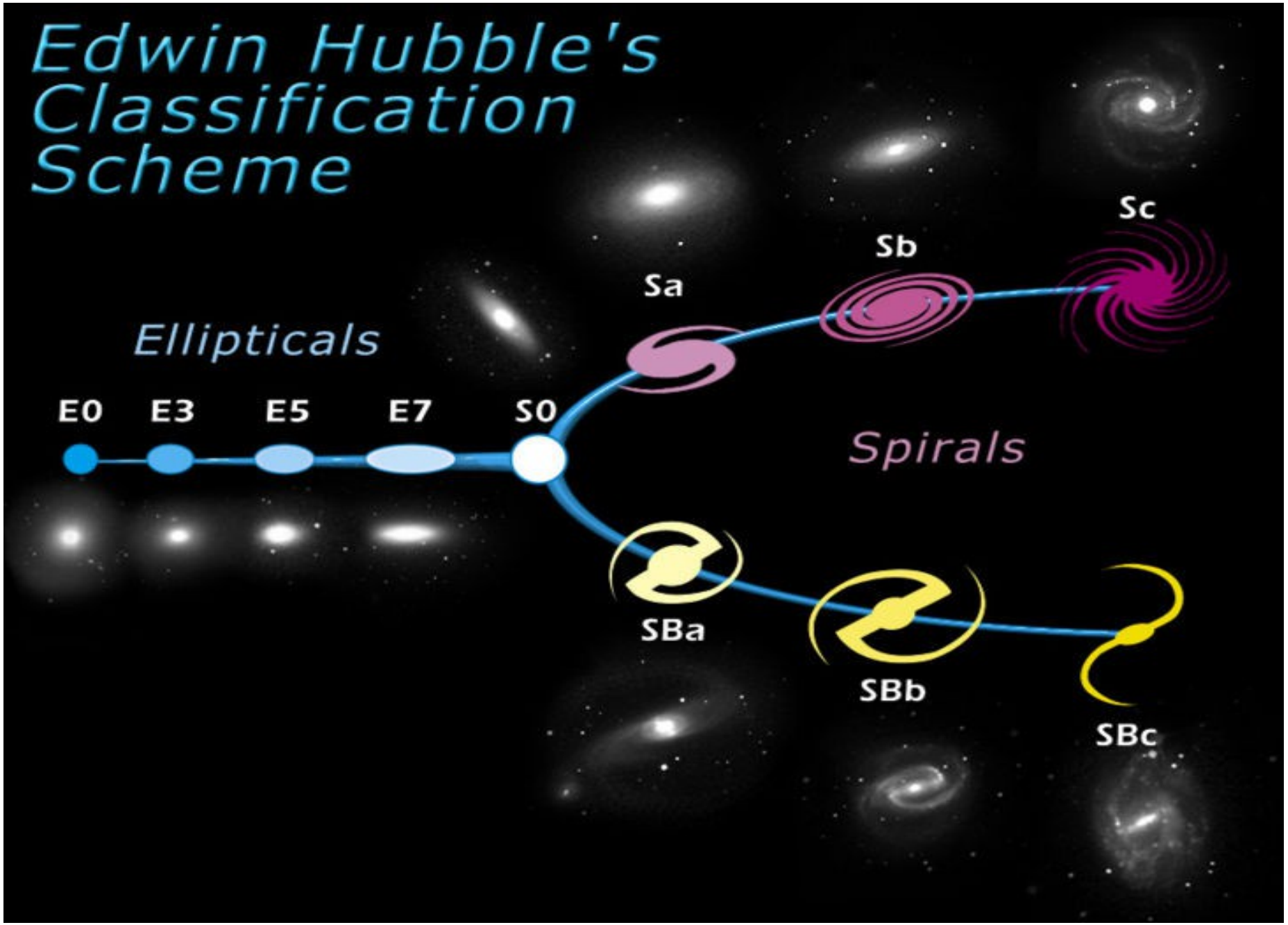
Possiamo veramente dare della "vecchia cicciona" ad una galassia??

Ovvero

Come stimare la massa (stellare) e l'eta' di una galassia

Marco Scodeggio
INAF IASF-Milano



Originally believed to be an evolutionary sequence, from early to late type galaxies

First chance of measuring a mass (and a distance) for a galaxy

THE ROTATION AND RADIAL VELOCITY OF THE CENTRAL PART OF THE ANDROMEDA NEBULA

By F. G. Pease

Mount Wilson Solar Observatory, Carnegie Institution of Washington

Communicated by G. E. Hale, December 27, 1917

Indications of rotation in spiral nebulae are quickly obtained by means of spectrographs of very short focus and small dispersion, especially when a wide slit and devices for narrowing the spectrum are used. For definitive values of the rotation, however, it is necessary that the scale be relatively large, the slit narrow, and the exposures very long.

To investigate the rotation of the great nebula in Andromeda, which had been reported by V. M. Slipher at the nineteenth meeting of the American Astronomical Society, an exposure of seventy-nine hours was made during August, September, and October, 1917, with the focal-plane spectrograph of the 60-inch reflector. This instrument which is used at the primary focus of

Measuring ages for star clusters (resolved stellar populations)

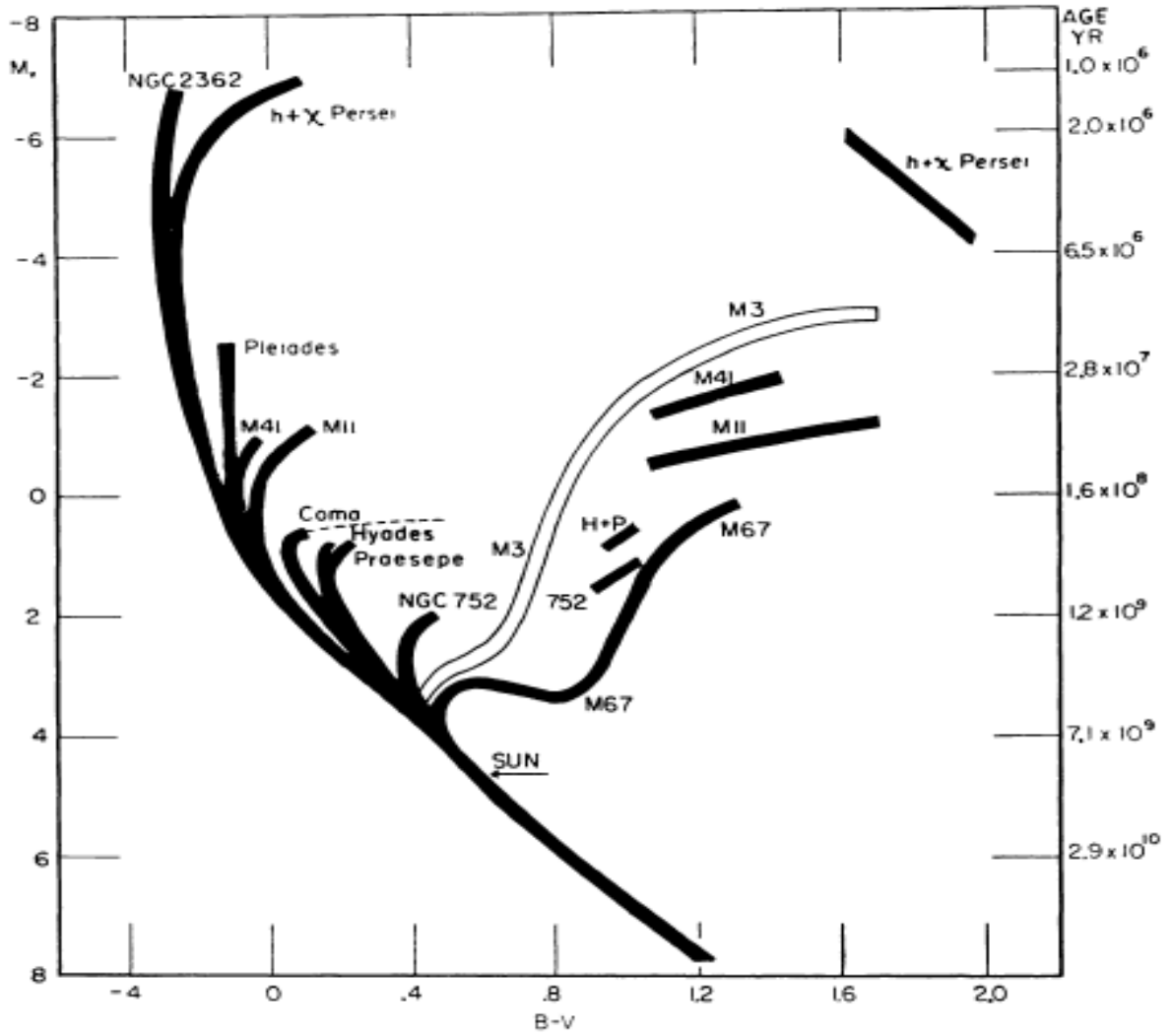


FIGURE 1 — A composite color-magnitude diagram of ten galactic clusters and one globular cluster. Ages corresponding to the various main sequence termination points are given along the right hand ordinate.

A. Sandage
1958

Measuring dynamical masses for galaxies (one at a time)

THE ROTATION AND MASS OF NGC 1792*

V. C. RUBIN, E. M. BURBIDGE, AND G. R. BURBIDGE
University of California, San Diego, La Jolla, California

AND

K. H. PRENDERGAST
Department of Astronomy, Columbia University, New York

Received February 15, 1964

ABSTRACT

The rotation of the Sc galaxy NGC 1792 has been determined. By analyzing the observed rotation-curve, density distributions and total masses as functions of the assumed c/a ratio of the galaxy have been obtained. It is found that the total mass is very close to $1.8 \times 10^{10} M_{\odot}$ and the mass-to-light ratio (photographic) is approximately unity. NGC 1792 is very similar in appearance to NGC 157 and NGC 1084, and its rotation-curve and total mass are likewise very similar.

NGS 1792 is an Sc galaxy, similar to NGC 157 and NGC 1084 which have been investigated in earlier papers of this series (Burbidge, Burbidge, and Prendergast 1961, 1963). A plate taken at the prime focus of the 82-inch telescope is reproduced in Figure

The first attempts at quantifying the evolution of a galaxy

THE ASTROPHYSICAL JOURNAL, **179**:427–438, 1973 January 15

THE HISTORY OF STAR FORMATION AND THE COLORS OF LATE-TYPE GALAXIES

LEONARD SEARLE, W. L. W. SARGENT, AND W. G. BAGNUOLO
Hale Observatories, Carnegie Institution of Washington, California Institute of Technology
Received 1972 June 13; revised 1972 August 9

ABSTRACT

We have calculated the U, B, V colors of simple model galaxies which are characterized by three parameters: α, which specifies the mass distribution of stars at birth, β, the reciprocal decay time of an assumed exponential decay in the rate of star formation, and their age. The computations are based on theoretical evolutionary tracks for individual stars.

The models for which $\beta \to \infty$ are shown to give a satisfactory account of the observed integrated colors of open clusters as a function of age. The observed colors of Sc and Irr I galaxies are found to be consistent with the following ideas.

a) All galaxies are approximately 10^{10} years old.

b) An initial luminosity function qualitatively similar to the Salpeter function obtains in all late-type galaxies, but irregulars are somewhat more enriched in massive stars than Sc's are.

c) The mean rate of star formation, averaged over sufficiently large regions of a galaxy and over sufficiently long times, is a declining function of time.

d) Different galaxies of the same morphological type have very different decay times for star formation, and many galaxies have experienced roughly uniform rates of star formation for the last 10^{10} years.

We propose that the range in colors of the late-type galaxies reflects this range in decay times and point out that, if so, the frequency of Type II supernovae will depend on both the mass and the color of the parent galaxy.

The first attempts at quantifying the evolution: predicting colors as a function of stellar age

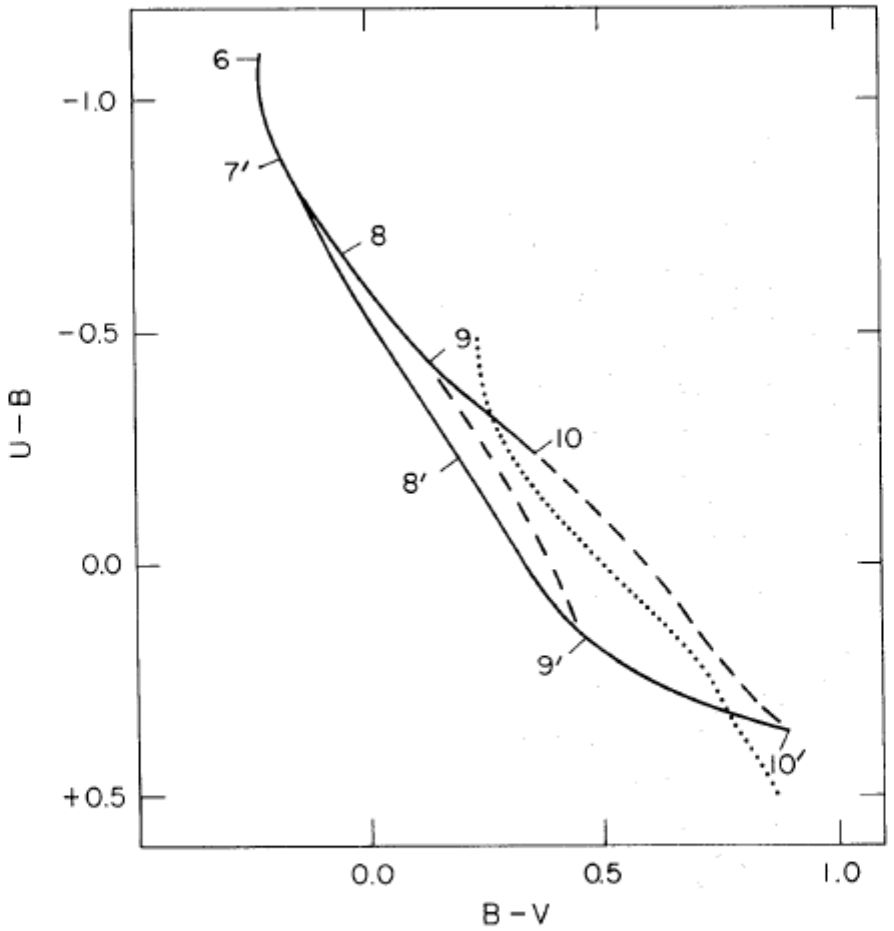


FIG. 4.—The two color relations for galaxies with secularly declining rates of star formation. The line 8, 9, 10 is the relation for uniform galaxies. The line 8′, 9′, 10′ is that for initial-burst galaxies. The dashed lines show the locations of galaxies 10^9 and 10^{10} years old. All galaxies in de Vaucouleurs's (1961) sample of 148 bright galaxies lie to the right of the dotted line.

Astronomers who could work on stars, galaxies, QSOs and the interstellar medium all at once

THE ASTROPHYSICAL JOURNAL, Vol. 152, May 1968

A QUANTITATIVE DESCRIPTION OF THE SPECTRA OF THE BRIGHTER FEIGE STARS*

WALLACE L. W. SARGENT
Mount Wilson and Palomar Observatories, Carnegie Institution of Washington,
California Institute of Technology

AND

LEONARD SEARLE
Mount Stromlo and Siding Spring Observatories
Research School of Physical Sciences, Australian National University

Received September 11, 1967

ABSTRACT

We have obtained 48 Å/mm spectrograms of thirty stars in Feige's (1958) list of blue stars at high galactic latitudes. Continuous energy distributions were measured for fourteen of these. The spectrograms have been classified on a system that used measured equivalent widths, line profiles, and *UBV* colors, in addition to visual inspection. In our sample we find fourteen normal A- and B-type stars. We suggest that the spectroscopically normal B stars, whose spectral types range from B3 to B6, are runaway stars that have been expelled from the galactic plane. We describe the spectra of four sdO stars and

The birth of stellar population synthesis

THE ASTROPHYSICAL JOURNAL, 186:35–49, 1973 November 15

ANALYTICAL APPROXIMATIONS TO THE EVOLUTION OF GALAXIES

BEATRICE M. TINSLEY*
Astronomy Program and Center for Theoretical Physics, University of Maryland
Received 1973 May 24; revised 1973 June 27

ABSTRACT

Analytical expressions are derived for the evolution of the luminosity, mass of stars, mass of invisible remnants, rate of ejection of gas from stars, and yield of heavy elements in idealized model galaxies. The equations are based on simple assumptions concerning the mass function of star formation and stellar evolution, and they apply to an arbitrary time-dependence of the stellar birthrate. Especially simple and instructive forms are derived for the expressions in the cases where star formation occurs uniformly and where it occurs in an initial burst. These results are used to show how certain properties of elliptical galaxies, globular clusters, and late-type galaxies depend on parameters characterizing their rate of star formation and the initial mass function. In spite of the severe limitations of this approach to galactic evolution, it sheds light on the results obtained from detailed numerical models, and it predicts a number of useful general relationships among galactic properties.

Subject headings: galaxies — star formation — stellar evolution — stellar statistics

15 pages, 60 equations and not a single figure !!!

Also the name is born.....

(but Beatrice herself died soon thereafter)

THE ASTROPHYSICAL JOURNAL, **203**:52–62, 1976 January 1

EVOLUTIONARY SYNTHESIS OF THE STELLAR POPULATION IN ELLIPTICAL GALAXIES. I. INGREDIENTS, BROAD-BAND COLORS, AND INFRARED FEATURES*

BEATRICE M. TINSLEY
The University of Texas at Dallas and Austin and Lick Observatory,
Board of Studies in Astronomy and Astrophysics, University of California, Santa Cruz

AND

JAMES E. GUNN
Hale Observatories, California Institute of Technology, Carnegie Institution of Washington

Received 1975 May 12

ABSTRACT

Broad-band photometric data and infrared line indices have been combined with new results on giant-branch luminosity functions to yield population syntheses for giant elliptical galaxies. If the main-sequence mass function is a power law of slope x, a value $x < 1$ is indicated. This yields rather rapid luminosity evolution and a large correction to the deceleration parameter q_0 as derived from the Hubble diagram for first-ranked cluster ellipticals. The uncertainties are discussed.

Subject headings: cosmology — galaxies: photometry — galaxies: stellar content

Modern stellar population synthesis: Stellar tracks + stellar spectra + IMF

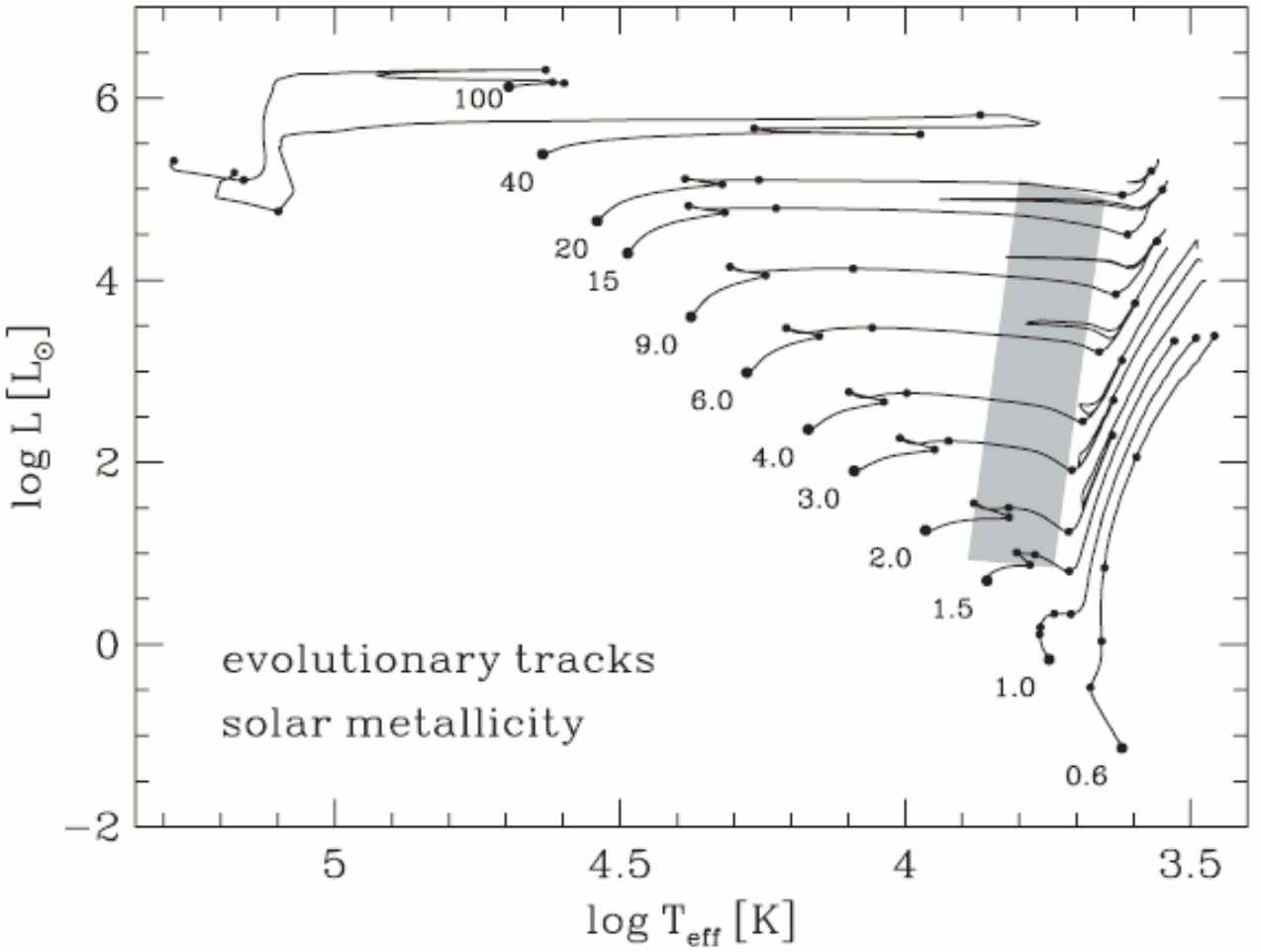


Fig. 10.3. Post-main-sequence evolutionary tracks of stars with solar metallicity. To avoid confusion, tracks for stars with masses smaller than $2\,M_\odot$ are terminated at their He flash. The six points on each track mark the positions reached by the star after the times from the zero-age main sequence listed in Table 10.1. The shaded area is the instability strip within which various variable stars are located. [Based on data published in Girardi et al. (2000)]

Modern population synthesis spectra

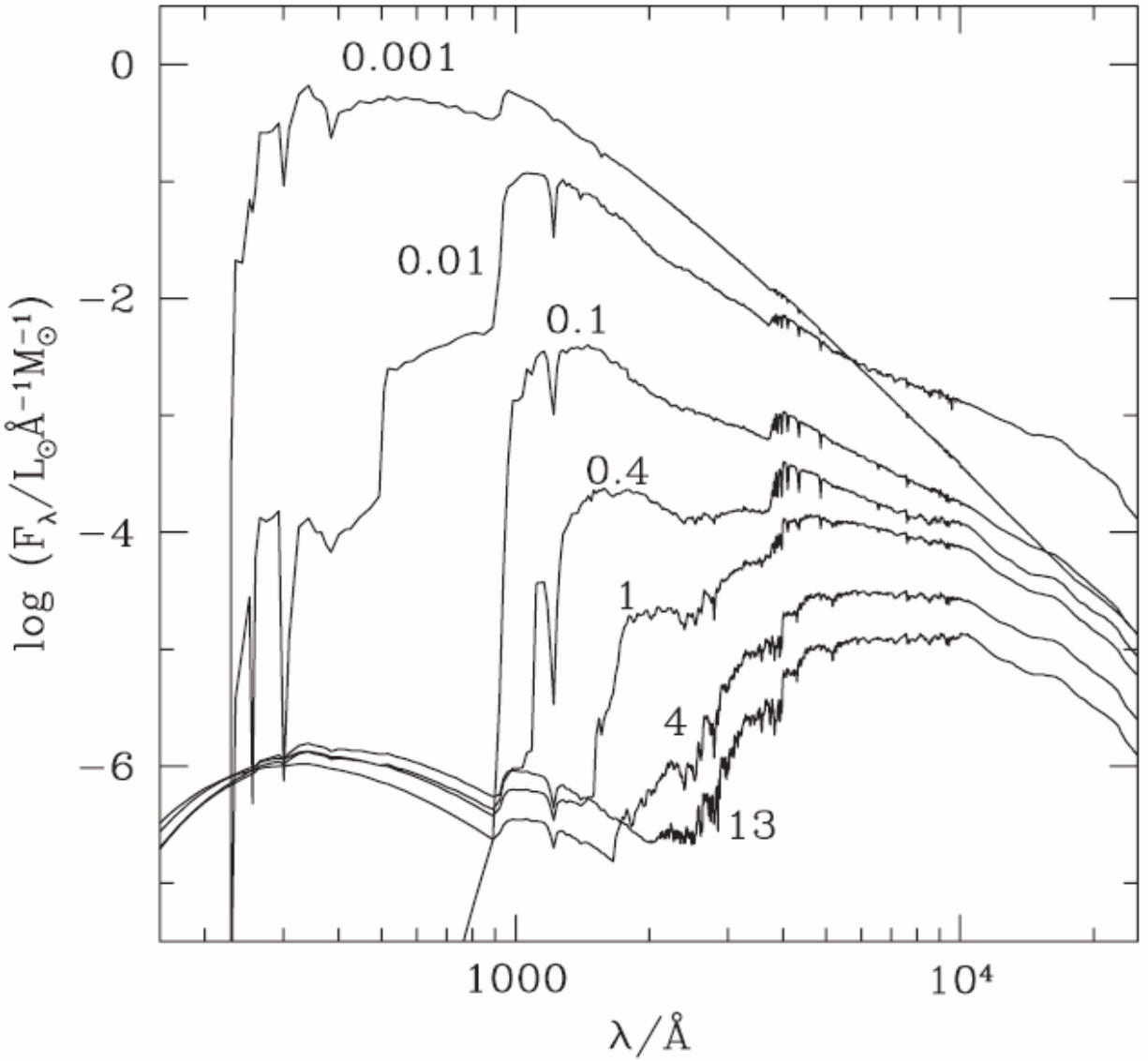


Fig. 10.5. The predicted spectra of a coeval stellar population at ages 0.001, 0.01, 0.1, 0.4, 1, 4, and 13 Gy
The model assumes solar metallicity and a Salpeter IMF. [Based on data kindly provided by S. Charlot]

Modern population synthesis to derive galaxy physical properties

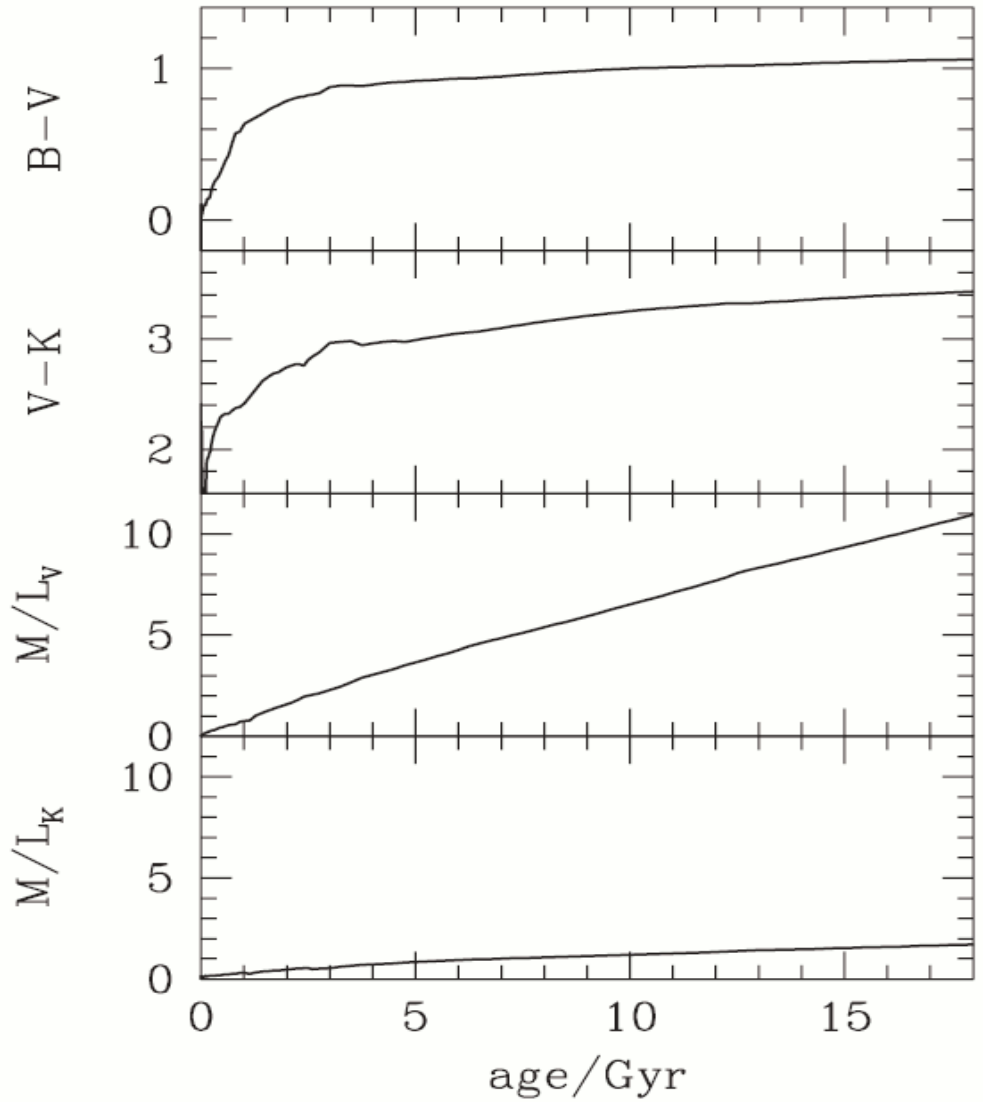


Fig. 10.6. The predicted $B-V$ and $V-K$ colors and mass-to-light ratios in the V and K bands for a coeval population of stars as functions of age. The model assumes solar metallicity and a Salpeter IMF. [Based on data kindly provided by S. Charlot]

Bruzual & Charlot models: the birth of stellar population synthesis and SED fitting for everyone

Astron. Astrophys. 312, L29–L32 (1996)

ASTRONOMY AND ASTROPHYSICS

Letter to the Editor

The mass dependence of the star formation history of disk galaxies

Giuseppe Gavazzi[1,2] **and Marco Scodeggio**[3]

[1] Università degli Studi di Milano, Via Celoria 16, I-20133 Milano, Italy
[2] Osservatorio Astronomico di Brera, Via Brera 28, I-20121 Milano, Italy
[2] Department of Astronomy and National Astronomy and Ionosphere Center, Cornell University, Ithaca, NY 14853, USA

Received 18 April 1996 / Accepted 18 June 1996

Abstract. Visible (U,B,V), Near Infrared (H) and UV (λ 2000 Å) photometric measurements of a complete sample of 928 nearby ($z<0.03$) late-type (spiral and irregular) galaxies are analyzed. The four sets of color indices UV-V, B-H, B-V, U-B are found tightly correlated with the galaxy H band luminosity (which is a reliable mass indicator). The synthesis population model of Bruzual & Charlot (1993) characterized by a Salpeter IMF and an exponential star formation relations between global galaxy properties and their mean (i.e. averaged over the entire galaxy) star formation history. Modeling of broadband optical colors (Searle, Sargent & Bagnuolo 1973, Larson & Tinsley 1978), and of the Hα emission (Kennicutt 1983, Gallagher, Hunter & Tutukov 1984, Kennicutt, Tomblyn & Congdon 1994) led to the conclusion that early-type galaxies formed most of their stars immediately after they were born, while late-type objects

Bruzual & Charlot models: predicting galaxy colors as a function of galaxy mass

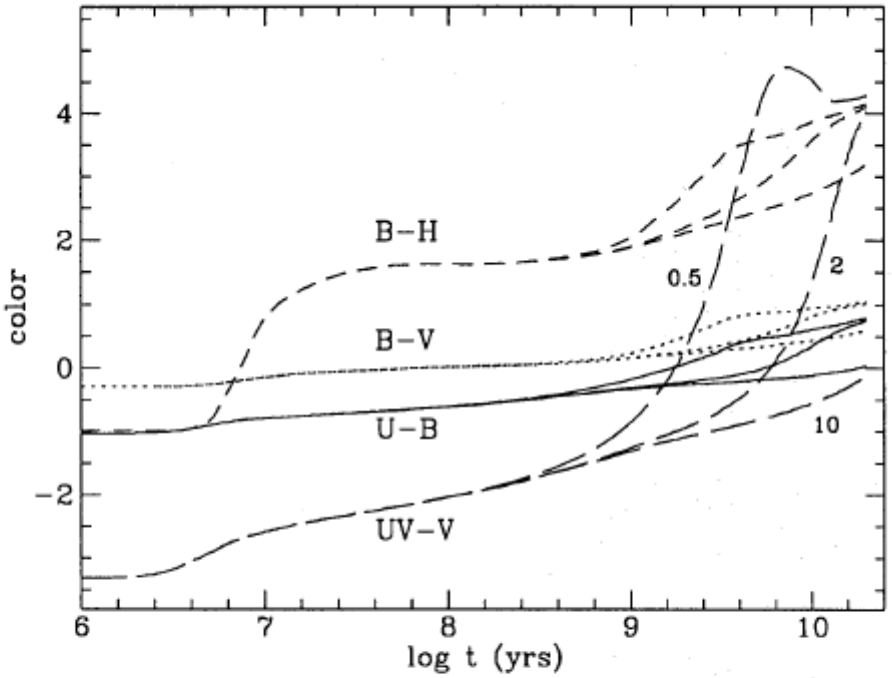
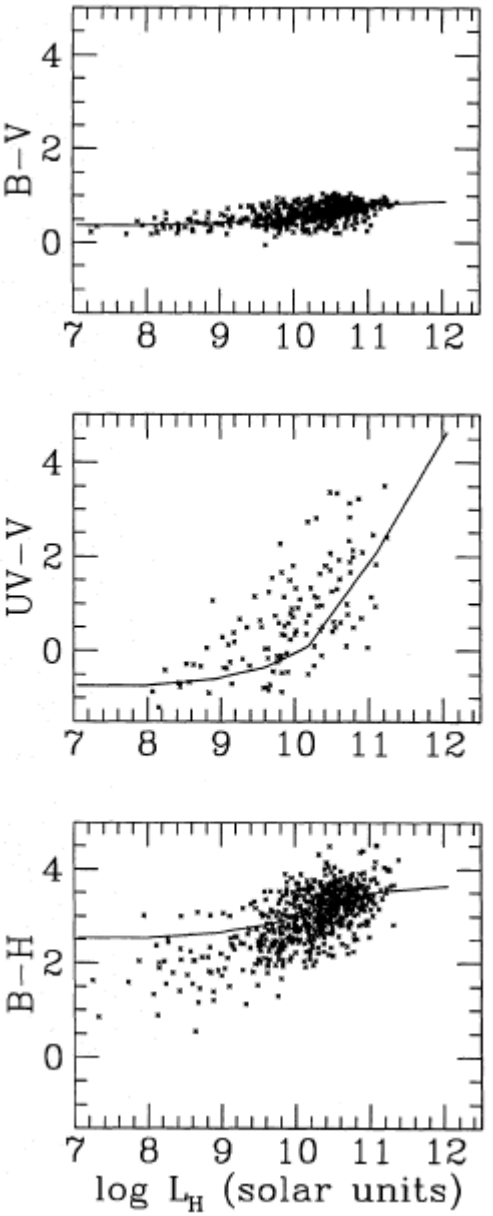


Fig. 2. The time evolution of the 4 colour indices according to the synthesis population model of Bruzual & Charlot (1993) with $\tau = 0.5$, 2 and 10 GYrs.



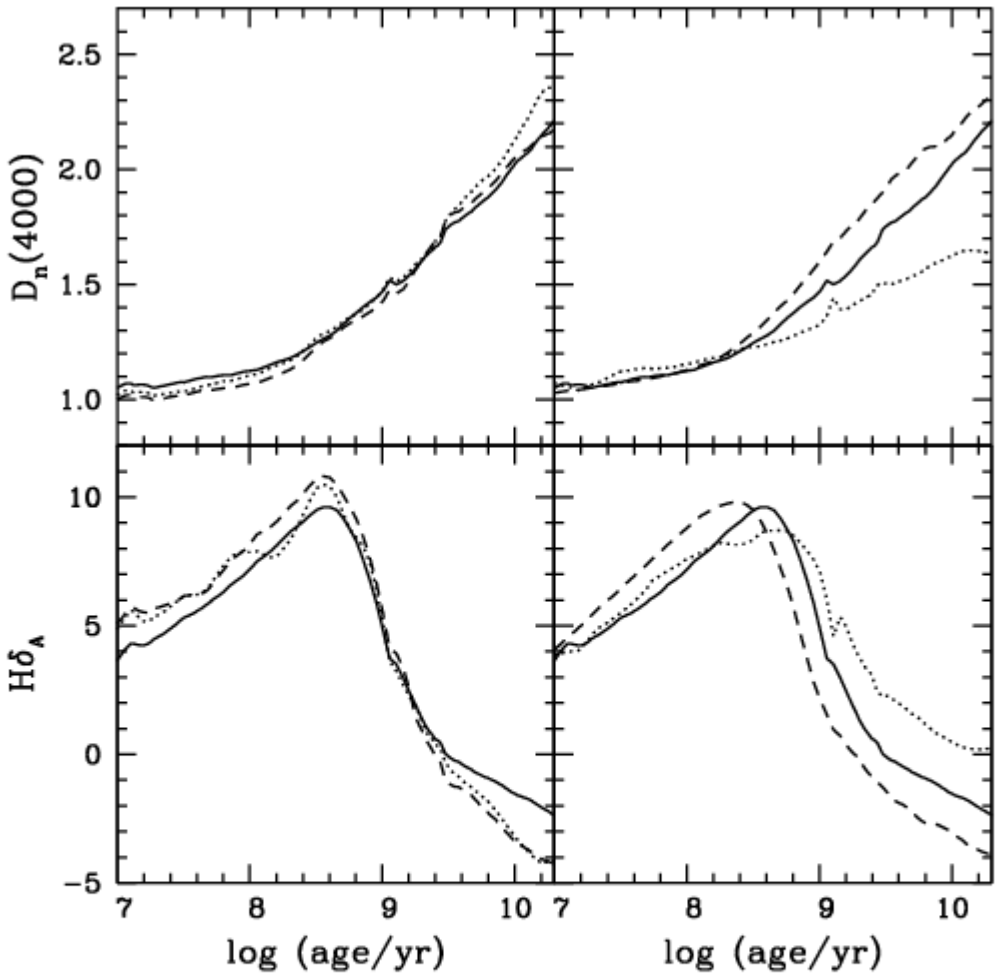
Gavazzi & Scodeggio 1996

The problem with SED fitting using broad-band colors

The main problem everybody is facing with SED fitting
is the degeneracy of the results:

- Degeneracy between age and metallicity
- Degeneracy between Star Formation Rate and Internal extinction
- Degeneracy between Star Formation time-scale and absolute age

Solving the problem using spectroscopic data

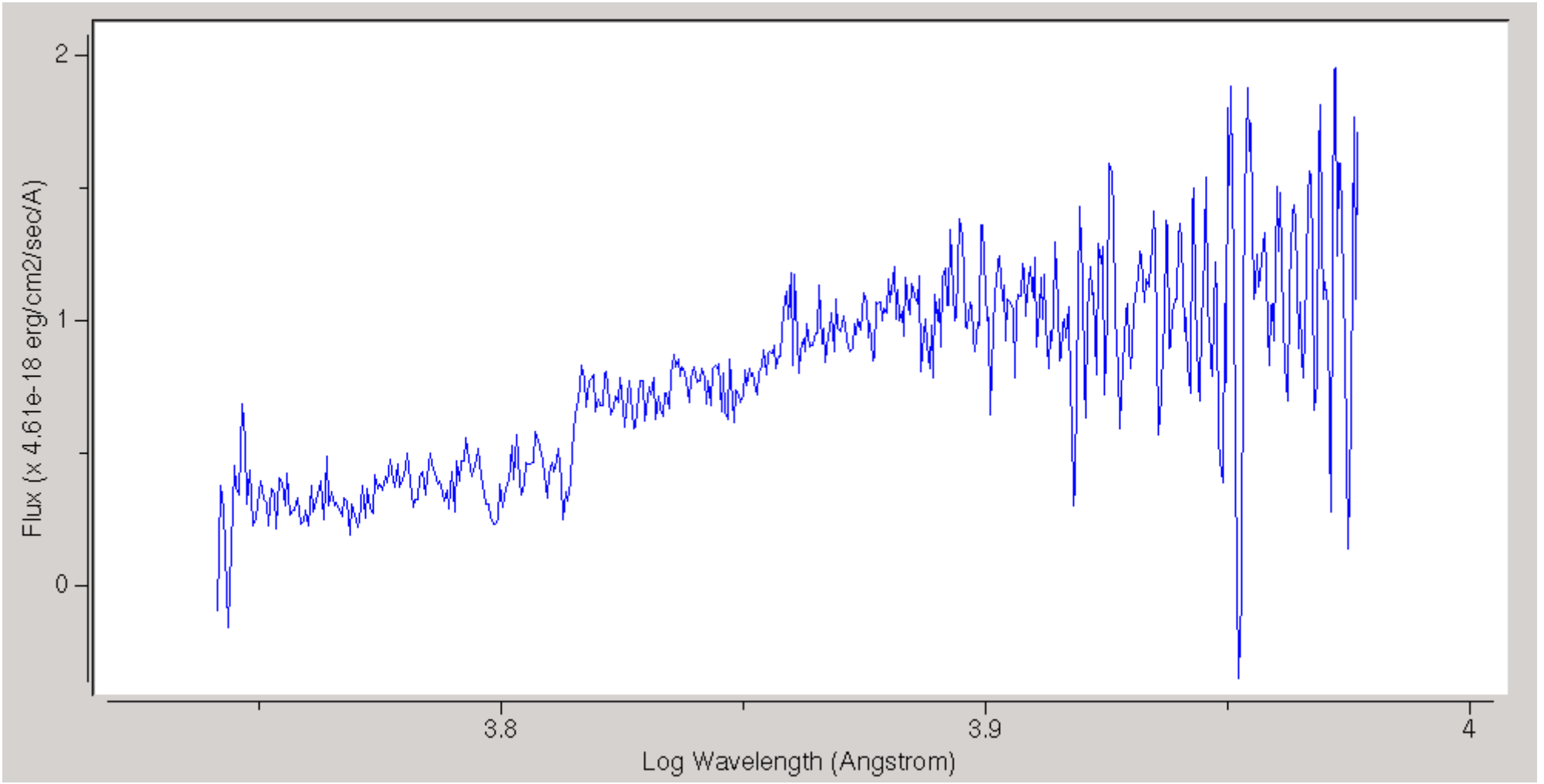


Kauffmann et al 2003

Figure 2: **Left:** The evolution of $D_n(4000)$ and $H\delta_A$ following an instantaneous, solar-metallicity burst of star formation. Solid lines show results from BC2002+STELIB, the dotted line shows results if the Pickles (1998) library is used, and the dashed line is for the Jacoby, Hunter & Christensen (1984) library. **Right:** The evolution of $D_n(4000)$ and $H\delta_A$ for bursts of different metallicity. The solid line is a solar metallicity model, the dotted line is a 20 percent solar model and the dashed line as a 2.5 solar model.

- 100,000 galaxy spectra (over 24 square degrees of sky)
- Primary goal is to study the large-scale distribution of galaxies
- Secondary goal is the study of galaxy evolution
- PI: Gigi Guzzo, OA Brera
- IASF Team: MarcoS, Bianca, Paolo, Luigi, DarioM, Sascha, DarioB, MarcoF
- See http://vipers.inaf.it

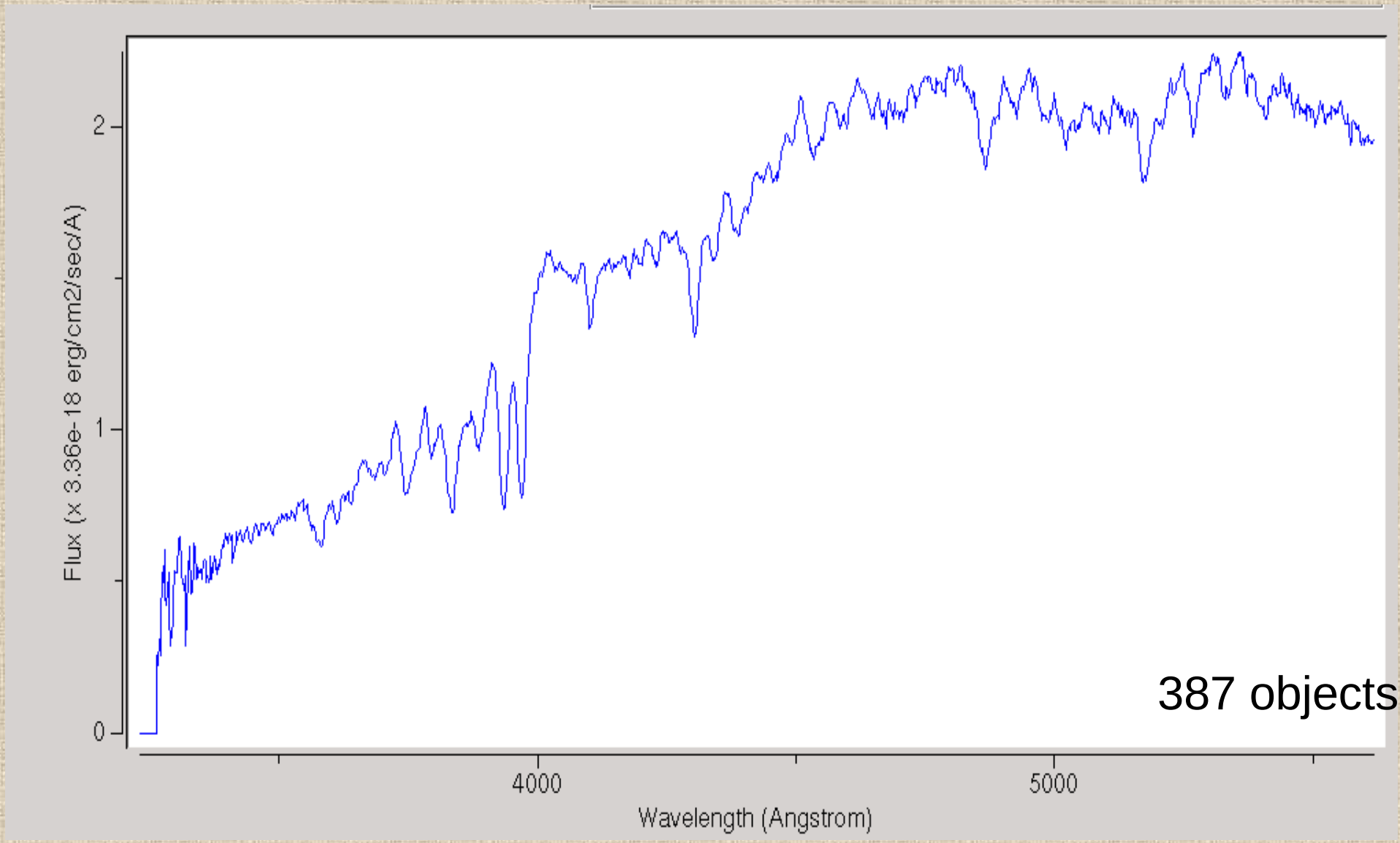
The VIPERS data quality cannot be comparable to that of the SDSS



Galaxy CFHTLS 112192732, z=0.639

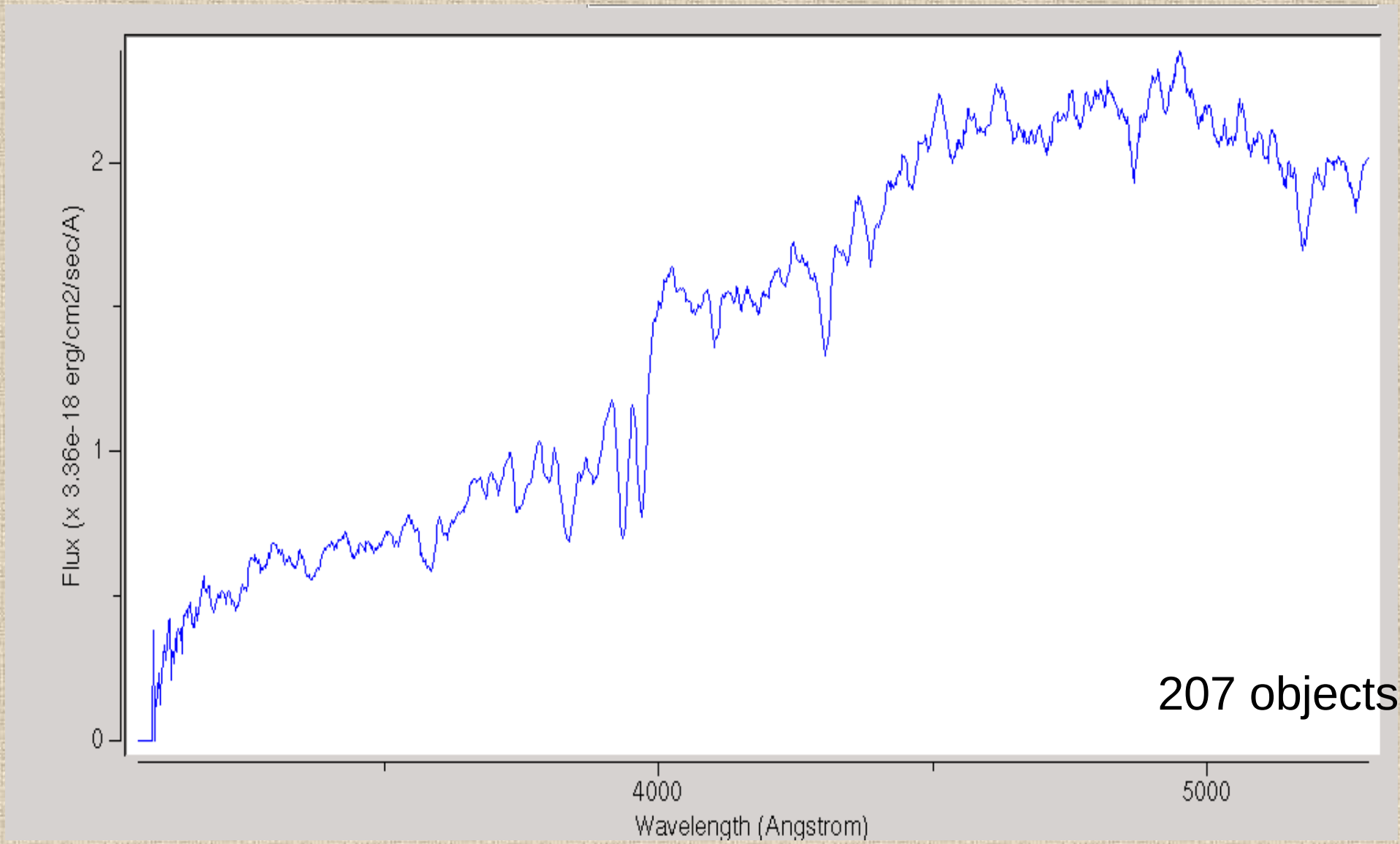
RESULTS WITH STACKED SPECTRA

$0.6 < z < 0.7$; $10.25 < \text{Log SM} < 10.50$



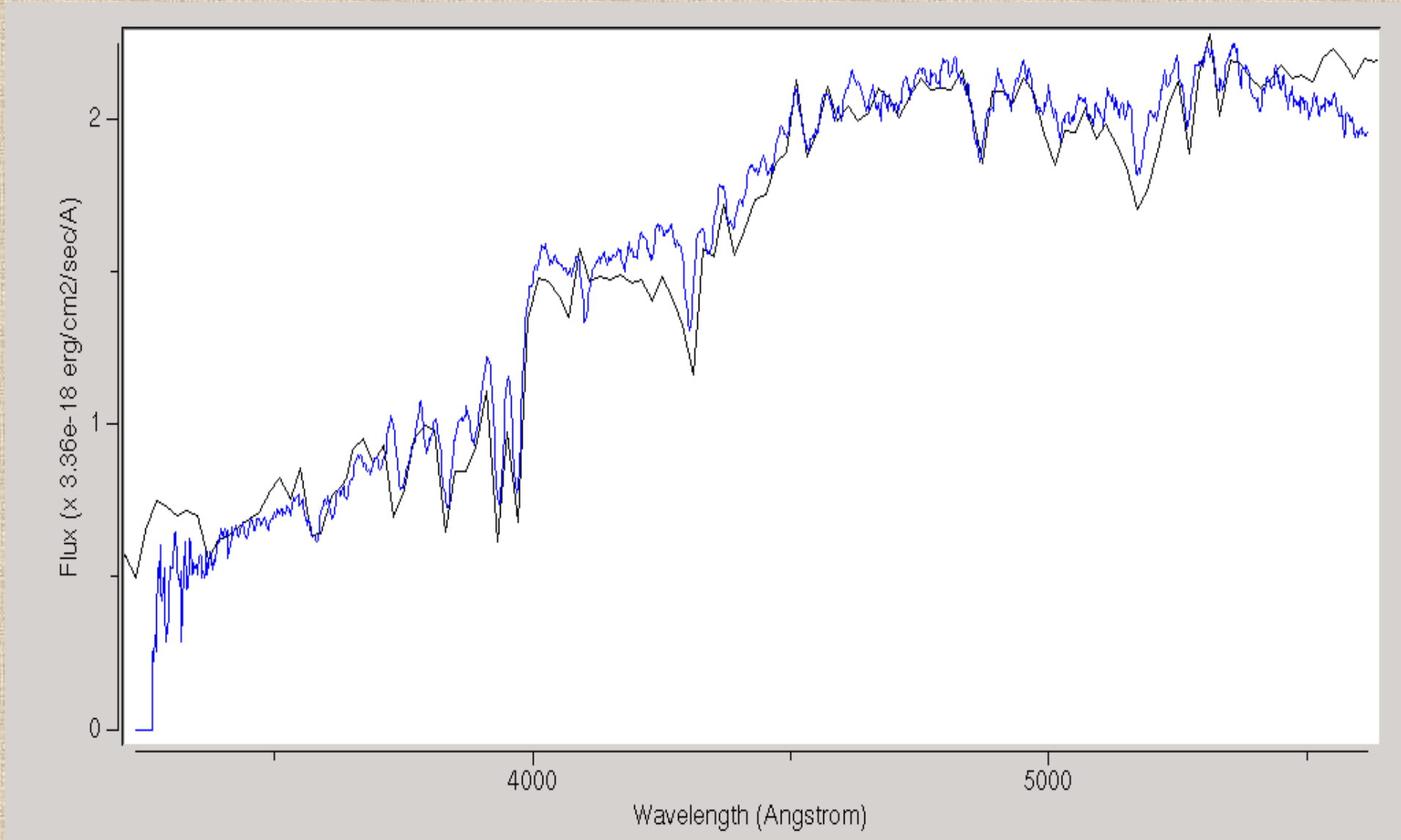
RESULTS

$0.7 < z < 0.8$; $11.00 < \text{Log SM} < 11.25$

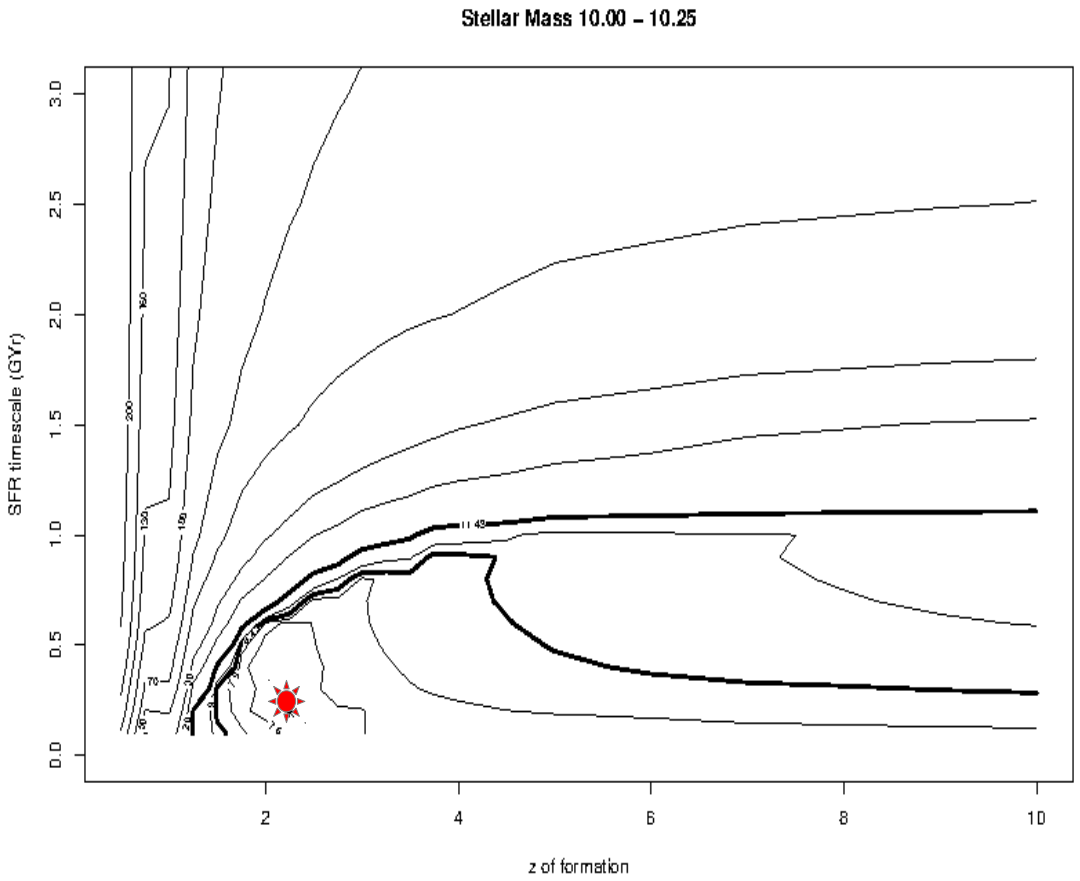


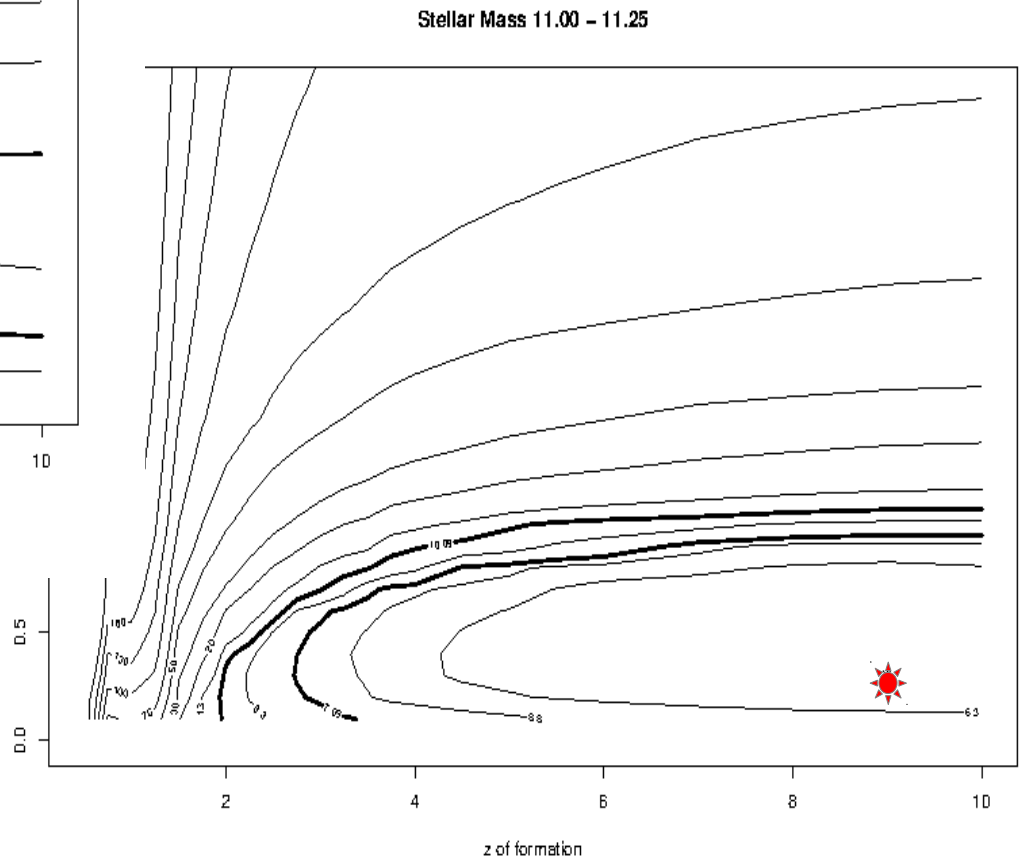
RESULTS: SED FITTING

$0.6 < z < 0.7$; $10.25 < \text{Log SM} < 10.50$



RESULTS


Stellar Mass 10.00 – 10.25
SFR timescale (GYr)
z of formation


Stellar Mass 11.00 – 11.25
z of formation

Conclusions

- Although single VIPERS spectra are too noisy to allow meaningful SED analysis for each galaxy, by stacking spectra of similar galaxies we will be able for the first time ever to study in detail (with spectra) galaxy evolution “in place”, and not just the fossil record available within the Local Universe objects.

- Still, we need some more work to understand how to decide when two galaxies are “similar enough” for this kind of exercise.

- Hopefully, by the one hundred year anniversary of galaxies becoming known for what they really are (2024) we will be able to tell also **HOW** they get to become what they really are....