Cold molecular gas detection in the central region of Abell 1795

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The riddle of cooling flows in Galaxies and clusters of galaxies
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1. The central regions of Abell 1795

2. Cold molecular gas detection

    - Iram 30m telescope observations
    - Plateau de Bure (Iram) interferometer observations

3. Morphology and dynamics of the cold molecular gas

4. Conclusions

The center of Abell 1795

The central galaxy

- Central cD galaxy at z=0.0632

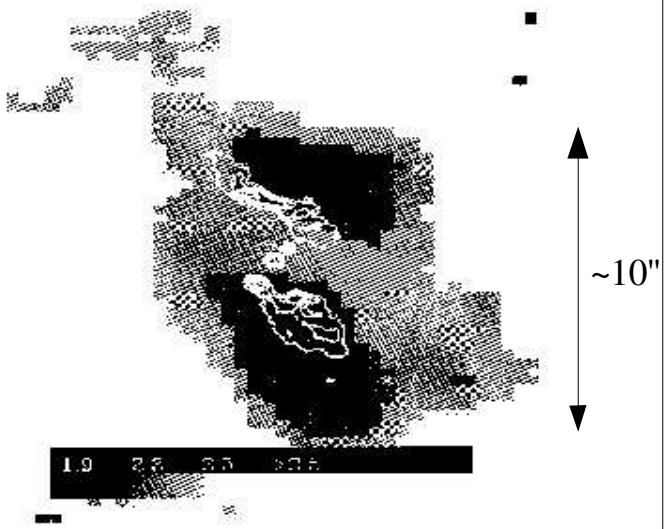
- FR I radio source with double lobes of 10kpc
- Emission line nebulosity around the galaxy

Van Breugel et al. (1984)

- Bright knots of blue continuum along the radio lobes indicates star formation

Mc Namara et al. (1996)

Radio map at 3.6cm Ge from (1991) superposed on a U-I color map.
McNamara & O'Connell (1993)



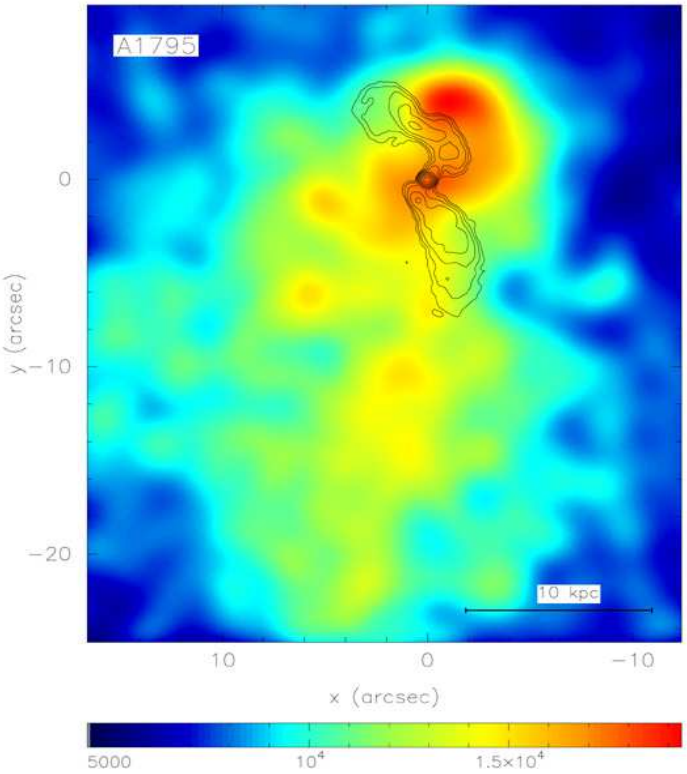
- Both radio jets appear to bend by 90° at the location of the blue lobes
- Peculiar velocity of the cD galaxy cz=19000km/s
- Mean cluster velocity in the inner 200 kpc ; cz=18636 km/s

Hill et al. (1988)

-374 km/s by comparison to the cD velocity

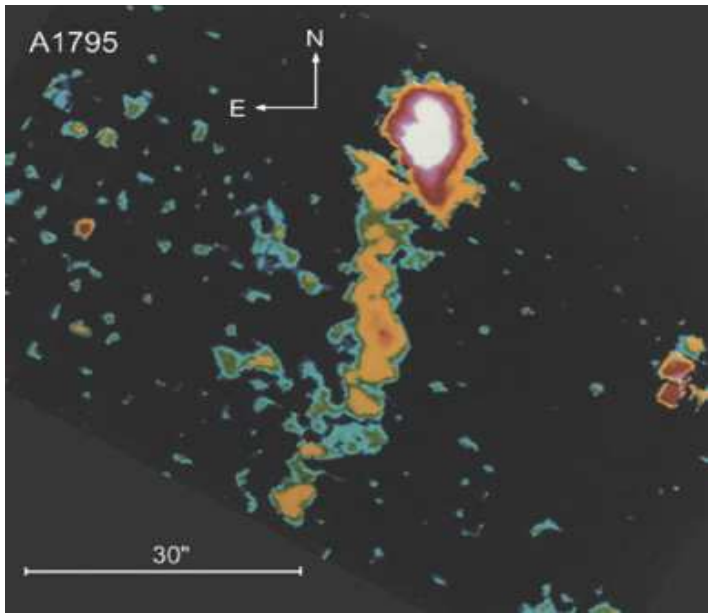
The center of Abell 1795

Hints of cooling flow



- Cooling time around the galaxy & in the filament : t_{cool}=300 Myr (Fabian et al. 2001)
- Strong cooling flow in the cluster center dM/dt=100M_{sol}/yr in the central 200 kpc (Ettori et al. 2002)
- XMM-Newton does not show detectable emission from gas cooling below 1-2 keV (Tamura et al. 2001)

Chandra X-ray image (Fabian et al. 2001)



Peculiar morphology

- H_{alpha} nebular emission line over ~ 40"
- Coincident with the X-ray filament

H_{alpha} + N[II] image (Cowie et al 1985)

Possible interpretation :

Cooling wake (Fabian et al. 2001) due to the movement of the cD in the cluster potential

A very cold component in the cluster center is detected

-> Search for cold molecular gas (~20 K) :

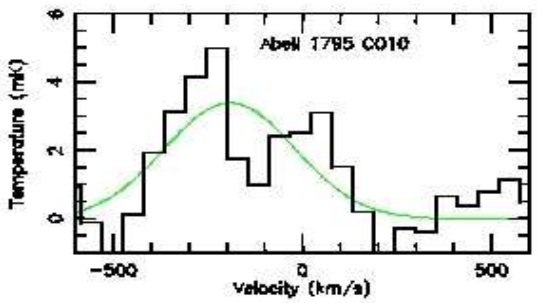
Iram 30m observations of 34 cooling flow clusters of galaxies

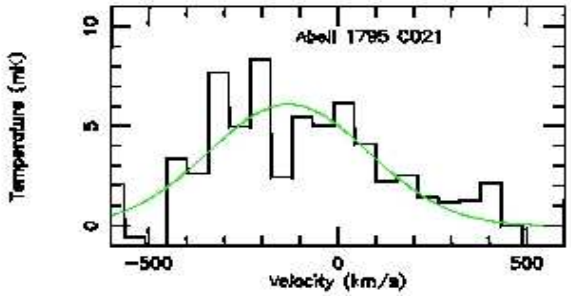
6 detections : A262, A646, A1068, A1795, RXJ0821+07, PKS0745-191

Molecular gas search in the inner

Iram 30m telescope observations

Primary beam : 22" at 115GHz
Observing time : 128 min





Large line width ~ 400 km/s

Ico(1-0) = 1.47 +/- 0.19 K.km/s

Ico(2-1) = 3.26 +/- 0.39 K.km/s

With a standard conversion factor Ico/N(H2)

-> M(H2)= 9.3 +/- 0.9 10^9 M_{sol} in the central 22"

Not in contradiction with recent mass deposition rates

DM/dt ~ 7.9 M_{sol}/yr in the inner 20" (Ettori et al. 2002)

Cooling time ~ 300 Myr

2.4 10^9 M_{sol} → Cold gas phase ~ 9 10^9 M_{sol} → 2.4 10^9 M_{sol} formed stars

If 20% of the cold gas is transformed in stars

Interferometric observations of Abell 1795

Instrument characteristics

CD configurations with 5 or 6 antennas : compact configuration

Primary beam 43" in CO(1-0) and 21" in CO(2-1)

Spatial resolution 3.83'‘ by 3.26" in CO(1-0) and 1.81'‘ by 1.31" in CO(2-1)

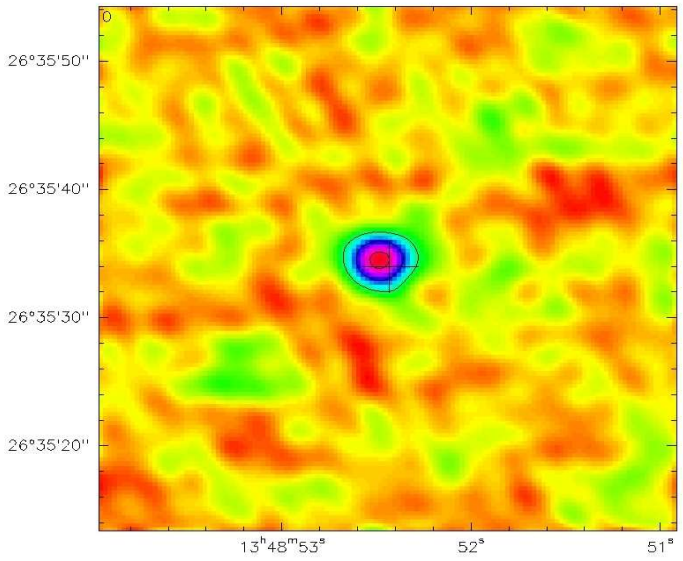
Spectral resolution smoothed at 89 km/s in CO(1-0) and 44 km/s in CO(2-1)

Analysis

GILDAS package -> data cube : 16 velocity maps for the 2 lines.

3 mm maps are subtracted from the continuum emission

Continuum at 3mm
(contours at 2mJy)



Continuum emission

Detection of a 3mm continuum source of 6mJy at the position of 4C+26.42

Continuation of the synchrotron emission detected at lower frequencies with a decreasing slope alpha=-0.98

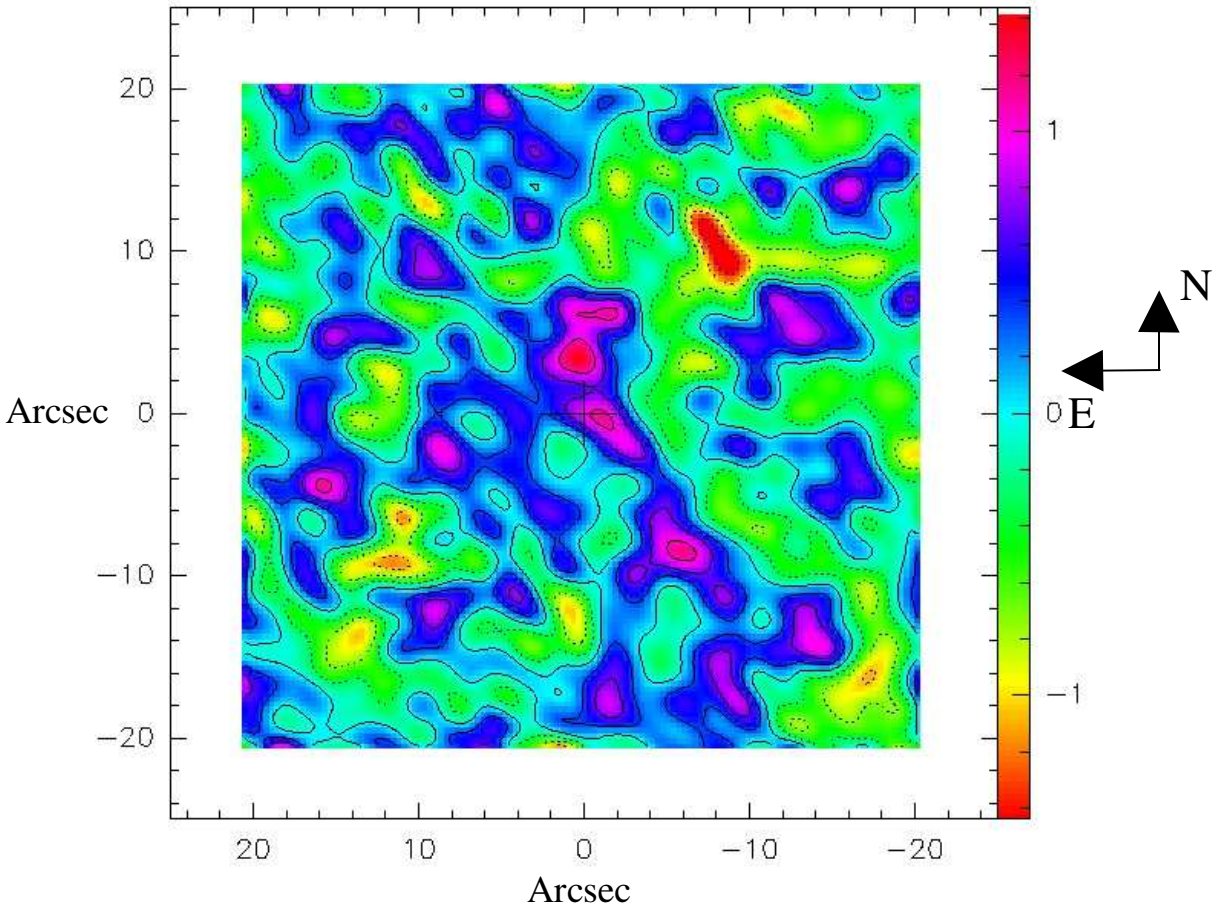
CO(1-0) and CO(2-1) maps

CO(1-0) image of the central 43" of Abell 1795

- 1 region (4 sigma) at North of the galaxy and an extended SW emission

- Ico in the Plateau de Bure map is only ~20% of the 30m telescope CO intensity.

-> extended emission as very short spatial frequencies are not covered by the interferometer



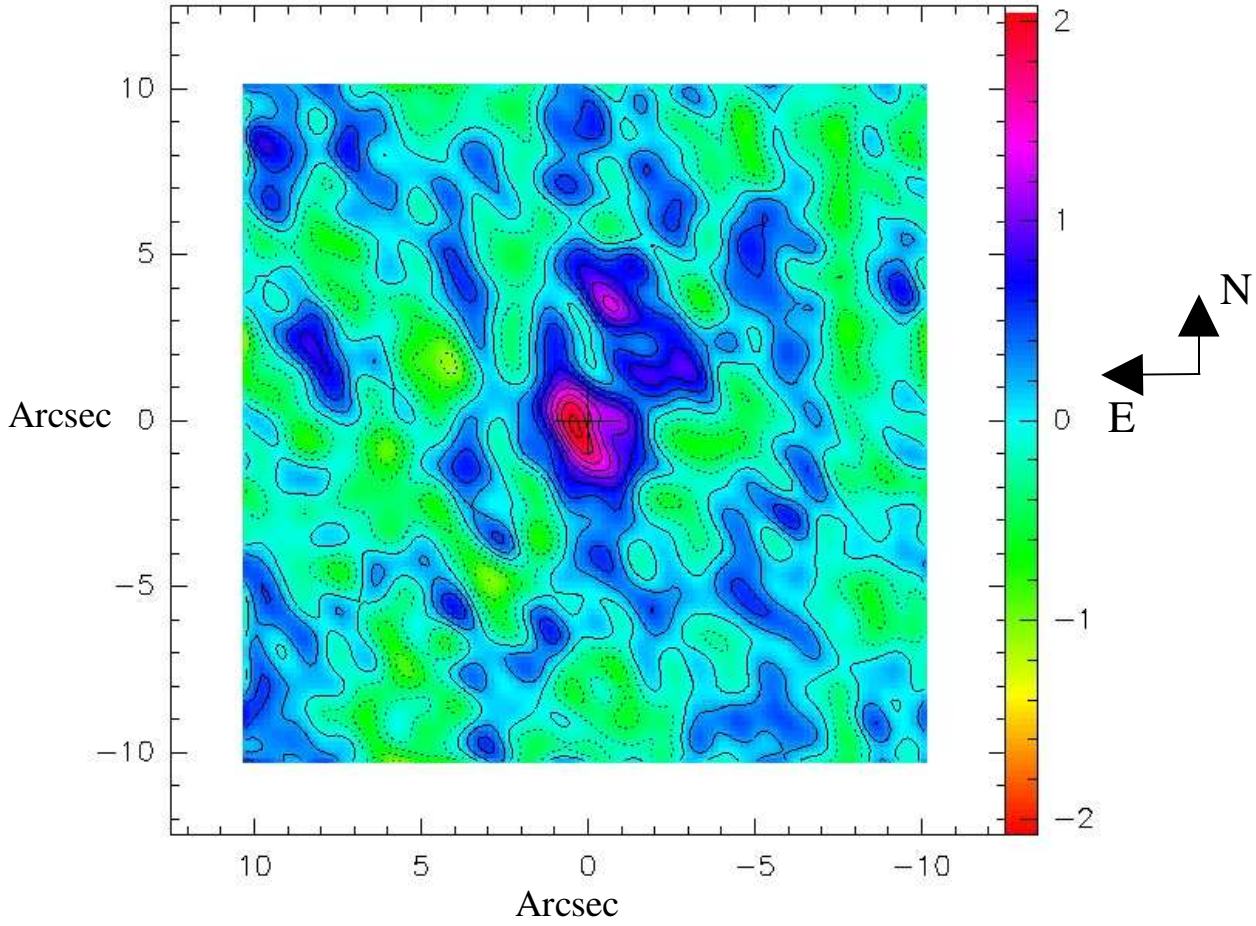
Sum of the velocity maps from -663km/s to 674km/s
Linear contours at 1 sigma = 0.36Jy/beam.km/s

CO(1-0) and CO(2-1) maps

CO(2-1) image of the central 22" of Abell 1795

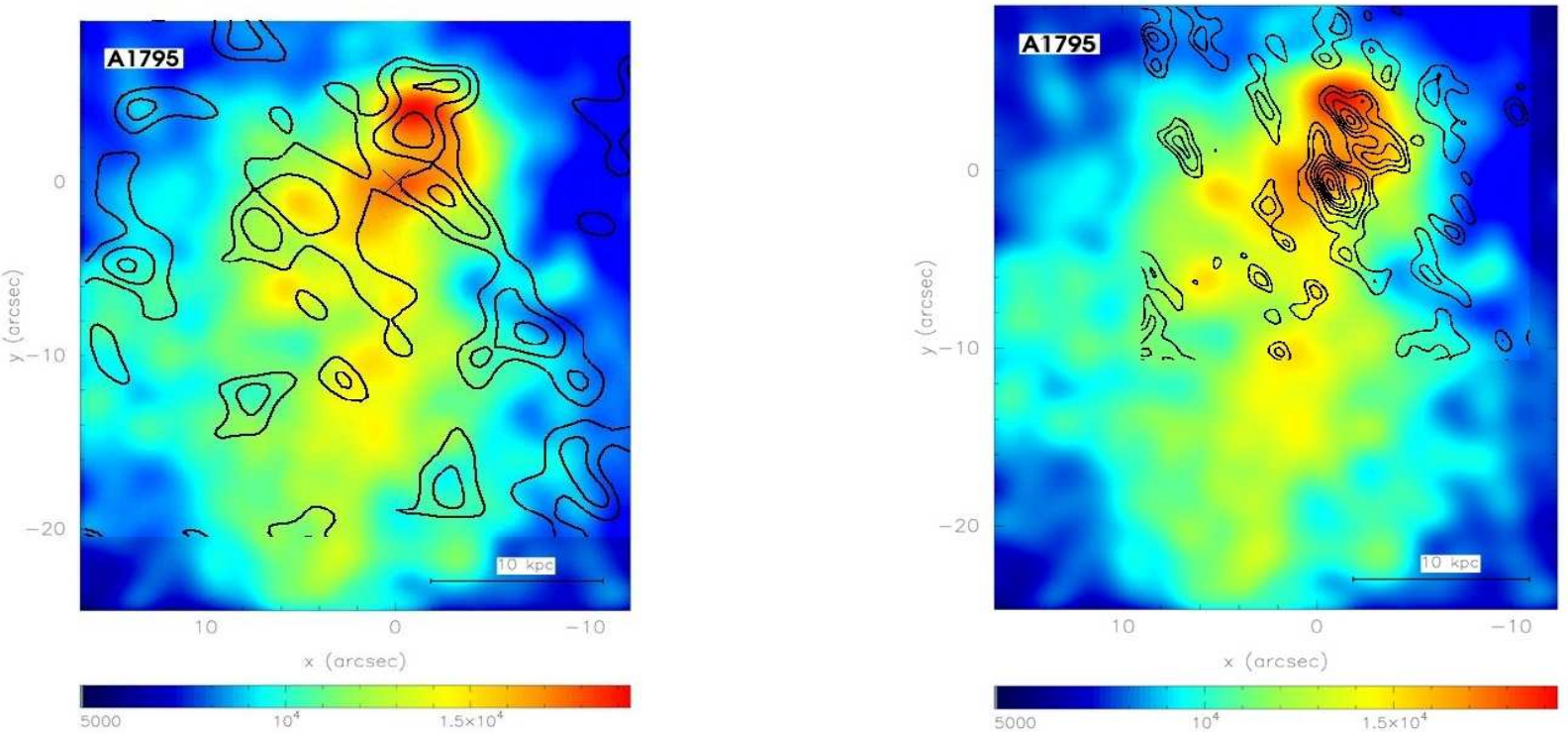
- 2 regions around the galaxy position

- Ico in the Plateau de Bure map is only ~20% of the 30m telescope CO intensity.



Sum of the velocity maps from -338km/s to 333km/s
Linear contours at 1 sigma = 0.26Jy/beam.km/s

CO contours and X-ray image

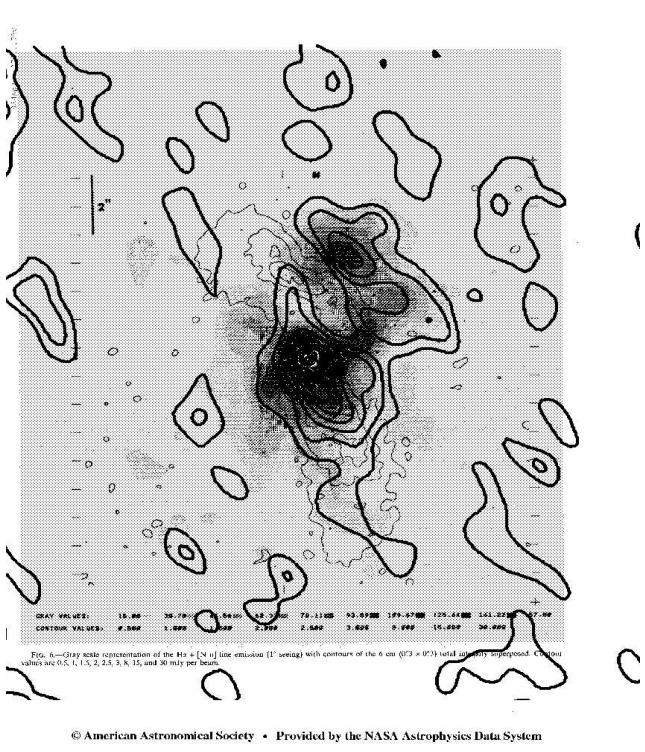


Chandra X-ray image (Fabian et al. 2001) superposed CO(1-0) and CO(2-1) contours

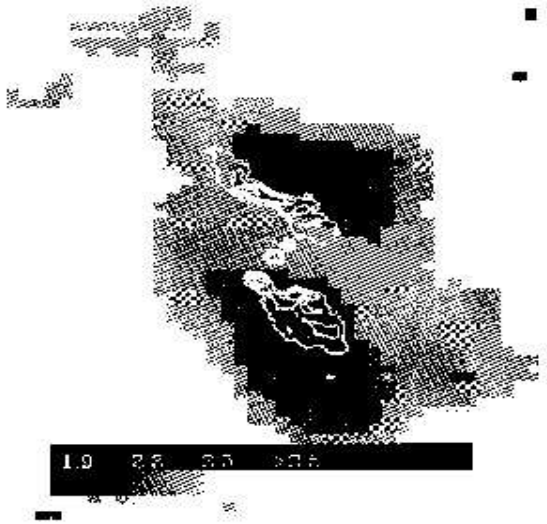
North CO emission coincident with the peak in X-ray

Not coincident with the galaxy position

CO contours and optical images



~10"



Radio map at 3.6cm Ge from (1991) superposed on a U-I color map.
McNamara & O'Connell (1993)

H_{alpha} + N[II] line emission Van Breugel et al. (1984) and CO(2-1) contours

Cold gas coincident with

- H_{alpha}+N[II] emission regions
- Blue continuum

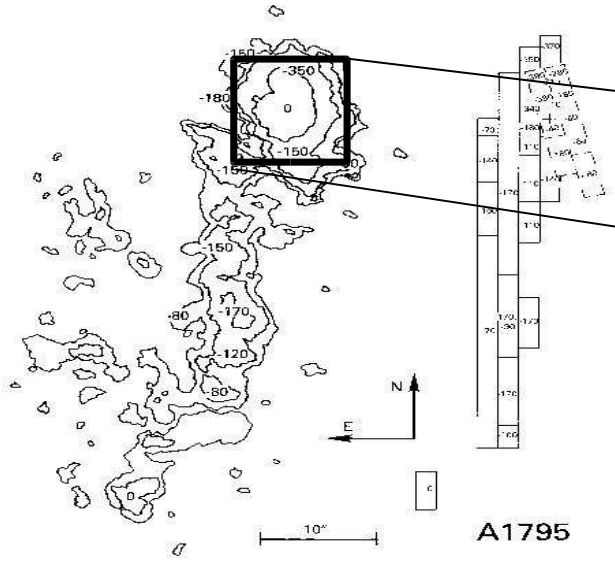
Confirm the correlation M(H2)-H_{alpha} (Edge 2001)

May be accumulated gas deposited by the cooling flow (multiphase medium)

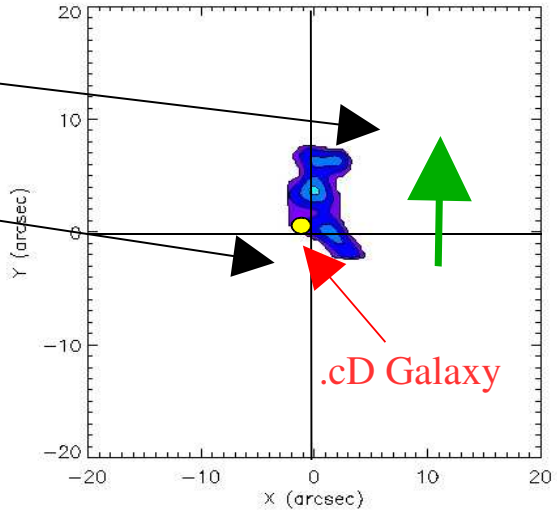
May have deflected the expanding radio lobes

Possible reservoir for star formation

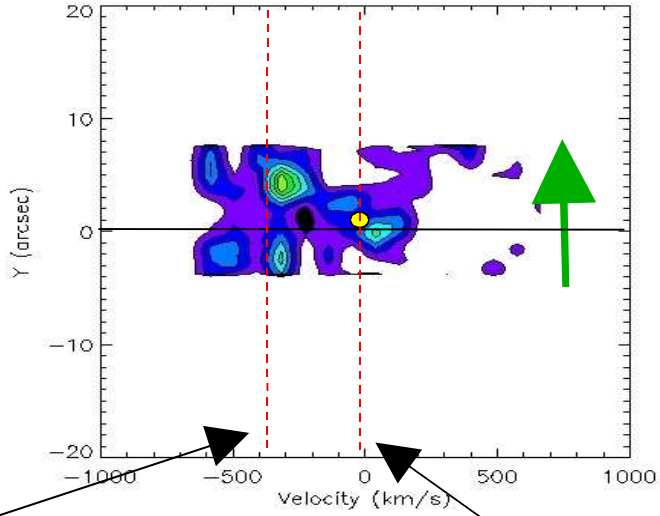
Cold molecular gas dynamics - central region



CO(1-0) contours



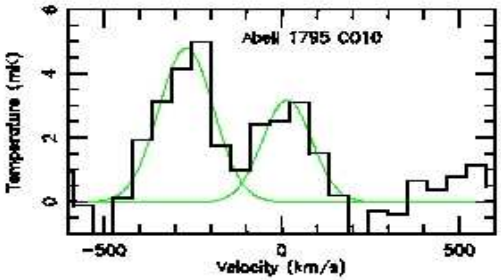
Position-velocity contours

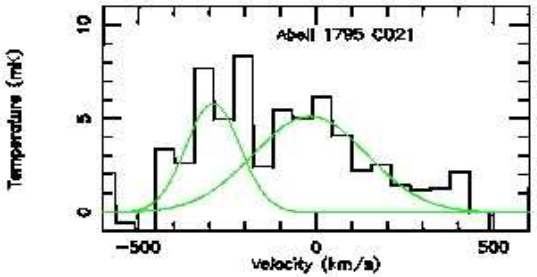


Central 200kpc cluster mean velocity

Galaxy velocity

Dynamics of the optical emission
(Hu et al. 1985)





Iram 30m telescope spectra

Conclusions

- Detection of cold molecular gas in the central region of Abell 1795 with the Iram 30m telescope and Plateau de Bure interferometer -> M(H2)= 9.3 +/- 0.9 10^9 M_{sol} in the central 22"

- No discrepency with the mass deposition rates in the central 22"

- Spatially extended emission ~20% of the single dish signal is found with the interferometer

- Maximum of CO emission coincident with X-ray and H_{alpha} emitting regions

- Evidence that a part of the cold gas is at the cluster velocity (might be a cold residual of the hot cooling gas), and another at the galaxy velocity (might be accreted cold gas)