STELLAR POPULATIONS IN THE CENTRAL KPC OF SEYFERT GALAXIES

G. Dumas, MPIA
E. Emsellem (ESO), C. Mundell (ARI, Liverpool)
LOW LUMINOSITY AGN
AGN FUELING

- Low accretion rates: $\sim 10^{-2} \, M_\odot/yr$
  - Need small amount of gas
  - Small-scale accretion events (King & Pringle 07)

- Angular momentum problem
  - Presence of gas in the inner 100pc in Seyfert galaxies
  - Transport down to few 0.1pc = remove totally the angular momentum!

- Fuelling mechanisms:
  - Galaxy interaction, mergers
  - Stellar bars, bar within bar scenario
LOW LUMINOSITY AGN
AGN FUELING

- No statistically-significant difference between Seyfert and non-active galaxies on spatial scales that encompass galaxy interaction, large-scale and nuclear bars and spirals

- Presence of dust and isophotal disturbance in Seyferts (Hunt & Malkan 04, Simões Lopes et al. 07)

- Kinematic study needed along with imaging
  - Kinematic differences between Seyferts and non-active galaxies?
  - Signature of fuelling mechanisms
  - Role of the host on nuclear activity?
LOW LUMINOSITY AGN
SF & NUCLEAR ACTIVITY

- Connection between nuclear activity and SF

- Role of the SF in the nuclear activity:
  - SF and AGN require fuel
  - SF consume the gas for the AGN
  - Stellar mass loss as fuel of the central engine

- Stellar population properties/nuclear activity
  - Differences Seyfert/non-active galaxies?
  - Context AGN fuelling/galaxy formation
LOW LUMINOSITY AGN
AGN FUELING

- Morphology & dynamics, stars & gas
  - 28 pairs Seyfert/non-active galaxies
    - matching large scales properties

- Two complementary surveys
  - **VHIKINGS** (Mundell et al. 07)
    - VLA: HI (21cm)
      - Galactic disk + nearby environment
  - **Sauron/Seyfert** (Dumas et al. 07)
    - Sauron: 3D spectroscopy
      - Ionized gas + stars
    - Central regions (< kpc)
LOW LUMINOSITY AGN
AGN FUELING

- Morphology & dynamics, stars & gas
  28 pairs Seyfert/non-active galaxies
  matching large scales properties

- Two complementary surveys
  - **VHIKINGS** (Mundell et al. 07)
    - VLA: HI (21cm)
    - Galactic disk + nearby environment
  - **Sauron/Seyfert** (Dumas et al. 07)
    - Sauron: 3D spectroscopy
    - Ionized gas + stars
    - Central regions (< kpc)
V_{sys} < 1600\text{km/s} 
Fe stellar absorption lines

15 galaxies:
7 pairs + 2 Seyferts

FOV = 41\text{"} \times 33\text{"}
2kpc to 20pc
SAURON DATA

 STELLAR KINEMATICS

- Spatial binning S/N>60

- Mask of emission lines
  - Broad lines
  - Multi-components

- Deconvolution: pPXF method
  (Cappellari & Emsellem 2004)
  - LOSVD distribution: $V$, $\sigma$, $h_3$, $h_4$
  - Optimal template
**SAURON MAPS**

**STELLAR KINEMATICS**

- Regular rotation patterns
- Kinematic and photometric PA aligned

Dominated by disc-like rotation for both Seyfert and control galaxies
Presence of $\sigma$-drops:

- Star formations, recent accretion event (Wozniak et al. 2003)
- Common in nearby spiral galaxies (Ganda et al. 2006, Peletier et al. 2007)
- Nuclear stellar disk
**Sauron Maps**

**Stellar Kinematics**

- Presence of $\sigma$-drops:
  - 6 Seyferts (75%), 1 non-active galaxy 17%

![Graphs of stellar kinematics for various galaxies](image)
**SAURON MAPS**

**STEellAR KINEMATICS**

- Presence of $\sigma$ -drops:
  - 6 Seyferts (75%), 1 non-active galaxy 17%
  - Seyferts 1: BLR emission line contaminate the central regions
  - $\Rightarrow$ Remain 50% of Seyfert and 17% of Control

  - $\sigma$ -drops frequency $\sim$40% in early type galaxies (e.g. Peletier et al. 07)
    - Seyferts consistent
    - Control galaxies significantly lower
SAURON MAPS

ABSORPTION-LINE STRENGTH

- Line strength indices
  - Lick/IDS system
  - Stellar population properties:
    Age, metallicity, abundances

- Sauron wavelength range
  - All FOV 4825-5275Å
    - \(\text{H}\beta, \text{Fe}5015, \text{Mg}\ b\)
  - \(\sim\)FOV/2 4825-5380Å
    - \(\text{H}\beta, \text{Fe}5015, \text{Mg}\ b + \text{Fe}5270\)
SAURON MAPS
ABSORPTION-LINE STRENGTH

NGC2655  NGC4459  NGC4579  NGC3351  NGC5194  NGC5055

Hb

Mg b

Fe 5015
SAURON MAPS
ABSORPTION-LINE STRENGTH

○ Smooth distribution
  ⇒ NGC4579
  ⇒ 50% Seyfert, 33% non-active

○ Structures with high H\(\beta\), low Mg\(b\) & Fe 5015: young stars
  • Compact central regions
    ⇒ NGC2655
    ⇒ 37% Seyfert, 17% non-active
  • rings
    ⇒ NGC3351
    ⇒ 13% Seyfert, 50% non-active
INDEX-σ RELATIONS

- Central values $R < \frac{R_e}{10}$

- Mg $b$-σ & H β - σ relations
  - Early type (Morelli et al. 08)
  - This work: Seyferts

- No significative difference Seyfert/control
  \[⇒\] Consistent with early type galaxies relations
AGE, METALLICITY, ABUNDANCE
SSP ANALYSIS

- Central values $R < R_e/10$

- Single-burst population models of Thomas et al. 2003
  - age
  - Metallicity
  - Abundance ratios
AGE, METALLICITY, ABUNDANCE
SSP ANALYSIS

- Central values $R < Re/10$

- Single-burst population models of Thomas et al. 2003
  - age
  - Metallicity
  - Abundance ratios

- Age
  - Seyfert slightly younger than control
  - Non statistically difference: ages between 8 and 10 Gyr
  - Seyferts 1: problems
AGE, METALLICITY, ABUNDANCE
SSP ANALYSIS

Central values $R < Re/10$

$\alpha$/Fe enhancement
- Between -0.2 and 0.2
- Control galaxies: median = 0.04
- Seyferts: median = 0.12

Metallicity
- Between 0.4 and 0.7
- Median at 0.6 for both Seyfert and control galaxies
**CONCLUSIONS**

- $\sigma$ -drops 50% Seyfert / 17% Control
  
  BUT Control frequency too low

- Line strength indice – $\sigma$ relation
  
  - Seyfert & Control galaxies consistent with early type spirals

- Seyfert systematically younger and super-solar $\alpha$/Fe enhancement
  
  BUT differences small!

*Non significant difference between Seyfert and Control galaxies*
CONCLUSIONS

- Maps of age, z and $\alpha$/Fe
  - Structures
  - gradients

- SSP analysis
  - Over simplification
  - If 2 population: SSP => old low Z population (Allard et al 06)

- NEED Two-population analysis
  - Link with sigma-drops: nuclear stellar disk
  - SF history in the nuclear region
**RADIAL PROFILES**

NGC2655  
NGC4459  
NGC4579  
NGC3351
**Kinematics Study**

**Pyring**

\[
V_{\text{LOS}} = V_{\text{sys}} + V_{\phi}(R,\phi) \cdot \cos(\phi) \cdot \sin(i) + V_{R}(R,\phi) \cdot \sin(\phi) \cdot \sin(i)
\]

\[
\begin{align*}
\cos(\phi) &= \frac{-(x - X_c) \cdot \sin(PA) + (y - Y_c) \cdot \cos(PA)}{R} \\
\sin(\phi) &= \frac{-(x - X_c) \cdot \cos(PA) - (y - Y_c) \cdot \sin(PA)}{R \cos(i)}
\end{align*}
\]

- 2D infinitesimally thin disk
- Tilted-ring method
- Fit of kinematics parameters: \(V_{\text{sys}}, \text{PA}, i, \text{center}, V_R, V_{\phi}\)

**NGC2655, stellar velocity fields**
**Radial Profiles**

- Elliptical rings: center, PA, I from fit of the stellar velocity field
- Radial profiles computed by averaging $\sigma$ and line strength maps over these rings