Extragalactic & Cosmology

Françoise Combes
Observatoire de Paris
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High resolution, nearby universe, Galaxy Nuclei
Dusty torus? Or hollow polar cone

Dynamics  Rotation curves at high $z$

Gas extensions around galaxies
Circum-galactic medium
Ionized gas, Ly$\alpha$ haloes, DLAs
Tidal stripping, outflows

Cooling Flows
H$\alpha$ filaments
Molecular gas inflow

Jelly-fish galaxies in clusters
H$\alpha$ tails, Molecular gas
High resolution VLTI: Polar dust distribution

Dust emission in the infrared, MIDI, MATISSE
Hot dust in the polar direction

Green: 100pc along the polar axis
Asmus et al 2016
MIR, VLT/Visir

149 AGN, 21 show extended dust distribution, 18 on the polar axis (MIR)

Gamez-Rosas et al 2022
Molecular torus inside a polar dusty cone

Garcia-Burillo et al 2019
X-rays, from $10^{23}$ cm$^{-2}$
up to $10^{25}$cm$^{-2}$

⇒ Compton-thick
~up to 100pc scale

$1''=70$pc, Gratadour et al 2015 SPHERE NIR
Detection of gravitational redshift, *GRAVITY Coll 2018*
Infrared Flares around the SgrA* black hole

GRAVITY 2018

Resolving the BLR

Mass of SMBH
Distance of
NGC 3783
3C273, IRAS09149

GRAVITY 2021

Vermot et al 2021

N1068
0.24pc ring
77% of galaxies are rotation dominated ($V/\sigma > \sim 2$)

Re ~$(1+z)^{-0.75}$

Re ~$(1+z)^{-1.48}$

25% quenched

Blue sequence

Re ~$M^{0.75}$

Red sequence

Wisnioski et al 2019

Hα, [NII], [SII]

3D-HST survey
Hα or CO rotation curves

Genzel et al 2020
Kinematics, dispersions

Galaxies at $z > 1.2$ are more baryon-dominated within $R_e$ than at $z=0$.

They have more dispersion

$\Rightarrow$ No NFW-cusp but a core

Ubler et al 2021

FIRE-2 represents better the observations (higher $\sigma$)

Genzel et al 2020

$M^*$

$f_{dm}$

$\Sigma_{baryon}$
Simulations of CGM

Black/Blue Ly-limit
Orange/red, DLA

Peeples et al 2019
Diagnostic in absorption (MUSE MEGAFLOW)

$\alpha$ is the position angle of the QSO wrt the major axis of the galaxy
$i$ the inclination of the galaxy on the los

Gas frequently outflowing
When in the disk, it rotates with it

Zabl et al 2019

![Diagram with labels $\alpha$, $i$, and $Mg\lambda 2796$]
MgII outflowing in a QSO sight line

MUSE Megaflow: **first MgII emission detection** from a QSO absorption
Extension 25kpc  \( z=0.7 \)  Origin from the outflow? (minor axis),
Excited by shocks at large distance

Zabl et al 2021
Extended Ly$\alpha$ haloes

Galaxies between $3 < z < 6$
Ly$\alpha$ 5-15 x extended than UV continuum

Neutral medium of several kpc

MUSE: Cold atomic gas illuminated by quasars

Blind survey for giant Ly-$\alpha$ nebulae around 17 bright RQQ at $3 < z < 4$
All QSO have 100-320kpc Ly-$\alpha$ nebulae
Borisova et al 2016

Wisotzki, Bacon, Blaizot et al 2016
MUSE Deep Field: Circum-galactic gas everywhere

Wisotzki, Bacon, Brinchman et al 2018

Field of 1’ x 1’
HDF-South
270 LAE 3 < z < 6

UV-selected galaxies

81% of LAE have an extended Lyα halo -40kpc
Kusakabe, Verhamme, Blaizot et al 2022

Large gas reservoirs:
inflows, outflows, both

Also traced by absorption
DLA, sub-DLA or Lyα forest
MgII in a galaxy group, z=1.31

White contours 1.5, 2, 3σ Blue contours: absorption
Over 1000 kpc²
Outflow in the central galaxy (P-cygni) + [FeII] minor axis

tides and outflows
Create the IGM

Leclercq et al 2022
Extended cold gas

Spiderweb (Emonts et al 18)  CANDELS-5001, (Ginolfi et al 17)

CI contours with ALMA  CO(4-3) on HST
Red contours, radio cont  z=3.5 protocluster
Cooling flows: Perseus

Salome et al 2008, 2011

Molecular Gas
Salomé et al 2006
M(H₂) \( \sim 10^{10} M_\odot \)

The bubbles create inhomogeneities and further cooling
At R\( \sim 20\)kpc, tc/tff \( \sim 10 \)

\( \Rightarrow \) thermal instability (McCourt et al 12)

Velocity much lower than free-fall
Salome & Combes 2004

Trailing wake A1795

McDonald et al 2009
60kpc tail

Hα

McDonald et al 2009
60kpc tail

X-rays

tcool = 300Myr = tdyn

Salome & Combes 2004

Russell et al 2017
ALMA: cold gas in cool core clusters

Abell 2597 ALMA CO(2-1) absorption in front of the AGN synchrotron

Red-shifted only
Dense clouds fueling the AGN

Tremblay et al 2016
ALMA, cold gas in absorption and emission

Most often, gas is inflowing towards the nucleus Fueling the AGN

Rarely, it is far from the center

Rose et al 2022
Ram-pressure stripping: resilient tails

ESO137-001: violent ram-pressure, but CO gas remains, and reforms

⇒ molecular filaments, with Hα and X-rays

Jachym et al 2014: Norma cluster
ALMA CO
more H$_2$ in
the tail than in disk

→ in situ formation

Jachym et al. 2019
Halphea with MUSE (VLT)

Outer regions swept first: remains the center
Transition from laminar to turbulent $> 6.5$ Myr

Fumagalli et al 2014
Comparison D100 & ESO137-001

Width of the ram-pressure tail decreases with time?

⇒ Older stripping in D100

Recalibrate to the same scale, same length  

Jachym et al 2015
Summary

- High resolution near AGN: polar dust, molecular tori

- Rotation curves at high z

- CGM detected now in emission (Ly$\alpha$, CI, CO..)
  Due to outflows, some inflows, excited by starbursts and AGN

- Cooling flows and wakes, when the BCG is in motion
  Molecules reform in the filaments

- Molecular filaments + H$\alpha$ through tides and ram-pressure
  from galaxies in clusters