A Near-Infrared Spectroscopic Analysis of Galactic Mergers: Revealing Obscured Accretion

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Motivations

- Galaxy interactions are vital and ubiquitous
  - Gas inflows trigger accretion

- Constrain true frequency of dual AGNs

- Dual AGNs as precursors to SMBH mergers
  - Source of intense gravitational waves
Problems

- Strong theoretical evidence for dual AGN
  - Despite decades of searching only a few have been found

- Traditional surveys have used optical wavelengths
  - Ambiguous
  - Easily attenuated by dust
    - Heavily obscured galaxies show higher fraction of merger signatures than less obscured galaxies
Sample Selection

WISE Color-Color Diagram

- Both galaxies exhibit red mid-IR colors
  - Indicative of obscured accretion

- Optically quiescent

- Less than 10 kpc separation
  - Very few dual AGNs found at this distance

- X-ray data available
  - Multi-wavelength analyses are crucial

(Wright et al. 2010)
Hidden Clues in Near-IR

• Near-IR is less affected by dust extinction than optical wavelengths

• Broadened Paschen alpha emission line

• Coronal Lines
  • Large ionization energies

• Emission line ratios
  • Constrain dominant excitation mechanism

• Age dependent features
  • Constrain age of underlying stellar population
Observations

Large Binocular Telescope (LBT)

- **LUCI** – LBT Near Infrared Spectroscopic Utility with Camera Instruments.

- The total integration time for each object was ~20 minutes.

- Ten observations fully reduced and analyzed.
  - Two coalesced objects and four galaxy pairs.

- Six more galaxy centers currently being reduced.

- Exposure times range between 10 and 30 minutes.

http://www.nasa.gov/topics/universe/features/lbti20101206-i.html#.VvWOp2MbCjg
**SDSSJ1036+0221**

- Plethora of high S/N emission and absorption features
  - Coronal Lines
  - CO bandhead

- No broadened Paschen alpha emission found
  - Orientation
  - Wings

Above: Full near-IR spectrum for SDSSJ1036+0221.
Below: Close up of Paschen Alpha emission line.

SDSS image for SDSSJ1036+0221.
The $H_2/Br\gamma$ line flux ratio can help distinguish between Starburst galaxies (SBs), AGNs, and Low Ionization Nuclear Emission Regions (LINERs) (Larkin et al 1998).

Our data do not cover the Pa$\beta$ emission, however the $H_2/Br\gamma$ line flux ratio is measured in seven individual galaxies (red lines).
Age of Stellar Population

Compare simulated stellar spectra to observed spectra

Brγ EW vs. age from Starburst 99 models

CO EW vs. age from Maraston Models

\[ Z = Z_\odot \]

\[ \log \left[ \frac{\text{EW(Brγ)}}{\AA} \right] \]

\[ \log \left[ \text{Age/yr} \right] \]

\[ \alpha = 2.35, M_\text{up} = 100 M_\odot \]
\[ \alpha = 3.30, M_\text{up} = 100 M_\odot \]
\[ \alpha = 2.35, M_\text{up} = 30 M_\odot \]

\[ \log \left[ \text{Age/yr} \right] \]

\[ \text{CO(6-3)} \text{ Equivalent Width (Å)} \]

SDSSJ0122+0100 Galaxy 2
SDSSJ01045+3519 Galaxy 2
SDSSJ1036+0221

\[ \text{Age (Gyr)} \]

\[ \log \left[ \text{Age/yr} \right] \]

\[ \text{CO(6-3)} \text{ Equivalent Width (Å)} \]

\[ \text{Brγ EW vs. age from Starburst 99 models} \]

\[ \text{CO EW vs. age from Maraston Models} \]

\[ \text{SDSSJ0122+0100 Galaxy 2} \]
\[ \text{SDSSJ0405+3519 Galaxy 2} \]
\[ \text{SDSSJ1036+0221} \]

\[ \text{M11 Chabrier} \]
\[ \text{M11 Kroupa} \]
\[ \text{M11 Salpeter} \]
\[ \text{Dual AGN CO(6-3) EW} \]

\[ \sim 8 \text{ Myr} \]

\[ < 20 \text{ Myr} \]
Conclusions

- Four out of six galaxies have evidence supporting the galaxy pair hosts dual AGNS
  - Remaining two galaxies are single coalesced AGNs

- WISE pre-selection technique is promising
  - Need more observations for real statistics
Future work

- Finish reducing / analyzing newest observations

- Simulate spectral energy distribution created by stellar populations 10-20 Myr old
  - Subtract from observed spectrum

- FWHM vs. IP
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