Dying of the Light: Cold Quasars & The Shutdown of Galaxy Growth

Dr. Kevin C. Cooke
University of Kansas

Allison Kirkpatrick, Michael Estrada, Hugo Messias, Alessandro Peca, Nico Cappelluti, Tonima Tasnim Ananna, Jason Brewster, Eilat Glikman, Stephanie LaMassa, T.K. Daisy Leung, Jonathan R. Trump, Tracey Jane Turner, Meg Urry

Science Question:
How do the supermassive black holes in the hearts of galaxies affect the formation of stars in their host?

Artist Conception Credit: Michelle Vigeant

Why Do Galaxies Stop Growing?

1) Massive galaxies in the present-day universe are dominated by a population with little to no star formation, while the early universe hosts the peak of the universe's star formation history (Fig. 1).

2) To understand how the shut down of star formation occurs, we study galaxies experiencing processes that stop its cold gas component from condensing into new stars.

Fig. 1) Galaxies tend to become less star-forming over time.

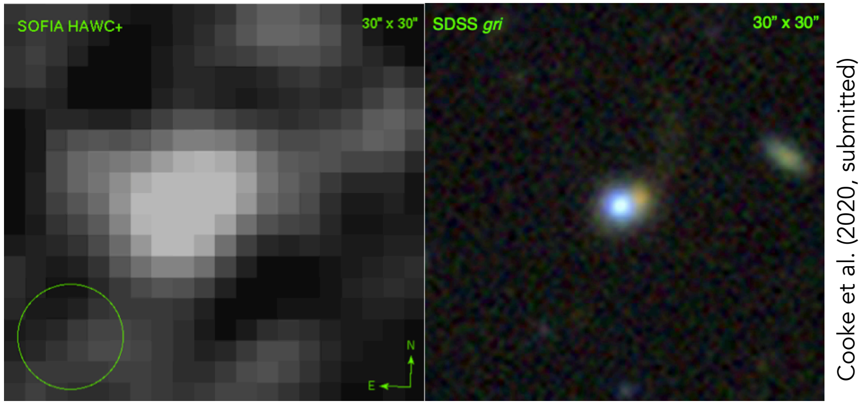
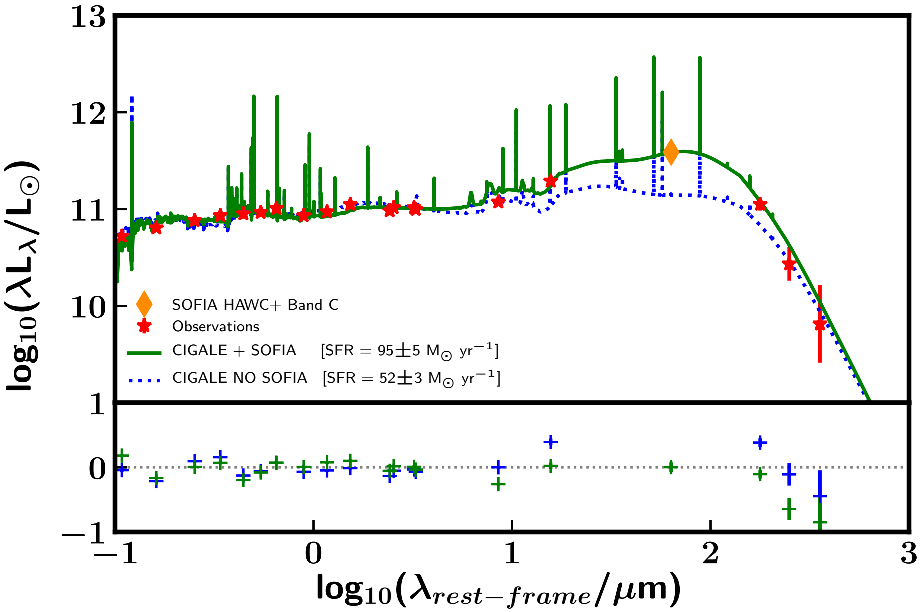


Fig. 2) Left: Cold Quasar 4479 seen in the Far-infrared (89 μm) using the SOFIA telescope. Right: Cold Quasar 4479 seen in the optical (~0.3-0.9 μm) using the Sloan Digital Sky Survey.

3) An actively accreting black hole, called an active galactic nucleus (AGN) or quasar, can be more luminous than its own host galaxy and warm up the surrounding gas supply, stopping star formation (AGN feedback, middle Fig. 1).

4) Cooke et al. (2020, sub.) has identified a galaxy (Fig. 2) hosting an AGN as well as a cold gas supply (seen in the infrared, left). This is called a `cold quasar', and is a rare galaxy caught in the process of AGN feedback.

How We Measure Galaxy Growth?



Cooke et al. (2020, submitted)

Fig. 3) We plot the total emission (y-axis) as a function of wavelength in microns (x-axis) for two emission models for CQ 4479 fit using the code CIGALE. The blue model includes only data from the Sloan Digital Sky Survey, Spitzer, and Herschel (red). The green model also includes data from SOFIA (orange).

NASA

SOFIA Telescope
Far-infrared (89 μm)
(orange point)

5) To understand how CQ 4479 is growing, we estimate star formation rate (SFR) and total stellar mass using fit stellar population models (lines) to the observed data (red points). To better constrain the star formation models that will dominated by the far-infrared emission, we performed new observations using the HAWC+ instrument on the SOFIA far-infrared telescope.

6) The inclusion of the single additional data point from SOFIA, used in conjunction with optical and other infrared observatories (Fig. 3), can change the SFR estimate by a factor of 2! This is a key example of the multi-wavelength nature of modern astronomy.

Results from Cooke et al. 2020

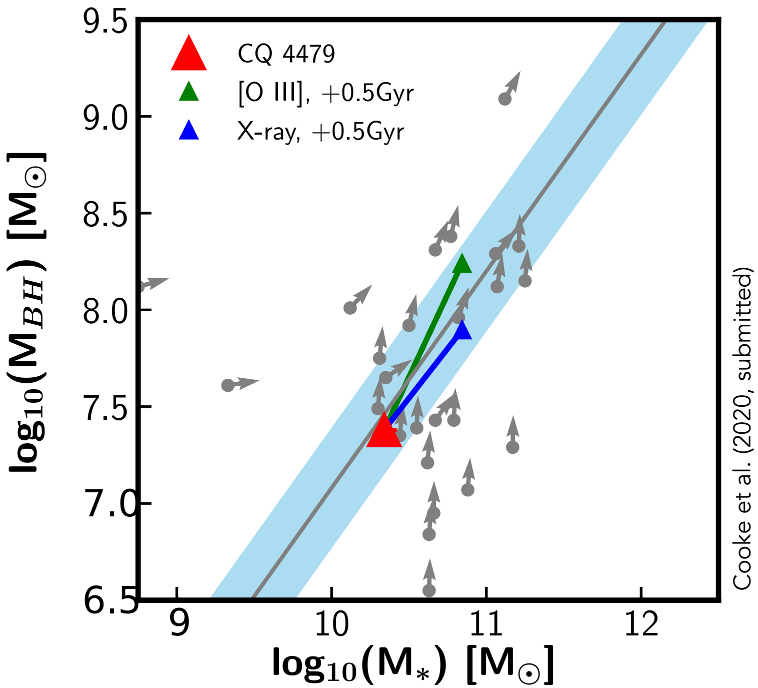


Fig. 4) We plot supermassive black hole mass (y-axis) and stellar mass (x-axis) for CQ 4479 as well as a comparison sample of luminous AGN (Sun et al. 2015, grey). Both are centered on a common evolutionary track (blue).

7) We compare the stellar growth estimated using the far-infrared fitting to the black hole growth rate, estimated using archival X-ray and optical data. We find that our target, CQ 4479 (red point) lies on the same evolutionary track (blue shaded) as other luminous AGN (Fig. 4).

8) This finding confirms that cold quasars represent an early stage to luminous AGN hosts, continuing to host a cold gas supply while a supermassive black hole is also feeding from the gas.

<u>Take-away</u>: ***Using the power of the far-infrared to constrain star formation estimates of a cold quasar, we find that these rare supermassive black hole hosts represent an early stage of AGN feedback. These systems provide a fascinating laboratory for understanding how AGN influence their galaxies and shut down their star formation.***