Spectroscopic Ages of Elliptical Galaxies – Subaru Observation

Nobuo Arimoto[1], Yoshihiko Yamada[1,2], Alexandre Vazdekis[3], and Reynier Peletier[4]

[1] National Astronomical Observatory of Japan, Mitaka, Tokyo 181-8588, Japan
[2] Institute of Astronomy, University of Tokyo, Mitaka, Tokyo 181-0015, Japan
[3] Instituto de Astrofisica de Canarias, Via Lactea, E-38200 La Laguna, Tenerife, Spain
[4] Groningen Kapteyn Laboratorium Rijksuniversiteit, Landleven 12, Postbus 800, 9700 AV Groningen, Netherlands

1 Introduction

Breaking age/metallicity degeneracy ([19], [1]) is crucial for understanding stellar populations in elliptical galaxies. Spectroscopic properties, such as line strength, can partially break age/metallicity degeneracy. Reference [19] found that Hβ index, defined in [4] (Lick indices), is relatively sensitive to luminosity-weighted age of galaxies. But emission line makes Hβ shallower, therefore correction of emission line effect is necessary. Hγ and Hδ indices, such as Hγ_A, Hδ_A, Hγ_F and Hδ_F, which are less affected by emission than Hβ, are defined in [8] and [20]. However, those indices are still affected by age/metallicity degeneracy, since they are measured on low resolution spectra (9–11 Å). Reference [8] defined Hγ_{HR} to find it strongly sensitive to age. But Hγ_{HR} is much affected by velocity dispersion (σ) of galaxies, since the bandpasses of feature and pseudocontinua are very narrow.

Recently, [18] introduced the new age indicator, Hγ_σ, which they show is very successful in breaking the age/metallicity degeneracy and usable for wide range of σ. While the presence of non-solar abundance ratio in most early-type galaxies ([7], [10], [15] etc.) introduces systematical errors of ages if using Lick indices, errors from Hγ_σ come almost only from poisson noise. We have newly measured Hγ_σ of 27 elliptical galaxies by using Subaru and other telescopes to determine the ages and metallicities, from which we can discuss a possible star formation history in ellipticals and their origin.

2 Observation, Sample Selection, and Data Reduction

We performed our observations with three telescopes, WHT 4.2m, NTT 3.6m, and Subaru 8.2m. The details of our observations are listed in Table 1. Spectral resolution of the observations is 2.4–3.1Å, which coincident with 70–90 km s^{-1} of σ, and dispersion ranges from 0.44–0.92 Åpix^{-1}. Spectral coverage is set to include Hγ feature at λ ∼4340Å. Multiple exposures of 15-35 minutes were acquired for each galaxy, as well as CuArNe (WHT), ThAr (NTT, Subaru) arc

ESO Symposia: Multiwavelength Mapping of Galaxy Evolution and Formation, pp. 302–307, 2005.

lamp exposures for λ calibration at each galaxy pointing. For WHT observation, we took Tungsten lamp flat exposures to remove wiggles in the spectra. We also observed a spectrophotometric standard star, G191B2B (WHT), LTT4364 (NTT), Feige 34, and G191B2B (Subaru).

Table 1. Overview of Our Observations

Telescope	WHT 4.2m	NTT 3.6m	Subaru 8.2m
Date	1997 Oct. 28−29 1999 Apr. 21−22	2002 May 19-21	2002 Apr. 17−18 2003 Jan. 27 2003 Jun. 26
Instruments	ISIS blue R600B grating EEV12 CCD	EMMI Grating #12 Blue #31 CCD	FOCAS 300R grism, L600 filter SITe CCD
Gain	1.01 e^-/ADU	1.44 e^-/ADU	1.99 e^-/ADU
Readout Noise	3.9 e^-	4.9 e^-	8−10 e^-
Dispersion	0.44 Åpix^{-1}	0.92 Åpix^{-1}	0.67 Åpix^{-1}
Resolution	2.4 Å	2.5 Å	3.1 Å
Wavelength Range	3800−5250 Å 4000−5500 Å	3900−4750 Å	3800−5800 Å
Spatial Scale	0".57pix^{-1} (binning 2 pixels)	0.74 pix^{-1} (binning 2 pixels)	0".21pix^{-1} (binning 2 pixels)

We observed 14 and 13 *genuine* elliptical galaxies in the Virgo cluster and in the field (group), respectively. Table 2 lists the basic parameters of the observed galaxies, such as radial velocity (V_r), effective radii (r_e), velocity dispersions (σ), visual magnitude (m_V), colour of $U-V$, $B-V$, telescope, exposure time, used slit width, and signal to noise ratio around 4340Å. Our Virgo sample were mainly taken from [3] along a well defined colour-magnitude relation. Our field (group) sample were selected from LEDA database ([12], [13], [14]) with the following criteria: 1) nearby sample, i.e., $V_R < 3500$ km/s; 2) neither very faint nor small galaxies, $\log r_{25} < 0.14$, $M_B < -18.5$; 3) morphological type index t < -2.9; 4) no strong emission line; 5) low extinction, i.e., $|b| > 20$ deg. In both Virgo and field, we selected galaxies to cover a wide range of σ, 70–300 km s^{-1} and luminosity.

Data reduction was done with the standard IRAF packages in the standard way; i.e. overscan correction, bias subtraction, flat fielding, λ calibration, sky subtraction and flux calibration. We achieved $\Delta\lambda$ (error of λ) smaller than 0.07Å in the λ calibration, which is one of the most important process in the age determination by $H\gamma_\sigma$, since even small λ shift affects the $H\gamma_\sigma$ measurement significantly ([18]). Cosmic rays were removed using the "cleanest" task in the REDUCEME package. Exposures whose spectra around $H\gamma$ feature were hit by cosmic ray were excluded, since even 'cleanest' task could not remove them in a perfect way. Flux calibration was done with the observed flux standard stars.