Recent Star Formation in Early Type Galaxies hosting AGNs

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MOTIVATION

Demography of massive dark objects (MDOs) in local spheroids (Ferrarese 02)
QSO optical (z ~ 6) and X ray (z ~ 3) luminosity functions (Fan et al. 03, Cristiani et al. 04)

AGN activity is common transient phenomenon (Cavaliere & Vittorini 02)

single engine + triggering mechanism

central MDO

destabilization of the gas (dynamical interaction)

high z        violent aggregation processes during spheroid formation
low z         mild interactions of host galaxies in the field

Dynamical interaction is accompanied by star formation

• theoretical studies of the merging process (e.g. Kojima, M & Noguchi, M., 97)
• spectroscopic studies of local field early type galaxies in pair or showing shells (Longhetti et al 00, Bressan et al 06)

Common mechanism responsible of two different phenomena

QSO shining and SP rejuvenation
The stellar population content of QSO host galaxies

To cast light on this point, many imaging studies have been performed in recent years on the host galaxies of nearby and distant AGNs

(Bahcall 97, Mobasher et al. 93, Falomo et al 00, Percival et al. 01, Dunlop et al. 03, Pagani et al 03, Falomo et al 04, 05)

Imaging studies: \(\Rightarrow\) global properties: morphology, luminosity, scale-lengths

The host galaxy properties of luminous AGN \((z < 0.5)\)

- RLQ preferentially found in luminous E exceeding \(L^*\) by 1—2 mag
- RQQ in E & S of lower luminosity (E for luminous RQQs)
- BL Lac (nuc L factor 5-10 < typical QSO) found in unperturbed E

Imaging studies: \(\Rightarrow\) unable to address the issue of stellar content of these galaxies

Presence of young stellar populations ?

(but for very preliminary insights with multicolor images e.g. Jahnke et al. 01; Labiano et al. 05)
Strategy: adequate spectroscopy of the surrounding nebulosity

Till now only pioneering work has been done on this side
  (e.g. Boroson et al 85; Nolan et al 01)
  off-nuclear spectroscopy of about 20 QSO galaxies
  poor S/N, inadequate seeing, effects of QSO scattered light
Somewhat more detailed study on individual sources
  (e.g. Canalizo & Stockton 00, Labiano et al 05)

We are carrying out a spectroscopic study of early type galaxies hosting AGNs
We report on the discovery of ongoing/recent star formation in PKS 2005-489 (Bl Lac) & 2115-037 (RQQ)
Observations

- PKS 2005-489 BL Lac at $z = 0.071$, $D = 321$ Mpc
- 2115-037 RQQ at $z = 0.241$, $D = 1200$ Mpc, ($H_0 = 70$, $\Omega_M = 0.7$, $\Omega_{\Lambda} = 0.3$)
- VLT FORS1 Long slit spectra centered on the nucleus
  - Two exposures of 1200 (1500) seconds each in August 2002
  - Good seeing conditions (1 arcsec)
  - S/N > 300 in the nucleus, 50 at 3 arcsec from the centre
  - Wavelength range: 4840 and 7200 Å, $R = 1000$
PKS 2005-489

Nucleus

Outer regions 3-4 kpc

Comparison Galaxy
Spatial profile

Intensity of the emission

Star profile

Flux in the nearby continuum
Conclusions a)

Spatial intensity profile of the line emission regions together with the kinematics and emission diagnostics of the gas show presence of a rotating ring with ongoing star formation at 4 kpc from the nucleus.

**SFR** $\approx 1.2 \text{ Mo/yr}$ (Panuzzo et al. 03 models)

$\text{SFR} \approx \frac{dM}{dt}_{\text{ACC}} (\approx 0.8 \text{ Mo/yr})$ from $L_{\text{BOL}}$ (Xie et al. 2004) and $\log(M_{\text{BH}}) \approx 8.9$ (Falomo et al. 03)

$M_{\text{Burst}} = \text{SFR} \times 1\text{E8 yr} \approx 1.2\text{E8 Mo} \approx 0.03\% M_{\text{HOST}}$ (4 E11 Mo from R=-23.1)

!! Tiny rejuvenation episode !! much below typical 1% observed in ETGs

**Intrinsic velocity of the ring should be** $V_C \approx 420 \text{ km/s}$

from $V_C - \sigma_C$ relation (Pizzella et al. 05) & $\sigma_C \approx 250 \text{ km/s}$ (from R Mag)

Since $V_r \approx 75 \text{ km/s}$ inclination angle of the ring is 80 degrees : ring almost face on

SF ring nearly perpendicular to the radio jet (like 3C218 - Hydra A - Melnick et al. 1997)
2215-037

CaII K & H Inversion
CaII K & H Inversion

Early type galaxy with strong H absorption
blend CaII H + H\(\varepsilon\)

Early type galaxy without strong H

SDSS E type galaxies (Clemens et al. 2006)
Template QSO = QSO Nucleus – galaxy (until CaII K disappears)
Host Galaxy (outer region)

Host Galaxy

Host QSO subtracted (shifted)

% QSO Estimated from [OIII] lines
What kind of stellar pop. in host galaxy?
Conclusions b)

We detected CaII K & H inversion in 2115-037 host galaxy spectrum. It usually indicates contamination by A stars (Leonardi & Rose 96).

High S/N allows subtraction of galaxy template from nuclear spectrum:
- \( \rightarrow \) QSO Template
- \( \rightarrow \) QSO contamination

QSO host galaxy spectrum consistent with presence of young stars.

Young population best traced in 3700-4100 Å region.
Diagnostic diagram

- Nucleus
- Outer regions
- Shock model
We propose

- Spectroscopic observations of nearby ($z \leq 0.2$) active galaxies (Radio Quiet Quasars, Radio Loud Quasars, BL Lac objects and Radio Galaxies) to investigate their stellar population content: 25 QSOs 10 BL Lacs 10 RG
- This spectroscopic survey, together with previous studies, based on the images of the sources yielding the morphological and photometrical properties of the host galaxies, will allow us to probe the link between nuclear activity and stellar content in the host galaxies.
- The results will be consistently compared among matched sub-samples and with a control sample of local early-type galaxies of similar luminosity.
The Method

Long slit spectra of the targets, taken on-axis, are extracted at various spatial positions in order to optimise the signal from the host galaxy and to provide a clean subtraction of the nuclear light contamination.
• A number of observational evidences for a tight link between star formation and nuclear activity have been reported
  
  (Bressan et al 02, Heckman et al. 04, DellaValle e al 05, Canalizo et al. 06)

• However, whether these rejuvenation episodes are triggered by a reactivation of the SMBH (Ho 2005), or the reactivation is only concomitant with the SFR, still remain a very debated issue

• To cast light on this point, many imaging studies have been performed in recent years on the host galaxies of nearby and distant AGNs
  
  (Bahcall 97, Dunlop et al. 03, Pagani et al 03, Falomo et al 04, 05).

• Test connection between the re-activation of the central MDO and the star formation