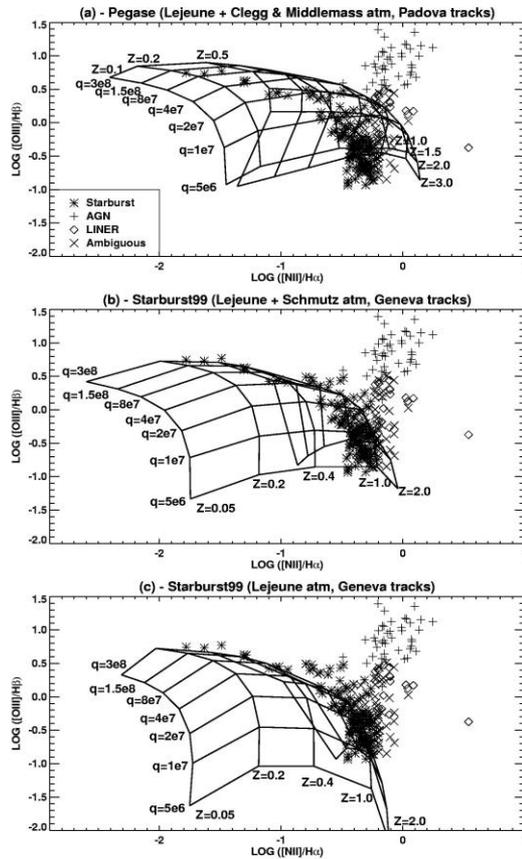


FIG. 9.—VO87 diagnostic plot $\log [N II]/H\alpha$ vs. $\log [O III]/H\beta$ for (a) the continuous starburst models based on the PEGASE SED, (b) continuous starburst models based on the STARBURST99 SED with Lejeune plus Schmutz atmospheres, and (c) continuous starburst models based on the STARBURST99 SED with Lejeune atmospheres. The theoretical grids of ionization parameter and chemical abundance are shown in each case. [See the electronic edition of the Journal for a color version of this figure.]

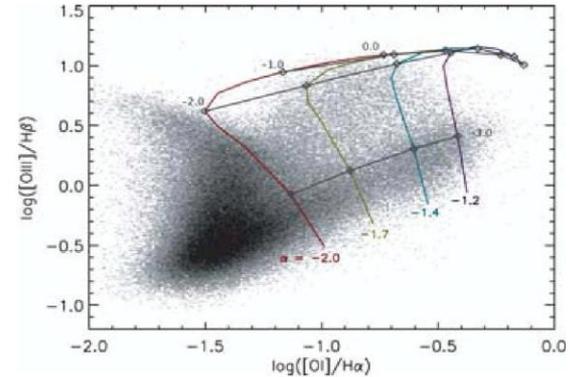
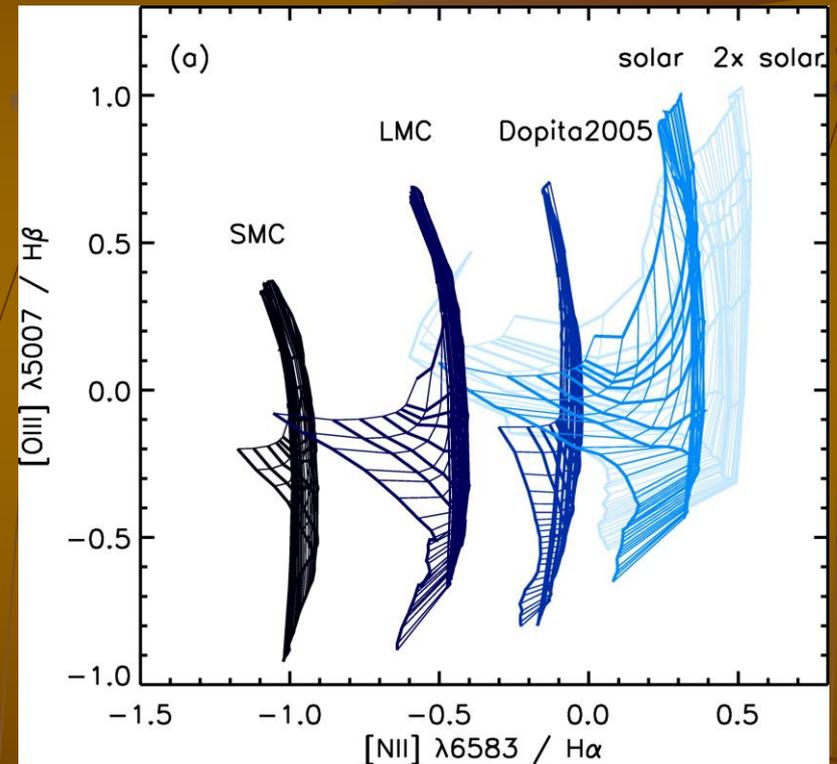
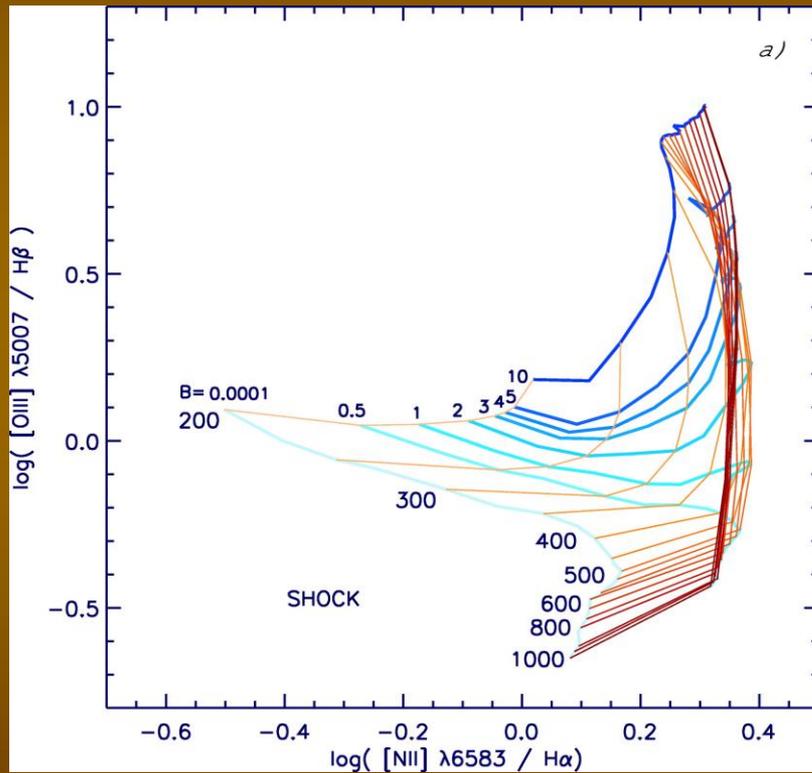


Figure 23. The $[O III]/H\beta$ versus $[O I]/H\alpha$ diagnostic diagram showing the SDSS galaxies (black points) and our theoretical dusty radiation pressure dominated AGN models. These models were calculated assuming a metallicity of $2 Z_{\odot}$ and a hydrogen density of 1000 cm^{-3} . The model grids are given for four ionization parameters $[\log(U) = 0, -1, -2, -3]$ and four power-law indices ($\alpha = -1.2, -1.4, -1.7, -2.0$) as marked. The radiation field in LINERs requires a lower ionization parameter than that in Seyfert galaxies, and LINERs with strong $[O I]/H\alpha$ require a harder radiation field than required by Seyferts.

Активным ядром

Молодыми звездами

Ударное возбуждение: Allen et al. (2008)



Солнечная металличность

Наблюдательные реперы: ядра галактик из обзора SDSS

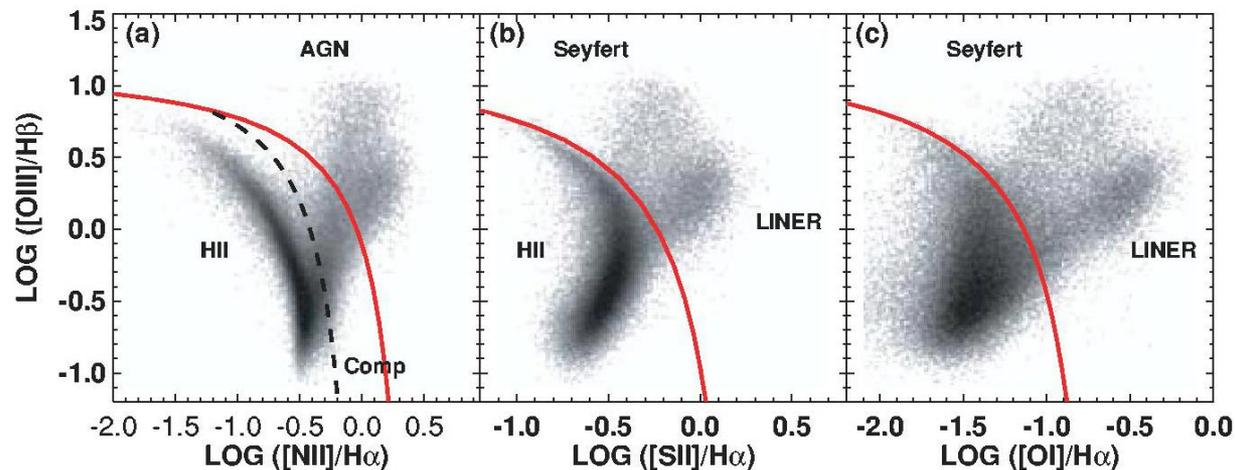


Figure 1. (a) The $[\text{N II}]/\text{H}\alpha$ versus $[\text{O III}]/\text{H}\beta$ diagnostic diagram for SDSS galaxies with $S/N > 3$. The Ke01 extreme starburst line and the Ka03 classification line are shown as the solid and dashed lines, respectively. (b) The $[\text{S II}]/\text{H}\alpha$ versus $[\text{O III}]/\text{H}\beta$ diagnostic diagram; (c) the $[\text{O I}]/\text{H}\alpha$ versus $[\text{O III}]/\text{H}\beta$ diagnostic diagram.

Для газа, возбужденного молодыми звездами, есть калибровки металличности по $[\text{N II}]$ и $[\text{O III}]$

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