Star formation suppression by an AGN (in NGC 1266 and maybe more)

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NGC 1266 appears to be a “quiescent” S0

NGC 1266 hosts a massive molecular disk (>10⁹ M☉)
and a massive (>10⁶ M☉) molecular outflow that is multiphase being driven by an AGN

A young (1/2 Gyr) stellar population outside the nucleus is the most recent (obvious) SF event

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NGC 1266 contains massive molecular outflow

$M_{\text{gas}} \sim 4 \times 10^9 M_\odot$ (Young et al. 2011)

$M_{\text{outflow}} \sim \text{few} \times 10^8 M_\odot$

(Alatalo et al. 2011, new HCN and CS(2-1) have wings)

Outflow mass flux $\sim 110 M_\odot \text{ yr}^{-1}$

Outflow dynamical time $< 3$ Myr (Alatalo et al. 2011)
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NGC 1266 is a poststarburst galaxy

NUV imaging show a larger distribution of young stars than the current site of the molecular gas.

A stellar population analysis shows that the population is poststarburst of age (~500 Myr) with mass fraction ~10%

Alatalo et al. 2014a
Modeling the SED of 1266 results in $\text{SF} \sim 2.2 \, M_\odot \, \text{yr}^{-1}$ is an upper limit, if all of this emission is from stars (it isn’t) and the free-free fit say $\text{SF} < 0.9 \, M_\odot \, \text{yr}^{-1}$.

$L_{\text{TIR}} \approx 3 \times 10^{10} \, L_\odot \, (1.2 \times 10^{44} \, \text{ergs s}^{-1})$

Alatalo et al. 2014b, submitted
Last burst of SF happened \( \sim 500 \) Myr ago and the nuclear molecular gas has remained since then.

SFR calculated using the free-free emission indicates a SFR of \( >0.9 \, M_\odot \, \text{yr}^{-1} \) (the ALMA decomposed data agree).

\[ \Sigma_{\text{gas}} \approx 10^4 \, M_\odot \, \text{pc}^{-2} \]
(from CO, CS and HCN)

Using dense gas (CS) size and assuming SF/CS co-spatiality, NGC 1266 is a factor of \( \sim 70 \) off the K-S relation.
A scenario to explain NGC 1266

Alatalo et al. 2014a, 2014b (submitted)
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6. Gas re-ignites radio jet?

Duty cycle?

Alatalo et al. 2014a, 2014b (submitted)
we need a systematic search for these sorts of objects.

Case studies are great, but can’t tell us about a population.

What is the duty cycle of the SF quenching?

What evolutionary pictures lead to an AGN expulsion of molecular gas?

Can we begin to understand NGC 1266-like objects?

What is the redshift evolution of these objects?
Finding the needle in the haystack

NGC 1266 hosts an AGN-driven outflow, but also contains a unique set of optical features

shocked ionized gas (Davis et al 2012)

young(ish) stellar population
Alatalo et al. 2014a
shocked ionized gas ratios + poststarburst stellar population

= 

a Shocked Poststarburst Galaxy (spog)

NGC 1266 is a spog.
SPOGS: First results

- **ELG**
  - $N_{\text{parent}} = 130788$

- **Seyferts**
  - $N_{\text{seyfert}} = 4765$

- **EW(H$\delta$) > 5Å**
  - $N_{\text{EW,H$\delta$}} = 46936$

- **SF**
  - $N_{\text{sf}} = 111972$

- **LINERs**
  - $N_{\text{liner}} = 11327$

- **SPOGS**
  - $N_{\text{spog}} = 1067$

Alatalo et al. 2014c (submitted)
SPOGS result: a surprise
a WISE infrared transition zone

when in doubt, cross-correlate with WISE

GZ sample from Schawinski et al. 2014; Alatalo et al. 2014c (submitted)
SPOGS result: a surprise

a WISE infrared transition zone

GZ sample from Schawinski et al. 2014; Alatalo et al. 2014c (submitted)
SPOGS* colors

u-r and W2-W3 transformation sequence

ELG

Seyferts

EW(H\(\delta\)) > 5\(\AA\)

SF

LINERs

SPOGs*

\(N_{\text{elg}} = 130788\)

\(N_{\text{seyfert}} = 4059\)

\(N_{\text{EW H\(\delta\)}} = 39132\)

\(N_{\text{sf}} = 93920\)

\(N_{\text{liner}} = 8091\)

\(N_{\text{spog}} = 857\)

Alatalo et al. 2014c (submitted)
The molecular outflow seen in NGC 1266 is about $110 \, M_\odot \, yr^{-1}$, far too large to drive with its star formation rate ($dM/dt/SFR \sim 100$).

ALMA observations have shown that star formation is suppressed currently by a factor of 70.

A radio duty cycle might explain how NGC 1266 has come to be (and provide a look at how AGNs are able to remain obscured.)

NGC 1266 is a shocked poststarburst galaxy (spog).

WISE+SDSS is a great tracer of transitioning galaxies.

The SPOGs survey seems to have found what it was looking for (transitioning objects)…