THE STELLAR POPULATIONS AND INTERNAL REDDENING OF SPIRAL GALAXIES

by

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Outline

• Motivation
• Goals
• Sample, Observations, and Calibration
  – Measurement of the magnesium b triplet, Mgb
  – Measurement of the optical-infrared color, B-K
  – Diagram used to analyze color and population gradients
  – Comparison to Stellar Population Synthesis Models
• Results
• Conclusions and Future Work
MOTIVATION

- Would like to understand the evolution of galaxies. Therefore, need to understand the current state and history of their contents: stars, gas, and dust.

- In the area of stellar populations spiral disks are not as well studied as bulges and ellipticals.

- In particular are color gradients in disks due to reddening or stellar population changes?
COLOR GRADIENTS

- Need a reddening independent measure of the population such as the magnesium b triplet, Mgb, at 5177Å.
- Need a color with large wavelength range such as B-K, an optical infrared color
- Need Mgb and B-K at same locations in a galaxy.
- Need spatial resolution in the spectroscopy.
GOALS

• To image disks in BVRI & JHK.
• To obtain long slit optical spectroscopy.
• To measure B-K gradients and Mgb gradients.
• To use B-K and Mgb to investigate the cause of the color gradients.
Galaxy Selection

- Galaxies were selected from the Aaronson (1982) Tully-Fisher sample.
- The criteria were
  - Size: Small enough to be observed with a 3' long slit.
  - Inclination: Less than 56°
  - Color: Match another galaxy’s $B_T - H_{-0.5}$.
- This resulted in 5 pairs of 10 spiral galaxies.
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<th>$\log(D_{25})$</th>
<th>$\log(R_{25})$</th>
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OBSERVATIONS

- BVRI CCD images taken at the MDM 51″ McGraw Hill Telescope.
- JHK NICMOS images collected at the Steward Observatory 61″ at Catalina.
- 3600Å to 6000Å spectral images captured at MMT using the red channel spectrograph with 300l grating (18Å resolution). Spectral images with 600l grating (9Å resolution) were also obtained.
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<sup>a</sup>Columns marked Pos1 or 2 indicate the number of exposures at that slit position.

<sup>b</sup>Columns B, V, R, & I are the number of exposures taken in that filter.

<sup>c</sup>Columns J, H, & K are the number of sequences of exposures taken in that filter.
CALIBRATION

• BVRI CCD images reduced in the standard way.
• Landolt standards at range of airmass, times, and colors used to determine photometric solution.
• JHK images collected and reduced in the usual way that accounts for large sky brightness.
• Not photometric so previous photometry of galaxies used to determine zero points.
• The spectral images reduced in standard way.
• IDS line standards used to confirm transformation to Lick System.
TRANSFORMING TO STANDARD MAGNITUDES

- To form B-K the B and K magnitudes must be on the standard system.
- The B imagery was obtained on a photometric run. The photometric solution is used to assign B magnitudes to galaxy measurements.
- Because the K data was not photometric comparison to previous photometry of the galaxies gives the zero points.
- However, previous photometry is in H. So a fiducial H-K is needed. That is provided by 2MASS.
THE LICK SYSTEM

- A system of 21 standard line indices.
- Based on IDS observations of many line standard stars.
- The model outputs line indices on the Lick System.
TRANSFORMING TO LICK SYSTEM

- The main difference between instrumental EWs and the Lick EWs is the difference in resolution between the MMT spectra and the IDS spectra.

- The effect of broadening on the EW has been determined by González (1993). I use this relationship to determine a scale factor that compensates for the difference in resolution.

- My corrected EW(Mgb), $3.9 \pm 0.25\text{Å}$, differs insignificantly from the Lick value, $4.0 \pm 0.2\text{Å}$ (Worthey 1993) measured in the line standard SA103-95.

- No other corrections are applied.
EW(Mgb)_{rouse} = 3.9 \pm 0.25 \text{Å}

EW(Mgb)_{lick} = 4.0 \pm 0.2 \text{Å}
MODEL SELECTION

• Bruzual & Charlot, Worthey, and Bressan (Padova) models agree within 25-30% (Charlot et al. 1996).

• This work uses Worthey's (1994) evolutionary synthesis.

• A wide range in age and metallicity is provided.

• Many basic observable quantities are provided such as standard magnitudes, colors, Lick line indices.

• Used successfully to analyze ellipticals (González 1993, Trager et al. 2000)
$\text{EW(Mgb)} = 1.5 \pm 0.2 \, \text{Å} (\text{Aperture} = -0.7''$)

$\text{EW(Mgb)} = \Delta \lambda (1 - F_1/F_c)$
NGC 5204 Position One

 EW(Mgb) (Å) vs Position ("")

 B-K vs Position ("")
CONCLUSIONS

- The faint regions of spiral disks have been observed in the optical bands, near infrared bands and spectroscopically with spatial resolution.
- This forms a very unique data set that has many uses.
- The galaxies analyzed were very different in their internal character.
- NGC 4654 shows a decrease in reddening outward with little or no population gradient.
- NGC 6384 shows a population gradient that increases in age and metallicity towards the center. There is a decrease in reddening outward in the outer disk.
CONCLUSIONS CONTINUED

• NGC 5204 resembles NGC 4654 although no gradients were detected.

• NGC 6384 is in the field. NGC 4654 and NGC 5204 are cluster galaxies.

• Perhaps the differences seen here are due to their different environments.

• Apparently one age or metallicity is not sufficient to describe NGC 6384.

• Simple stellar populations are very useful in analyzing the disks. However, they are insufficient to describe disks.

• Very old metal rich nor very metal poor populations of any age contribute to the integrated light of the three galaxies.
FUTURE WORK

• Look at the other slit positions & galaxies.
• Look at other colors to estimate the internal reddening law.
• Look at other lines to see if reddening is confirmed.
• Separation of emission from absorption in H to get better separation of age and metallicity
• Bulge-disk decompositions & surface brightness distributions
• Color distributions & true color images
• Test galaxy evolution models
• Are large Tully-Fisher residuals related to internal properties?