Can outflow-driven turbulence quench star-formation? The curious case of NGC 1266

Justin Otter[1], Katherine Alatalo[1,2], Kate Rowlands[1,2], and Tim Heckman[1]

[1]Johns Hopkins University, USA

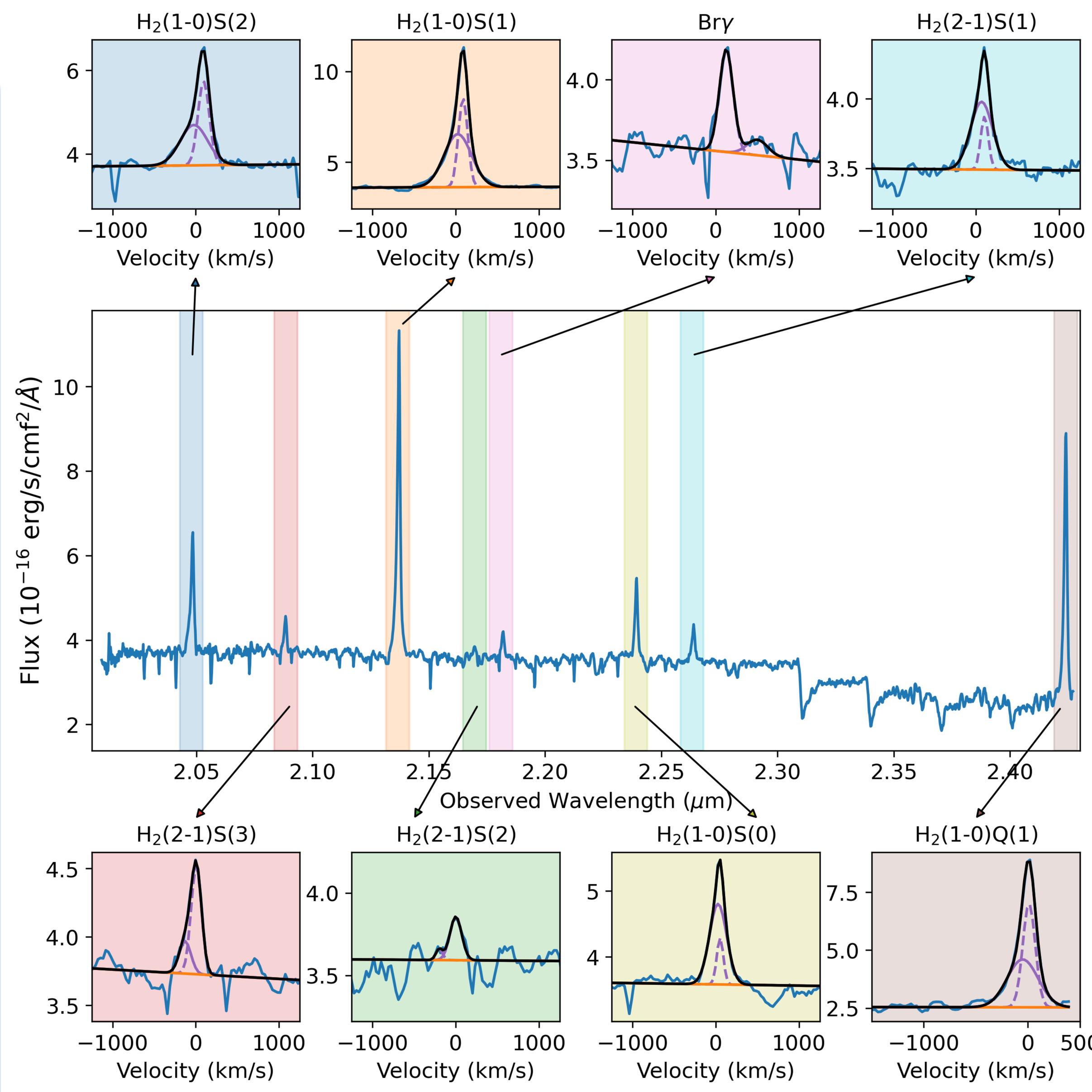
[2]Space Telescope Science Institute, USA

I. QUENCHING AND STABILIZATION

- Is galaxy quenching driven by gas removal or gas stabilization?
- Presence of molecular gas reservoirs in quenching galaxies shows stabilization is important (e.g. Rowlands+15, Otter+22).
- How is gas stabilized against star-formation?
- One possibility is turbulence and shocks driven by outflows.
- NGC 1266 is the ideal case study to investigate these questions!

NGC 1266

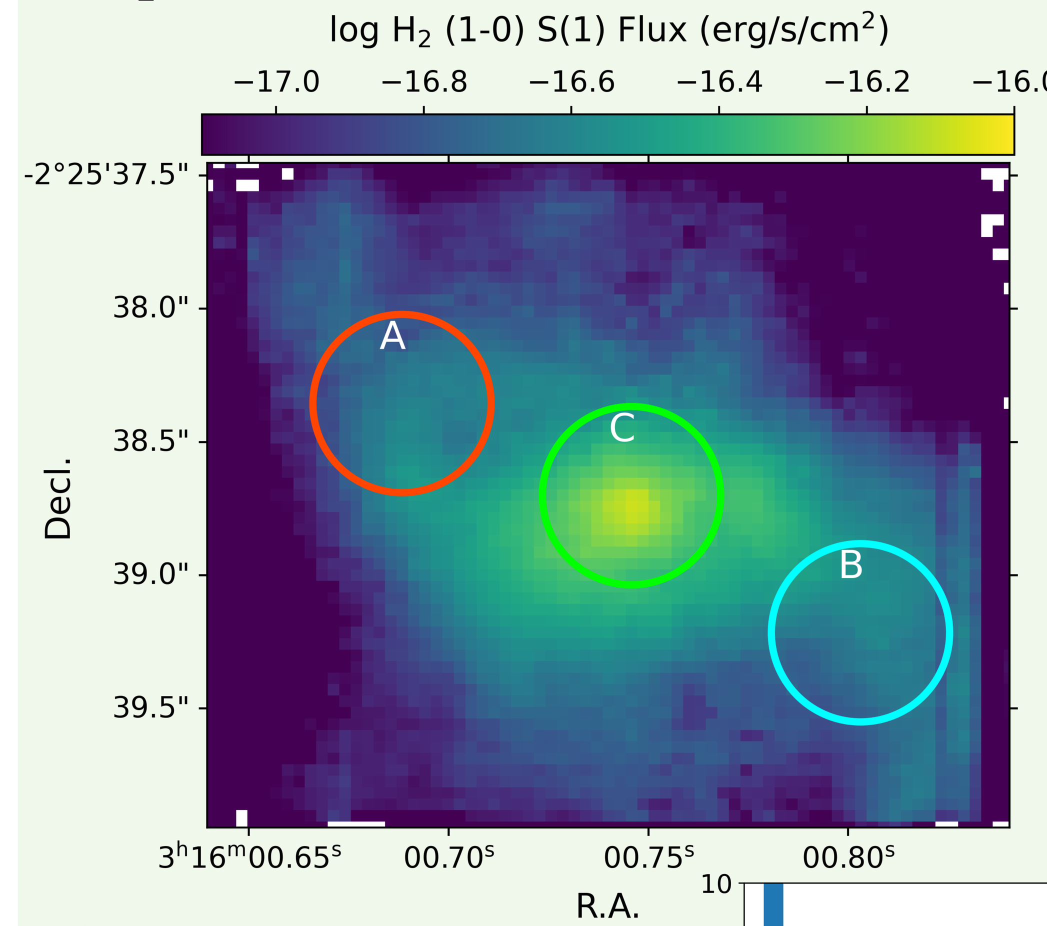
- Nearby (30 Mpc)
- AGN host.
- Powerful outflows [Sec II].
- Shocked ISM [Sec III]
- Suppressed star-formation with gas reservoirs [Sec IV].
- Has a wealth of multi-wavelength data!



Above: Gemini NIFS K-band central spectrum with H_2 lines and Brγ fitted with two Gaussian components.

III. SHOCKS

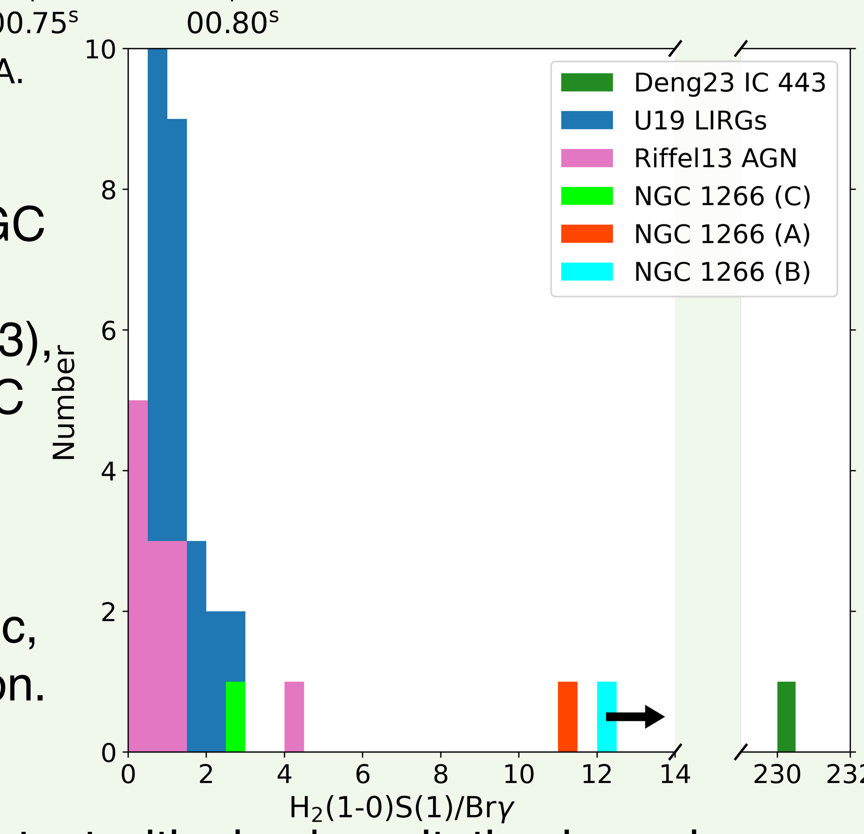
- Optical emission lines and CO SLED both consistent with shocks
- H_2 ro-vibrational emission traces the shock structure



Left: Gemini NIFS flux map of H_2 (1-0) S(1). The circles show the apertures for plotted points below.

Right: H_2 (1-0) S(1)/Brγ flux ratio histogram for the above NGC 1266 apertures and LIRGs (U+2019), AGN (Riffel+2013), and shocked SN remnant IC 443 (Deng+2023)

- The H_2 / Brγ ratio is high outside the central 100 pc, indicating shock excitation.

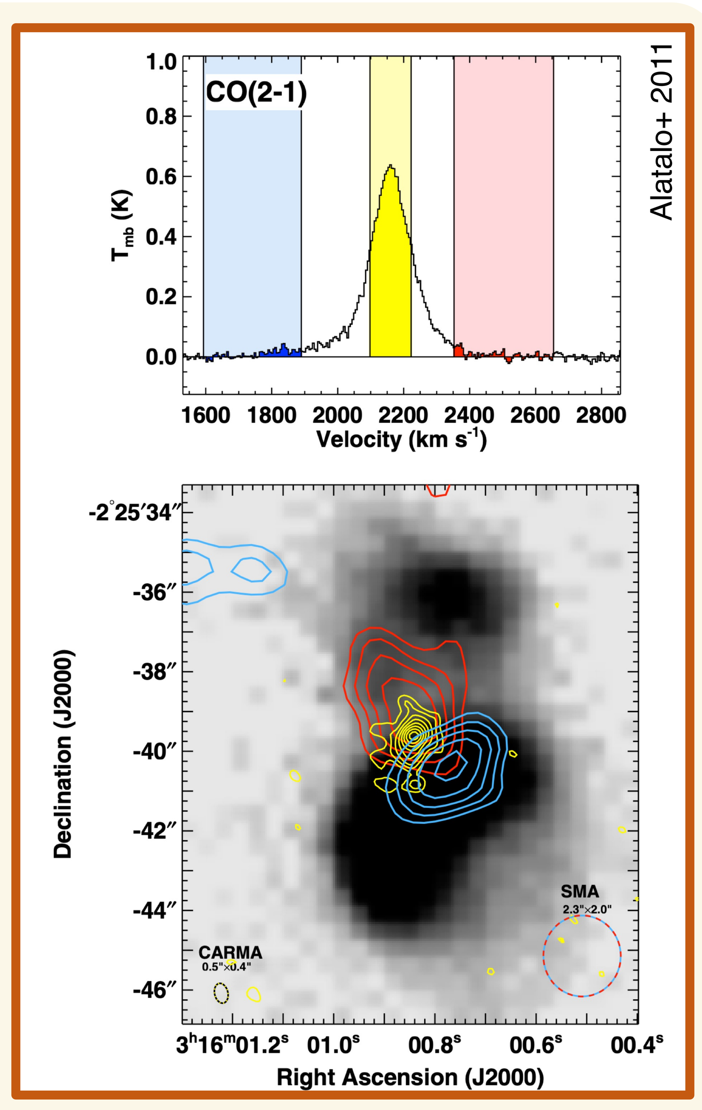


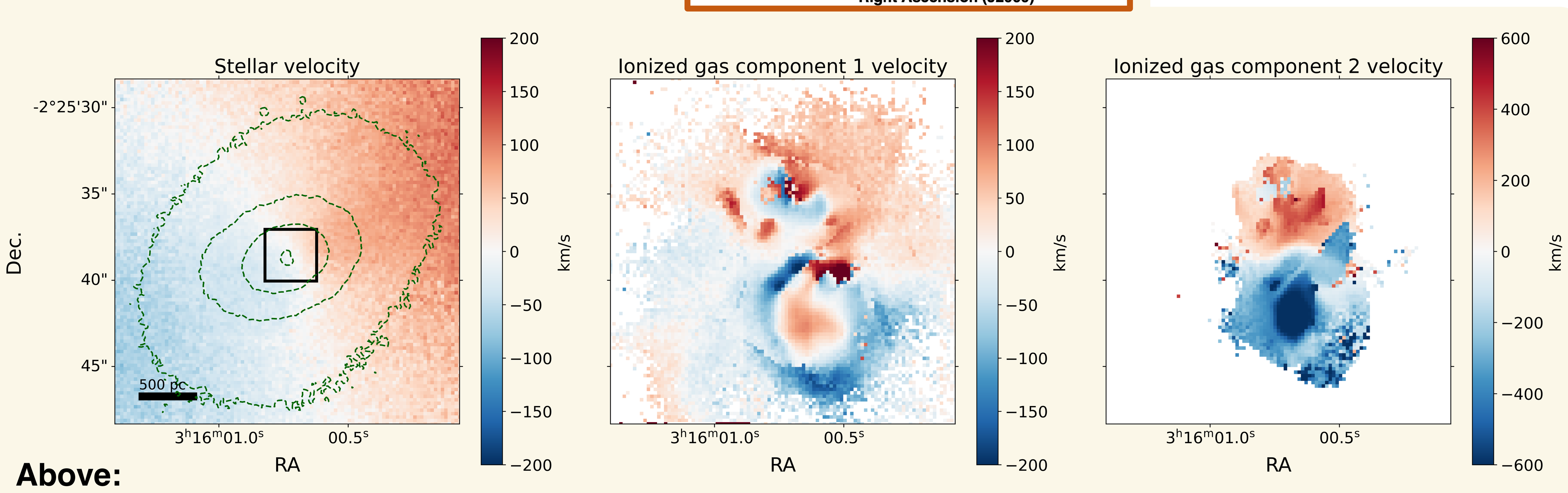
- H_2 line ratios are consistent with shock excitation in each aperture.
- We measure an excitation temperature of ~4000 K, and an ortho-to-para ratio of ~3.

II. OUTFLOW KINEMATICS

- The outflow in NGC 1266 is multiphase and detected in CO, optical emission lines, and ro-vibrational H_2 lines.
- Mass outflow rate of 13 $M_\odot$/yr.

Right:
CO data showing the cold molecular gas outflow (Alatalo+2011).
Top: SMA CO(2-1) with contoured regions highlighted.
Bottom: high velocity SMA CO(2-1) contours in red and blue, and CARMA CO(1-0) contours in yellow, overlaid over the SINGS Hα image.

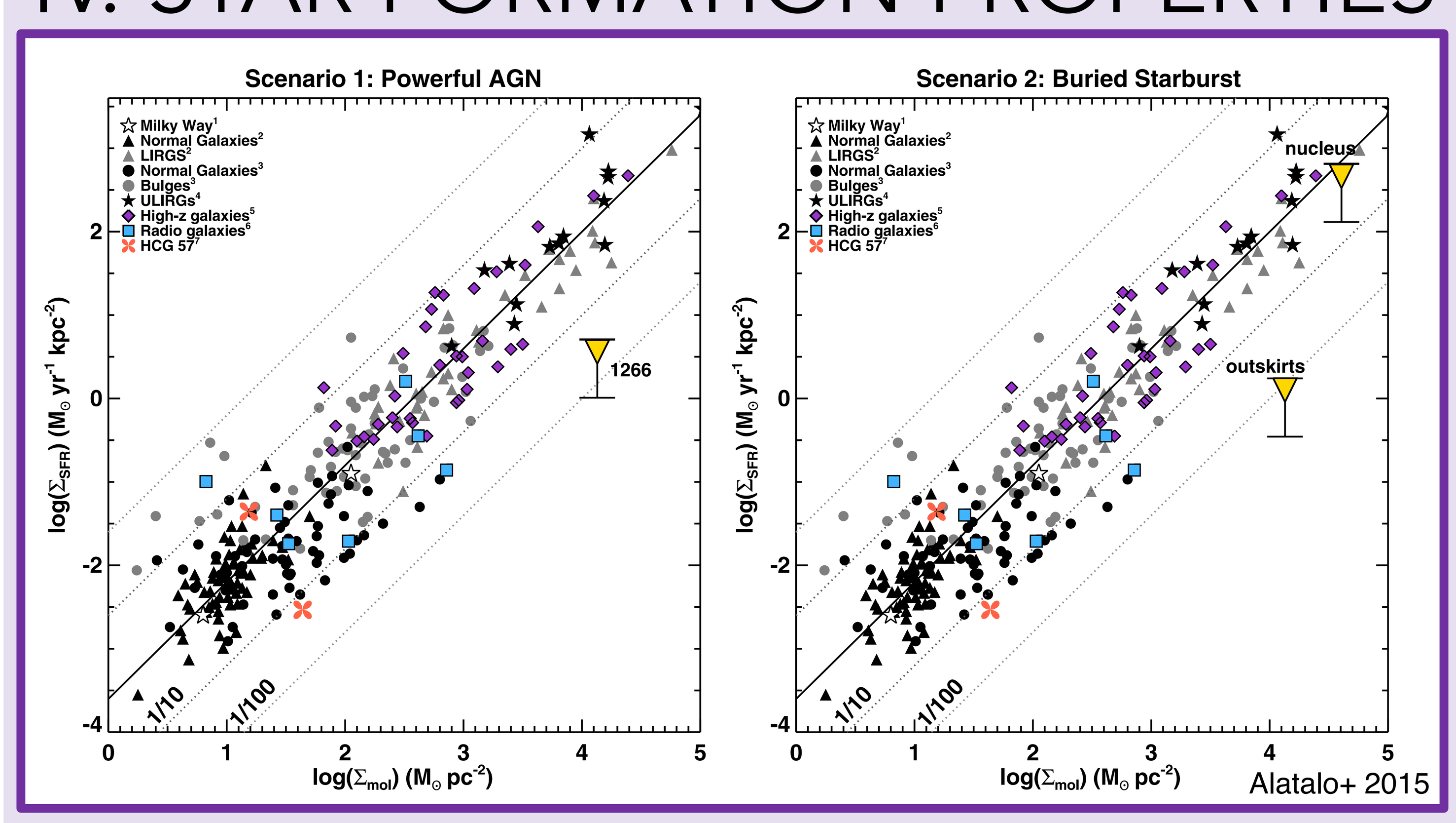




Above:
MUSE stellar and ionized gas velocity fields.
Left: stellar velocity field with *HST* H-band contours in green.
The black box is the Gemini-NIFS FOV.
Center: ionized gas component 1 (narrow) velocity field.
Right: ionized gas component 2 (wide) velocity field.

Component 2 tends to be wider than component 1 and traces an outflow dual-bubble structure, with maximum outflow velocities of 800 km/s.

IV. STAR FORMATION PROPERTIES

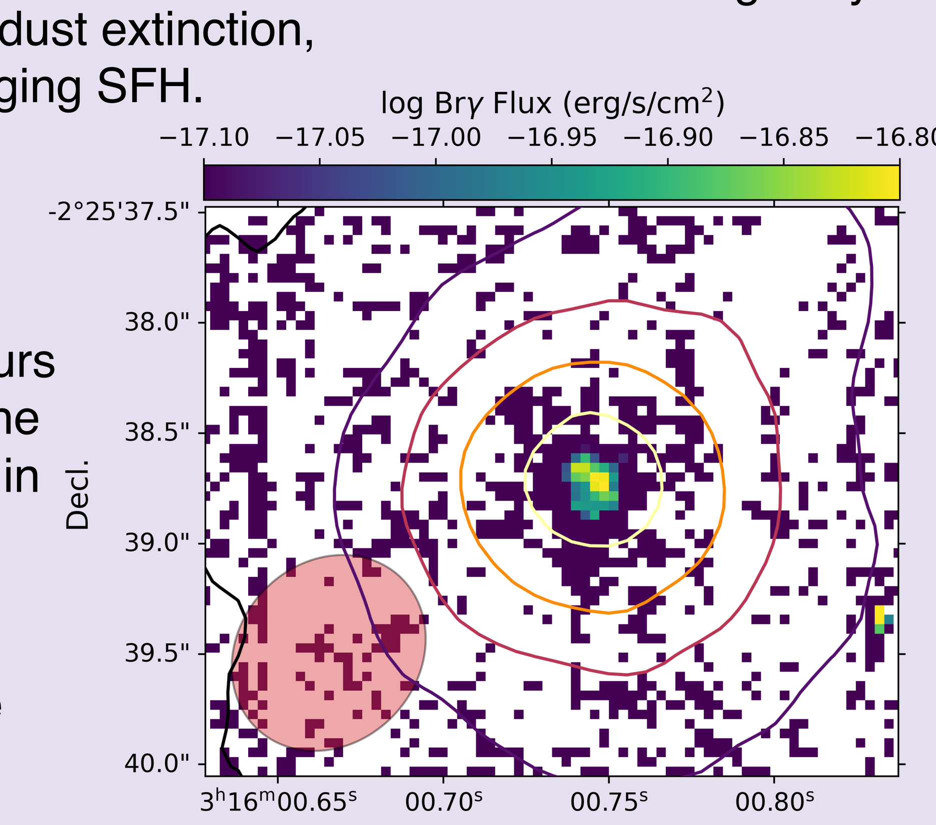


Left: Kennicutt-Schmidt relation with multiple star-formation tracers for NGC 1266 (Alatalo+2015). Without spatial information, it is unclear if star-formation is in a central starburst or distributed. Both scenarios require significant star-formation suppression in much of the galaxy.

- SFR tracers range from (~0.2-2 $M_\odot$/yr) due to dust extinction, AGN/shock contamination, and a rapidly changing SFH.

Right:

- NIFS Brγ map with CARMA CO(1-0) contours overlaid, and the CO beam size in the bottom left.
- The CO has a much larger extent than the Brγ emission.



- Brγ does not trace the shock, so it is likely from the AGN or star-formation.
- Assuming it is entirely from star-formation and using the Paβ/Brγ extinction measurement from Riffel+13, we measure a SFR of 0.28 $M_\odot$/yr in a <100 pc central region.

V. DISCUSSION

The current picture:

- NGC 1266 hosts a powerful, multiphase outflow driving shocks throughout the galaxy.
- The center of NGC 1266 has a rotating molecular gas disk with significant star-formation only in a small central region.
- H_2 ro-vibrational emission reveals hot (~4000 K), shocked molecular gas in the nucleus of NGC 1266. The spatial resolution of Gemini-NIFS shows the resolved structure of the shock for the first time.

Immediate questions:

- Can turbulence in the molecular gas explain the observed star-formation suppression in NGC 1266?
- Is the outflow driving turbulence in the molecular gas?
- What is the duty cycle of outflow driven turbulence and star-formation suppression?

Beyond NGC 1266:

- Is this turbulence-AGN-star-formation feedback a ubiquitous phase of quenching?
- How does turbulence regulate star-formation on global scales?

Contact me!

Comments and questions are welcome, find me during a coffee break or email me: jotter2@jhu.edu

Personal website:

Me